Atraumatic Perfusion and the Membrane Lung – A Quiet Revolution

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Although membrane oxygenators are known to be physiologically superior to bubble oxygenators, their application in open-heart surgery has been very limited because of inefficient gas transfer and large priming volumes. It has been recently shown that a Teflon membrane containing micropores of 3-5 μm will allow free transit of oxygen and carbon dioxide while retaining separation of liquid and gas elements, resulting in a very simple and efficient microporous membrane oxygenator, which approaches the efficiency of the human alveolar membrane. The avoidance of the blood-gas interface, low-prime volume (2,000 cm³ total), flow rates to 6 liter/min, and the virtual elimination of blood trauma have resulted in a superb instrument for routine bloodless open-heart surgery.

A remarkable dividend is the precise and individual control of blood PCO₂ and PO₂, the former being very readily adjusted to any desired level by altering the oxygen flow rate into the unit, while the latter can be precisely adjusted by altering the 'shim pressure' which very precisely alters PO₂ by adjusting the thickness of the blood film which traverses the membrane.

In recent experience at the University Hospital, London, Canada, a prospective comparison was made between 240 consecutive adult patients operated upon, using this superior instrument in a refined atraumatic pump circuit with total isovolemic hemodilution (to a mean hematocrit of 26%), and 70 consecutive adult patients using conventional bubble oxygenator equipment and techniques.

Although the preparation and operation of the membrane oxygenator requires a period of extra training, the benefits are most rewarding:

The postoperative chest drainage was reduced threefold, reflecting a

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significant improvement in postoperative platelet counts. Postoperative bleeding became rare. Plasma hemoglobin levels were improved by 400%, reflecting a reduction in red cell trauma. There was an impressive improvement in hemoglobin values at time of hospital discharge, perhaps because of less late hemolysis than in the bubbler group.

As a result, over 80% of the patients in the membrane group required no bank blood either intraoperatively or postoperatively, in spite of the fact that one third of patients had valve replacements and congenital problems, the remainder being coronary bypass procedures. The mean bank blood requirement was 0.7 units compared to a standard North American figure of 8.5 units. This represented blood bank savings of over 2,000 transfusions in one year when compared to standard methods. Even more important was the benign postoperative course of each patient with insignificant pulmonary and renal problems, minimal febrile response, and early discharge from hospital, undoubtedly related to improved tissue atraumatic perfusion under isovolemic hemodilution, and to the avoidance of the microaggregates found in bank blood.

The advantages become even more apparent in prolonged open-heart operations such as extensive coronary bypass or multiple valve replacement, where the preservation of the patient's coagulation factors become crucial.

Although early clinical experience with various membranes for long-term support has been somewhat discouraging, these new engineering refinements represent a step towards better management of such problems as deep hypothermia for intracranial aneurysm and aortic arch surgery; the management of shock lung, virus pneumonia, pulmonary fat embolism and lung trauma.