Clinical Report

Oxygen venous embolism after the use of hydrogen peroxide during lumbar discectomy

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Purpose: The knee-prone position is commonly used for patients undergoing spinal surgery. Venous air embolism in such a position may be produced by the negative venous pressure gradient between the ambient air and the venous plexuses of the spinous process. When hydrogen peroxide is used to cleanse the wound, oxygen is produced. We report a case of suspected oxygen venous embolism during lumbar discectomy in the knee-prone position after use of H_2O_2.

Clinical Features: Immediately after irrigation of a discectomy wound with H_2O_2, a dramatic decrease of the $P_{ET}CO_2$, blood pressure and oxygen saturation coincident with ST segment elevation occurred suggesting a coronary gas embolism. Symptomatic treatment was initiated immediately and the patient recovered without any sequelae.

Conclusion: Although hydrogen peroxide has an innocuous reputation, cases of accidental ingestion or massive gas embolism after wound irrigation leading to death have been reported. A review of the literature suggests that many of the clinical and physiopathological features of air and oxygen emboli are similar. For both, measures of prevention and treatment of complications are similar. We argue that the use of hydrogen peroxide should be avoided during procedures where the position of the patient (sitting, knee-prone) increases the risk of gas embolism and that hydrogen peroxide is a potentially dangerous solution.

Objectif : La position genupectorale est fréquemment utilisée pour la chirurgie de la colonne vertébrale. Dans cette position, l'embolie gazeuse peut être causée par la création d'un gradient veineux négatif entre l'air ambiant et les plexus des apophyses épineuses. Nettoyer une plaie avec du peroxyde d'hydrogène dégage de l'oxygène. Nous rapportons un cas d'embolie veineuse causée par de l'oxygène associé à l'utilisation de H_2O_2 pendant une discoïdectomie lombaire en position genupectorale.

Éléments cliniques : Immédiatement après l'irrigation d'une plaie de discoïdectomie avec du H_2O_2, une chute dramatique de la $P_{ET}CO_2$, de la pression artérielle et de la saturation en oxygène est survenue en même temps qu'une dépression du segment ST suggérant une embolie gazeuse coronarienne. Le traitement symptomatique a été initié immédiatement et le patient a récupéré sans aucune séquelle.

Conclusion : Malgré sa réputation d'innocuité, on a rapporté des cas d'embolies massives fatales après l'ingestion accidentelle de peroxyde d'hydrogène ou après une irrigation de plaie avec ce produit. Une revue de la littérature suggère que plusieurs des caractéristiques cliniques et physiopathologiques des embolies aériennes et d'oxygène sont identiques. Dans les deux cas, les mesures préventives et curatives sont les mêmes. Nous croyons qu'il faut éviter d'utiliser le peroxyde d'hydrogène pendant des interventions où la position du patient (assise, genupectorale) augmente le risque d'embolie gazeuse et qu'une solution de peroxyde d'hydrogène pourrait être dangereuse sous ces conditions.

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HYDROGEN peroxide solution is commonly used for irrigation of wounds because of its antimicrobial, cleansing and vasoconstricting properties. In the presence of tissue and blood catalase, hydrogen peroxide rapidly decomposes to water and oxygen, each millilitre of H_2O_2 3% solution releases 10 ml O_2.[1]

Gas embolism produced by hydrogen peroxide has been reported following oral ingestion, after wound irrigation and during surgery in the reverse Trendelenburg position.[2,4] Oxygen embolism after wound irrigation with H_2O_2 in the prone position has never been described, but in 1991 Albin *et al.*[5] reported cases of venous air embolism during laminectomy in the knee-prone position, focusing on the modification of the cardiovascular variables associated with this position. We describe a case of suspected oxygen embolism following the use of hydrogen peroxide during a discectomy in the knee-prone position.

