Correspondence

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Testing of a New In-line Blood Warmer

To the Editor:—A new in-line blood warmer, the DW 1220,* comprising a plastic warming cuff inserted around an electrically heated cylinder, has recently been introduced. This dry-heat warmer is small and easy to handle, and is equipped with an alarm light to warn of electrical malfunction. A built-in thermometer shows the temperature of the warmer. The manufacturer claims that this warmer has a low flow resistance and does not cause hemolysis, and that refrigerated blood flowing into the warmer at 150 ml/min exits at approximately +31 C. Until now the polythene Portex Coil®, when placed in an effectively stirred water bath, has been superior to other in-line blood warmers.[1,2] Therefore, we compared the DW 1220 with the Portex Coil.

The flow resistances of the warmers were determined by infusing a 58 per cent glycerol–water solution through them (at two constant flow rates) using an infusion pump, and measuring the pressure developing proximal to the warmers. Six determinations for each condition were made, and mean values and one standard deviation were calculated. The viscosity of the glycerol solution used is about that of whole blood.

Five units of 15-day-old CPD whole blood (+5 C) were transfused through the DW 1220 by gravity at flow rates of 15 to 25 ml/min. Three samples of the warmed blood and two control samples were taken from every unit for determination of plasma hemoglobin (by a benzidine method[3]) and potassium. These were the indicators of erythrocytic damage.

The warming efficiency of each warmer was tested using cold water. Five Fenwal® blood bags containing 500 ml of +5 C water were inserted in a pressure infusor (Fenwal), connected to an ordinary transfusion set (Fenwal, FDC 2115) and this to the warmer being tested. The flow rates were calculated from the weight of the water and the time needed for its transfusion. The water temperature at the distal end of the set (infusion temperature) was continuously measured by a hypodermic probe.† The lowest point of the infusion temperature curve for each water unit was determined and the mean infusion temperatures were calculated. The DW 1220 was handled ac-

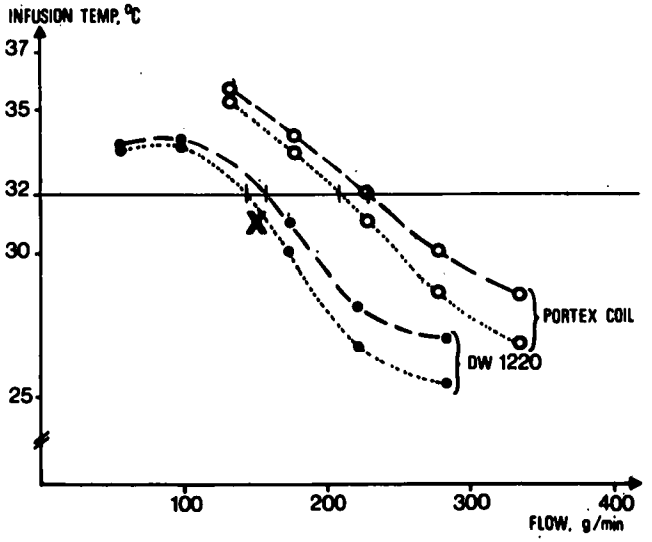

FIG. 1. The warming efficiencies of DW 1220 and the Portex Coil. Cold (+5 C) water units were transfused at different flow rates through a transfusion set connected to the warmer tested. Solid lines connect the mean infusion temperatures and dotted lines the lowest infusion temperatures obtained for each unit. The cross indicates the infusion temperature for blood at a 150 ml/min flow rate given by the manufacturer and the horizontal line the minimum acceptable infusion temperature during a massive blood transfusion, as reported by Russell.[1]

* Gorman-Rupp Industries Division, Bellville, Ohio.

