Active Air Removal Device Reduces Intravenous Air Burden Introduced by Warmed Fluids

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Background/Introduction: To avoid perioperative hypothermia and possibility of related adverse outcomes the intraoperative use of fluid warmers has become routine. One of the risks of fluid warming is "outgassing" of dissolved air since solubility of air in fluids decreases with warming.[1] The result is an iatrogenic air burden with varying adverse consequences depending upon the size and location of the embolism. To estimate the amount of air burden (outgassing) that occurs in a typical infusion of packed red blood cells, we measured the volume of air liberated from refrigerated bovine blood after warming. The goal is to simulate the clinical situation where human blood is maintained refrigerated and then warmed in a fluid warmer during infusion.

Methods: 500mL of bovine blood (Lampire Biological, Pipersville, PA), chilled to 8^0C, was infused through a Y connector to two separate infusion lines. The cold blood bag output line was split into 2 lines using a Y connector so that the same source of fluid entered each test setup. The output lines from the y-set are fed separately through an Alaris infusion pump (BD, Franklin Lakes, NJ) and then through Smiths Hotline H-90 fluid warmers (Smith's Medical, Minneapolis, MN) programmed at 41^0C. One of the fluid warmers was connected directly to an air collection cylinder (Qosina, Ronkonkoma, NY). The other was connected to the ClearLine IV air removal device (ClearLineMD, Woburn, MA). The ClearLine IV output was connected to the air collection cylinder. The collection tubes were configured for easy weighing on a calibrated scale. All tubing was primed so as to eliminate air in the tubing. Three separate runs were conducted at infusion rates of 100, 150 and 200 ml/hr. A FLIR IR gun (FLIR, Wilsonville, OR) was used to document the fluid temperature at the CLIV input and output and fluid warmers inputs and outputs. Temperature was +/- 2^0 C.
Air that is generated by the outgassing of the warmed blood cells makes its way to the collection tube and the air displaces the fluid in the filled collection tube. The air volume of air was determined using the weight change of the liquid filled collection tube. Each collection tube was weighed at the beginning of each test run (full capacity), and at the end of each test run, after infusion of 250mL of blood. The collection vessel change in weight in grams was used to determine the volume in cc or ml of air generated in the warming process assuming the density of the blood to be 1gm/cc.

Results: An average of 4cc of air per 250mL infused blood was found in the air cylinder using the Hotline fluid warming system, compared to an average of 0cc of air in the air cylinder after the ClearLine IV device. Temperature readings were consistent in both setups and within the expected specifications.

	200mL/hour	150mL/hour	100mL/hour
Without ClearLine IV	3.0cc	3.5cc	5.7cc
With ClearLine IV	0cc	0cc	0cc

Conclusions: The data indicate that outgassing of air does occur during warming and further that the active air elimination device is effective for removing the outgassed air. Infusion rate alters the amount of outgassed air. These results are particularly relevant when large volumes of warmed fluids are administered and especially for small pediatric patients.

References:

1) Varga C, Luria I, Gravenstein N. Intravenous Air: The Partially Invisible Phenomenon. Anesth Analg. 2016 Nov;123(5):1149-1155. PubMed PMID: 27749346.

KEY WORDS. Fluid warmer, hypothermia, air embolus, gas, air bubbles, Clearline IV, patient safety

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[1] Varga C, Luria I, Gravenstein N. Intravenous Air: The Partially Invisible Phenomenon. Anesth Analg. 2016 Nov;123(5):1149-1155. PubMed PMID: 27749346