
Warming Characteristics of a Dual Reservoir Cooler/Heater Unit

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Abstract

A study of the Hemotherm model 400 dual reservoir cooler/heater was undertaken to determine whether warming times are affected by running both the oxygenator heat exchanger and the warming blanket from a single warming source. Forty patients were divided into two groups of twenty each. Group A patients were warmed to 37°C using only the heat exchanger of the oxygenator. Group B patients were warmed using the oxygenator's heat exchanger and blanket simultaneously at the initiation of warming. There was no statistical difference between the two groups with regards to the patient's body weights, B.S.A.'s and bypass times. Group A showed a significantly faster rise in both arterial and venous blood temperatures. There was no statistical difference demonstrated for the rise in esophageal, bladder or the Hemotherm model 400 unit temperatures. The heating blanket did not contribute to the warming of the patient. Using the data obtained from this study, a formula based on the rise in temperature corrected for B.S.A. was developed to predict the total time needed to warm any patient.

Introduction

There have been no reported studies comparing the warming characteristics of the Cincinnati Sub-Zero (CSZ) Hemotherm model 400 dual reservoir cooler/heater unit when used with an oxygenator heat exchanger alone and when used in conjunction with a warming blanket. The Hemotherm model 400 is a second generation cooler/heater having several improvements over the older Blanketrol^a unit, whose performance has been previously documented.¹ These improvements include independently controlled reservoirs for cold and warm water sources, microprocessor circuitry and a fully sealed control panel.

The manufacturer states that one can use the Hemotherm model 400 unit for both the oxygenator's heat exchanger and the patient's warming blanket simultaneously. This is accomplished with the use of two pairs of Hanson quick-connector fittings, one pair each for the oxygenator's heat exchanger and the blanket.

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This study of the Hemotherm model 400 was undertaken to determine whether warming times were affected by running both the heat exchanger and blanket from a single warming source. The hypothesis is that those patients who did not have the blanket plugged in at the start of the warming period will warm faster than those patients who were warmed using both the oxygenator's heat exchanger and blanket simultaneously for two reasons: 1) because of the extra load that the warming blanket puts on the Hemotherm model 400 unit of Group B; and 2) because of the limited effect of the warming blanket.

Methods and Materials

A CSZ Hemotherm model 400 unit and blanket were used on 40 patients undergoing elective aorto-coronary bypass surgery. The Hemotherm model 400 unit has a cooling system which consists of a one-half horse power heavy-duty compressor operating a standard Freon cooling unit. The cooling range is from 32°C to 3°C, with a reservoir capacity of eight quarts. The heating system consists of two electric heating elements of 300 watts and 1200 watts. The warming range is from 25°C to 42°C, with a reservoir capacity of six quarts. The flow rate is measured at 19 LPM at a maximum of 15 psi to the oxygenator and 10 psi to the blanket. The unit is portable and requires a 20 ampere 115 volt grounded circuit to operate.

The extra-corporeal circuit consisted of a Shiley M-2000^b membrane oxygenator, and a Shiley Custom tubing pack^b for all patients. Cannulation consisted of a Sarns two-stage venous return catheter^c into the right atrium, and a Shiley 6.5 mm aortic arch cannula^b into the ascending aorta. Blood flows while on bypass were maintained between 2.0 l/min/m² during hypothermia and up to 2.4 L/min/m² while warming the patient. All patients were cooled systematically to 28°C using the Hemotherm unit without the blanket plugged in.

