



# Veno-arterial extracorporeal membrane oxygenation and prolonged use of mechanical compression device combine for good outcome after hypothermic cardiac arrest: a case report

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**Abstract:** The use of mechanical compression devices to deliver chest compressions in conjunction with veno-arterial extracorporeal membrane oxygenation (VA ECMO) in the setting of cardiac arrest is growing. Herein, we report a case of hypothermic cardiac arrest requiring VA ECMO and prolonged use of an external compression device. A 38-year-old morbidly obese male (BMI 66.5) was admitted after being found down by a river. The patient was hypothermic (27.4 °C; outside temperature 4 °C) and in active asystolic cardiac arrest. A LUCAS chest compression system (Jolife, Lund, Sweden) was placed and transesophageal echo (TEE) was performed. This revealed cardiac standstill and suboptimal placement of the LUCAS device which was repositioned under TEE guidance. After difficult VA-ECMO cannulation, LV venting was required but coagulopathy, hypothermia, and body habitus precluded immediate endovascular mechanical unloading device placement. Therefore, the LUCAS was continued. After 380 minutes of VA ECMO, 460 minutes of LUCAS device support, and gradual rewarming to normothermia, the patient was cardioverted to sinus tachycardia and an Impella CP was placed. Over the next 96 hours infusions were reduced and biventricular function normalized. The Impella CP was removed on day 7, VA ECMO on day 12, and extubation occurred on day 15. He discharged with no neurologic deficits on day 34, a right sided above knee amputation his only notable hospital complication. The combined support of an external compression device and VA ECMO allowed for return of spontaneous circulation despite a downtime greater than 100 minutes. Further, TEE guidance allowed for optimal LUCAS positioning.

**Keywords:** Extracorporeal CPR (ECPR); mechanical compression device; LUCAS device; transesophageal echocardiography; hypothermia; cardiac arrest

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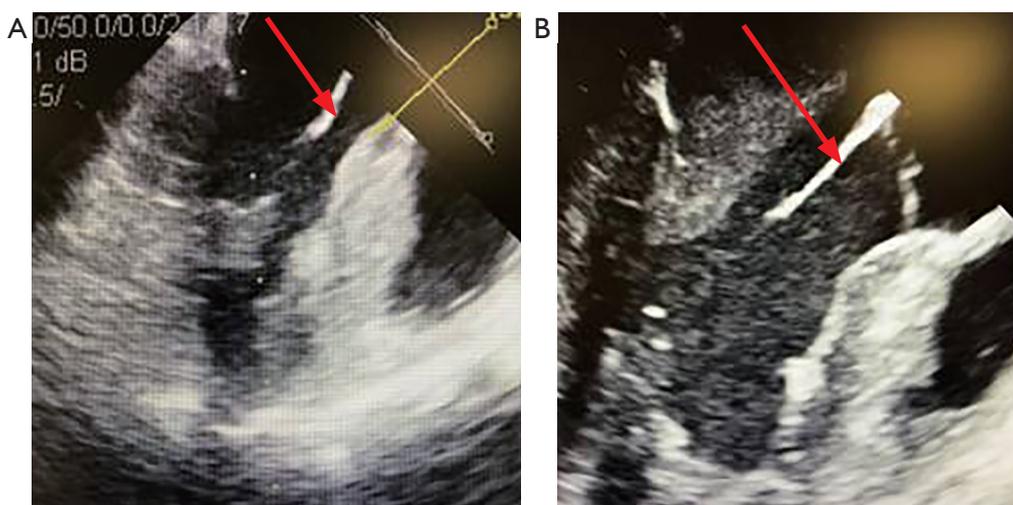
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## Introduction

The use of automatic mechanical devices to deliver compressions during cardiac arrest is becoming widespread, and the data surrounding extracorporeal membrane oxygenation (ECMO) in this setting is similarly growing (1,2). The need for additional mechanical support to unload the left ventricle (LV) during peripheral ECMO is also well-

established (3). Herein, we report a case of hypothermic cardiac arrest requiring veno-arterial (VA) ECMO in which LV unloading was necessary but endovascular mechanical devices could not be placed. Concomitant, prolonged use of an external mechanical compression device along with VA ECMO facilitated a positive neurologic and clinical outcome.



