CASE REPORT

Cerebral blood flow measured by transcranial Doppler ultrasound during manual chest wall or automated LUCAS-2 compressions during cardiopulmonary resuscitation

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None

Effective chest wall compressions are essential to ensure a minimum of cerebral blood flow during resuscitation, but manual compression maneuvers are not always efficacious. The LUCAS system delivers chest wall compressions that comply with international recommendations. Using transcranial Doppler ultrasound to measure cerebral blood flow, we compared flow during the cardiopulmonary resuscitation of 6 patients before and after placement of the LUCAS device. Two of the patients in cardiorespiratory arrest secondary to subarachnoid bleeding had no cerebral blood flow with either manual or automated compressions. For the other 4 patients, cerebral blood flow was better during the automated compressions from the LUCAS system. [Emergencias 2012;24:47-49]

Key words: Brain ischemia. Chest wall compression. Cardiopulmonary resuscitation. Transcranial Doppler ultrasound.

Introduction

During cardiopulmonary resuscitation (CPR), it is essential to perform continuous high-quality chest compressions (CC) to ensure blood flow to the heart and brain[1]. However, the number of high-quality CC decreases with time, and after the third minute, the percentage of quality CC falls below 20%[2] due to rescuer fatigue. There are also frequent breaks in CC, which may represent only 48% of total time spent on resuscitation, partly due to breaks for defibrillation[3]. The combination of low-quality CC together with frequent interruptions may compromise cerebral perfusion and therefore the probability of recovery without sequelae.

The LUCAS® device is a mechanical chest compressor that performs CC with active decompression at a frequency of 100 per minute at a depth of 5 cm[4]. It is "immune" to fatigue and does not have to be stopped for defibrillation.

Transcranial Doppler (TCD) ultrasound allows non-invasive measurement of blood flow velocity in the cerebral arteries by detecting relative changes in the frequency of ultrasound emitted by a probe, generally placed at the level of the temporal region, an "insonation window", for measuring blood flow of the middle cerebral artery (MCA). Flow (ml / min) in a vessel depends on that vessel's diameter and speed[5]. Assuming constant MCA diameter during the CPR procedure, the use of TCD allows us to compare cerebral blood flow velocity induced by manual CC versus that induced by the LUCAS® chest compressor.

Case reports

We report on cases of sudden cardiac arrest

(SCA) seen between January and June 2011 by the advanced life support (ALS) unit of the Sistema d'Emergències Mediques (EMS) of Barcelona, equipped with ultrasound and staffed by a physician trained in the use of TCD. The researcher was trained in live patients during 6 sessions by neurologists, experts in the technique, before the collection of cases. We included adult patients treated by the ALS unit during on-duty shifts for non-traumatic witnessed SCA. Criteria for exclusion were known or evident pregnancy, known terminal illness or presence of biological signs of death.

During CPR, the researcher carried out TCD measurement of peak flow in the MCA at a depth between 5 and 6 cm, obtained during manual CC before placement of the LUCAS® device and again after device placement, using the temporal window. Peak flow was considered that calculated by ultrasound based on clearly recognizable waveforms. At no time did these measurements delay or interfere with CPR. The ultrasound device used was a Toshiba Viamo®.

Our EMS is responsible for out-of-hospital accident and emergency patient care in Catalonia. In the city of Barcelona and its metropolitan area, it has 8 ALS mobile units (staffed by a physician, a nurse and an emergency medical technician), which serve a population of 2,237,912. These mobile units have been equipped with LUCAS® compressors since 2008 and, in 2010, attended a total of 403 cases of SCA.

Given the small sample size, we only present descriptive statistics for quantitative variables, expressed as means and standard deviation. During the study period, 6 patients met the inclusion criteria and none of the exclusion criteria. Three patients were men, with a mean age 66 ± 11 years and 3 were women with a mean age of 48 ± 23 years old. One patient with SCA secondary to myocardial infarction with ST segment elevation (STEMI) showed recovery of spontaneous circulation (ROSC) before ultrasound measurements could be made, but after ROSC, MCA blood flow was 96 cm / sec. The patient was discharged from hospital with good neurologic function. Two young women suffered SCA secondary to subarachnoid hemorrhage (SAH); no flow was observed during CC performed manually or mechanically by LUCAS®. One of them presented ROSC and no new TCD measurements were made in order not to interfere with post-resuscitation care. Of the remaining 3 patients, mean maximum flow velocity (MFV) during manual CC was 31.6 ± 8.32 cm / sec compared with 50.6 ± 27.1 cm / sec during mechanical CC (Figure 1).