Topical hypothermia in addition to pump infused cardioplegia was utilized on all patients. The topical protocol consisted of one liter of Physiolsol^d applied during each cardioplegic infusion. No patients had a left ventricle vent, nor was any

a. Cincinnati Sub-Zero Products, Cincinnati, OH

b. Shiley, Inc., Irvine, CA

c. Sarns, Inc., Ann Arbor, MI

d. Abbott Laboratories, North Chicago, IL

	Group A		Group B		P-value
	Mean	S.D.	Mean	S.D.	
Patient weight (Kg)	80.6	21.6	76.3	12.0	p>.500
B.S.A. (m ²)	1.93	.28	1.87	.17	p>.505
By-pass time (minutes)	100.8	17.2	107.5	28.0	p>.534

	Group A		Group B		P-value
	Mean	S.D.	Mean	S.D.	
Esophageal temperature	.386	.080	.382	.082	p=.894
Arterial temperature	.327	.055	.289	.039	p=.013*
Venous temperature	.320	.061	.286	.042	p=.021*
Bladder temperature	.239	.076	.214	.058	p=.256
Cool/heat unit temp.	.306	.049	.281	.041	p=.103
C/h unit temp. drop (°C)	31.6	1.53	31.1	.810	p=.182

* indicates statistical significance (p<0.05)

Table 1- Patient Data

cardiac jacket or insulation pad used.

Esophageal, arterial, venous and Hemotherm model 400 unit temperatures were measured using Yellow Springs^e Instrument (YSI) 400 series temperature probes. The Hemotherm model 400 unit's probe was attached to the hose four inches from the water inlet port of the oxygenator. The patient's bladder temperature was measured by using an Electromedics^f Foley catheter 2100 series temperature probe. The probes were connected to an Adalab-PC^g data acquisition system via a junction box. All temperature information was processed using the Providence Perfusion Software Package on an IBM AT^h computer. This real-time computer system along with our protocol for temperature probe calibration has been described previously.² Baseline measurements were recorded at the onset of warming, and data collected every 30 seconds thereafter until the patient's esophageal temperature reached 37°C.

The 40 patients were divided into two groups of 20 each. Group A patients were warmed to 37°C esophageal using the heat exchanger of the oxygenator only. The blanket was plugged in only after the patients' esophageal temperature reached 37°C, and was left plugged in until the patient left the O.R. Group B patients were warmed using the oxygenator's heat exchanger and blanket at the onset of the warming process. The blanket was left on until the patient left the O.R. A regular blanket is placed under the patient and on top of the warming blanket to prevent tissue damage.

e. Yellow Springs Instrument Co., Yellow Springs, OH

f. Electromedics, Inc., Englewood, CO

g. Interactive Microware, Inc., State College, PA

h. IBM Corporation, Boca Raton, FL

i. "The Number Cruncher" (J. Hintze), The Interactive Statistical Analysis System, Kaysville, UT

Table 2- Temperature rise expressed in degrees/minute

Results

The results are summarized in Tables 1 and 2. Statistical comparisons were made with a package developed for microcomputers.ⁱ The esophageal, arterial, venous, bladder and Hemotherm model 400 unit temperatures are expressed as the rise in temperature from baseline to 37°C in degrees per minute. The Hemotherm model 400 temperature drop was measured in degrees C. There was no statistical difference between the two groups in the patients' body weights, B.S.A.'s and bypass times. Group A showed a significantly faster rise in both arterial and venous temperatures. No statistical difference was demonstrated for the rise in esophageal, bladder or the Hemotherm model 400 unit temperatures. The lowest Hemotherm model 400 temperature (Hx drop) reached at the initiation of warming showed no statistical difference between the two groups.

Discussion

It was observed that all temperatures rose faster in Group A than in Group B (Figure 1). However, significance was demonstrated only for the arterial and venous temperature rise (Table 2). There was not statistical significance between the two groups for esophageal, bladder or cooler/heater temperature rise.

If the venous blood temperature best represents the mean body temperature,³ then one could make a case for not plugging in the heating blanket until the patient temperature reaches 37°C. The patients in Group A did warm significantly faster than those in Group B, whose blankets were plugged in at the beginning of the warming process, as monitored by venous blood temperature. However, if one uses the bladder temperature as the true "core" temperature of the patient, then there is no significant difference between the two groups.

