Safety and efficacy of head cooling in a porcine model of cardiopulmonary resuscitation with chest compression only and without airway protection

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INTRODUCTION

Morbidity and mortality after successful cardiopulmonary resuscitation depends largely on recovery of neurologic function. At present, therapeutic hypothermia becomes a useful tool for providing neuroprotection following cerebral ischemic events, including global cerebral ischemia following cardiac arrest (1). Currently the hypothermic treatment is initiated following successful resuscitation in order to minimize reperfusion injury following ischemia. However, the results from several experimental investigations have indicated that hypothermia during CPR might provide additional survival benefits and therefore hypothermia should be initiated as soon as possible (2). We utilized the RhinoChill device (BeneChill Inc., San Diego, CA) that vaporizes an inert volatile liquid, perfluorocarbon (PFC), into the nasopharynx, where it rapidly produces evaporative cooling. When we employed this method to produce head cooling during CPR, after 10 minutes of untreated cardiac arrest significantly greater likelihood of successful defibrillation and better neurological recovery were demonstrated. Significantly better post resuscitation myocardial function was also observed in animals that received selective head cooling during CPR. We subsequently confirmed the beneficial effects of trans-nasal cooling on outcome of CPR in models of more prolonged untreated cardiac arrest (3, 4). However, all our previous investigations on selective head cooling have been performed in a model of CPR which included endotracheal intubation and alternation of chest compressions and ventilations with a 30/2 ratio. In the present study, we investigated the efficacy and safety of early head cooling during CPR in a model of cardiac arrest with chest compressions (CC) only, and without airway protection and ventilation. We hypothesized that early head cooling during CPR without airway protection and ventilation would be safe and effective.

METHODS

Domestic male pigs, weighing 39 kg, were endotracheally intubated and mechanically ventilated. The femoral artery and vein were cannulated such to monitor aortic and right atrial pressures and coronary perfusion pressure (CPP) was calculated. Ventricular fibrillation (VF) was electrically induced and untreated for 7 min. Coincident with the onset of VF, mechanical ventilation was discontinued and the endotracheal tube was removed. Continuous CC, with a mechanical chest compressor (Thumper, Michigan Instruments, Grand Rapids, MI) were then delivered for 5 min prior to defibrillation. Coincident with start of CC, animals were subjected to selective head cooling with the RhinoChill device (BeneChill Inc., San Diego, CA). Immediately after return of spontaneous circulation (ROSC), animals were re-intubated and ventilated with oxygen. Head cooling was continued for an additional hour following ROSC. Core and jugular temperatures were continuously measured. Arterial PO2 and PCO2, echocardiographic post resuscitation myocardial function, survival and neurological function were measured.

RESULTS

All animals were successfully resuscitated after 317 ± 24 sec of CPR and following a single defibrillation attempt. Two minutes after ROSC, core temperature decreased 0.5ºC and jugular vein temperature more than 3.5ºC (Figure 1). CPPs were well maintained over the threshold level for successful resuscitation over the 5 min of CC (Figure 2) and VF was terminated with only a single defibrillation attempt.

Arterial PO2 was 105 ± 3 mmHg at baseline, 85 ± 14 mmHg after 7 min of untreated VF and 233 ± 169 mmHg after the 5 min of unventilated CC with cooling (Table). FiO2 was 100% post-ROSC and was progressively tapered to 21% over 3.5 ± 2 hrs. PFC was aspirated during chest compression and confirmed radiologically. Subsequent respiratory care included positive pressure ventilation with low tidal volume and prone position for 8 ± 4 hrs. There were no adverse respiratory effects. Animals were successfully extubated. At 24 and 96 hrs, all animals were breathing normally. Echocardiographically assessed post-resuscitation myocardial function did not significantly decrease following ROSC (Figure 3) and animals survived for more than 96 hours with full neurological recovery.

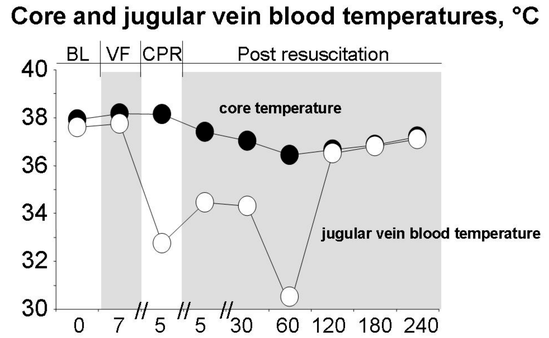

FIGURE 1

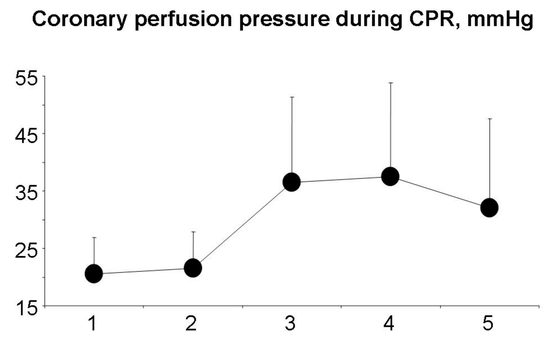

FIGURE 2

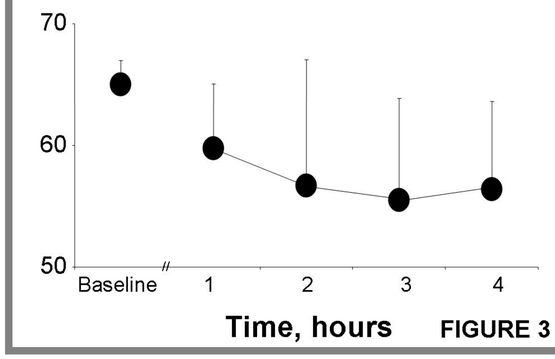

FIGURE 3

	Baseline	VF 7 min	CPR 5 min
PaO_2 mmHg	105 ± 3	85 ± 14	233 ± 169
$PaCO_2$ mmHg	38 ± 1	27 ± 8	29 ± 14

CONCLUSIONS

In this model, early trans-nasal cooling during CPR with chest compressions only, without ventilation and airway protection, is feasible for oxygenation, resuscitation and survival. Early trans-nasal cooling could be therefore potentially applied prior to ACLS.

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