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Case Report Open Access

Intracardiac Epinephrine Injection during Open Thoracotomy and Circulatory Arrest

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Introduction

The intracardiac injection of epinephrine is a procedure that is rarely used in modern day cardiopulmonary resuscitation. We report a case of intracardiac epinephrine injection during open thoracotomy and pulseless electrical activity that resulted in return of cardiac function.

Successful intracardiac injection of stimulants was first reported in 1922 in patients under chloroform anesthesia who sustained circulatory arrest [1]. Shortly after, dozens of additional case reports arose including the use of 1 mL of 1:1000 epinephrine injected directly into the ventricle as a last resort in a patient with syphilitic coronary arteritis [2]. However, more recently few case reports have detailed the use of intracardiac epinephrine.

Case Report

A day prior to our case presentation, the patient, a 51-year-old 110 kg male, was brought to the hospital as a level 1 trauma after a motor vehicle struck his motorcycle. His past medical history included hypertension and dyslipidemia. He had no surgeries in the past. His medication list at the time of presentation included atenolol, ezetimibe, lisinopril, and lovastatin. Upon arrival in the trauma bay, he was found to be in cardiac arrest with resuscitation and advanced cardiac life support in progress. Resuscitation and massive blood product transfusion continued with return of carotid pulses after 26 minutes. He went to the operating room at that time for emergent external fixation of pelvic diastasis, over sewing of the femoral artery secondary to traumatic limb amputation, and exploratory laparotomy with blood loss estimated at 6,000 mL. He was then managed in the intensive care unit by the trauma surgery team. Overnight he had high wound drain output with acute anemia requiring blood transfusions, prompting the need for repeat laparotomy.

While in the intensive care unit and prior to his abdominal re-exploration, he had been started on multiple vasoactive medications including norepinephrine 0.3 mcg/kg/min, vasopressin 0.04 units/min, and epinephrine 0.25 mcg/kg/min as well as nitric oxide at 42 ppm. He was weaned off the vasopressin and epinephrine infusions prior to transport to the operating room and was solely on norepinephrine. He remained on a fentanyl infusion at 200 mcg/hr and had been following commands off sedation. He was transferred to the operating room and remained on the intensive care unit ventilator in airway pressure release ventilation mode. General anesthesia was induced with scopolamine 0.6 mg IV and fentanyl 250 mcg IV. Pre-operative infusions of fentanyl and norepinephrine were continued. Bispectral index was monitored and the ventilation mode was changed to pressure control with maintenance of appropriate oxygenation and ventilation after muscle relaxation with rocuronium 50 mg IV.

During initial re-exploration of the abdomen, bilateral bulging diaphragms were noted by the surgical team. A left chest tube was replaced without significant changes in ventilation or hemodynamics. The right chest tube was replaced and found to contain a large blood clot. The new right chest tube immediately began to drain significant amounts of blood and a decision to proceed with right anterolateral thoracotomy was made. The massive transfusion protocol was activated as the surgical team worked to complete right, middle, and upper lobe lung wedge resections with over sewing of right lung injuries. The right anterolateral thoracotomy was then extended to form a bilateral anterolateral thoracotomy.

Massive blood loss continued and resuscitation was ongoing with rapid infusion of blood products. However, ST depressions were noted in leads II and V. A transesophageal echocardiogram was performed and findings included severe global hypokinesis of the right ventricle with markedly decreased systolic function. The epinephrine infusion was restarted shortly after at 0.3 mcg/kg/min due to worsening hemodynamics and inhaled nitric oxide was increased to 80 ppm. Due to massive ongoing blood loss, the patient decompensated into pulseless electrical activity and cardiac massage was initiated. The patient remained in pulseless electrical activity for 6 minutes despite cardiac massage, multiple doses of intravenous epinephrine, and a dose of atropine. The decision was then made to perform an intracardiac epinephrine injection of 1 mg into the left ventricle. Within 15 seconds of injection, mechanical cardiac function returned.

The patient maintained pulses through the remainder of the operation. Estimated blood loss for the case was 15,000 mL. Vasoactive support during the procedure totaled, 1 mg intracardiac epinephrine, 1 mg atropine, 10.5 mg IV epinephrine, and 10 mg norepinephrine. The patient received 5000 mcg factor VIIa, 1000 mL tromethamine, 36 units packed red blood cells, 24 units fresh frozen plasma, 2 units platelets, 1 unit cryoprecipitate, 5500 mL normal saline, and 1000 mL hydroxyethyl starch.

