

## The Eighth Annual Meeting of the Society of Thoracic Surgeons

### Effect of Debris in Stored Blood on Pulmonary Microvasculature

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Stored human blood develops significant amounts of amorphous particulate "debris". This debris, following transfusion is filtered by the lung and has been suggested as a factor in the production of posttraumatic pulmonary insufficiency. The present study investigated debris formation in dog blood and the effect of stores autologous blood transfusion on the pulmonary circulation.

Sixteen dogs were bled, 33 cc. per kilogram, into ACD bags. The blood was stored at 4° C. and studied at intervals for debris formation by measurement of screen filtration pressure (SFP). SFP increased significantly from 10 mm. Hg to a mean level of 27 mm Hg. at three weeks.

After three weeks, the same dogs underwent thoracotomy. Pulmonary vascular resistance was determined for each lung from pressure and flow measurement (R equals P/F). Stored autologous blood was transfused into one pulmonary artery. In 8 animals, the blood was filtered through a dacron wool filter to remove the debris. The other 8 received unfiltered blood. Vascular resistance was determined again in each lung. Biopsy of both lungs was performed. The mean ratio of perfused lung vascular resistance to non-perfused lung vascular resistance increased significantly for the 8 dogs receiving unfiltered blood from .93 pre-infusion to 1.63 post-infusion ( $p < 0.05$ ). No change in vascular resistance was noted in animals receiving unfiltered blood. Biopsies demonstrated microembolization to the infused lung in animals receiving unfiltered blood.

The evidence indicates that transfusion of 21-day-old stored autologous blood in dogs produces pulmonary microembolization resulting in increased vascular resistance in the infused lung. Furthermore, this microembolization can be prevented by adequate blood filtration.

Editor: The formation of aggregates and other debris in stored ACD blood is maximal (95%) in about five days, according to additional data presented.

Dr. William Lee suggested the use of micro-emboli filtration for all banked blood used in priming the pump-oxygenator circuit, or the use of *no* blood in the prime.

Dr. William Neville told those in attendance that he felt the condition known as "pump" lung was due primarily to diffuse micro-emboli composed of platelet-leukocyte aggregates and fat agglomerates. He recommended the use of full-flow micro-emboli filters in the venous and cardiotomy reservoir drainage lines.

In his summation, Dr. McNamara told of radio-actively tagging fibrinogen and finding much fibrin in debris collected on the surfaces of the micro-emboli filtration media.

### The Bjork-Shiley Prosthesis: A Significant Advance in the Aortic Replacement

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From May 1970 to September 1971, we have used the central flow tilting-disc Bjork-Shiley aortic prosthesis for aortic valve replacement in 133 consecutive patients. Of the 133 patients, 101 had single aortic valve replacement, 30 had double valve replacement and 2 had a simultaneous coronary vein bypass graft. The hospital mortality for the total group was 12 patients. None of these deaths were attributed to the prosthesis *per se*.

There were only 3 late deaths; one was due to a massive myocardial infarction, another was due to subacute bacterial endocarditis and the third died at another hospital of intractable cardiac arrhythmia.

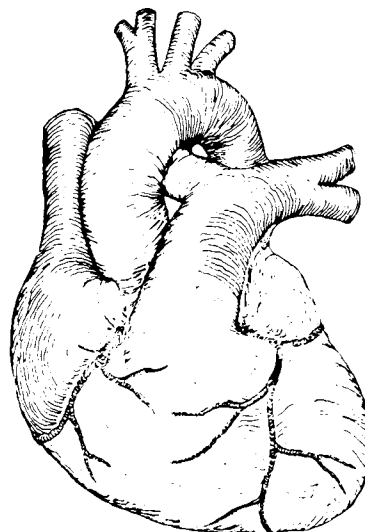
Postoperative complications included 3 patients with early neurologic complications, none apparently due to the prosthesis design. During the follow-up period there have been no recognizable complications or deaths due to emboli. Nevertheless all patients are receiving anticoagulant therapy. One patient required reoperation for a paravalvular leak, and 4 required reoperation for coronary bypass graft operation, only 1 of these patients had coronary disease preoperatively. Postoperative cardiac catheterization has shown a significant decrease in systolic ejection gradient. These gradients have been less than those reported with ball valves. The clinical results have been excellent so that the use of this new prosthesis is recommended to others.

Dr. Denton Cooley spoke of 647 insertions of the Bjork-Shiley aortic prosthesis between September 1969 and December 1971 with a 9.6% mortality. He inserted 321 mitral valves during the same period.

Dr. Derward Lepley discussed his experience with the Bjork-Shiley valves: a 20% aortic mortality and 5.3% mitral mortality. He also mentioned three instances of emboli due to early removal from anticoagulants.

Dr. C. Walton Lillehei introduced his pivoting disc prosthesis designed by bio-engineer Robert Kaster and himself (See "Organs and Tissues", Volume III, Number 1, page 18). This valve features a Pyrolite disc that opens a full 80 degrees, as opposed to the 55 to 60 degrees of other designs. Fifty-one valves have been inserted with a mortality of 5.9%. He anticoagulates for three months.

Dr. Arthur Beall showed the latest model of his disc valve. Instead of the Teflon disc and Teflon-covered cage, it features a Pyrolite disc and Pyrolite-covered cage.



