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Experimental paper

Myocardial perfusion and oxidative stress after 21% vs. 100% oxygen ventilation and uninterrupted chest compressions in severely asphyxiated piglets☆

Anne Lee Solevåg[a,b,c,*], Georg M. Schmölzer[a,b], Megan O'Reilly[a,b], Min Lu[a,b], Tze-Fun Lee[a,b], Lisa K. Hornberger[b], Britt Nakstad[c], Po-Yin Cheung[a,b]

[a] Centre for the Studies of Asphyxia and Resuscitation, Neonatal Research Unit, Royal Alexandra Hospital, Edmonton, Canada
[b] Department of Pediatrics, University of Alberta, Edmonton, Canada
[c] Department of Pediatric and Adolescent Medicine, Akershus University Hospital, Lørenskog, Norway

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ABSTRACT

Aim: Despite the minimal evidence, neonatal resuscitation guidelines recommend using 100% oxygen when chest compressions (CC) are needed. Uninterrupted CC in adult cardiopulmonary resuscitation (CPR) may improve CPR hemodynamics. We aimed to examine 21% oxygen (air) vs. 100% oxygen in 3:1 CC:ventilation (C:V) CPR or continuous CC with asynchronous ventilation (CCaV) in asphyxiated newborn piglets following cardiac arrest.
Methods: Piglets (1–3 days old) were progressively asphyxiated until cardiac arrest and randomized to 4 experimental groups ($n = 8$ each): air and 3:1 C:V CPR, 100% oxygen and 3:1 C:V CPR, air and CCaV, or 100% oxygen and CCaV. Time to return of spontaneous circulation (ROSC), mortality, and clinical and biochemical parameters were compared between groups. We used echocardiography to measure left ventricular (LV) stroke volume at baseline, at 30 min and 4 h after ROSC. Left common carotid artery blood pressure was measured continuously.
Results: Time to ROSC (heart rate $\geq 100\ min^{-1}$) ranged from 75 to 592 s and mortality 50–75%, with no differences between groups. Resuscitation with air was associated with higher LV stroke volume after ROSC and less myocardial oxidative stress compared to 100% oxygen groups. CCaV was associated with lower mean arterial blood pressure after ROSC and higher myocardial lactate than those of 3:1 C:V CPR.
Conclusion: In neonatal asphyxia-induced cardiac arrest, using air during CC may reduce myocardial oxidative stress and improve cardiac function compared to 100% oxygen. Although overall recovery may be similar, CCaV may impair tissue perfusion compared to 3:1 C:V CPR.

Introduction

Resuscitation of asphyxiated infants with 100% oxygen is associated with increased oxidative stress,[1] increased morbidity and mortality.[2,3] A meta-analysis reported that using air instead of 100% oxygen reduces mortality by 30%, corresponding to the potential saving of more than 100,000 infant lives annually.[2,3] However, available studies examined infants who were supported with assisted ventilation only, without the need of chest compression (CC). The use of air instead of 100% oxygen in neonatal cardiac arrest is debated and the 2015 International Liaison Committee on Resuscitation (ILCOR) guidelines advocate 100% oxygen when CC are needed.[4] However, the ILCOR acknowledges the minimal evidence to support this recommendation. Indeed, newborn animal studies indicate that ventilation with air is as effective as 100% oxygen during CC, at least after brief asystole[5,6] ILCOR

Abbreviations: CC, chest compressions; CPR, cardiopulmonary resuscitation; CCaV, continuous CC and asynchronous ventilation; C:V, chest compression to ventilation; ILCOR, International Liaison Committee on Resuscitation; ROSC, return of spontaneous circulation; SpO_2, oxygen saturation; HR, heart rate; $paCO_2$, partial arterial CO_2; $ETCO_2$, end-tidal CO_2; V_T, tidal volume; CO, cardiac output; LVOT, left ventricular outflow tract; PW, pulsed wave; SV, stroke volume; CPAP, continuous positive airway pressure; PEEP, positive end-expiratory pressure; PEA, pulseless electrical activity; PPV, positive pressure ventilation; MMP, matrix metalloproteinase; GSH, glutathione; GSSG, oxidized glutathione.

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* Corresponding author at: Neonatal Research Unit, Royal Alexandra Hospital, 10240 Kingsway Avenue NW, T5H 3V9 Edmonton, Alberta, Canada.
E-mail address: a.l.solevag@medisin.uio.no (A.L. Solevåg).