**Figure 1** Echocardiography showing (A) the compressed LV outflow tract due to malposition of LUCAS device and (B) uncompressed LV outflow tract with optimized LUCAS positioning. LV, left ventricle.

### Case presentation

A 38-year-old male (height 184 cm, weight 225 kg, BMI 66.5) with a history of gastroesophageal reflux disease, hypertriglyceridemia, alcohol dependence, depression, morbid obesity and previous suicide attempts was admitted to the emergency department (ED) via ambulance after being found on a riverbank with only his lower legs submerged in the water. It was winter and the average outside temperature was 4 degrees Celsius (39.2 Fahrenheit). The length of his exposure and whether there had been any near drowning or traumatic injury was unknown. The last known contact with the patient was approximately 5 hours prior to being found by passers-by.

On assessment by EMS he was unconscious, had agonal breaths and was in asystole. Assisted ventilation with bag-valve mask and CPR were immediately instituted. On admission to the ED he had a Glasgow Coma score (GCS) of 3, agonal breathing, remained in asystole with ongoing CPR, and was hypothermic at 27.4 degrees Celsius. He was intubated and a LUCAS chest compression system (Jolife, Lund, Sweden) was placed and initiated. A hospital ‘Shock Team’ call was initiated, a cervical collar was placed, and a transesophageal echo (TEE) was performed while spinal precautions were instituted. (The hospital ‘Shock Team’ protocol activates a telephone messaging service for cardiothoracic critical care, advanced heart failure, cardiothoracic surgery, an ECMO nurse specialist, cardiac anesthesia, and echocardiography to rapidly develop and

initiate a mechanical support strategy.)

The TEE showed cardiac standstill, no pericardial effusion or valvular abnormalities, and suboptimal placement of the LUCAS device. The device was placed slightly too high on the chest and was compressing the ascending aorta. The device was repositioned under TEE guidance until it was effectively compressing the LV without obstructing the outflow tract (*Figure 1*). The ‘Shock Team’ decision was made to place him on a VA ECMO circuit to support his cardiovascular system and allow for rewarming to normothermia.

At this stage, known downtime was a total of 35 minutes. Initial blood work revealed a pH of 7.09, lactate of 3.7, base excess of -7.0, and a pO<sub>2</sub> of 63 mmHg. Venous and arterial cannulations were performed via the left femoral approach. The patient’s body habitus, difficult anatomy, and hypothermia precluded percutaneous cannulation and thus a cut-down was performed. Further complicating cannulation was his apparent disseminated intravascular coagulopathy (DIC), though initial blood testing revealed hemoglobin level of 13.7 g/dL, platelets of 260 and international normalized ratio of 1.4. A subsequent left femoral arterial injury required emergent vascular surgery repair and movement of venous and arterial ECMO cannulas to the right femoral vein and artery. Ultimately, due to the various obstacles described, institution of VA ECMO took a total of 70 minutes, bringing the total known downtime to 105 minutes.

During this time he received multiple medications

including sodium bicarbonate, calcium chloride, epinephrine, norepinephrine, vasopressin, vancomycin, piperacillin-tazobactam, fentanyl, and propofol. The LUCAS device provided 80 minutes of CPR during resuscitation and institution of VA ECMO, which was now delivering 5.5 L of flow per minute retrograde into the femoral artery. TEE re-evaluation post ECMO cannulation showed continued cardiac standstill and no aortic valve opening despite aggressive use of continuous epinephrine and milrinone.

The need for ongoing mechanical LV unloading was obvious. However, traditional endovascular devices like an intra-aortic balloon pump or an Impella were thought unusable, given the aforementioned vasoconstriction, acidosis, coagulopathy, BMI of 66, and overall poor target vessels as evidenced by the difficulty in placing the ECMO cannulas. Thus, the decision was made to continue utilizing the LUCAS device to assist in venting the LV. Position of the LUCAS device was once again optimized using TEE to maximize compression of the LV without obstructing the outflow tract.

During the prolonged time to institute cardiac support his acid-base status and coagulation parameters had deteriorated significantly: pH 6.97, bicarbonate 10mmol/L, base excess -21.8, INR 2.3, platelets 138,000/ $\mu$ L, and fibrinogen <80 mg/dL. We continued cardiovascular hemodynamic support with VA ECMO and the LUCAS device while rewarming to provide the most optimal setting for cardiac and neurologic recovery. Continuous renal replacement therapy was instituted from the ECMO circuit to facilitate normalization of the acid-base status.

