Trauma and Emergency Care

Review Article

Open chest CPR in non-traumatic cardiac arrest: A case report and review of the literature

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Abbreviations: Cardio pulmonary resuscitation: CPR; Open chest cardio pulmonary resuscitation: OC-CPR; Closed chest CPR: CC-CPR; Ventricular Fibrillation: VF;

Introduction

During the first half of the 20th century the standard treatment for cardiac arrest was open chest cardiac massage but beginning in the 1960s closed chest compressions gradually came to replace open chest cardiac massage in cardiac arrest as the gold standard of treatment despite the fact that studies showed cardiac output, cerebral perfusion and patient outcomes where significantly better in open chest massage.

Open chest cardio pulmonary resuscitation (OC-CPR) has several drawbacks that help explain why today it has been almost entirely eclipsed by closed chest CPR (CC-CPR). When Kouwenhoven et al. [1] began the popularization CC-CPR they empathized that it didn't require immediate access to an operating theatre and could be performed by essentially anyone anywhere in contrast to OC-CPR that demanded both considerable skill and the right equipment.

OC-CPR continued to be performed in emergency departments and operating rooms but today almost exclusively in cases of traumatic cardiac arrest or cardiac arrest following cardiac surgery.

In this article we will present the case of a patient who initially was taken to hospital with a suspected traumatic cardiac arrest, who turned out to have a medical cardiac arrest where OC-CPR was successfully performed. We also present a review of the relevant literature and make the case that OC-CPR may have been regaled to medical history somewhat prematurely.

Case report

We present the case of a patient initially thought to have suffered a traumatic cardiac arrest who appears instead to have suffered a medical cardiac arrest and was successfully resuscitated using OC-CPR. The patient, a 74 year old male, had three previous myocardial infarctions in the 1980s and CABG had been performed in 1992, at the time of the cardiac arrest the patient also suffered Diabetes Mellitus type II, which had led to the amputation of the lower leg on one side, and systolic heart failure with an ejection fraction of 30-35%.

The patient was driving in a tunnel when witnesses report he suddenly crossed into the other lane and crashed into the wall of the tunnel. When the ambulance arrived the patient was unconscious and pulseless, CC-CPR was initiated and the patient was defibrillated three times but remained in ventricular fibrillation (VF), a LUCAS chest compression system was applied in the ambulance.

At arrival to the ER at Sahlgrenska University Hospital the patient remained unconscious and pulseless. As the patient had suffered trauma but the sequence of events according to witnesses suggested that the car crash was perhaps secondary to a medical cardiac arrest both the trauma surgeon and the cardiologist where summoned to the chock/trauma room in the ER.

The patient is evaluated according to ATLS and the cardiologist performed an ultrasound cardio-echography that showed pulseless electrical activity. The trauma surgeon decides to perform a thoracotomy, no traumatic pathology is found and OC-CPR is initiated.

The aorta is clamped and manual cardiac massage is initiated. The patient remains in VF and is given Atropine, Amidarone and Epinephrine before two 25 J defibrillations are performed. Manual massage is resumed, the patient is given another dose of Atropine, Amiodarone and Epinephrine and two more defibrillations at 50 J are attempted but the patient remains in VF.

The patient is given more Atropine, Amiodarone, Epinephrine and now calcium is added and another two defibrillations at 50 J and the patient has a return of spontaneous circulation (ROSC).

The thoracotomy is closed with a skin suture, the patient remains intubated and is sent to the Cardio-angio-lab for a percutaneous coronary angiography.

The coronary angiography does not find any culprit lesions and the patient is sent to the intensive care unit. In the intensive care unit the patient is placed in a therapeutic hypothermia, later the same evening he develops coagulopathy and starts bleeding from the thoracotomy wound.

He is transfused with erythrocytes and thrombocytes and taken for a full body CT which is blank, the patient is then taken to the operating room for a revision of the wound. The patient is later extubated and transported to another hospital where he makes a full recovery. The patient receives an implantable cardioverter defibrillator and returns home.

Discussion

In the 1960s Kouwenhovens popularization of CC-CPR was not the only revolution taking place in the treatment of sudden cardiac death. Where previously defibrillation was performed during OC-CPR the

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1960s also bought efficient defibrillators for external use to the clinic. Bringing these advances together was the introduction of the first Coronary Care Unit at Royal Infirmary in Edinburgh by Dr Desmond Julian who showed that trained staff, close monitoring of patients and CPR together drastically improved the outcomes in patients suffering acute coronary disease.

