Abstracts Presented at AmSECT's 27th International Conference
March 10–14, 1989

ANTICOAGULATION

Heparin Resistance In the Pre-Cardiotomy Heparin Therapy Patient

Dennis C Rivard*

Patients who undergo heart surgery utilizing cardiopulmonary bypass are systemically anticoagulated with heparin. Heparin is also used for anticoagulation in patients with unstable angina. A discrepancy has been observed in reactivity to heparin in the operating room between patients who are on I.V. heparin therapy and those who are not.

A comparison study utilizing 40 patients was performed. Group A consisted of 29 patients who had no recent history of heparin therapy pre-operatively. Group B consisted of 20 patients who had been on I.V. heparin therapy up to 4 h prior to their surgery. All patients were coronary artery bypass grafting candidates and were heparinized for cardiopulmonary bypass utilizing a 3000U/kg protocol with a target activated clotting time (ACT) of 480 s. Heparin lot numbers were evenly distributed between the 2 groups.

Group A demonstrated a mean post heparin bolus ACT of 541 s, while Group B showed a mean ACT of 358 s. The nonheparin therapy patients required an additional perioperative heparin dose of 3,800 U to maintain the ACT above 480 s. The heparin therapy patients had a mean additional dose of 16,500 U.

Patients who receive I.V. heparin therapy prior to cardiopulmonary bypass require additional heparin to adequately anticoagulate them for extracorporeal circulation.

Department of Cardiac Surgery, 618 Blalock, The Johns Hopkins Hospital, N Wolfe St, Baltimore, MD 21205

Ancrod vs Heparin: The Resulting Effect on Oxygenator Performance During Routine Cardiopulmonary Bypass

AM Benak*, V Zulys, MJ Henderson, B Calvier, TL Zombolos, MFX Glenn

Ancrod, a thrombin-like enzyme extracted from the Malayan Pit Viper (Agkistron rhodostoma), has been used extensively in the treatment of deep vein thrombosis and for the symptoms of peripheral artery disease. It has now been proposed as an alternative anticoagulant for extracorporeal membrane oxygenation (ECMO). In order to investigate the effect of Ancrod on the performance of the semi-porous hollow fiber membrane oxygenator during cardiopulmonary bypass (CPB), in-line pressure measurements (pre- and post-oxygenator) and blood gas analysis were carried out in an operative setting. A control group of 20 patients scheduled for coronary artery bypass grafts were anticoagulated with Heparin. The study group of 20 patients underwent controlled defibrinogenation with Ancrod. There were no significant differences between groups with respect to blood gas values (pO_2, pCO_2) or pressure gradients across the membrane oxygenator. Comparison of electron micrographs from various surfaces of the CPB circuit demonstrated less cellular and proteinaceous material deposited on the study group's circuit.

This study confirms the efficacy of Ancrod as an alternative form of anticoagulation for CPB.

217 Glenlake Ave, Toronto, Ontario, Canada M6P 1E9

Cardiopulmonary Bypass Without Systemic Heparinization for 24 Hours

Ludwig & Segesser*, Marko Turina

Cardiopulmonary bypass without systemic heparinization was realized by the means of heparin surface COATED oxygenators and tubing sets and analyzed in

comparison to UNCOATED oxygenators and tubing sets with systemic heparinization (ACT>500 s). Seven dogs were perfused for up to 24 h (when perfusion was electively terminated) with a pumpflow of 50 mL/min/kg bodyweight and either heparin surface COATED equipment (34±5 kg) or UNCOATED equipment (40±7 kg) by cavoaortic cannulation after median sternotomy. In addition to continuous monitoring of hemodynamics, blood samples for blood gas, biochemical and hematological analyses were taken before, 5 min after beginning of cardiopulmonary bypass and at regular intervals thereafter:

Mean duration of perfusion was 23±2 h for COATED versus 21±6 h for UNCOATED. Adequate gas exchange was obtained with COATED and UNCOATED equipment throughout the perfusion. Plasma hemoglobin production was significantly lower with COATED equipment which allowed open-chest cardiopulmonary bypass without return of shed blood for 13±1 h.

