Protection against ischemia-reperfusion injury in prolonged resuscitation: A case report and review of literature

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Case Report

Abstract

BACKGROUND: The severity of ischemia/reperfusion injury determines the neurologic outcome after successful cardiopulmonary resuscitation.

CASE REPORT: We present a case of prolonged open-chest resuscitation who survived without neurologic sequel. Multiple applied strategies to limit the deleterious effects of ischemia and reperfusion injury, that is, infusion of magnesium sulfate and mannitol, protective lung ventilation and optimal postoperative pain control prevented the end organ damage in this patient. During the 40 min open-chest resuscitation, ventricular defibrillation was successfully attempted with extrathoracic paddles.

CONCLUSION: The appropriate use of pharmacologic and non-pharmacologic protective strategies could modify the inflammatory cascade and minimize the deleterious effects of reperfusion after prolonged periods of ischemia. The successful defibrillation in this patient warrants the use of standard paddles in open-chest surgeries where surgical small paddles are not available.

Keywords: Resuscitation, Ischemia, Reperfusion, Neuroprotection, Addiction, Extrathoracic Defibrillation

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Introduction

The successful cardiopulmonary-cerebral resuscitation requires intensive care to prevent end organ damage or neurologic sequel. Multiple pharmacologic strategies have been proposed to protect vital organs from ischemia/reperfusion injury.[1] However, their overall clinical benefit is controversial. Since conducting clinical trials addressing human resuscitation is difficult, and the clinical pictures are highly variable, any evidence for the effectiveness of a treatment modality even in a single patient would be valuable. In this report, the treatments with possible protective mechanisms have been explained.

Case Report

A 27-year-old man was emergently transported to the operating room due to hemorrhagic shock and cardiac tamponade following penetrating chest trauma. The patient was confused, with a heart rate of 134/min and blood pressure (BP) of 72/34. Induction of anesthesia was performed with ketamine 30 mg and succinylcholine 70 mg, and the patient intubated.

The surgeon approached the patient with an anterolateral thoracotomy. Immediately after pericardiotomy the patient became asystole. Open cardiac massage was started for the patient and continued for about 40 min, when electrocardiographic monitoring revealed ventricular fibrillation. Amiodarone 300 mg was slowly infused for the patient. Because internal paddles were not available, extrathoracic defibrillation with monophasic shock 200 J using standard paddles was attempted. The cardiac rhythm immediately changed to sinus rhythm with a BP of 102/47. Magnesium sulfate 2 g was slowly infused for the patient. The BP remained stable in the remaining time of the operation. The stab wound (approximately 2 cm) in the apex of the left ventricle was sutured, pericardium was closed, chest tube was inserted, the ribs were approximated and finally chest wall was closed.

During the 40 min cardiopulmonary resuscitation (CPR) the patient received only a small

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dose of hyoscine (5 mg) to guarantee his amnesia. From successful defibrillation to the end of surgery, two bolus doses of ketamine 20 mg was administered for the patient. Muscle relaxation was established with cisatracurium 4 mg intraoperatively and reversed with neostigmine and atropine at the end of surgery. The patient was mechanically ventilated with tidal volume of 400 ml and respiratory rate of 12/min. The fluids given to the patient in the operating room included isogroup partially cross-matched packed red blood cell 8 units, fresh frozen plasma 4 units, lactated Ringer's solution 2000 ml, hypertonic saline 5% 200 ml, normal saline 1000 ml, and mannitol 20% 150 ml. The patient was transported to the surgical intensive care unit (ICU), while intubated but with spontaneous breathing. He was not awake but showed motor response to painful stimulation.

