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Case Report

A rare complication of cardiopulmonary resuscitation applied during transportation by ambulance: A case report of flail chest

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Abstract:

Cardiopulmonary resuscitation (CPR) to be applied during patient transfer by ambulance differs from CPR applied in the field or in the hospital in terms of physical condition. Especially the deeper and faster chest compressions recommended in the latest CPR guidelines, when administered during ambulance transport, may result in a further increase in traumatic CPR complications. However, in the current CPR guidelines, there are no clear recommendations regarding additional measures that can be taken to reduce the complications and increase the efficiency of CPR during patient transport. In this study, a case of flail chest that developed after short-term CPR application during ambulance transport is presented. The aim of this study was to evaluate the flail chest complication and solution suggestions that may occur due to chest compressions applied during transportation.

Keywords:

Cardiopulmonary resuscitation, case report, flail chest, lung injury, rib fractures

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Introduction

The quality of cardiopulmonary resuscitation (CPR) is determined by the depth and speed of chest compressions and a short interval between them. During manual CPR, the rescuer should apply pressure at a depth of at least 5 cm, but the depth should not exceed 6 cm. In adult cardiac arrest, the compression rate should be 100–120/min. The duration of chest compression and release should be equal, and complete release (recoil) in the chest wall must be permitted after compression.[1] Low pressure applied to the chest reduces the patient's chances of survival by lowering the quality of CPR, whereas excessive pressure can lead to traumatic complications such as clavicle and rib fracture, tracheal bleeding, sternum fracture, pneumothorax, hemothorax, hemopericardium, rhabdomyolysis, aortic injuries, and even cardiac tamponade.[2,3]

Early initiation of CPR in patients in whom cardiopulmonary arrest is determined is closely linked to increased survival and fewer neurological sequelae. CPR must, therefore, be initiated without delay and maintained in patients with arrest during ambulance transportation. However, physical conditions may make it difficult for compression and speed to be kept at recommended levels and for the interval between compressions to be kept to a minimum during ambulance transportation. In association with this, the quality of CPR applied in the ambulance may be

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poor due to low compression depth, and traumatic CPR complications may increase due to excessive compression depth. Additional precautionary measures and recommendations aimed at preventing this were evaluated by Marcus *et al*. as a "Recommendations Report," with mechanical compression devices (MCD) being recommended for CPR during ambulance transport.[4] However, the American Heart Association Guideline published in 2020 recommends mechanical devices under conditions in which high-quality CPR is not possible or inadvisable in terms of rescuer safety, although the level of evidence for this recommendation is low (2b).[1] The recommendation was also made in an open-ended manner, the decision whether ambulances fall under this scope being left to the rescuer. New studies are therefore needed to resolve problems in CPR during ambulance transport.

This study reports a case of a male patient developing cardiopulmonary arrest during ambulance transportation, with flail chest developing following the return of spontaneous circulation (ROSC) after application of CPR in the ambulance. The aim of this study is to evaluate the flail chest complication that may develop in CPR performed in moving vehicles, the additional to be taken to prevent this complication and the MCD that can be used.

Case Report

A 50-year-old man presented to a secondary health-care institution due to malaise, cold sweating, and chest pain. Electrocardiography (ECG) performed due to typical chest pain revealed ST elevation on inferior derivations, and the patient was referred to our institution for coronary angiography with a preliminary diagnosis of inferior myocardial infarction. Ventricular fibrillation (VF) arrest first developed during ambulance transport. We learned that chest compression had been initiated with biphasic defibrillation at 200 joules, and that endotracheal intubation had been performed due to complete loss of consciousness. VF was again detected at the second pulse check. The defibrillated patient was asystolic at the third and fourth pulse checks. ROSC was established at the 10th min of cardiopulmonary arrest (CPA) at the fifth pulse check, and chest compression was terminated. The patient was intubated on arrival, with a spontaneous respiration rate of 28, arterial blood pressure of 100/60 mmHg, heart rate 122 beats/min, and body temperature of 36°C. Oxygen saturation with 100% oxygen was 89%. First ECG revealed an elevation in the inferior leads and ST depression in D1-AVL, similarly to the first ECG performed in the previous hospital. Paradoxical breathing movement in the left hemithorax was observed at the initial visual assessment [Video 1 and Figure 1].