The patient was deliberately and slowly rewarmed, 0.5 to 1 degree Celsius per hour, using the warmer on the ECMO circuit. After 6 hours and 20 minutes of VA ECMO support, concomitant Lucas device support (a total of 460 minutes using the Lucas device), and gradual rewarming, the patient had a spontaneous change of rhythm at 35.6 degrees Celsius to ventricular fibrillation. We performed a single DC-cardioversion shock at 200 J which converted him to a sinus tachycardia. A repeat TEE now showed an ejection fraction of 10% after ceasing the activity of the LUCAS. We continued to warm to normothermia using VA ECMO. Over the next 16 hours his coagulopathy and acid-base status improved. As we now had some clinical stability we performed a full body CT to rule out any traumatic injury and it was entirely negative. We then transferred him to the operating room for placement of a right axillary Impella CP for left ventricular decompression,

a left-sided lower extremity distal perfusion cannula, and bilateral four compartment fasciotomies for a raised creatinine kinase of 18,284 U/L and reduced peripheral pulses of the lower limbs.

His head CT was normal as was continuous EEG over a period of 48 hours. Normal circuit anticoagulation was instituted to prevent complications. Over the next 96 hours we made significant reductions in inotropic and vasopressor requirements and TEE showed significant recovery of the biventricular function to normal. The Impella CP was removed 7 days after insertion following a weaning protocol. VA ECMO support was weaned over the ensuing 4 days and it was removed 12 days after initiation with full recovery of biventricular function. Over the next three days he was weaned from mechanical ventilation and extubated. He was transferred out of the ICU on hospital day 18 and underwent a right-side above-the-knee amputation on hospital day 22, the unfortunate ultimate result of vascular/perfusion injury sustained during his mechanical support course. He ultimately discharged to a rehabilitation center on day 34 and returned home 56 days after initial presentation.

## Discussion

The use of extracorporeal and mechanical support during cardiac arrest has been well-described (4,5). Indeed, the 2015 American Heart Association guidelines for cardiopulmonary resuscitation discuss extracorporeal-CPR (ECPR) and “mechanical piston devices” as potential therapeutic options in certain cardiac arrest scenarios, including hypothermia (6). Asystolic, hypothermic arrest is perhaps the most unique niche in which ECPR can be applied, as additional mechanical LV unloading will be almost universally required in the setting of peripheral ECMO. In our literature search, we were unable to find another report describing such extended use of a mechanical compression device (such as the LUCAS device) to facilitate left ventricular unloading.

The LUCAS device has been described as an effective compression device while ECMO is being initiated (7), and centers have begun protocolizing the combined use of both modalities during ECPR (8). Prolonged use of the LUCAS device (without ECMO) during cardiac arrest is described, with the longest run time we could find being 2 hours and 45 minutes (9,10). In this case, the LUCAS device was utilized continuously for nearly 8 hours while the patient was cautiously rewarmed.

Another important highlight of this case is the use of TEE to optimize LUCAS device position, as the literature supporting this practice is also scant. Giraud, et al describe a case of ineffective chest compressions as well as right heart myocardial damage thought related to the LUCAS (11). Indeed in our case, before the LUCAS device was visualized and repositioned under TEE guidance, the aorta was being compressed with every beat, thus minimizing (if not entirely negating) the intended offloading effect.

While the LUCAS device played a pivotal role in this successful case, the use of mechanical compression devices is not without its reported complications. Lung, rib, and visceral trauma have all been described in the literature, and more recent trials have failed to demonstrate a survival benefit compared to manual CPR (12,13). A recent randomized non-inferiority trial including 122 LUCAS device patients did not find significantly more serious visceral damage than manual CPR (14). In the case described here, manual compressions would likely not have been sustainable for such a prolonged period.

## Conclusions

Prolonged LV unloading using an external compression device (LUCAS) in the setting of peripheral VA ECMO is feasible and was necessary while correcting hypothermia, coagulopathy, and acid-base abnormalities in this case. TEE guidance was critical to optimizing LUCAS position on the chest. The combined support allowed for return of spontaneous circulation and a successful neurologic outcome despite a downtime of greater than 100 minutes.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Informed Consent:* Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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