	5 min		8 h		16 h	
	COATED	UNCOATED	COATED	UNCOATED	COATED	UNCOATED
pH	7.5+0.1	7.5+0.1	7.4+0.1	7.4+0.1	7.4+0.0	7.4+0.1
$PaCO_2$ kPa	3.1+0.0	3.2+0.1	3.9+0.5	4.0+0.6	3.9+0.4	4.1+0.4
PaO_2 kPa	43+11	44+7	32+10	28+8	38+8	26+6
plasma hemoglobin	0.2+0.0	0.2+0.0	0.3+0.0	1.3+0.4	$p<0.05$	

Cardiovascular Surgery, University Hospital, CH8091, Zürich, Switzerland

COMPUTER ASSISTED CPB MANAGEMENT

A Computer-Based Audio Challenge-Response Cardiopulmonary Bypass Checklist System

RG Berryessa, JB Riley, JC Crowley, R Harshaw

Comparisons continue to be made between perfusion and aviation. Although there are similarities, commercial aviation has a significantly lower accident rate. Extensive safety systems including the routine use of checklists are major factors in safe air travel.

Experience with the use of a checklist for cardiopulmonary bypass has proven useful for managing risk and assuring quality, and recent publications on safety and cardiopulmonary bypass standards mandate the use of checklists.

An audio checklist management system employing digital speech technology has been borrowed from the aviation industry. A small, mast-mounted, battery-operated device employs a lifelike voice to challenge the perfusionist with a cardiopulmonary bypass checklist. The perfusionist responds verbally and advances to the next checklist item by pressing a remote button. The device records the exact time that an item is checked and prints a document upon completion of the checklist for inclusion in the record. The audio checklist includes pre-bypass set-up, pre-initiation, pre-cardioplegia infusion, pre-termination, and post-bypass checklists. Emergency procedure checklists for common perfusion incidents may be called-up by the perfusionist. The computer may be programmed to generate custom checklists to meet an individual perfusionist's need.

The audio checklist device assures consistency and frees the perfusionist from a cumbersome paper checklist system. Use of the audio checklist minimizes the diversion of the perfusionist's eyes and attention from equipment and events during cardiopulmonary bypass.

16818 Via del Campo Court, San Diego, CA 92127

The Effect of a Real-Time Computer System on Patient Morbidity and Mortality During Cardiac Surgery

Charles F Jerabek*, Howard G Walton

Computer systems, manufactured by large corporations and assembled by individual hospitals, have recently been incorporated into the practice of perfusion. However, no study has been undertaken to determine whether these systems are effective in reducing patient mortality or morbidity.

This study compares 100 CABG patients (50 before the implementation of a real-time computer monitoring system and 50 using the Providence Perfusion Software Package). The unique aspect of this experiment was that the perfusionist was also the software programer so that the argument of a learning curve skewing the data is not valid.

No statistically significant differences ($p<.05$) were found in the pre-operative comparison of the 2 groups. Since no real-time surgical data was recorded on the control group evaluation of intraoperative data was not attempted. Post-operative data showed no statistical difference between the 2 groups.

In light of this information the cost-effectiveness of a prepackaged system must be examined and other alternatives should be explored.

Providence Medical Center, 4805 NE Glisan, Portland, OR 97213

Improved Quality Control Utilizing Continuous Blood Gas Monitoring and Computerized Perfusion Systems

George A Justison*, Sandra Parsons

The effect of continuous blood gas monitors and computerized perfusion documentation systems on performance and reproduction of clinical events during cardiopulmonary bypass (CPB) is studied.

Patients undergoing elective coronary artery bypass procedures were randomly placed into 3 groups. Group 1 received no continuous monitoring devices in the extracorporeal circuit (ECC) and received manual documentation. Group 2 had continuous arterial blood gas monitoring in the ECC and manual documentation. Group 3 incorporated continuous arterial blood gas monitoring and computerized documentation. Each record was analyzed to determine compliance with the parameters outlined below.