Whereas patients suffering acute coronary disease where previously given morphine for the pain, ordained six weeks of bedrest and put wherever free beds could be found in the hospital this was a tremendous improvement. As CC-CPR proved to be adequate in many forms of cardiac arrest and CPR was administered with increasing frequency treating every medical cardiac arrest with a highly invasive and dangerous procedure requiring large amounts of resources became less and less appealing to physicians.

As CC-CPR in the following years replaced OC-CPR there was still research showing better outcomes with OC-CPR and a continuing role for OC-CPR in resuscitation algorithms for medical cardiac arrest has repeatedly been suggested but so far without much effect. OC-CPR has several drawbacks [2,3]. First it is costly as it demands access equipment typically only found the operating room or ER. Second it requires both anesthesiological and surgical expertise to perform an OC-CPR correctly and in a timely manner. But even when performed by an experienced physician this operation carries considerable risk.

The patient will risk damage to intercostal nerves and blood vessels, damage to the lung, injury to the vagal nerve and finally injury to the myocardium itself. With a skilled operator these risks can be minimalized but as the thoracotomy in OC-CPR by its very nature will be unscheduled and by necessity performed in a limited time complications are hard to eliminate. After OC-CPR has been performed correctly the reason for the cause of the cardiac arrest will have to be treated, typically with a percutaneous coronary intervention and the patient will have to be treated in the ICU until in a stable condition. Thus the two main drawbacks of integrating OC-CPR into the treatment algorithm for medical cardiac arrest are increased costs, due to increased resource demands, to the health care provider and the risk of complications for the patient.

After performing a comparison of OC-CPR and CC-CPR in dogs Pike et al in their 1908 paper note “Often a faithful trial of extra-thoracic massage has failed to start the heart. In nearly all of these cases direct massage has afterward proved effective” [4].

While no studies exist comparing outcomes in OC-CPR and CC-CPR in humans there are many performed on dogs echoing the findings of Pike et al showing the superior hemodynamics, higher success rate in achieving ROSC, improved cerebral perfusion and superior outcomes in dogs receiving OC-CPR compared to CC-CPR [4-8].

In patients there are no prospective or randomized trials, there are the data from Stephenson et al on intra hospital cardiac arrest where 28% of patients achieved ROSC following OC-CPR and Briggs et al where 58% of patients achieved ROSC when OC-CPR was initiated within 4 minutes survived [9,10].

In a retrospective study Takino et al. found that patients with non-traumatic cardiac arrest that received OC-CPR within 5 minutes of arrival at their hospital had significantly better survival and outcomes compared to patients only receiving CC-CPR [11].

We believe there is a place for OC-CPR in non-traumatic cardiac arrest. For the patient to benefit OC-CPR has to be initiated in a timely fashion, in animal models the benefits of OC-CPR appear to decrease sharply if initiated after 30-40 minutes of CC-CPR [12]. Published clinical materials also indicate the superiority of initiating OC-CPR as early as possible [10,11].

In a setting where the competence and equipment for performing a thoracotomy, in most hospitals this will be the ER, we believe there is reason to believe CC-CPR non-responders might be benefited by timely conversion to OC-CPR. The ability to produce a higher cardiac output compared to CC-CPR coupled with the ability to temporarily occlude the aorta manually leads to increase coronary flow and myocardial perfusion increasing the chances of achieving ROSC. The vastly superior cerebral perfusion produced by OC-CPR [5,6] is another argument for prompt conversion to OC-CPR in the CC-CPR non-responder to prevent cerebral damage.

While the specifics of when and where to implement OC-CPR in the treatment of cardiac arrest remains an open for discussion there is much to suggest a wider role for OC-CPR in cardiac arrest outside of its traditional role in post-operative and traumatic cardiac arrest.

Conclusion

OC-CPR is hemodynamically superior, more effective in achieving ROSC and produces better cerebral perfusion than CC-CPR. Although a risky and highly invasive procedure there are significant benefits if utilized correctly in the correct patient population.

Disclosure

The authors declare no conflicts of interest.

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