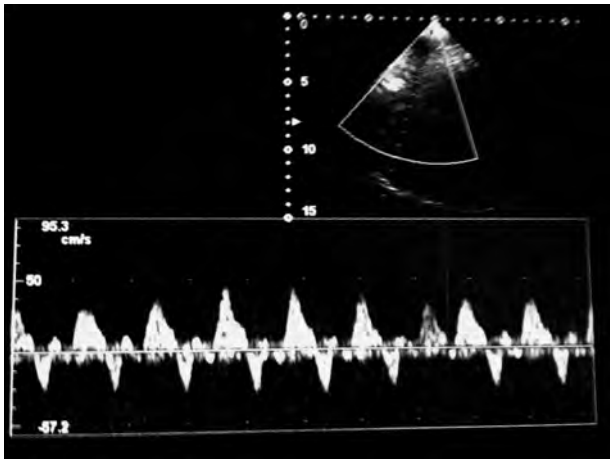

Figure 1. Middle cerebral artery flow at 5 cm achieved with the LUCAS® device.

Discussion

MFV measured by TCD ultrasound in healthy individuals varies between 60 and 120 cm / sec, with a tendency to decrease with age[6]. In this study, one patient had a standard MFV after recovering from SCA secondary to STEMI. To our knowledge, there are no publications on human cerebral blood flow after ROSC. Changes in cerebral blood flow occur immediately after aneurysm rupture[7]. In an experimental study with rats, Ostrowsky observed that, immediately after induced subarachnoid hemorrhage, intracranial pressure increased more than 10 times with respect to baseline values, gradually declining during the first hour to 4 times baseline values. This means that cerebral blood flow in live rats with good cardiac function decreased within minutes to ± 26 % of baseline values[8]. This result is consistent with the absence of flow we observed in two patients with SCA secondary to SAH, because the mean arterial pressure generated by CC, whether manual or mechanical, was not sufficient to achieve adequate brain perfusion pressure.

In the present study we observed higher MFV during CPR with the LUCAS® compared to that achieved with manual CC, which may correspond to increased cerebral blood flow during CPR. We found no studies on human brain perfusion that compared mechanical chest compressor with traditional CPR maneuvers, but in animal models better cerebral perfusion was obtained using the LUCAS® device.

Steen et al., in an experimental study on pigs with induced SCA, observed significantly higher carotid artery flow in those animals treated with LUCAS® than in those treated with manual CC[4]. Rubertson observed that pigs receiving CC with the LUCAS® device achieved cerebral flow of about 65% of baseline values versus only 40% in those treated with CC[9]. This is consistent with the results obtained in our study, where the MFV of patients receiving manual CC was 31.6 ± 8.3 cm / s, (35% of normal values),versus 50.6 ± 27.12 cm / s (56%) in patients treated with the LUCAS® device.

We conclude that patients suffering SCA secondary to subarachnoid hemorrhage seem not to receive cerebral blood flow during resuscitation with either manual or LUCAS® chest compression. In the remaining patients, the mechanical device appears to have improved cerebral blood flow compared with manual CC. This study is limited by its small sample size and single investigator, and by the absence of invasive measurements to compare the results obtained.

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Flujo cerebral medido por doppler transcraneal durante la reanimación cardiopulmonar con compresiones torácicas manuales o realizadas por un compresor torácico mecánico

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Es fundamental realizar compresiones torácicas de gran calidad para garantizar un flujo mínimo al cerebro durante la resucitación, pero las compresiones torácicas manuales no siempre son de gran calidad. El compresor torácico LUCAS® realiza compresiones torácicas de acuerdo con las recomendaciones internacionales. El flujo cerebral puede medirse mediante *doppler* transcraneal. En este estudio se compara el flujo cerebral medido por *doppler* durante la reanimación cardiopulmonar antes y después de la colocación del LUCAS® en 6 pacientes. En dos pacientes en parada cardiorrespiratoria secundario a una hemorragia subaracnoidea no se observó flujo cerebral ni con compresiones torácicas manuales ni con LUCAS®. En el resto de pacientes, se observó un mayor flujo cerebral cuando se utilizó el dispositivo LUCAS® que cuando se realizaron compresiones torácicas manuales. [Emergencias 2012;24:47-49]

Palabras clave: Isquemia cerebral. Compresión torácica. Resucitación cardiopulmonar. *Doppler* transcraneal.