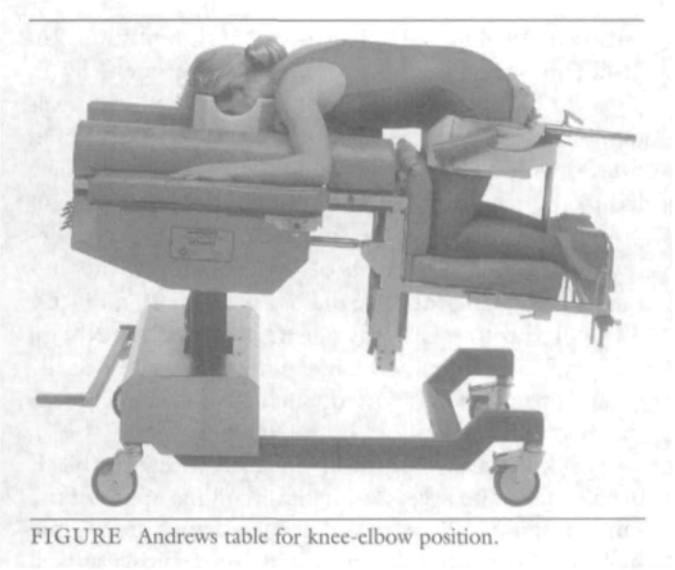

FIGURE Andrews table for knee-elbow position.

Case report

A 27-yr-old healthy ASA 1 man was admitted for an elective L4-5 discectomy with a diagnosis of spinal stenosis causing back pain without neurological deficit. In the operating room, monitoring consisted of a three lead ECG (II), pulse oximeter, Datex capnograph anaesthetic gas analyzer and non-invasive blood pressure (NIBP). Anaesthesia was induced with 150 µg fentanyl followed by 300 mg thiopentone *iv*. Tracheal intubation was facilitated with 5 mg pancuronium. After induction, the legs were wrapped in elastic dressings and the patient was turned to the knee-prone position on an Andrews table (Figure) with the abdomen hanging freely. The table was left in a neutral position. Anaesthesia was maintained with isoflurane 0.5–0.7% ET in a mixture of O_2/N_2O 30/70% supplemented with fentanyl boluses of 50 µg prn. Blood pressure ranged from 95/65 to 105/70 mmHg while heart rate was 80–90 min^{-1}, SpO_2 97–98% and $P_{ET}CO_2$ 29–31 mmHg.

Fifty minutes after the surgery started, $P_{ET}CO_2$ abruptly decreased from 31 to 13 mm Hg, the shape of the curve remaining normal. The blood pressure measured less than one minute later was 74/54 mm Hg and the heart rate was unchanged. Oxygen saturation decreased to 94%, N_2O was turned off and the lungs were ventilated with O_2 100%. Ventilation pressures remained normal and no problem or leak in the anaesthesia machine or circuits were detected. Simultaneously, the ECG (derivation II) showed ST segment elevations suggestive of acute myocardial ischaemia (Pardee waves). The surgeon was informed. He told us that he was beginning to close the wound and that he had rinsed it a few minutes earlier with 20 ml hydrogen peroxide 3% solution (diluted 50/50 with saline 0.9%). While the lungs were ventilated with oxygen, $P_{ET}CO_2$, SpO_2 and blood pressure returned to normal after four minutes, and the ST elevations disappeared after five minutes. The patient was given 100 mg hydrocortisone *iv* for prevention of cerebral damage caused by possible cerebral gas embolism. Following the termination of surgery, anaesthesia was discontinued and the trachea was extubated. The patient demonstrated no postoperative sequelae.

Discussion

It not possible to prove the diagnosis of pulmonary gas embolism since an oesophageal stethoscope, precordial Doppler or transoesophageal echocardiography were not used. Nevertheless, on the basis of clinical presentation, such a diagnosis was strongly suspected. The episode occurred about two minutes after the wound was irrigated with H_2O_2. The sudden decrease in $P_{ET}CO_2$ was not caused by a problem with ventilation and was followed by a decrease in BP.

We hypothesize that the ECG signs of acute coronary artery insufficiency in a young healthy patient and the transitory nature of these signs were suggestive of a coronary gas embolism. Venous entrained gas can reach the left side of the heart if the embolism volume is large or if a right to left intracardiac shunt is present. Although it does not rule out a right to left shunt, an echocardiogram failed to demonstrate a cardiac malformation. It is plausible, then, that the volume of gas was large and that the pulmonary absorption capacity was surpassed. It has been demonstrated, in animals, that transpulmonary passage of venous air embolism occurs if the threshold for pulmonary absorption is surpassed.[6] In pigs, this threshold was found to be

between 0.1 and 0.4 $ml \cdot kg^{-1} \cdot min^{-1}$.[7] Interestingly, in 1967, intravenous H_2O_2 was used experimentally in pigs as a means of extrapulmonary oxygenation. It was demonstrated that a solution of H_2O_2 3% diluted 50/50 with NaCl 0.9% perfused in the right ventricle led to the rapid formation of bubbles with subsequent pulmonary and systemic embolisation, severe methemoglobinaemia and death of the majority of the animals.[8] In the present case, the use of some 20 ml H_2O_2 3% diluted with saline may generate as much as 200 ml oxygen. Even when partially embolized, and especially when nitrous oxide is used, such an amount exceeds the absorption threshold of the lungs.

