Active Humidification and Perioperative Temperature Regulation Using a Novel Heated Airway Circuit after Deep Hypothermic Circulatory Arrest

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Introduction

Deep hypothermic circulatory arrest (DHCA) is used in a variety of cardiovascular surgical procedures including aortic arch repairs and pulmonary thromboendarterectomies. Cooling and rewarming during cardiopulmonary bypass (CPB) and DHCA takes considerable time and contributes to the postprocedural coagulopathy and physiologic perturbations seen during these cases. Temperature afterdrop following separation from CPB has been described,[1, 2] and may contribute to associated coagulopathy and metabolic acidosis.[3] The use of the ANAPOD Heated Humidification System® (ANAPOD) was evaluated in order to determine the effect of active vs. passive fresh gas flow heating and humidification on post-CPB temperature regulation in patients undergoing DHCA.

Methods

As part of a QI initiative, we compared the use of passive airway warming (hygroscopic in-line filter) to an actively heated, humidified ventilator circuit (ANAPOD Heated Humidification System®) in consecutive cohorts of cardiac surgical cases requiring DHCA (see Table 1). In both control and ANAPOD groups, low fresh gas flow was utilized (< 4L/min) and standard institutional temperature regulation measures were used including increasing the ambient room temperature, lower body forced air warming system (3M™ Bair Hugger™ System), and surface conductive rewarming (Kimberly Clark Patient Warming System). Ventilation was initiated 10-15 minutes prior to separation from CPB and in the ANAPOD group the heated circuit was set at 42 C which delivers heat and humidification at a temperature of 37 C through the endotracheal tube. Arterial and venous inflow, nasal and bladder temperatures were measured. The primary end-point was the drop in nasopharyngeal (NPT) temperature ("afterdrop") from CPB separation to 60 minutes later. An unpaired, one-tailed t-test was used to compare the change in NPT between the ANAPOD group and control. Other variables between the ANAPOD and control group were compared with an unpaired, two-tailed t-test.

Results

Fifteen patients were mechanically ventilated with the ANAPOD circuit and 10 patients were mechanically ventilated using the standard circuit during separation from CPB after rewarming from DHCA. Pertinent patient demographics and characteristics were similar between the two groups (Table 1). While there was no difference between nasopharyngeal (NPT) or venous cannula temperatures (Tven) at separation from CPB between ANAPOD or standard circuits (Table 2), statistically significant differences were demonstrated in the change in NPT at 30 min (P=0.02) and 60 min post-CPB (P=0.03), and at the end of surgery (P=0.04) (Table 2, Figure 1).

Table 1 : Patient Characteristics

	Control (n = 10)	Anapod (n = 15)	P Value
Age	*58.5 ± 10.1*	*57.8 ± 13.8*	0.89
Male Gender (%)	*80*	80	
Body Surface Area	*2.2 ± 0.27*	2.1 ± *0.26*	0.23
Lowest Nasopharyngeal Temperature (C)	*16.1 ± 2.5*	16.0 ± *2.4*	0.90
Lowest Bladder Temperature (C)	*20.4 ± 3.7*	19.4 ± *3.4*	0.48
Lowest Venous Cannula Temperature (C)	*15.8 ± 2.1*	15.6 ± *2.6*	0.79
Surgery			
Pulmonary Thromboendarterectomy	*n = 5*	n = 8	
Aortic Arch Repair	*n = 5*	n = 7	
Circulatory Arrest Time (min)	*22.1 ± 22.0*	*27.7 ± 24.4*	0.56
Cardiopulmonary Bypass Time (min)	*226 ± 73*	227 ± *64.0*	0.98
Cross Clamp Time (min)	*143 ± 43.0*	134 ± *45.5*	0.75
Cooling Time (min)	*117 ± 46.3*	108 ± *52.8*	0.64
Rewarming Time (min)	*114 ± 37.4*	104 ± *36.7*	0.52
Mean Post CPB Blood Product Transfusion			
PRBC	*0.6 ± 0.97*	*0.40 ± 0.83*	*0.58*
FFP	*0.4 ± 1.3*	*0.27 ± 1.0*	*0.78*
PLT	*1.3 ± 1.5*	*1.3 ± 0.90*	*0.94*
Cryo	*1.3 ± 0.95*	*1.2 ± 1.3*	*0.83*

