Mechanical cardiopulmonary resuscitation device in an accident and emergency department: a case report and literature review
急症室中使用機械性心肺復甦儀器：個案報告及文獻覆查

LW Chan 陳立華, TW Wong 黃大偉, CC Lau 劉楚釗

We present a case of resuscitation of a 38-year-old lady with ventricular fibrillation using the Lund University Cardiopulmonary Assist System (LUCAS), a mechanical cardiopulmonary resuscitation (CPR) device. Return of spontaneous circulation was obtained after prolonged resuscitation but the patient eventually succumbed nine days after admission to the coronary care unit. The role of mechanical CPR devices in resuscitation in the accident and emergency department is discussed. (Hong *Kong j.emerg.med.* 2008;15:49-52)

我們描述一宗搶救一名心室纖維性顫動的38歲女士的個案，使用一個機械性心肺復甦儀器：隆德大學心肺輔助系統（LUCAS）。病人經長時間搶救後恢復自發性循環，但最終於收進冠狀動脈深切治療部9天後死亡。本章並討論機械性心肺復甦儀器在急症室復甦過程中的角色。

Keywords: *Cardiopulmonary resuscitation, heart arrest, heart-assist devices, hospital emergency service*

關鍵詞：心肺復甦法、心臟停頓、心臟輔助儀器、醫院緊急服務

Case report

An unconscious 38-year-old lady was admitted to our Accident & Emergency Department (AED) in October 2007. She was the mother of a student at a school. She was attending the parents' day when she was noted by school staff to be breathless. According to the ambulance staff, she collapsed shortly at 10:33 am and prompt bystander cardiopulmonary resuscitation (CPR) was started. Ventricular fibrillation (VF) was detected by the automatic external defibrillator and three shocks were given in the ambulance.

The patient was in VF on arrival at the AED. We had been using the Lund University Cardiopulmonary Assist System (LUCAS), a mechanical CPR device during resuscitations in our department since August 2007 (Figure 1). The LUCAS was promptly applied at 10:47 am, 14 minutes after the collapse to commence mechanical chest compression and active decompression. Resuscitation had been vigorous for this young lady who had a short arrest interval. She was intubated and mechanical ventilation was started. Amiodarone 300 mg bolus followed by 150 mg twice was given. Adrenaline 1 mg intravenously every 3 minutes was also administered. Magnesium 2 g intravenously was administered 28 minutes after the start of resuscitation in the AED. The end-tidal CO_2 had all along been low at 5 mmHg with no return of

Correspondence to:
Chan Lap Wa, MRCP (UK), FHKCEM, FHKAM (Emergency Medicine)
Pamela Youde Nethersole Eastern Hospital, Accident & Emergency Department, 3 Lok Man Road, Chai Wan, Hong Kong
Email: chanlapwa2006@yahoo.com.hk

Wong Tai Wai, FRCSEd, FHKCEM, FHKAM(Emergency Medicine)
Lau Chor Chiu, MRCP(UK), FCEM, FHKAM(Emergency Medicine)

circulation. She was given multiple biphasic defibrillations at 200J for persistent VF.

Subsequently, restoration of spontaneous circulation was achieved 48 minutes after the start of CPR in the AED. There was a good radial pulse and the first blood pressure was 118/60 mmHg and pulse rate was 80 per minute. The end-tidal CO_2 was 45 mmHg. The medical department was consulted and the patient was admitted to the coronary care unit (CCU) for further management.

In the CCU, the patient remained in a comatose state with recurrent ventricular fibrillation. She was treated with dopamine and amiodarone infusion. Subsequently, the VF was terminated by overdrive pacing. Therapeutic hypothermia was given for 24 hours but with no improvement. The ECG in the CCU revealed downsloping ST segments from V1 to V3 suggesting the Brugada syndrome (Figure 2). The patient eventually succumbed nine days after admission to the CCU. The patient's children were referred to the paediatric department for cardiac screening of the Brugada syndrome.

Discussion

The Brugada syndrome is one of the causes of sudden death in young patients. In 10-30% of cases a mutation in the gene SCN5A, encoding the cardiac voltage-gated sodium channel $Na_v1.5$, has been found. Sudden onset of fatal ventricular tachyarrhythmia can occur. The diagnosis is made by noting coved or saddle-shaped

Figure 1. The LUCAS in operation at scene (Courtesy of Ultra Care Company Limited).

