Oxygen Uptake and Carbon Dioxide Elimination during Epinephrine-induced Arrhythmias in Humans

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Halothane sensitize the myocardium to exogenous catecholamines. Many cases of epinephrine-induced arrhythmias during halothane anesthesia[1–5] have been reported, but there is no reports regarding minute oxygen uptake ($\dot{V}O_2$), or minute carbon dioxide elimination ($\dot{V}CO_2$) during epinephrine-induced arrhythmias.

This case report is interesting for the following reasons: $\dot{V}O_2$ and $\dot{V}CO_2$ increased suddenly during accidental epinephrine-induced arrhythmias and prostaglandin E_1 (PGE_1) might suppress myocardial irritability.

The causes of the increase in $\dot{V}O_2$ and $\dot{V}CO_2$ during epinephrine-induced arrhythmias and the protective mechanisms of PGE_1 against myocardium are discussed through this case.

Report of a case

The patient was a 68-year-old woman, whose height, weight, and body surface area (BSA) were 141 cm, 45 kg and 1.32 m^2, respectively. She had a left breast cancer and underwent an extensive radical mastectomy and parasternal lymphnodes dissection. She had neither particular history nor systemic disease except hypertension.

Induced hypotension using PGE_1 was scheduled under nitrous oxide, oxygen, and halothane anesthesia. Since her usual systolic blood pressure was about 150 mmHg, 75–80% of her usual blood pressure (100–120 mmHg: systolic pressure) was intended for induced hypotension. For continuous blood pressure monitoring and analysis of blood gases a radial artery catheter was inserted.

Fifty ml of 0.9% saline solution containing epinephrine was administered locally for the purpose of hemostasis just before the incision. Arterial blood pressure increased suddenly and multifocal ventricular arrhythmias appeared when the surgery started. Therefor, the anesthetic agent was changed from halothane to enflurane. Its concentration was increased to 3.5% inspired (approximately 2 MAC) for deepening anesthesia and 40 mg of lidocaine was immediately injected intravenously against arrhythmias. However, her blood pressure continued to increase to 240 mmHg with ventricular tachycardia. The surgery was imme-

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diately interrupted, and we confirmed the concentration of epinephrine administered to the patient was 1/5,000 instead of 1/500,000. Sixty mg of lidocaine was administered additionally, and 0.2–0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$ of PGE_1, which had been prepared for induced hypotension and 1 $mg \cdot kg^{-1} \cdot min^{-1}$ of lidocaine was infused simultaneously. The arrhythmias disappeared and the abnormally elevated blood pressure gradually decreased. In order to remove the influences of locally administered epinephrine as quickly as possible, the surgery was started again. The patient's blood pressure was kept at the level of about 110/60 mmHg with PGE_1. The urine output was maintained at more than 1 $ml \cdot kg^{-1} \cdot hr^{-1}$.

$\dot{V}O_2$ and $\dot{V}CO_2$ were measured continuously using a non-invasive Respiratory Anesthetic Metabolic Scanning Monitoring System (RAMSCAN®)[6,7] from the start of anesthesia to the end of anesthesia. The RAMSCAN consists of a mass spectrometer and a mini-mixing chamber (Bymixer)[8]. $\dot{V}O_2$ and $\dot{V}CO_2$ increased suddenly in accordance with blood pressure elevation. When the accident was occurred, $\dot{V}O_2$ increased two times transitorily and then 1.5 times for about 10 min. $\dot{V}CO_2$ also increased two times and this lasted about 10 min. During induced hypotension with PGE_1. $\dot{V}O_2$ and $\dot{V}CO_2$ were stable at the normal level. After the administration of PGE_1 was stopped, the blood pressure remained relatively stable, while $\dot{V}O_2$, $\dot{V}CO_2$ and R (gas exchange ratio) fluctuated remarkably. It suggested that her systemic metabolism was unstable. After emergence from anesthesia, no neurological sequelae were noticed and her postoperative course was uneventful.

Discussion

During halothane anesthesia, the maximum dose of 1/100,000 epinephrine solution is 0.15 $mg \cdot kg^{-1}$ [1]. The amount which we planned to use for this case was 50 ml of 1/500,000 solution. Unfortunately, very severe arrhythmias, including multifocal ventricular dysrhythmia and ventricular tachycardia were induced by 10 mg of epinephrine accidentally.

It is considered that the increase in $\dot{V}O_2$ and $\dot{V}CO_2$ was caused by the increase in cardiac work as well as the increase in systemic metabolic rate caused by epinephrine.

Anesthesia itself has the protective effect against surgical stress and the administration of PGE_1 has a pharmaceutical effect in a significant decrease of the release of epinephrine from the adrenal gland besides vasodilatation[10,11]. Since the plasma concentrations of catecholamines were not measured, it could not be explained why the patient's blood pressure remained stable though $\dot{V}O_2$ and $\dot{V}CO_2$ fluctuated after PGE_1 administration was stopped.

The increase in $\dot{V}O_2$ and $\dot{V}CO_2$ and severe arrhythmias induced by overdose of epinephrine were suppressed by deep enflurane anesthesia and continuous administration of PGE_1 and lidocaine.

Prostaglandin E_1 also has a coronary dilatory effect[12]. PGE_1 may reduce coronary spasms[12].

PGE_1 increase myocardial oxygen supply, decrease myocardial oxygen consumption and markedly improves myocardial oxygen balance.

PGE_1 was used for vasodilatation in order to reduce afterload. PGE_1 has been known to antagonize epinephrine-induced arrhythmias[9].

Nitroglycerin (TNG), beta-blockers, and calcium channel antagonists are also effective for treatment of dysrhythmia of various types. Nitroglycerin is a systemic venous vasodilator[13], whereas PGE_1 is an arterial vasodilator[14]. Because of this latter effect interfering with epinephrine-

induced vasoconstriction, the administration of PGE_1 seemed to be reasonable for treatment of our case.

The mechanisms of suppression $\dot{V}O_2$ and $\dot{V}CO_2$ during administration of PGE_1 in our case may be due to a decrease in endogenous epinephrine secretion[10,11]. Our case also show a protective effect of PGE_1 against epinephrine-induced ventricular irritability.

These effects were supported by the facts that metabolic parameters ($\dot{V}O_2$, $\dot{V}CO_2$ and R) were stable during PGE_1-induced hypotension after epinephrine-induced arrhythmias.

This case report suggests that if massive doses of epinephrine is accidentally injected during anesthesia, ventricular irritability and an increase in $\dot{V}O_2$ and $\dot{V}CO_2$ can be suppressed by prostaglandin E_1.

Appendix

The Respiratory Anesthetic Metabolic Scanning Monitoring System (RAMSCAN)[7,8] which we use in our institute every day has following capacities. The mixing chamber (Bymixer)[6] has a 90% response time capacity of 24.8 seconds (ventilation volume: 7.5 $l \cdot min^{-1}$). The mass spectrometer has a sampling time capacity of 15 seconds. Therefor, this system can correspond to the metabolic changes in a short span of time, that is within one minute.

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