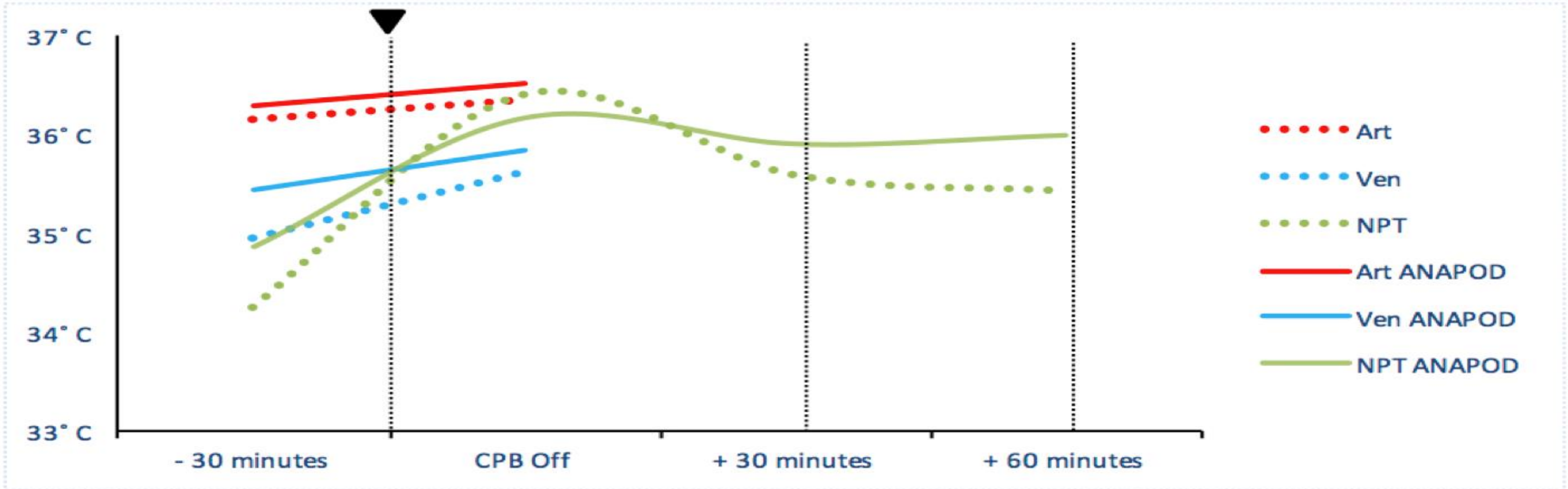

Figure 1. Mean temperatures for ANAPOD (solid lines) and Control Groups (dotted lines) during various time points related to CPB separation and post-CPB temperature regulation. Black arrowhead indicates start of mechanical ventilation with each airway circuit type. Art = arterial cannula temperature; Ven = venous cannula temperature; NPT = nasal temperature ; ANAPOD = ANAPOD Heated Humidification System®;

Table 2: Temperature Differences between Anapod and Control Groups

	Control	Anapod	P Value
Venous Cannula Temperature at separation of CPB (C)	35.6 ± *0.45*	35.8 ± *0.43*	0.18
Nasopharyngeal Temperature at separation of CPB (C)	36.4 ± *0.43*	36.4 ± *0.54*	0.89
Change in Nasopharyngeal Temperature 30min post CPB	−0.88 ± *0.78*	−0.33 ± *0.43*	0.02
Change in Nasopharyngeal Temperature 60min post CPB	−0.96 ± *1.1*	−0.25 ± *0.68*	0.03
Change in Nasopharyngeal Temperature at End of Surgery	−0.87 ± *1.1*	−0.19 ± *0.80*	0.04

Discussion

Blood warming through active heat and humidification warmed the patient during mechanical ventilation. The ANAPOD circuit significantly attenuated the temperature afterdrop upon CPB separation when compared with standard airway circuits in our sample population of patients undergoing DHCA. Future studies are needed to look at whether this attenuation in temperature afterdrop has an effect on acidosis, coagulopathy, and other clinically relevant end-points. Additionally, with such effective temperature management, separation of bypass at lower temperatures may be feasible, thus reducing CPB time and duration of surgery.

References

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