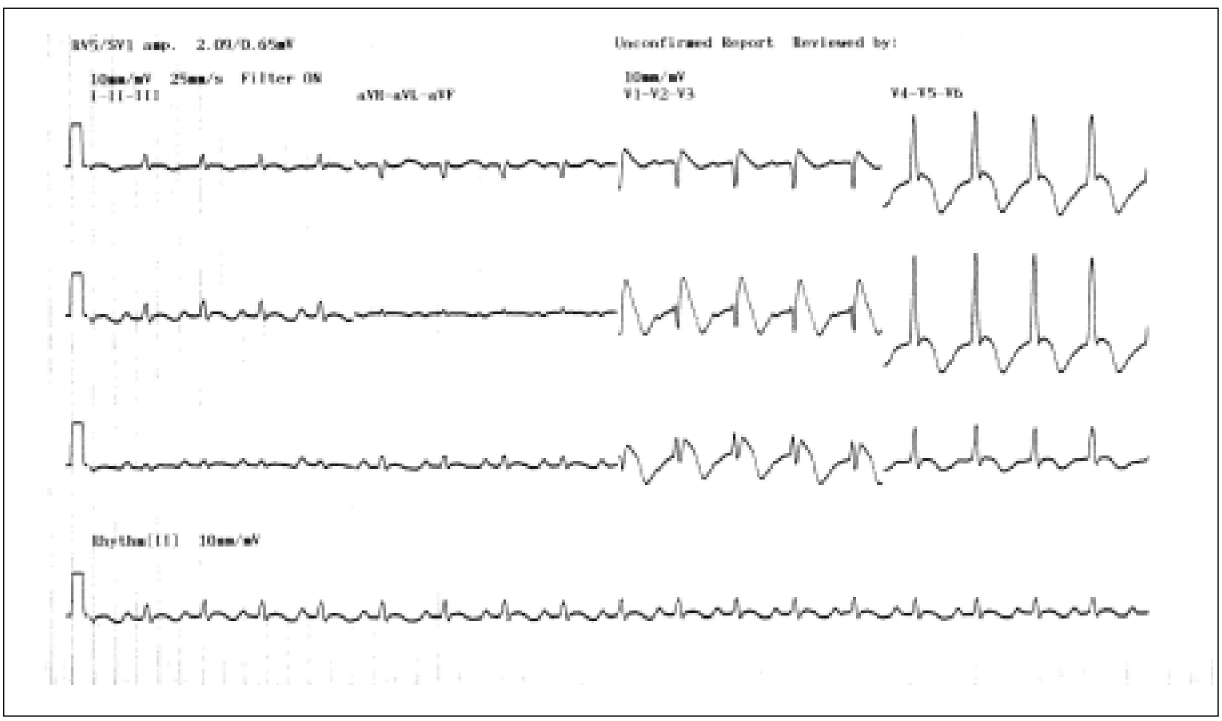

Figure 2. 12-lead ECG of the patient showing coved ST elevation over medial chest leads suggestive of the Brugada syndrome.

ST elevation in medial chest leads in the ECG. Occasionally, this is associated with partial or complete right bundle branch block. The definitive treatment is implantation of internal cardioverter defibrillator.[1]

The provision of uninterrupted, high quality chest compression was emphasized in the 2005 Advanced Cardiac Life Support (ACLS) guidelines. Rescuers should 'push hard, push fast' at a rate of 100 compressions per minute at a depth of 1.5 to 2 inches for adult patients. The chest should be allowed to recoil completely.[2] Studies using manikins showed that the quality of chest compression would start to deteriorate over 90 seconds.[3] Compressions would become too shallow or slow and there might be frequent hands-off periods when no effective circulation was produced. Even with correctly executed manual CPR, only around 20% of normal cardiac output was produced which would further be jeopardised by human fatigue. Mechanical CPR devices have been developed to provide continuous and consistent chest compressions in resuscitation.

At present, there is no evidence that the use of mechanical CPR devices improves survival to hospital discharge with intact neurological status. However, there are animal and human studies showing that mechanical CPR improves haemodynamics during resuscitation and the short term survival to hospital admission.[4]

The LUCAS (JOLIFE AB, Lund, Sweden) was used in resuscitating this young lady. It is an air driven portable mechanical CPR device. It can be connected to wall or cylinder gas inlets. It consists of a silicon rubber suction cup and a pneumatic cylinder. The cylinder is mounted on two legs which are connected to a back plate where the patient rests on. It gives continuous compression and active decompression at a rate of 100 per minute. The maximum depth of chest compression is 2 inches.[5]

Steen et al showed that LUCAS CPR increased aortic, right atrial and coronary perfusion pressure in pigs during induced VF when compared to manual CPR.[5] Rubertsson et al reported improved cerebral blood flow using a laser-Doppler flow probe during LUCAS CPR for induced VF in pigs.[6]

In his study of 100 out-of-hospital cardiac arrest patients receiving LUCAS CPR, Steen et al reported a survival rate of 25% after 30 days with good neurological status for patients with:

1. witnessed cardiac arrest
2. bystander CPR
3. VF being the presenting rhythm
4. LUCAS applied within 15 minutes after the call for ambulance
5. therapeutic hypothermia applied on hospital arrival

On the other hand, for all unwitnessed cardiac arrest cases and patients where the LUCAS was applied more than 15 minutes after the call for ambulance, no 30-day survivor was noted. Steen suggested that for patients with witnessed cardiac arrest where stable return of spontaneous circulation (ROSC) could not be obtained, transport should be made under mechanical CPR to a hospital where revascularisation service was available.[7] For our patient, the LUCAS was applied 14 minutes after witnessed cardiac arrest. The poor prognosis was therefore not unexpected.

