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Clinical paper

Mechanical chest compressions improve rate of return of spontaneous circulation and allow for initiation of percutaneous circulatory support during cardiac arrest in the cardiac catheterization laboratory

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ABSTRACT

Background: Performing advanced cardiac life support (ACLS) in the cardiac catheterization laboratory (CCL) is challenging. Mechanical chest compression (MCC) devices deliver compressions in a small space, allowing for simultaneous percutaneous coronary intervention and reduced radiation exposure to rescuers. In refractory cases, MCC devices allow rescuers to initiate percutaneous mechanical circulatory support (MCS) and extracorporeal life support (ECLS) during resuscitation. This study sought to assess the efficacy and safety of MCC when compared to manual compressions in the CCL.

Methods: We performed a retrospective analysis of patients who received ACLS in the CCL at our institution between May 2011 and February 2016. Baseline characteristics, resuscitation details, and outcomes were compared between patients who received manual and mechanical compressions.

Results: Forty-three patients (67% male, mean age 58 years) required chest compressions for cardiac arrest while in the CCL (12 manual and 31 MCC). Patients receiving MCC were more likely to achieve return of spontaneous circulation (ROSC) (74% vs. 42%, $p = 0.05$). Of those receiving MCC, twenty-two patients (71%) were treated with MCS. Patients receiving percutaneous ECLS were more likely to achieve ROSC (100% vs. 53%, $p = 0.003$) and suffered no episodes of limb loss or TIMI major bleeding. There were no significant differences in 30-day survival or survival to hospital discharge between groups.

Conclusions: Use of MCC during resuscitation of cardiac arrest in the CCL increases the rate of ROSC. Simultaneous implantation of MCS, including percutaneous ECLS, is feasible and safe during MCC-assisted resuscitation in the CCL.

Background

Cardiac arrest is not an uncommon event in the cardiac catheterization laboratory (CCL), occurring in approximately 1.3% of all patients undergoing coronary angiography [1]. It often resolves quickly with cardiopulmonary resuscitation and swift defibrillation. However, a subset of patients will not respond to immediate resuscitative efforts and will require prolonged advanced cardiac life support (ACLS). In these cases, return of spontaneous circulation (ROSC) is often not achieved until after percutaneous coronary intervention (PCI) or additional mechanical circulatory support is provided. In the era of complex coronary intervention and more frequent use of percutaneous mechanical circulatory support for cardiogenic shock, the incidence of refractory cardiac arrest in the CCL is likely to increase. In addition, the emergence of routine coronary angiography for survivors of undifferentiated cardiac arrest will likely increase the incidence of cardiac arrests in the CCL.

Performing prolonged ACLS in the CCL is challenging. The position of imaging equipment prevents typical manual compressions, limiting compression effectiveness and dramatically increasing rescuer fatigue. In addition, responders may be exposed to ionizing radiation without significant shielding. Mechanical chest com-

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Fig. 1. LUCAS™ mechanical chest compression device.

pression (MCC) devices provide automated, uniform compression delivery within a small space. Use of MCC in the CCL has successfully been used to perform simultaneous percutaneous coronary intervention and limits the radiation exposure of rescuers [2–6]. Reported success of MCC in the CCL lead to a Class IIa recommendation (level of evidence C) in the 2010 resuscitation guidelines and a strong recommendation in the European Resuscitation Council guidelines [7,8].

At our institution, we have used the LUCAS™ (Physio-Control Inc/Jolife AB, Lund, SWE), a piston-driven MCC device (Fig. 1), to perform mechanical CPR in the CCL since April 2014. In our laboratory, The LUCAS™ is used as a bridge to PCI, initiation of percutaneous mechanical circulatory support (MCS), or both. The aim of this study was to assess the efficacy and safety of MCC when compared to manual chest compressions in the CCL.

