Case Report

Compartment syndrome of the hand as a complication of prolonged mechanical cardiopulmonary resuscitation

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Summary

A 45-year-old man suffered compartment syndrome of the hands as a complication of prolonged cardiopulmonary resuscitation. He was admitted following a hypothermic out-of-hospital cardiac arrest due to cold-water submersion. The patient was in cardiac arrest for 4 h with mechanical cardiopulmonary resuscitation delivered using the Lund University Cardiac Arrest System (Jolife AB, Lund, Sweden). Cardiopulmonary resuscitation along with aggressive rewarming achieved return of spontaneous circulation. He developed compartment syndrome in his left hand which was likely exacerbated by having his arm strapped to the Lund University Cardiac Arrest System device throughout the resuscitation. The compartment syndrome was managed conservatively. Despite preservation of neurological function the patient died of complications from the cardiac arrest after an extended intensive care unit stay. We recommend healthcare providers unstrap patient's hands during prolonged mechanical cardiopulmonary resuscitation.

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Accepted: 22 September 2019
Keywords: hypothermia; peripheral compartment syndrome: diagnosis
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Introduction

High-quality chest compressions are the cornerstone of successful maintenance of circulation during resuscitation. The International Liaison Committee on Resuscitation suggests the use of mechanical cardiopulmonary resuscitation (CPR) in certain situations, for example, in patients who require prolonged CPR secondary to thrombolysis treatment or hypothermic patients requiring rewarming [1]. The Lund University Cardiac Arrest System (LUCAS®; Jolife AB, Lund, Sweden) is used by ambulance and retrieval services for mechanical CPR. To prevent a patient's unsecured arms from hindering transport the hands can be strapped in an upright position to the LUCAS device, as per the manufacturer's recommendation (Fig. 1).

Compartment syndrome is a well-recognised complication from limb malposition or external compression during surgery [2]. The classical initial presentation of pain disproportionate to the injury will not be obvious in the obtunded patient, for example, after cardiac arrest. Missing the diagnosis of compartment syndrome can lead to permanent muscle damage occurring within 4–8 h and permanent nerve damage occurring within 12–24 h [2]. The diagnosis can be confirmed by measuring compartment pressures. If the compartment pressure is within 30 mmHg of the patient's diastolic pressure the diagnosis is confirmed and treatment with fasciotomy is recommended [3].

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We describe acute compartment syndrome of the hand following 4 h of mechanical CPR. To our knowledge this has not been reported previously in the literature.

Figure 1 Photograph showing a volunteer in the LUCAS with hands in upright strapped position as recommended by the manufacturer.

Report

A 45-year-old man was brought to the emergency department in cardiac arrest following a cold-water drowning. His comorbidities included human immunodeficiency virus and chronic pain secondary to multiple injuries that he sustained from a fall from height. His regular medications were antiretrovirals, quetiapine and oxycodone.

A lifeguard rescued the conscious patient from the English Channel, he was taken on board a boat and shortly lost consciousness and was found to have no cardiac output. Chest compressions were started and the patient was taken ashore where hypothermic cardiac arrest was confirmed with a rhythm of ventricular fibrillation. The patient's trachea was intubated and a LUCAS device was applied with his arms secured in the hand straps. The patient had 10 defibrillation shocks and 1 mg adrenaline following which he was transported to the emergency department via helicopter. The duration of time in which the patient was in cardiac arrest before arrival at the emergency department was 1 h (Table 1).

Upon arrival, the patient's temperature was 24 °C. He remained in ventricular fibrillation and the LUCAS device was used continuously throughout his resuscitation. The focus of resuscitation was rewarming of the patient, with temperature monitored by rectal probe. He was warmed with Bair Hugger™ (3M, Saint Paul, MN, USA) and Blanketrol® (Cincinnati, OH, USA) warming blankets, 2 l of warmed intravenous fluids injected through a Ranger™ (3M, Saint Paul, MN, USA) fluid warmer, as well as

Table 1 Timeline of patient's admission and treatment.