The patient remained intubated in the ICU for 48 h under sedation with morphine sulfate and midazolam. Magnesium sulfate 1 g/h and maintenance dose of amiodarone were infused for the first 24 h postoperatively. During this period, respiratory support was performed with continuous positive airway pressure mode with pressure support 10 cm H_2O and positive end expiratory pressure equal to 5 cm H_2O. The patient tolerated this mode comfortably. Laboratory data in the first postoperative day showed increased creatinine (Cr = 1.6), hyperkalemia (K = 7.5), hypocalcemia (Ca = 6.7), hemoglobin = 10.6 mg/dl, platelet count = 108,000 and international normalized ratio equal to 1.9. Other laboratory examinations, including blood sugar, liver function tests, and other electrolytes were within normal range. The patient was given kay oxalate for his hyperkalemia. Serum creatinine decreased gradually, and electrolytes normalized in the following days without the need for dialysis.

The patient was extubated in the 3rd postoperative day when he became conscious. Analgesia with elastomeric infusion pump containing morphine sulfate was continued for the next 3 days and then changed to oral analgesic medications. Chest tube was removed in the 5th postoperative day. On the 8th postoperative day, he was discharged to home with good general condition without any neurologic sequel.

Discussion

The reported patient survived from 40 min of open-chest CPR without any neurologic sequel. The effective CPR along with protection against ischemia-reperfusion injury in the vital organs is the key factor in survival from prolonged cardiac arrest. Uninterrupted open-chest cardiac massage was performed for the reported patient. However, it is expectable to have some degrees of ischemia in vital organs after 40 min of resuscitation followed by reperfusion injury in heart, lung, brain, and kidneys. We applied multiple strategies to limit the deleterious effects of reperfusion and inflammation in this patient including administration of magnesium sulfate and mannitol, protective lung ventilation, and optimal postoperative pain control.

We administered magnesium sulfate 2 g after defibrillation for its reported neuroprotective[2,3] and cardioprotective properties.[4,5] Noteworthy, preliminary studies suggest that magnesium may have renoprotective effects.[6] We also used mannitol 30 g for renal protection. Its clinical benefit in ischemic conditions such as during cross-clamp of aorta in cardiac surgery has been approved,[7] but its effects following resuscitation is not fully investigated. It may also reduce brain edema and may improve cerebral perfusion in patients with mild brain damage following resuscitation.[8] However, its overall contribution to survival has not been sufficiently disclosed.

Our patient was an intravenous drug user experiencing a wide spectrum of substances. It is established that drug abuse has deleterious effects on several organs via direct toxic effects or triggering inflammatory process. However, it is not known whether exposure to chronic inflammation specifically drug abuse can reduce the harmful effects of an acute inflammation such as ischemia reperfusion injury. It seems reasonable to generalize the "pre-conditioning mechanism" to this area based on the positive results of earlier preliminary studies. A study showed that a pre- or a post-conditioning treatment with extremely low doses of tetrahydrocannabinol provides effective long-term cognitive neuroprotection.[9] Another laboratory study showed that in vivo administration of morphine 12 h prior to hypoxia/hypoglycemia can induce neuroprotective effects.[10] It has been suggested that morphine dependence protects the kidney against ischemia/reperfusion injury via opioid receptor-dependent pathways.[11] The role of opioids in different forms of preconditioning including ischemic and pharmacologic insults has been described.[12] Taken together, it seems reasonable to conclude that drug abusers may show different responses to ischemic conditions. This hypothesis and its clinical applications need to be validated in further investigations.

Another interesting point in the clinical scenario of this patient was the successful defibrillation with external paddles. Classically, defibrillation in open heart surgery is performed with small surgical paddles using 10-20 J of electricity. The impedance will change in thoracotomy. Thus, external defibrillation may result in myocardial stunning secondary to the delivery of high-energy shocks or conversely the applied energy may be ineffective. In the absence of small sterile "surgical" paddles, standard external paddles were placed on the chest wall, and defibrillation was successfully attempted with monophasic 200 J shock. This successful experience suggests using standard paddles for defibrillation in open cardiothoracic surgeries when surgical paddles are not available.

Conflict of Interests

Authors have no conflict of interests.

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