Systemic Oxygen Balance And Hemodilution During Normothermic Cardiopulmonary Bypass In Dogs

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Citation

W Plöchl, B Liam, D Dickerman, R Sarpal, D Cook, T Orszulak, R Daly. *Systemic Oxygen Balance And Hemodilution During Normothermic Cardiopulmonary Bypass In Dogs*. The Internet Journal of Anesthesiology. 1997 Volume 2 Number 3.

Abstract

INTRODUCTION

Hemodilution is standard practice during cardiopulmonary bypass (CPB), but the limits of hemodilution at differing extracorporal temperatures have not yet been systematically determined. [1]

With the shift towards normothermic CPB in the last few years, this question is more relevant. Given the higher oxygen demand associated with "warm" bypass, there is a tendency to transfuse more frequently, but this is not based on a systematic evaluation of hemoglobin requirements.

The purpose of this study was to characterize systemic oxygen balance with progressive hemodilution and define the minimal hematocrit (Hct) which supports whole body oxygen consumption during normothermic CPB.

METHODS

Following IACUC approval, 9 dogs were studied.

General anesthesia was maintained with fentanyl and midazolam infusion, muscle relaxation with pancuronium.

Animals underwent normothermic CPB (nasopharyngeal temperature 38°C) using a whole blood prime. Mean arterial pressure (MAP) was maintained at 60 mmHg strictly by increases in pump flow.

Hemodilution: Hct was progressively reduced by removing blood from the CPB circuit and replacing it with 6% Dextran 70.

Arterial and mixed venous blood samples were obtained at stable CPB conditions at target Hcts (39%, 25%, 18%, 14%, 9%).

Systemic oxygen delivery (DO2) and consumption (VO2) were determined using standard formulae.

RESULTS

Hemodilution was associated with a progressive decrease in total peripheral resistance but MAP was stable throughout the study by increases in pump flow (Table 1, Fig. 1).

Figure 1

Figure 1

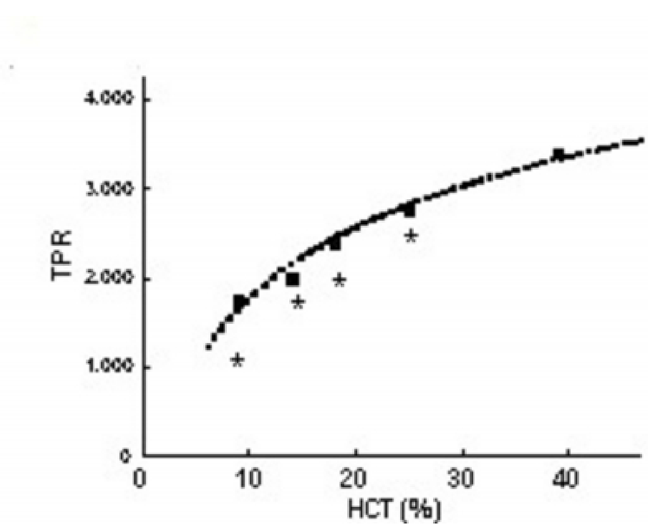
Table 2. Effect of Hemodilution on TPR, Pump Flow, and Systemic Oxygen Balance during Normothermic CPB

CPB Period	Hct (%)	MAP (mmHg)	TPR ($dynes \cdot s \cdot cm^{-5}$)	Pump Flow ($L \cdot min^{-1} \cdot m^{-2}$)	DO_2 ($mL \cdot min^{-1} \cdot m^{-2}$)	VO_2 ($mL \cdot min^{-1} \cdot m^{-2}$)	OER (%)	Lactate ($mmol \cdot L^{-1}$)
1	39±6	62±10	3390±900	1.9±0.5	327±69	131±31	41±7	3.3±0.8
2	25±2*	62±4	2760±640*	2.3±0.4	274±54	134±21	50±7	3.1±0.8
3	18±2*	62±3	2370±840*	2.9±0.9*	230±69*	108±17*	49±16	3.4±1.5
4	14±1*	62±5	1990±570*	3.4±0.9*	217±61*	106±13*	52±13	3.9±1.9
5	9±1*	62±5	1740±570*	3.8±1.1*	182±48*	93±30*	54±18	4.6±2.1*

Data are mean ± SD (n=9), * $p < 0.05$ vs. CPB period I by repeated measures ANOVA

CPB - cardiopulmonary bypass; Hct - hematocrit; MAP - mean arterial pressure; TPR - total peripheral resistance; DO_2 - systemic oxygen delivery; VO_2 - systemic oxygen consumption; OER - oxygen extraction ratio;

Figure 2



Total peripheral resistance (TPR) in dynes·s·cm-5 vs.

hematocrit (Hct) during the five cardiopulmonary bypass periods. Values are mean (n=9). The regression curve was generated from 45 individual values of TPR at individual Hcts.

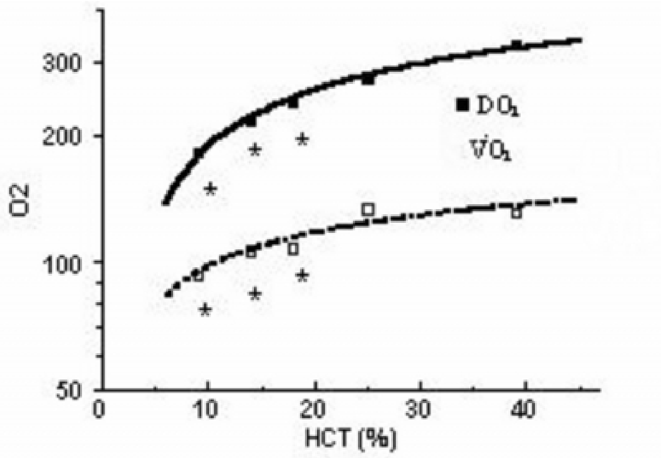
DO2 at a Hct of 25% was 274± 54 mL·min·m2 and did not differ from the DO2 at a Hct of 39%.

When Hct was reduced to 18% DO2 significantly decreased to 238±69 mL·min·m2 (Table 1, Fig. 2).

Similarly, was stable between Hcts of 39% and 25% and showed a significant reduction at a Hct of 18% and below (Table 1, Fig. 2).

Figure 3

Fig. 2: Whole body oxygen consumption (VO2) and oxygen delivery (DO2) in mLÂ·min-1Â·m-2 vs. hematocrit (Hct) during the five cardiopulmonary bypass study periods. Values are mean (n=9). Each regression curve was generated from 45 individual values for DO2 and VO2.



DISCUSSION

During normothermic CPB the minimum Hct supporting whole body oxygen supply and demand is greater than 18%.

The critical Hct for during warm bypass is greater than under non-bypass condition, although critical DO2 is unchanged.

Animals on CPB are less tolerant of hemodilution than intact animals because the flow increases practical with CPB do not approximate the increases in cardiac output of intact animals. [2]

The critical Hct for the body during warm CPB is higher than that for the brain under the same conditions, as cerebral oxygen demand in dogs is met with a Hct as low as 15%. [3]

References

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