The Effects of an Automatic Low Pressure Ventilation Device versus Manual Ventilation During Cardiopulmonary Resuscitation in a Porcine Model of Cardiac Arrest

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BACKGROUND

• In clinical resuscitation, ventilations are often excessively frequent and impair effective artificial circulation.
• An automated ventilation device which prevents overventilation and can be used during continuous chest compression without interruption could increase the efficiency of cardiopulmonary resuscitation (CPR).

OBJECTIVES

To assess the effects of a high frequency, positive pressure ventilation device on hemodynamics and gas exchange during CPR.

METHODS

•12 Yorkshire pigs with either sex, 35-45 kg
•Anesthesia:
thiopental, 8mg/kg; isoflurane, 1-4%
•Measured parameters:
* Airway Pressure (airwayP)
* Esophageal Pressure (esoP) - custom-made air filled balloon
* PEEP
* $ETCO_2$ } $CO_2SMO^{®}$
* SpO_2
* pH
* pCO_2 } Arterial Blood Gases
* pO_2
* Aortic Pressure (AoP)
* Right Atrial Pressure (RaP) } Millar®
• Coronary Perfusion Pressure (CPP)
* max-CPP: the maximum difference between AoP and RaP, diastolic
* mean-CPP: the mean difference of segments between AoP and RaP, diastolic
• Each pig had VF induced 3 times:
* 30-second VF, no CPR, no ventilation, then
* 5-min VF with CPR and ventilation

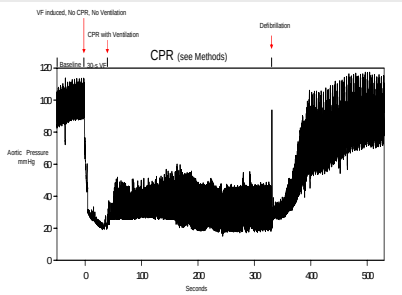
• Chest compressions - piston driven compressor:
* Frequency: 95 compressions/min
* Depth: 4-7 cm or 25% of the anterior-posterior diameter of the chest wall

• Ventilation
* 3 ventilation methods in balanced random order:
A. Manual ventilation: 12 breaths/min
B. Oxylator^{P15F20}: Max P = 15 cmH_2O, Flow = 20 L/min
C. Oxylator^{P20F30}: Max P = 20 cm H_2O, Flow = 30 L/min
* Oxylator
◦ An automatic nonelectronic (no electrical power required) ventilator, powered by compressed gas, which automatically provides inflow when the airway pressure falls < 2 cmH_2O (I phase).
◦ Inspiratory flow rate is fixed at 20 or 30 L/min.
◦ Continuous flow until a device specific maximum airway pressure is reached (15 or 20 cmH_2O); flow then stops (E phase)

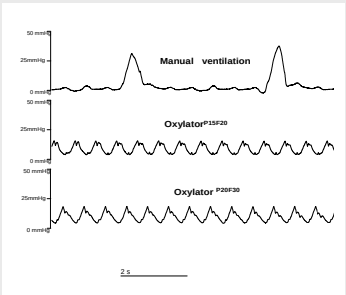
• Defibrillation: after 5-min CPR,
200J, 250J, 300J and 360J x 3 times,as needed

• 3 episodes/pig in balanced random order

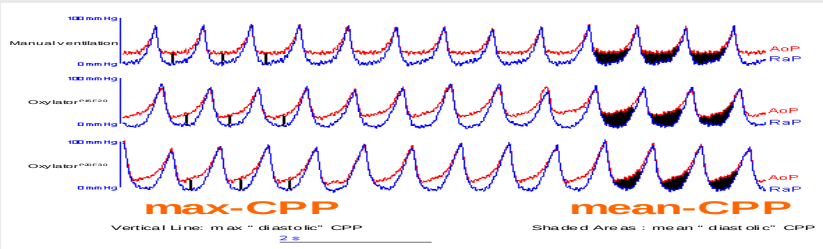
Single VF Episode



Pig # 7 Airway Pressure During Experimental CPR



Pig #12 Aortic and right atrial pressure during CPR



RESULTS

Table 1

	Ventilations	max-CPP(mmHg)	mean-CPP(mmHg)	esoP-p(mmHg)	esoP-t(mmHg)	airwayP-p(mmHg)	airwayP-t(mmHg)
n = 12	Manual	20.4±4.8	20.7±10.1	11.2±5.7	1.7±4.4	36.5±10.4	1.0±1.9
n = 12	Oxylator^{P15F20}	28.0±5.5	24.1±7.4	8.1±4.9	-1.3±3.1	12.4±1.0	0.7±1.6
n = 12	Oxylator^{P20F30}	19.6±7.0	21.6±11.4	12.6±6.7	4.4±6.4	17.2±2.0	4.7±3.5

Manual vs Oxylator^{P15F20}: **; Oxylator^{P15F20} vs Oxylator^{P20F30}: ##; Manual vs Oxylator^{P20F30}: ***; Oxylator^{P15F20} vs Oxylator^{P20F30}: #; Manual vs Oxylator^{P20F30}: ##

$^{**}p<0.002$, $^{***}p<0.0002$; $^{\#}p<0.02$, $^{\#\#}p<0.002$; mean±SD; episodes = 36

Abbreviations: max-CPP, maximum CPP; mean-CPP, mean CPP; esoP-p, peak esophageal pressure; esoP-t, trough of esophageal pressure; airwayP-p, peak airway pressure; airwayP-t, trough of airway pressure

Table 2

	Ventilations	PEEP(cmH_2O)	$ETCO_2$ (mmHg)	SpO_2 (%)	pH	pCO_2(mmHg)	pO_2 (mmHg)
n = 12	Manual	1.1±0.6	21.2±3.3	91.1± 7.0	7.65 ±0.1	22.8±3.3	289.1±45.7
n = 12	Oxylator^{P15F20}	2.8±0.8	34.4±4.1	92.2 ±5.3	7.41±0.1	36.6±6.7	356.2±97.5
n = 12	Oxylator^{P20F30}	3.3±1.3	24.7±4.5	90.7 ±8.7	7.57±0.1	26.3±6.3	417.9±35.9

Manual vs Oxylator^{P15F20}: ***; Oxylator^{P15F20} vs Oxylator^{P20F30}: ###; Manual vs Oxylator^{P20F30}: **; Oxylator^{P15F20} vs Oxylator^{P20F30}: ##; Manual vs Oxylator^{P20F30}: ***; Oxylator^{P15F20} vs Oxylator^{P20F30}: ###

$^{**}p<0.002$, $^{***}p<0.0002$; $^{\#\#}p<0.002$, $^{\#\#\#}p<0.0002$; mean±SD; episodes = 36

Abbreviations: PEEP, positive end-expiratory pressure; $ETCO_2$, end-tidal CO_2; SpO_2, oxygen saturation ; pCO_2, partial pressure of CO_2; pO_2, partial pressure of O_2

• No significant order effects.
• No difference in the threshold for defibrillation among the groups.

CONCLUSION

The automated pressure and flow limited ventilation device (at max pressure = 15 cmH_2O and max flow = 20 L/min) during CPR results in higher max-CPP and $ETCO_2$ than manual ventilation despite continuously positive airway pressure and high frequency of ventilation.