The heating blanket does not contribute to nor detract from

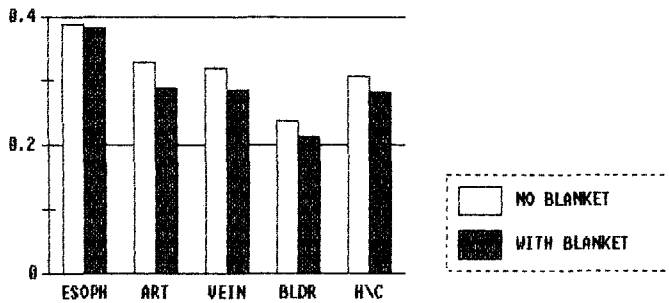


Fig 1: Temperature change in Degrees per minute

Figure 1: Temperature change in degree/ minute

the patient's warming times. We have concluded that the warming blanket does not provide enough of a difference to warrant its continued use in the O.R.

There were two interesting additional observations made during the course of this study. They are both related to the temperatures of the water coming from the Hemotherm model 400 unit.

At the start of warming, the water temperature dropped to a mean of 31.6°C for Group A, and to a mean of 31.1°C for Group B as measured by the in-line Yellow Springs probe. The temperature indicated on the readout of the unit was between 33 and 34°C, a drop from the initial 42°C. This difference is explained by the fact that the digital readout on the unit is displaying the temperature of the water in the bath. The in-line probe was attached to the hose of the Hemotherm model 400 unit four inches from the oxygenator's water inlet connection. There is six feet of tubing running from the Hemotherm model 400 to the oxygenator. This accounts for a significant amount of room temperature water that must circulate through the system at the start of warming. A larger reservoir and/or a recirculating loop placed near the oxygenator's water inlet and outlet ports would help correct this problem.

The second observation was that the digital readout of the Hemotherm model 400 unit would display 41-42°C when the actual mean water inlet temperature for Group A was 39.1°C and was 38.9°C for Group B. A possible solution is to decrease the tubing length which leads from the Hemotherm model 400 unit to the oxygenator. Could the water bath temperature be safely increased to 42°C at the inlet of the oxygenator if that temperature were monitored? This could possibly decrease

warming times and shorten bypass times.

Using the data obtained from this study, a formula for predicting warming times was developed. It is based on the patient's B.S.A. From the data, the rise in temperature of the venous blood was corrected for B.S.A. (degrees rise/minute/B.S.A.). The mean rise in venous temperature corrected for B.S.A. was .6089 (S.D.=.0873) for Group A patients. The formula was set up and programmed into the Providence Perfusion Software Package as follows:

$$\frac{37^{\circ}\text{C venous temperature} - \text{starting venous temp} = .6089/\text{B.S.A}}{\text{Total warming time}} \quad \text{One minute}$$

$$\begin{aligned} \text{Total warming time} * (.6089 / \text{B.S.A.}) &= 37 - \text{SVT} \\ \text{Total warming time} &= \frac{37 - \text{SVT}}{(.6089/\text{B.S.A.})} \end{aligned}$$

The same type of formula can be set up for any of the temperatures that one wishes to follow. Group A patients had a mean rise in esophageal, arterial, and bladder temperatures corrected for B.S.A. of .7379(S.D. = .1393), .6238 (S.D. - .0898), and .4606 (S.D.:.1419), respectively. From that information, a prediction can be made as to when a patient will reach that temperature. These correction factors are specific only to the Providence protocol since the age of the cooler/heater unit, tubing length, and ambient temperature could all influence warming times.

References

1. Page, PA: Evaluation of a high efficiency heating-cooling system for hypothermic open heart surgery. *AmSECT Proceedings*, 1976. p. 51-52
2. Jerabek, C, Walton, HG, Sugden, EH. An inexpensive real-time computer system for cardiac surgery. *AmSECT Proceedings*, 1988. p. 23-27.
3. Swan, H. Metabolic rate, temperature and acid-base control: The best strategy and our needs to achieve it. *JECT*, 1985. 17;2:65-73.