Methods

The study is a retrospective registry analysis of patients who received ACLS while in the CCL at our institution between May 2011 and February 2016. Patients were identified by inclusion in a predefined registry of patients suffering cardiac arrest who received ACLS resuscitation and/or use of a mechanical chest compression device. Patients who arrived to the CCL with chest compressions (either manual or mechanical) ongoing were included. The decision to bring patients with ongoing cardiac arrest to the CCL was made at the discretion of the attending interventional cardiologist and was not part of an existing protocol at the time of the study.

Prior to April 2014, chest compressions were performed manually. After April 2014, compressions were initiated manually and continued until application and initiation of the LUCAS™ device. The timing of LUCAS™ initiation was at the discretion of the attending interventional cardiologist. All additional resuscitative efforts – including, but not limited to, medication administration, endotracheal intubation, and electrical defibrillation – were performed at the discretion of the interventional team.

In addition, when deemed necessary by the attending cardiologist, some patients received percutaneous MCS, including intra-aortic balloon pump (IABP), Impella® (Abiomed, Danvers, MA), and/or percutaneous extracorporeal life support (ECLS) during resuscitative efforts.

The use of LUCAS™ was stopped at the discretion of the attending interventional cardiologist either after achieving ROSC or when additional resuscitation was considered futile.

All charts and interventional reports of the included patients were examined. Predefined efficacy endpoints included ROSC, 30-day survival, and survival to hospital discharge. Predefined safety endpoints in patients receiving ECLS included TIMI major and minor bleeding, limb loss, and limb ischemia. TIMI major bleeding was defined as intracranial bleeding, hemorrhage associated with a drop in Hgb of greater than 5 g/dL or fatal bleeding. TIMI minor bleeding was defined as any bleeding requiring blood transfusion that did not fulfill criteria for major bleeding [9]. Limb loss was defined as either surgical or auto amputation. Limb ischemia was defined as a decrease in limb perfusion that was clinically considered to be a threat to limb viability. Limb ischemia was considered present if documentation noted limb ischemia, an acutely cold limb, or emergent vascular surgical procedure to restore limb perfusion.

Statistical analysis was performed using STATA (STATACorp, College Station, TX).

Results

Forty-three patients (67% male, mean age 58 years) required ACLS for cardiac arrest while in the CCL during the study period. Patient demographics, resuscitation characteristics, and the procedures performed are listed in Table 1.

The group receiving manual chest compressions ($n = 12$) was more likely to present with ST-elevation myocardial infarction (STEMI) or an acute coronary syndrome. The manual chest compression group was also more likely to receive IABP support (50% vs. 16%, $p = 0.03$). There was not a significant difference in the rate of successful percutaneous coronary intervention between groups.

Results of the predefined efficacy endpoints are listed in Table 2. Patients receiving MCC during ACLS were more likely to achieve ROSC than those receiving mechanical compressions (74% vs. 42%, $p = 0.05$). MCC was not associated with a significant increase in 30-day survival or survival to discharge.

Mechanical circulatory support

Of the thirty-one patients who received MCC, twenty-two (71%) were treated with MCS. Fourteen patients were supported with ECLS, three patients received Impella®, and five received IABP support (Table 1). Patients who received MCS were more likely to have had an initial rhythm of ventricular tachycardia or ventricular fibrillation at the time of arrest. Patients who received MCS were also younger and had better renal function than those who did not receive MCS.

Outcomes in patients receiving MCS are compared to those without MCS in Table 3. Patients who received MCS were significantly more likely to achieve ROSC than those who did not receive MCS (95% vs. 11%, $p = 0.004$). Thirty-day survival was more common in the group receiving MCS, although this was not statistically significant.

Extracorporeal life support group

Of the thirty-one patients who received MCC, fourteen patients (45%) were bridged to ECLS in the form of percutaneous veno-arterial extracorporeal membrane oxygenation. Patients who received ECLS were younger (mean age 49% vs. 61%, $p = 0.034$) and less likely to have coronary artery disease (31% vs. 82%, $p = 0.004$) than those who did not receive ECLS. The group that did not receive ECLS was more likely to undergo successful PCI.