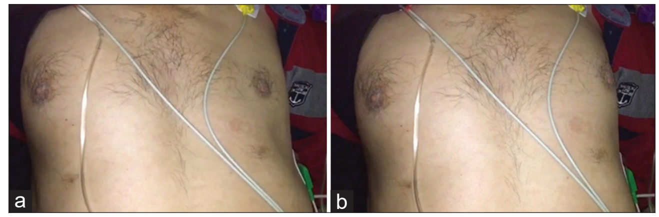

Figure 1: Visual evaluation of the patient. (a) Visual image showing left hemithorax collapsing in inspiratory. (b) Visual image showing left hemithorax rotates equally with the right hemithorax in expiration

Breath sounds were present at auscultation in both hemithoraces, but coarse rales and a relative decrease in breath sounds were detected in the left hemithorax compared to the right side. Detailed information from the ambulance personnel revealed no chest trauma other than CPR, and that CPR has lasted for 10 min, although due to the motion of the vehicle difficulty had been experienced in establishing the compression site and in maintaining compression at the recommended level. Thoracic computed tomography (CT) was performed following initial examination and the requisite blood tests. Hemothorax was not observed at thoracic CT, but bilateral fractures were present in ribs 4, 5, and 6 and unilateral fracture in rib 7 in the left hemithorax [Figure 2]. Although it is not a widely recommended approach today, a 2-kg weight was attached to the paradoxical left hemithorax of the patient who was intubated but had deep hypoxia. In this way, an improvement reaching 95% was obtained in oxygen saturation from 50%. Emergency coronary angiography was performed in this condition, at which occlusion was observed in the right coronary artery, a stent was successfully installed. Following angiography, surgical fixation of multiple rib fractures was considered high risk because of the patient's cardiac disease, and the multiple rib fractures were stabilized with an external adhesive plaster. The intubated patient was given meperidine for pain control at follow-ups and prophylactic moxifloxacin for pneumonia. He was extubated on the 3rd day, and no additional complications were observed. The patient was discharged with no need for additional surgery in terms of flail chest 9 days after coronary angiography.

Written informed consent was obtained from the relatives of the patients.

Discussion

Flail chest emerges with the development of an unstable section of the thorax moving independently of the other parts in association with multiple rib fractures (typically with at least three ribs being fractured in two different places). Free movement of one region in the thorax results in paradoxical chest motion. Contusion frequently occurs beneath the paradoxical moving

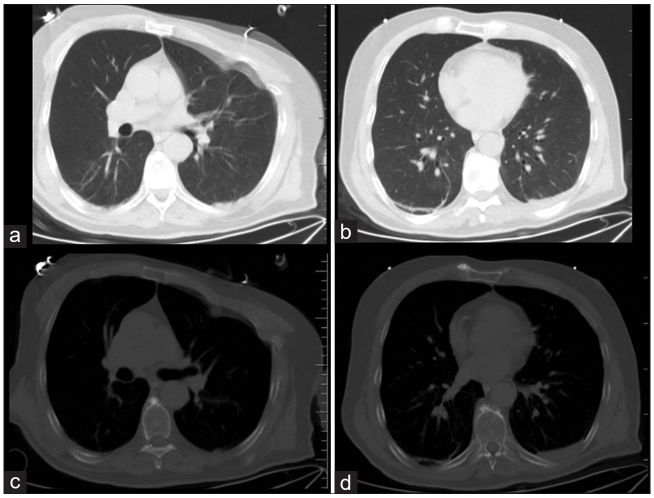

Figure 2: Computed tomography images of patient. (a) Computed tomography image in the lung window showing left hemithorax collapsing in inspiratory. (b) Computed tomography image in the lung window showing left hemithorax rotates equally with the right hemithorax in expiration. (c) Computed tomography image in the lung parenchyma window showing left hemithorax collapsing in inspiratory. (d) Computed tomography image in the lung parenchyma window showing left hemithorax rotates equally with the right hemithorax in expiration