Time post-cardiac arrest	Event
0:00 h	Hypothermic cardiac arrest with immediate CPR
0:10 h	LUCAS CPR started
1:00 h	Transfer via helicopter to local emergency department
1:00–4:10 h	Rewarming in emergency department with ongoing mechanical CPR
4:10 h	ROSC and transfer to ICU
1 day	Compartment syndrome confirmed and conservative treatment started
2 days	Renal replacement therapy started
5 days	Patient's trachea extubated
6 days	Noradrenaline stopped
13 days	Total parenteral nutrition started
23 days	Hypoxic cardiac arrest with ROSC, patient's trachea re-intubated
27 days	Withdrawal of treatment and death

CPR, cardiopulmonary resuscitation; LUCAS, Lund University Cardiac Arrest System; ROSC, return of spontaneous circulation; ICU, intensive care unit.

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intravesical and intragastric warmed fluids. Cardiac bypass, extracorporeal membrane oxygenation and haemofiltration were considered but not available and transfer to a tertiary centre was not deemed logistically feasible. The patient remained in ventricular fibrillation during rewarming and one 150-joule defibrillation shock was delivered for each 1 °C of temperature rise above 27 °C. At 32 °C return of spontaneous circulation was achieved. The CPR time in the emergency department was 3 h, with a total duration of cardiac arrest of 4 h, and five defibrillation shocks delivered in hospital.

He was transferred to the intensive care unit and 24 h postadmission the patient's left hand was swollen, bruised and cold. Bed-side ultrasound showed a signal was present in the ulnar and radial arteries proximal to the injury. The compartment pressure was measured at two sites in the hand, both reading 53 mmHg, with the diastolic blood pressure at 55 mmHg. The pressures confirmed compartment syndrome which was felt to be due to prolonged pressure and elevation from having the patient's hands strapped to the LUCAS device. This was treated with elevation and passive mobilisation rather than proceeding to fasciotomy. The swelling, discolouration and temperature of the hand gradually improved. He was extubated on day 5 and could actively move his hand, reporting mild pain only so no further management was required.

Following tracheal extubation, the patient was neurologically intact with no signs of ischaemic injury on computed tomography scan on day 11. Despite this, he suffered complications in other systems. He required renal replacement therapy throughout his admission. Due to ileus he had total parental nutrition from day 13 postadmission. He required minimal supplemental oxygen following tracheal extubation. Cardiac function was preserved, with vasopressors stopped on day 6 postadmission.

Despite the promising start on day 23 he decompensated due to hospital-acquired pneumonia and had a hypoxic cardiac arrest during intubation. Return of spontaneous circulation was achieved with one cycle of CPR but he deteriorated over the next 4 days with acute respiratory distress syndrome and died.

Discussion

This patient's long resuscitation preserved his neurological function but unfortunately the ischaemic injury to his other systems lead to his death. Good neurological outcome in hypothermic patients with prolonged CPR is well documented in the literature [4, 5].

Several studies have investigated the safety and documented the complications of mechanical CPR. The most common complications are traumatic chest wall injuries with rib fractures and sternal fractures occurring in 48–85% of patients [6–8]. Haemorrhage is also common with bleeding into the thorax, mediastinum, epicardium and pericardium reported [6]. Trauma to the underlying thoracic and upper abdominal organs is also a well-documented complication with serious or life-threatening damage in 7.4% [7]. Prolonged manual CPR has similar traumatic complications, although the rates are slightly lower than with some mechanical CPR devices [7].

We could find no cases in the literature detailing compartment syndrome secondary to strapping arms to a LUCAS device. Compartment syndrome is a recognised complication due to limb malposition in surgery, splints, medical devices or secondary to soft tissue injury [2, 9]. In this case it is likely that the prolonged strapping of the upper limbs to the LUCAS device contributed to the compartment syndrome. In theory, the vasopressors used also may have contributed to the compartment syndrome. We could find no reports of vasopressors causing compartment syndrome. In this patient, after the initial resuscitation, only low doses of noradrenaline were required and so it is unlikely to be a major factor. The compartment syndrome did not appear to have caused clinically significant muscle or nerve damage but it may have contributed to his renal failure. It is not clear if fasciotomy would have changed the outcome for this patient but it seems unlikely.

Strapping the arms to the LUCAS is necessary for transport and so patients arriving in hospital after out-of-hospital cardiac arrest will have their arms in straps. After arrival in hospital the hands can be removed from the straps while mechanical CPR is ongoing. If it will not inconvenience other aspects of the resuscitation removing hands from the straps should be considered in prolonged CPR.

Acknowledgements

Published with the written consent of the patient. Photographer, Nicola Finan, Medical Photographer, Conquest Hospital, Hastings, UK. No external funding or competing interests declared.

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