Parameter	Desired Range	Group 1	Group 2	Group 3
CPB Entry Interval	5 min	8.85	9.95	5.00
XC Entry Interval	5 min	8.55	10.22	5.00
Mean Sample Time	20 min	21.16	25.13	
		% Variance	% Variance	
PaH LOW	>7.35	2.51	1.4	
PaH HIGH	<7.45	25.1	8.4	
$PaCO_2$LOW	>35mmHg	57.8	15.4	
$PaCO_2$HIGH	<42mmHg	2.00	2.10	
PaO_2LOW	>150mmHg	10.1	2.70	
PaO_2HIGH	<250mmHg	37.2	7.00	

The implementation of continuous blood gas monitoring and computerized documentation systems reduces the number of variances outside of the desired limits for cardiopulmonary bypass and improves the ability of the perfusion staff to recreate clinical situations.

3036 Debra Court, Auburn Hills, MI 48057

MYOCARDIAL PROTECTION

An Investigation into the Influence of the pH of a Cardioplegic Solution on Markers of Myocardial Damage

S Whittaker*, V Sergeant, JA Illingworth, K Stoodley, GA Davies

Although crystalloid cardioplegic solutions are generally buffered to be alkalotic, some workers have advocated the use of an acidotic solution. In order to evaluate the influence of the pH of a crystalloid cardioplegic solution on post-ischemic markers of myocardial injury, we studied 30 rat hearts using an isolated perfused heart model, with a 1 h ischemic arrest at 20°C following single dose cardioplegia.

The pH of the cardioplegic solution was varied by adjusting the pCO_2. Six pH groups were studied with 5 hearts in each group, (group 1 pH = 7.0102 ± 0.0106 (± SEM), group 2 = 7.2044 ± 0.0077, group 3 = 7.4074 ± 0.0068, group 4 = 7.6082 ± 0.0071, group 5 = 7.801 ± 0.0082, group 6 = 8.0352 ± 0.0129).

Pre-arrest (control) and post-arrest coronary effluent enzyme levels, heart rate, coronary vascular resistance and ECG score were determined. In addition, times to spontaneous defibrillation were noted. There were no statistical differences between the control values.

Time in seconds from institution of reperfusion to spontaneous defibrillation in groups 1 to 6 respectively were 67.6 ± 2.379, 62 ± 1.949, 62 ± 1.483, 52.4 ± 3.326, 58.6 ± 1.631 and 55 ± 2.55 ($p < 0.01$ Kruskal Wallis Test). Post-arrest heart rates were 190 (one heart only), 203.33 ± 26.034, 217.5 ± 17.017, 235 ± 26.552, 214 ± 16 and 208 ± 15.29 (NS). The post-arrest ECG scores were 2.4 ± 0.5099, 1.2 ± 0.5831, 1.2 ± 0.7348, 0.2 ± 0.2, 0.6 ± 0.2449 and 0.6 ± 0.2449 (NS). Of note is that ECG scores of 2 or more were only observed in groups 1, 2 and 3. Post-arrest coronary vascular resistances were 134.6 ± 18.819, 118.6 ± 6.653, 78 ± 4.461, 65.8 ± 2.01, 68 ± 1.342 and 72.2 ± 5.774 ($p < 0.001$). Post-arrest coronary effluent creatine phosphokinase levels were 703.21 ± 149.97, 152.34 ± 27.959, 141.11 ± 12.67, 80.568 ± 16.025, 88.854 ± 17.391 and 88.108 ± 17.225 ($p < 0.005$). Post-arrest coronary effluent lactate dehydrogenase levels were 244.02 ± 60.516, 192.46 ± 68.234, 141.66 ± 56.317, 25.55 ± 10.974, 41.366 ± 4.428 and 35.2 ± 8.473 ($p < 0.001$).

These data support the conclusion that an alkalotic cardioplegic solution provides superior protection to the arrested heart.