## Comparative Evaluation of the Travenol and Lande-Edwards Membrane Oxygenators in a Neonatal Cardiopulmonary Bypass Unit

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A compact, low-prime cardiopulmonary bypass circuit which employs a membrane oxygenator has recently been developed for use in neonatal perfusions. In order to assess the comparative performance of the Travenol and Lande-Edwards membrane oxygenators when used in this circuit, two groups of 5 puppies weighing between 4-6 kg., underwent one hour of total bypass with each unit using a 50% blood-50% Normosol prime. The Lande-Edwards oxygenator required a thorough rinsing prior to use in order to perform effectively while the Travenol membrane could be used as packaged. All puppies were long-term survivors. Adequate oxygenation,  $\text{CO}_2$  exchange ( $\text{pO}_2 > 200$  mm. Hg,  $\text{pCO}_2 < 40$  mm. Hg) and tissue perfusion (mixed venous  $\text{pO}_2 > 25$  mm. Hg) together with low hemolysis (plasma hemoglobin  $< 45$  mg.% were demonstrated in both groups. Serum electrolytes remained normal. Thus, these results verified that total bypass using both types of membrane oxygenators was feasible with satisfactory hemodynamic performance, adequate gas exchange and long-term survival regardless of which membrane was selected. However, the relative ease of use (no rinse) and stability of the Travenol unit at low perfusion pressure (internal baffling prevents membrane collapse) suggest it is the unit of choice for use in small infants.

### Clinical Use of Peirce-General Electric Membrane Oxygenator

MARVIN M. KIRSH, E. C. PEIRCE, II, OTTO GAGO,  
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The New Peirce-General Electric copolymer membrane oxygenator combined with a Sarns roller pump was used clinically for the first time on 18 children undergoing open heart operation. The children ranged in age from 8 to 48 months (mean 27 months) and weighed between 3.6 and 15 kg. (mean 9 kg.). The priming volume of the 1 sq. M. oxygenator averaged 120 ml. of blood and 240 ml. for the 2 sq. M. oxygenator. The duration of perfusion varied from 45 to 180 minutes (mean 97 minutes) depending upon the complexity of the repair. During perfusion flow rates averaged 128 ml. per kilogram with a  $\text{pO}_2$  average of 298 mm. Hg (range 54 to 670). There was no significant change in acid-base balance during or immediately after the perfusion. Serum hemoglobin averaged 13.6 mg. percent preoperatively, increased 57.5 mg. percent at the completion of the perfusion and decreased to 22.5 mg. percent by 24 hours postoperatively. Platelet count preoperatively averaged 229,000 and decreased to 108,390 at the conclusion of the perfusion with an increase to 121,000 24 hours postoperatively. There was no excessive bleeding postoperatively.

A comparison between this group of patients and a similar group of patients undergoing perfusion with a pediatric Temptril bubble oxygenator will be made.

The copolymer membrane has been shown in this group of patients to be an effective, reliable and safe oxygenator and is worthy of further clinical use.

### Automatic Respiratory Gas Monitoring

STEPHEN Z. TURNEY, CHARLES McCLUGGAGE, and  
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A unique system for automatic sequential sampling of airway gases is in use in a multi-bed Shock Trauma Unit.



A series of gas sampling lines run from each bed area to a manifold. A small digital calculator is programmed to place automatically a mass spectrometer in an operative mode hourly, switch the manifold to a calibrating gas, then sequentially sample each occupied bed and finally revert to standby status. The analog waveforms from the spectrometer are conditioned for high and low levels corresponding to 1) inspiratory and 2) peak expiratory values of  $\text{O}_2$  and 3) peak expiratory  $\text{CO}_2$ . The waveforms are counted for 4) respiratory rate, and 5) the respiratory quotient is computed. These data are automatically printed. They are used in adjusting respirators in lieu of frequent blood gases and to monitor airway oxygen levels. Simultaneous blood gas sampling permits calculation of intrapulmonary shunts and arterial-alveolar gradients for  $\text{O}_2$  and  $\text{CO}_2$ . The system is employed with a pneumotachometer or gas collection chambers for more detailed measurements. Our experience with its reliability, accuracy and potential applications will be discussed.

### The Harmful Effects and the Treatment of Coronary Air Embolism During Open Heart Surgery

CLAIRE JUSTICE, and W. STERLING EDWARDS,  
Albuquerque, N. Mex.

Residual coronary air embolus after heart lung bypass is an occasional cause of poor myocardial contractility and low cardiac output. To quantitate the amount of myocardial depression from given amounts of air and to explore the most efficient way to remove coronary air, 19 experiments with dogs were carried out. During extracorporeal circulation, balloons were inserted into the right and left ventricular cavities to measure isovolumic myocardial contractility. Small amounts of air injected into the aortic root caused transient myocardial depression with rapid recovery. Repeated injections of small amounts of air produced an additive effect, more depression and slower recovery with each injection. A pure peripheral vasoconstrictor was not as effective as an inotropic drug such as ephedrine or isoproterenol in improving contractility. By far the most effective method of removing air from the coronaries and improving contractility and color of the myocardium was increasing perfusion flow rate for one minute to  $1\frac{1}{2}$  to 2 times normal. Large amounts of foam appeared from the coronary sinus when flow rates were increased, and hearts intractable to electrical defibrillation became pink and responded to a single shock. Clinical implications will be discussed.