

Clinical Summary

Manual versus mechanical cardiopulmonary resuscitation. An experimental study in pigs.

Liao Q, Sjöberg T, Paskevicius A, Wohlfart B, Steen, S. *BMC Cardiovascular Disorders*. 2010; 10:53.

Purpose:

The purpose was to compare manual CPR with LUCAS-CPR related to coronary perfusion pressure, CPR-related injuries and ROSC.

Methods

- There were 2 groups of rescuers: Manual CPR group (n=8) and LUCAS-CPR group (n=8). During CPR, the swine were ventilated, without interrupting chest compressions, with 100% oxygen via a Boussignac ET tube and Ruben bag. Multiple arterial and venous catheters were inserted for monitoring, flow measurements and blood sampling.
- CPR was started 5 minutes after VF was induced. Manual CPR was performed by pairs of paramedics and ambulance nurses from Lund Ambulance Station; pairs relieved each other after 2 minutes of compressions. A metronome was used to assist in maintaining a constant frequency compression rate of 100/min in the manual group. All rescuers took CPR training according to the 2005 ERC guidelines using a manikin in the 14 days prior to the experiment. Manual compression placement was standardized by correctly positioning LUCAS device on the swine and marking the spot in ink (around the suction cup). The rescuers provided compressions within the circle.
- Single 360J defibrillation shocks were followed by 2 minutes of CPR. Defibrillation was delivered with ongoing LUCAS-CPR; there was an approximate 2 second delay between compressions and defibrillation with manual CPR. Adrenaline 0.01 mg/kg was administered if ROSC was not obtained after 3 shocks, up to 3 times. Measurements continued for 1 hour if there was ROSC. Autopsies were performed after each experiment ended noting rib/sternal fractures, position of catheters, or lung, heart and abdominal organ injury.

Results:

- All eight animals in the LUCAS-CPR group obtained ROSC after the first defibrillation; three animals in the manual group obtained ROSC, one after the first defibrillation, one after defibrillation and 2 minutes of CPR and one after defibrillation, 10 minutes of CPR and multiple doses of adrenaline.
- Each pig received about 60 compressions less in the manual group than the LUCAS group due to changing out rescuers for compression and pauses for defibrillation.

Physiologic results (during CPR):

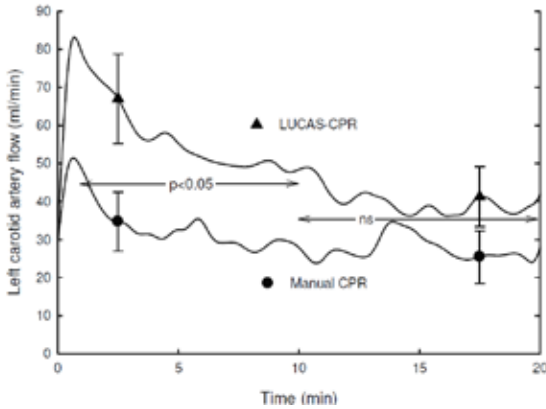
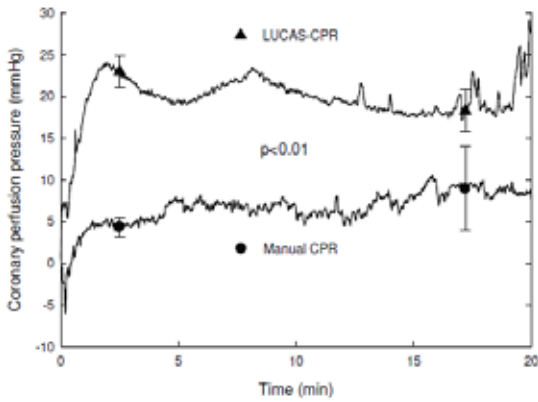
- The coronary perfusion pressure (CPP) was significantly higher ($p < 0.01$) with LUCAS-CPR (~20 mmHg vs. ~5 mmHg).
- The aortic compression pressure was significantly higher in the LUCAS group ($p < 0.05$).
- The intrathoracic aortic pressure was significantly higher with LUCAS-CPR while right atrial pressure was significantly lower.
- Left carotid arterial flow was significantly higher ($p < 0.05$) with LUCAS-CPR during the first 10 minutes.
- EtCO₂ values were statistically significant ($p < 0.05$) higher with LUCAS-CPR (25.5 mmHg vs. 16.5 mmHg).
- There were no significant differences in peak airway pressure or blood gases in the groups; arterial oxygenation was excellent.

Autopsy Results:

- The hearts were in ischemic contracture (stone heart) with no lumen seen on cross section of the left ventricle in the 5 pigs that did not achieve ROSC (manual group).
- Significantly more rib fractures ($p < 0.01$) occurred in the manual group; (manual total of 54 fractures, left side 33, right side 21 vs. LUCAS total of 33 fractures, left side 30, right side 3).
- Two serious injuries were noted in the manual group: one right-sided pressure pneumothorax (air escaping when the right pleura was opened, right lung collapsed), and one vertical deep liver rupture (500 ml blood in the abdomen, which is about 20% of the blood volume of a pig this size).
- After the experiment, the thorax recoiled better in the LUCAS-group, because most ribs were intact on one side.

Conclusion:

LUCAS-CPR is significantly more efficient and gives less injury than manual CPR in this porcine model.



Discussion:

- The animals in the LUCAS group received continuous compressions without a need to stop due to rescuer fatigue or for rescuer safety during defibrillation attempts.
- The animals in the manual CPR group were without CPR for about 4 seconds for each change between ventilation and compression, and the coronary perfusion pressure dropped to zero. It took about 10 seconds when the compressions were restarted to regain the CPP that had been obtained during the previous 2-minute period of continuous manual CPR.
- Studies have shown the difficulty providing optimal manual compressions consistently, many compressions are either too shallow or too deep. Too deep compressions may cause severe injuries, as was seen in one pig in the manual group.
- The suction cup of LUCAS assisted the sternum to return to its neutral position resulting in a negative pressure in the right atrium during the initial part of decompression phase. "This, together with a significantly higher intrathoracic aortic pressure during the end-decompression phase in the LUCAS group, explains the significantly higher CPP in that group."

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