NHRF Cardiac Research Laboratories, Killingbeck Hospital, York Road, Leeds, LS14 6AQ England, UK

Preservation of Neonatal Myocardial Function Following Ischemic Arrest

Alfred H Stammers*, Edward L Bove, Linda J Veit

The protection of the ischemic neonatal myocardium was studied utilizing both cardioplegic and noncardioplegic solutions. Six groups of isolated 7-day-old working rabbit hearts, exposed to 120 min of mild hypothermic (30°C) arrest, were treated with either an oxygenated (OXY) or nonoxygenated (NOXY) cardioplegic (CP), or physiologic saline (PS) solution.

The results indicated that postischemic aortic flow, cardiac output (CO) and stroke volume were significantly depressed in all OXY groups, but not in the NOXY CP groups. Recovery of CO remained near baseline in hearts treated with either singledose NOXY (94.4 ± 2.5% Mean ± SEM) or multidose NOXY (94.3 ± 2.3%) CP, but was significantly depressed in multidose OXY CP (76.2 ± 6.2%), multidose OXY PSS (74.8 ± 6.6%) and singledose OXY PSS (74.8 ± 3.0%), $p<.05$. Coronary sinus creatine kinase (CK) was significantly elevated during ischemia in both PSS and multidose OXY CP groups, and remained elevated following reperfusion. In the NOXY CP groups postischemic CK was not significantly elevated.

This study demonstrated that the addition of oxygen to either CP or PSS solutions failed to protect the neonatal myocardium.

Department of Thoracic Surgery, Taubman Health Care Center, Box 0344, University of Michigan, 2120 E Medical Center Drive, Ann Arbor, MI 48109

The Use of the Classical Shunt Equation in the Evaluation of Coronary Hypoxemia During Cardiopulmonary Bypass

Charles F Jerabek*, Howard G Walton, Sally Doerfler

With the decreasing usage of left heart venting in routine C.A.B.G. operations, there is a possibility of coronary artery hypoxemia impairing myocardial recovery after the removal of the aortic cross clamp. This study was undertaken to determine whether coronary artery hypoxemia was present in the period following clamp removal and if the degree of hypoxemia could be predicted.

Fifteen patients were studied with blood gas samples being drawn from the aortic root (as near to the coronary ostia as possible), oxygenator inflow line, radial artery line and oxygenator venous return line at a rewarming temperature of at least 33°C. Relative coronary artery hypoxemia was present in 9 patients. No pre-operative tests predicted the patients at risk for developing this condition. A modification of the classical shunt equation proved to be the most accurate test ($r = .86$) to predict coronary artery pO_2 levels.

Proposed solutions to the problem of coronary artery hypoxemia include left heart venting when the shunt is >5% (a value of 15% is acceptable when oxygenator pO_2 exceeds 250), leaving the patient hooked to the anesthesia machine with a sweep gas FiO_2 of 100% and the use of PEEP or low frequency ventilation during the rewarming period.

Providence Medical Center, 4805 NE Glisan, Portland, OR 97213

The Effect of Gas Scavenging on Hollow Fiber Membrane Oxygenator Performance

Charles F Jerabek*, Howard G Walton, Sally Doerfler

During a routine cardiopulmonary bypass a patient's blood gases did not respond in the expected manner. After detailed review it was determined that the gas scavenging system was effecting the hollow fiber membrane oxygenator's performance, even though it was set up according to manufacturer's recommendations.

Using a closed oxygenator-deoxygenator system primed with recently outdated human blood, the hypothesis that changing gas scavenging suction levels effected oxygenator performance was tested. Pump speed, venous blood gas levels, temperature, hemoglobin, FiO_2 and sweep gas rate were all kept constant. The results showed that as suction levels increased oxygenation capacity decreased according to the formula:

Suction (torr) = 5130* .98^ (Arterial pO_2 − Venous pO_2) [r = −1].

However, ventilation capacity increased following the equation:

Suction (torr) = −945.26 + 65.67*(Venous pCO_2-Arterial pCO_2) [r = .78].

Sweep gas flow rate was 2.5 L/min and FiO_2 was 50%. Results were comparable when a different FiO_2 was used as a baseline.