The knee-prone position on an Andrew's table is used to facilitate access to the interlaminar space of the lumbar spine. When the abdomen hangs freely, the hydrostatic pressure diminishes in the vena cava as well as in the epidural veins and blood loss is decreased. Di Stefano *et al.*[9] measured caval pressures in patients installed on a Hasting's frame (table designed to allow prone position with the abdomen hanging freely) and found values ranging from +2.0 to 6.6 cm H_2O. The risk of air embolism is increased by the negative hydrostatic pressure gradient between the epidural and central veins and by factors tending to contract the blood volume. The use of hydrogen peroxide in these conditions might lead to venous absorption of H_2O_2, with subsequent formation of oxygen bubbles and, depending on the volume of gas produced, to symptomatic systemic gas embolisation.

Experimentally, as little as 0.1 ml air injected into the coronary arteries can cause myocardial ischaemia. Rovai *et al.*[10] established the presence of air embolism as a case of transient ischaemia during coronary surgery. Usually, as in this case, the ischaemia resolves within a few minutes without requiring any therapeutic manoeuvres, but the effect of air on the coronary circulation may persist if a greater amount of gas is introduced. Concerning our patient, it is possible that the transpulmonary passage of oxygen affected not only the coronary but also other arterial beds. The monitoring available allowed only the detection of coronary and pulmonary embolism. Since the embolic phenomenon was time limited, embolic events in other beds were not detectable and no signs were present after the patient awoke. Whether or not oxygen embolism has a better prognosis than air embolism (facilitated resorption due to the aerobic cellular metabolism) is not well known, although intravascular oxygen-rich gas might be cleared more quickly.[11,12]

In the literature, most cases of gas embolism involve air (diving, extracorporeal circulation, central lines, neurosurgical procedure in sitting position). Some rare cases involve oxygen following the use of H_2O_2 and CO_2 during laparoscopic procedures.[13] The management of these cases has been challenged by the lack of prospective randomized studies. Currently, it is based on empirically acquired preventive and therapeutic measures. Avoiding the use of H_2O_2 would be the easiest measure to prevent oxygen embolism. Diluting H_2O_2 or flooding the wound with saline may reduce the venous entrapment of oxygen as it will reduce the risk of gas entrapment. Increasing right atrial pressure by binding the legs (or using military antishock trousers: MAST), avoiding volume depletion and ventilating the lungs with positive end-expiratory pressure was demonstrated to reduce markedly the incidence of venous air embolism.[14] Non invasive detection measures should be used whenever gas embolism may occur.

In cases of venous gas embolism, placing the patient in the Trendelenburg position is recommended, although it might favour coronary arterial embolisation.[15] Avoiding nitrous oxide is mandatory as it increases the volume of air bubbles, being 34 times more soluble in blood than N_2. In cases of oxygen embolism, N_2O will not increase the volume of the bubbles, but ventilating the lungs with oxygen will help to improve O_2 delivery. Preventing cerebral complications of gas embolism with corticosteroids is controversial. Dutka *et al.*,[16] during experimental cerebral arterial air embolism in dogs, showed some improvement in recovery when dexamethasone was used prophylactically but not when used therapeutically. Corticosteroids are currently not recommended for the treatment of gas embolism but 21-aminosteroids or oxygen radical scavengers such as allopurinol, dimethyl sulfoxide and mannitol, which are under investigation, may improve neurological outcome when given prior to cerebral ischemia.[17]

Finally, once cerebral or neurological damage following arterial gas embolism has developed, hyperbaric oxygen therapy may be indicated. Tovar *et al.*,[18] in an excellent review, present the physical and physiological basis that might justify the use of other therapeutic tools (mannitol, antiplatelet medication, strict glucose control) to treat cerebral air embolism.

Conclusion

We present a case of probable pulmonary and coronary oxygen embolism secondary to wound irrigation with H_2O_2 during discectomy in a patient in the knee-prone position. Although H_2O_2 is considered to be innocuous in most circumstances, it may be the cause of potentially serious complications. The knee-prone position may increase the risk of venous embolism. Using hydrogen peroxide in such a position should be

avoided because reliable detection measures (Doppler for example) are not easy installed (or universally available) and, in the eventuality of a massive embolic event, reanimation manoeuvres would be highly compromised.

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