Autopulse (Revivant Corporation, Sunnyvale, CA) is another mechanical CPR device that has been approved for use by the Food and Drug Administration. In Autopulse, a load distributing band, analogous to a large blood pressure cuff, is wrapped around the patient's chest. The band is controlled by a rotating motor so that cyclical compressions are applied to the anterior and anterolateral parts of the chest wall. Timerman et al reported that the Autopulse increased peak aortic pressure, right atrial pressure and coronary perfusion pressure when compared to manual CPR during the treatment of in-hospital cardiac arrest patients.[8] A prehospital study conducted in Richmond, Virginia utilising historical controls found improved outcomes including survival to hospital discharge in patients with sudden cardiac arrest treated with the Autopulse.[9] However, the Autopulse Prehospital International Resuscitation (ASPIRE) trial, a multicentre, cluster randomised study testing the effectiveness of the Autopulse against standard CPR, was terminated early due to a decrease in survival to hospital discharge at some study sites.[10] The discrepancies between these two studies were attributed to differences in patient populations, training, monitoring and methodology. Large scale, well designed randomised control trials are therefore essential in evaluating the impact of mechanical CPR devices in resuscitations.

Mechanical CPR devices should be promptly applied to improve the outcome during resuscitation. To shorten the application interval, mechanical CPR devices have been used during prehospital resuscitations. Both Autopulse and LUCAS are portable and can be carried in backpacks by ambulance staff. They can be applied to patients at scene soon after cardiac arrest. Mechanical chest compression can be continued during transfer from the patients' home to the ambulance. Ambulance staff may also find it useful as they can sit down and monitor the ongoing mechanical CPR in the ambulance. This is important as good manual CPR is difficult in the moving vehicle.

Mechanical CPR device is a great help for prolonged CPR. It does not relieve us from the difficult decision of when to terminate the resuscitation effort. This can be a difficult task for the emergency physician especially for previously young and healthy patients who are 'too good to die'. According to the 2005 ACLS guidelines, 'a patient should be given a reasonable trial of CPR and ACLS provided that the patient has not expressed a decision to forego resuscitative efforts. The final decision to stop efforts can never be as simple as an isolated time interval.'[11] For this case, we had endeavoured to inform the relatives the grave prognosis and the poor neurological recovery throughout the resuscitation and after ROSC, prior to the CCU admission.

Acknowledgement

We must thank the medical and nursing colleagues of the AED, Pamela Youde Nethersole Eastern Hospital for their tireless contribution during the resuscitation. I am also grateful to Mr Rico Yan of Ultra Care Company Ltd. for supplying the photograph of the LUCAS in this article.

Conflict of interest

The authors have not received any financial support from Ultra Care Company Ltd., the distributor of LUCAS in Hong Kong.

References

1. Abriel H, Dizon JM. Brugada Syndrome. eMedicine [Online]. [Cited 2007 Dec 10]. Available from: http://www.emedicine.com/med/TOPIC3736.HTM#target2
2. American Heart Association. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, Part 4: Adult basic life support. Circulation [Online]. [Cited 2007 Dec 10]. Available from: http://circ.ahajournals.org/cgi/content/full/112/24_suppl/IV-19
3. Ashton A, McCluskey A, Gwinnutt CL, Keenan AM. Effect of rescuer fatigue on performance of continuous external chest compression over 3 minutes. Resuscitation 2002;55(2):151-5.
4. Cooper JA, Cooper JD, Cooper JM. Cardiopulmonary resuscitation: history, current practice and future direction. Circulation 2006;114(25):2839-49.
5. Steen S, Liao Q, Pierre L, Paskevicius A, Sjöberg T. Evaluation of LUCAS, a new device for automatic mechanical compression and active decompression resuscitation. Resuscitation 2002;55(3):285-99.
6. Rubertsson S, Karlsten R. Increased cortical cerebral blood flow with LUCAS, a new device for mechanical chest compressions compared to standard external compressions during experimental CPR. Resuscitation 2005;65(3):357-63.
7. Steen S, Sjöberg T, Olsson P, Young M. Treatment of out-of-hospital cardiac arrest with LUCAS, a new device for automatic mechanical compression and active decompression. Resuscitation 2005;67(1):25-30.
8. Timerman S, Cardoso LF, Ramires JA, Halperin H. Improved hemodynamic performance with a novel chest compression device during treatment of in-hospital cardiac arrest. Resuscitation 2004;61(3):273-80.
9. Ong ME, Ornato JP, Edwards DP. Use of an automated, load-distributing band chest compression device for out-of-hospital cardiac arrest resuscitation. JAMA 2006;295(22):2629-37.
10. Hallstrom A, Rea TD, Sayre MR, Christenson J, Anton AR, Mosesso VN Jr, et al. Manual chest compression vs use of an automated chest compression device during resuscitation following out of hospital cardiac arrest, a randomized trial. JAMA 2006;295(22):2620-8.
11. American Heart Association. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, Part 7.2: Management of cardiac arrest. Circulation 2005;112;IV-58-IV-66.