The patient was transferred back to the intensive care unit and was responding to commands the next day. He remained on vasopressor support with stable hemoglobin levels for the next two weeks. During that time he continued to respond to commands and returned to the operating room twice for irrigation and debridement procedures. Unfortunately, he developed sepsis from multidrug-resistant Gram-negative bacteria that did not improve despite optimal therapy. Two weeks after our involvement he was no longer following commands

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and his sedation requirements greatly decreased. Family meetings took place and life support was withdrawn a week later.

Discussion

Epinephrine has been used as the mainstay medication for cardiopulmonary resuscitation despite little evidence that it improves outcomes [3]. The 1 mg dosing commonly used today is not a result of scientific studies, but comes from observations by surgeons who performed intracardiac injections in the operating room [4-6]. What we do know is that the alpha-adrenergic properties of epinephrine lead to increased myocardial and cerebral blood flow during cardiopulmonary resuscitation. Negative effects include reduced subendocardial perfusion, increased myocardial work, and post-resuscitation myocardial dysfunction. Despite this, epinephrine remains in standard cardiopulmonary resuscitation guidelines around the world.

Decades ago, intracardiac injection of epinephrine was considered a standard practice. More recently, closed-chest percutaneous intracardiac administration of epinephrine has been removed from cardiopulmonary resuscitation guidelines in the United States. There are risks associated with percutaneous intracardiac injection including coronary artery laceration, cardiac tamponade, and pneumothorax, though this point is debated [7-11]. These perceived risks are minimized during open thoracotomy where direct access to a cardiac ventricle is available. The preferred route of epinephrine administration is intravenous or intraosseous, which includes arrest in the peri-operative and operative setting. Intracardiac injection of epinephrine should be used only during open cardiac massage or when other routes are unavailable [12].

Our patient remained in cardiac arrest despite multiple doses of intravenous vasoactive agents and directs cardiac massage. In this setting, intracardiac injection of epinephrine was attempted in light of failure of other resuscitative efforts. Our patient received 1mg of a 1:1000 solution of epinephrine injected into the left ventricle. Similar outcomes are obtained when epinephrine is injected into either the right or the left ventricle [13-14]. Current guidelines recommend intravenous epinephrine in a 1:10,000 concentration, without direct mention of the concentration for intracardiac injection. A 1:1000 concentration was used for intracardiac injection in many of the original case studies, though no data is available to recommend one concentration over the other for intracardiac injection. There are wide variations in the recommended dose of intracardiac epinephrine, with most sources giving ranges from 0.1-1 mg or 0.3-0.5 mg. There is a lack of data showing improved outcomes with any particular dose of intracardiac epinephrine. Further, many of the original observations involved a 1 mg dose [5]. Given the current recommendation for 1 mg epinephrine intravenous during cardiac arrest [15] and that intracardiac epinephrine be reserved for open thoracotomy when intravenous injection has failed or is not possible, we recommend a 1 mg epinephrine dose for intracardiac injection. Since intramyocardial injection can lead to irreversible cardiac injury, it would be prudent to use a needle length that exceeds typical cardiac wall thickness and to aspirate prior to injection to help ensure intraventricular placement. A 1.5" (3.8 cm) 22 G needle should be sufficient for ventricular puncture while reducing the risk of significant puncture site bleeding, as may occur with a large-bore needle. Our patient had dramatic return of hemodynamics after intracardiac epinephrine injection, suggesting this procedure may have a useful role in cardiopulmonary resuscitation during open thoracotomy and cardiac massage.

Conclusion

Intracardiac epinephrine injection during cardipulmonary arrest in the peri-operative setting should be reserved for patients receiving cardiac massage during open thoracotomy. We feel the potential benefit of this procedure in this setting outweighs the risks. When conventional resuscitation measures fail during cardiopulmonary arrest and open thoracotomy, we recommend consideration for the intracardiac injection of epinephrine. In this setting, we recommend 1 mg epinephrine in either 1:1000 or 1:10,000 concentration injected into into either ventricle using a narrow-bore needle.

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