TABLE 1. Flow Resistances of the DW 1220 and the Portex Coil

	Flow Rate (ml/min)	Flow Resistance (torr)
DW 1220	56.5 22.4	85.7 ± 1.2 34.0 ± 0.6
Portex Coil	56.5 22.4	48.3 ± 0.5 19.0 ± 0.0

TABLE 2. Plasma Hemoglobin and Potassium Values (Mean) in 15-day-old CPD Blood Warmed with the DW 1220

	Plasma Hemoglobin, mg/l		Plasma Potassium, mmol/l	
	Control	Warmed	Control	Warmed
Unit 1	311	301	18.8	18.9
Unit 2	408	411	17.4	17.6
Unit 3	583	533	19.2	18.7
Unit 4	395	355	15.6	15.3
Unit 5	248	260	16.4	16.9

† 524, Yellow Springs Instruments Company.

cording to the instructions of the manufacturer and the Portex Coil was placed in a stirred thermostat-controlled water bath. The room temperature was +24 C and the operating temperature of both warmers +36.8 C.

We found that the flow resistance of the DW 1220 was 1.8 times that of the Portex Coil at both flow rates used (table 1). Warming of blood with the DW 1220 did not cause any increase in plasma hemoglobin or potassium (table 2), indicating that no erythrocytic damage occurred. Finally, the Portex Coil tolerated a considerably higher flow of cold water than did the DW 1220. The mean infusion temperature decreased to +32 C at flow rates of 228 (Portex Coil) and 157 ml/min (DW 1220). The highest infusion temperature with the DW 1220 (+34 C) was obtained at a flow rate of about 85 ml/min. At lower flow rates the infusion temperature decreased because of cooling of the water in the line distal to the warmer (fig. 1).

We believe that the higher flow resistance of the DW 1220 can be explained by the long narrow inlet and outlet tubings of the warmer. Since cold blood warms about as rapidly as cold water,[4] we conclude that the warming efficiency of the DW 1220 is considerably less than that of the Portex Coil, probably because the cylinder of the DW 1220 warms the cuff only from one side. Furthermore, the long, narrow uninsulated outlet tubing allows the warmed blood to cool down, especially at low flow rates.

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An Unusual Malfunction of an Anesthetic Machine

To the Editor:—The following case is presented to illustrate an unusual anesthetic machine failure involving the outlet check valve. This particular machine failure developed despite a careful and thorough preanesthetic machine check.

REPORT OF A CASE

A 10-year-old healthy Caucasian boy (ASA classification 1; weight 36 kg) was brought to the operating room after receiving premedication consisting of 75 mg pentobarbital and 0.2 mg glycopyrrolate administered intramuscularly. The patient was scheduled for revision of a previous radical mastoid procedure. After careful check of the anesthetic machine (an Ohio Unitrol Model Heidbrink® Gas Machine) an inhalational induction was initiated, using halothane, nitrous oxide, and oxygen administered via a Bain system. Anesthesia was induced with nitrous oxide, 8 l/min, oxygen, 3 l/min, and 0.5 per cent increments of halothane to a maximum concentration of 4 per cent. After the patient had received 4 per cent halothane for a few minutes, the flowmeter readings suddenly dropped to 2 l/min nitrous oxide and 1 l/min oxygen. An attempt was made to increase the flows, but the flowmeter readings remained at the same levels. Despite a total flowmeter reading of 3 l/min, the reservoir bag would not remain filled. Attempts to fill the reservoir bag by oxygen flush were unsuccessful. The anesthetic induction was prolonged and the patient experienced an extended excitement stage. The patient vomited and was immediately turned on his side, and suctioning of the oropharynx was performed. Another Ohio Anesthetic Machine was brought into the room and quickly checked. Immediately following oropharyngeal evacuation, an intravenous line was started and the patient was given an intravenous bolus of 200 mg thiamylal followed by 50 mg succinylcholine, and orotracheal intubation was performed atraumatically. Anesthetic maintenance was carried out with halothane, nitrous oxide, and oxygen using the second anesthetic machine. The remainder of the operation and recovery were uneventful.

A subsequent check of the anesthetic machine in question revealed that the mushroom valve from the outlet check valve had become dislodged and eventually had become trapped within the pipeline system (see fig. 1). An inspection of the mushroom valve revealed it to be intact but of a softer consistency than a new mushroom valve. The rubber mushroom valve involved in this case may have dislodged due to either incorrect seating within the outlet check valve during maintenance or a defect of the mushroom valve.*

The outlet check valve is located downstream from the vaporizers. It is a one-way valve that contains a

* The local Ohio Medical service agency was contacted about this incident and a report was filed.