segment and gives rise to respiratory distress. Potential accompanying pathologies such as hemothorax, pneumothorax, and circulatory disorders can be life-threatening. Enarson *et al*. reported flail chest as a complication of CPR at a rate of 5.6% in 1977.[5] A figure of 14.8% was reported in an autopsy series in 2017.[6] The fact that the depth and frequency of chest compressions have been increased in CPR guidelines published in the last decade has led to an expected increase in such complications.[1] CPR applied using this new method in moving vehicles, such as ambulances, must be expected to cause an increase in severe traumatic complications. In the present study, flail chest complications developed in as little as 10 min in a patient undergoing chest compression with a targeted compression number of 100–120 and depth of 5–6 cm. We think that the most important reason for this is an inability to properly establish the site of the chest compressions applied in a moving vehicle and slippage toward the left hemithorax. Manual chest compression applied during transportation by ambulance was seen to cause the potentially fatal complication of flail chest.

There is still significant controversy concerning the use of MCD in out-of-hospital cardiac arrests in the early stage of CRP to prevent CPR-related complications.[7] Hock *et al*. suggested that MCD enhances the quality of CPR.[8] Seewald *et al*. reported an increase in ROSC with MCD in a study from 2017.[9] In a meta-analysis from 2019, Zhu *et al*. reported no difference between MCD and manual CPR in terms of achievement of ROSC, discharge from hospital, and neurological outcomes.[10] However, the patient populations in these studies consisted of the entire out-of-hospital cardiac arrest population, rather than the population undergoing CPR during ambulance transfer. It is not, therefore, possible to compare the effectiveness and complications of MCD and manual CPR in this specific population undergoing CPR during ambulance transfer. Although some authors have espoused the view that MCD should constitute a component of life support, the evidence for their replacing manual compression is currently insufficient,[11] and the fact that no advantage has been shown in terms of survival has prolonged the controversy. However, these devices are known to provide such benefits as facilitating patient transfer and standardization of compression depth and rhythm under difficult conditions.[12] From that perspective, MCD may be more useful than manual CPR in mobile environments such as ambulances and may be more effective in reducing complications secondary to CPR, such as flail chest. A second alternative might be to stop the ambulance and perform CPR in the stationary vehicle. However, this decision should be made according to the patient. The main treatment for our patient was primary percutaneous intervention, and it is recommended to evaluate percutaneous intervention even during CPR in these patients. In such patients, MDCs can be an effective tool both not to delay the necessary emergency intervention and to ensure the continuation of quality CPR.

This report describes a case of VF arrest, with a relatively higher likelihood of ROSC compared to other arrests, undergoing CPR in the ambulance. ROSC was achieved following 10-min resuscitation, but the complication of flail chest developed even with such short-term chest compression in a moving vehicle. No clinical studies have evaluated appropriate MCD for preventing complications associated with compression trauma as a result of chest compression and during ambulance transport, and new studies are now needed on this subject.

Conclusion

Flail chest was observed as a complication following brief CPR performed inside a moving vehicle. The most important cause of this complication is difficulty in targeting the exact anatomical location on the sternum where chest compression is to be performed during CPR in a moving environment. This study shows that CPR performed in moving environments according to the new guideline can give rise to severe mechanical complications. Studies concerning mechanical CPR or a new method of potential benefit in reducing such complications in a moving environment are now needed.

Author contributions statement

Conceptualization; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Data curation; Güner Yurtsever (equal), Adnan Yamanoğlu (lead), Ejder

Saylav Bora (equal), Fatih Esad Topal (equal), Formal analysis; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Funding acquisition; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Investigation; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Methodology; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Project administration; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Resources; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Software; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Supervision; Güner Yurtsever (equal), Adnan Yamanoğlu (lead), Ejder Saylav Bora (equal), Fatih Esad Topal (lead), Validation; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Visualization; Güner Yurtsever (equal), Adnan Yamanoğlu (lead), Ejder Saylav Bora (equal), Fatih Esad Topal (equal), Writing – review & editing; Güner Yurtsever (equal), Adnan Yamanoğlu (equal), Ejder Saylav Bora (equal), Fatih Esad Topal (equal).

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understand that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Conflicts of interest

None Declared.

Consent to participate

A signed consent form was obtained from the patient.

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