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may permit the inclusion of new data to inform practice if it becomes available before the next complete evidence evaluation is due.[7,8]

Restoration of myocardial function after hypoxia-ischemia depends on blood oxygenation and myocardial perfusion. In adult animals, performing uninterrupted CC increases coronary perfusion pressure (CPP).[9] No data is available to suggest that this may also be the case in newborns. Schmölzer et al.[10] found no difference in return of spontaneous circulation (ROSC) or mortality comparing 3:1 C:V CPR and continuous CC with asynchronous ventilation (CCaV) using 100% oxygen in asphyxiated newborn piglets with profound bradycardia. No study has investigated air vs. 100% oxygen during CCaV in neonatal CPR. The aim of this study was to compare air and 100% oxygen combined with 3:1 C:V CPR or CCaV in newborn piglets with severe asphyxia and cardiac arrest. We hypothesized that CCaV with air would improve ROSC compared to the currently recommended 100% oxygen with 3:1 C:V CPR.

Methods

Subjects

Newborn mixed breed piglets (1–3 days, 1.7–2.4 kg) were obtained on the day of experimentation from the Swine Research Technology Center, University of Alberta. All experiments were conducted in accordance with the guidelines and approved by the Animal Care and Use Committee (Health Sciences), University of Alberta and presented according to the ARRIVE guidelines.[11] The protocol is presented in Fig. 1.

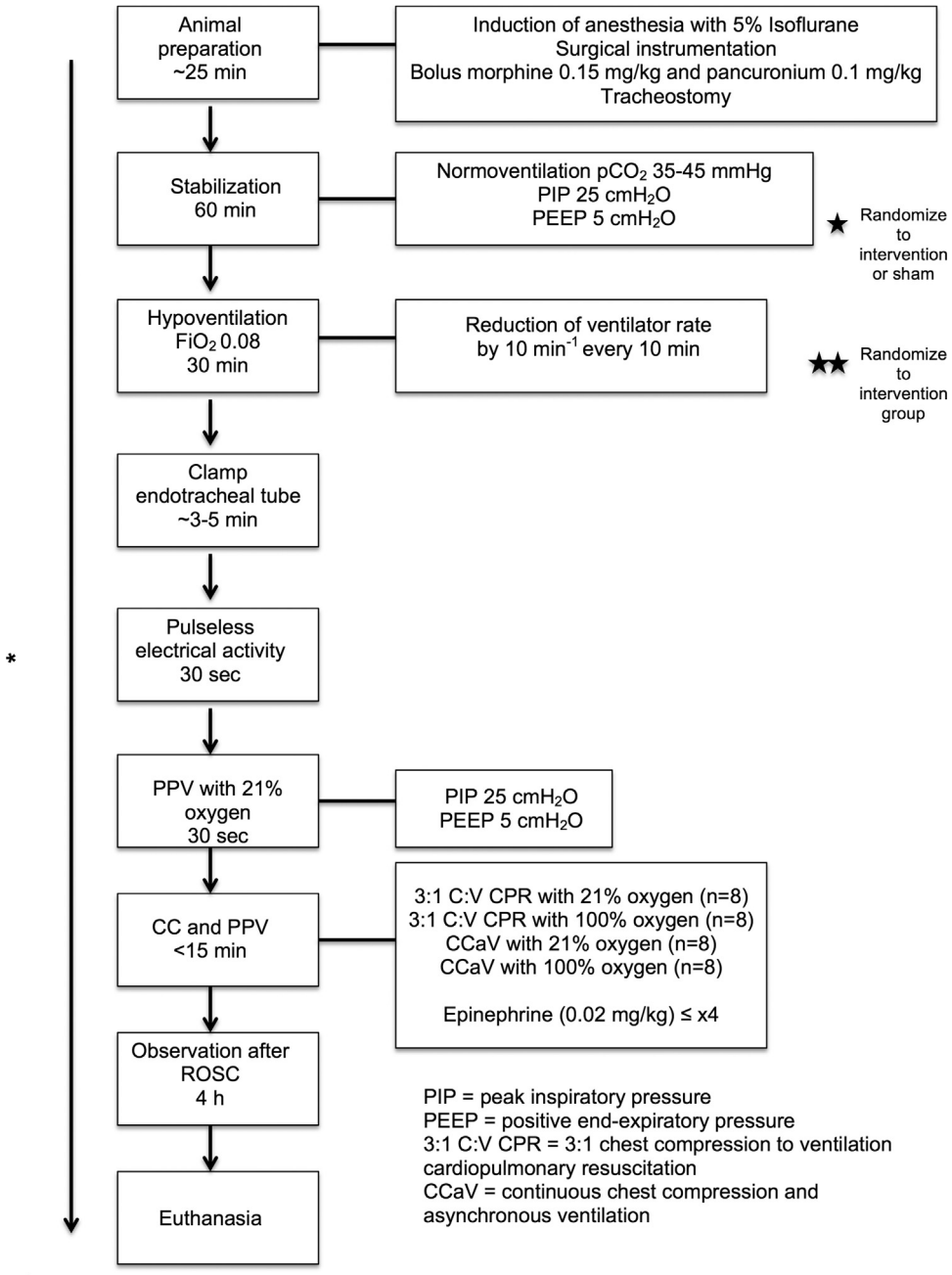

Fig. 1. Experimental protocol.