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Experimental Evaluation of the New Galen Disposable Bubble Oxygenator

Ung-Gill Jeong, MD,* and Julio C. Davila, MD**

To assess the performance of the new Galen bubble oxygenator,* two groups of ten female mongrel dogs underwent three hours of total cardiopulmonary bypass, using lactated Ringer's solution for the prime. The popular Bentley Temptrol oxygenator** was used as a control. Structurally, the two oxygenators differ only slightly.

The efficiency of oxygenation, hemolysis and heat exchange were studied.

Methods and Material

Mongrel dogs weighing between 20 and 30 kg were anesthetized with intravenous pentobarbital (Nembutal), 30 mg per kg of body weight without prior medication. The Stanton AVR respirator was used for pulmonary ventilation through an endotracheal tube.

The left femoral artery was cannulated with a 4 to 6 mm plastic cannula. The right chest was opened through the fourth intercostal space and a large cannula was inserted into the right atrium through the right atrial appendage. The dog was heparinized (3 mg per kg of body weight) and placed on cardiopulmonary bypass.
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Figure 1
Oxygenation during all phases of total cardiopulmonary bypass in both groups of dogs (average and range).

The arterial and venous pressures, electrocardiogram and arterial line, heat exchanger, water and esophageal temperatures were monitored continuously. Arterial and venous PO2, pCO2 and pH were determined before, during and at end of the experiments along with hemoglobin, hematocrit, plasma hemoglobin and platelets. Heat transfer to and from flowing blood was measured during cooling and rewarming.

Results

Both the Galen and Bentley oxygenators were capable of maintaining excellent oxygenation during cardiopulmonary bypass (Figure 1). The CO2 exchange was adequate in both groups, with mean arterial pCO2 values remaining below 40 mmHg during bypass (Figure 2). Mixed venous PO2 indicative of tissue perfusion were 39 and 43 mmHg in both groups (Figure 3). As a whole, the

Galen required lower oxygen flow rates (the ratio of oxygen flow to blood flow: 1.9: 1 for Galen and 2.5 : 1 for Bentley) to provide suitable gas transport and was about 25% more efficient than Bentley, judged by oxygen extraction per kg of body weight and per liter of oxygen flow.
Evaluation of Galen Disposable Bubble Oxygenator

Calculation of calorie transfer rate (calories per liter of blood flow, per liter of water flow, per minute) during cooling and rewarming demonstrated that the Bentley heat exchanger was 26% more efficient than the Galen (Figure 5). Since water flow rate through the former is limited because of rupture hazard, the net performance of the Galen was slightly better (Figure 6).

Figure 4
Mean plasma hemoglobin (average and range).

Figure 5
Calorie transfer rate at five minute intervals during cooling and rewarming.

Figure 6
Esophageal temperature during cooling and rewarming.

Discussion

Bubble oxygenators have wide clinical use in cardiopulmonary bypass because they are practical and give adequate oxygenation and acceptably low hemolysis rates. Efforts were made to evaluate the oxygenation, heat exchange and hemolysis as other authors studied with other oxygenators.1-7

Adequate oxygenation (average arterial \( pO_2 = 248 \), range: 54 to 530), \( CO_2 \) exchange (arterial \( pCO_2 = 23 \), range: 9 to 35) and tissue perfusion (mixed venous \( pO_2 = 39 \), range 21 to 118), as well as low hemolysis (free plasma hemoglobin = 81, range: 28 to 132) were demonstrated in both groups. Platelets were low in both groups at the end of experiments due partly to hemodilution.

Hemolysis remained low in both groups. The mean plasma hemoglobin values at the end of three hour bypass was less than 100 mg per 100 ml (Figure 4).

Platelets were lower than the control in both groups (Galen 103,330 and Bentley 101,875) due partly to hemodilution.
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Conclusion

Calculation of calorie transfer rate during cooling and rewarming demonstrated that the Bentley heat exchanger was more efficient. However, since water flow rate through this unit is limited, the net performance of the Galen was slightly better.

The Galen oxygenator appears to be safe and satisfactory for clinical trials.

References