The conclusion was that gas scavenging suction predictably effects hollow fiber membrane oxygenator performance and can be used as an adjunct in blood gas management. However, if a perfusionist wishes to minimize the effects of gas scavenging then a regulated low pressure vacuum source must be used.

Providence Medical Center, 4805 NE Glisan, Portland, OR 97213

Eyes as Brain Mirror During Extracorporeal Circulation

R Barthelemy*, Ch Pomes, P Bec

It is well known that ocular modifications give a hint about cerebral modifications. Ocular modifications were studied before, during and after extracorporeal circulation (ECC) in 23 patients (using bubbler or membrane oxygenators with or without arterial filters). The study concerned the measure of visual acuity (long and short distance), ocular tension, ocular fundus, skiascopy, visual field, fluoresceine angiography.

The results showed an anemia of the ocular fundus at the start of ECC (complete dilution). The intensity of the anemia observed was dependent of the rapidity of the start of the ECC.

Other results did not show any significant modifications before and after ECC.

We can conclude that progress in technics, materials used, solutions and drugs perfused, and anesthesia allows actually a surgical ECC without any ocular, and we think, brain problems for the patient.

Hapital Rangueil, I Avenue, Jean Poulhès - 31054 Toulouse Cèdex - France

Hollow Fiber Membrane Oxygenator Reduces Platelet Loss During Simulated Extracorporeal Circulation

Colleen M O'Connor*, Nina Stenach, Carol A Fisher, David S Warsaw, Russell F Stahl, V Paul Addonizio

Contact between blood and the extracorporeal circuit results in adverse alterations in platelet number and function. To determine the effect of surface composition and flow on these changes, 450 mL of heparinized (5 U/mL) blood from random, aspirin-free volunteers was recirculated at a flow rate of twice the circulating volume for 2 h at 37°C through circuits with an identical surface area (1.0m^2) containing either a spiral coil, silicon rubber, membrane oxygenator (SC) or a hollow fiber, polypropylene membrane oxygenator (HF).

In SC circuits (n = 5), platelet counts fell to 10 ± 3% (x ± SEM) of initial levels within 5 min of ECC but rose to 60 ± 9% at 2 h. In contrast, in HF circuits (n = 5), platelet count fell to only 53 ± 7% at 5 min of ECC and rose to 82 ± 14% at 2 h. Plasma levels of the platelet-specific, protein platelet factor (PF)4 rose to 2780 ± 222 ng/mL by 5 min, reaching 6338 ± 767 ng/mL at 2 h in SC circuits. In contrast, PF4 in HF circuits rose to 836 ± 73 ng/mL and 2640 ± 410 ng/mL, respectively. Although platelets in SC circuits became insensitive to ADP (≥ 50 uM) within 5 min, platelets from HF circuits aggregated to ADP (17 uM) despite 2 h of ECC.

We conclude that the hollow fiber membrane oxygenator not only reduces adhesion, maintaining the circulating platelet count, but also reduces platelet protein release and preserves platelet function as well.

97 Ashland Ave, Apt 5B, Bala Cynwyd, PA 19004

Platelet Preservation During Simulated Cardiopulmonary Bypass Via Phosphodiesterase Inhibition

Nina Stenach*, Colleen M O'Connor, Carol A Fisher, David S Warsaw, Russell F Stahl, V Paul Addonizio

Inhibition of platelet function reduces adverse platelet alterations during CPB but agents most efficacious must be given intravenously. Consequently, we evaluated a new type III phosphodiesterase inhibitor (PDEI), CK2130 (100 uM), comparing it with the most commonly prescribed PDEI, dipyridamole (100 uM).

450 mL of fresh heparinized (5U/mL) blood, drawn from aspirin-free volunteers, was recirculated for 2 h at 37°C in a polypropylene circuit (1.0 m^2) containing a spiral-coil membrane oxygenator. In control circuits (n = 5), platelet counts fell to 10 ± 3% (x ± SEM) of initial levels within 5 min and sensitivity to ADP disappeared. Plasma levels of a platelet-specific protein platelet factor (PF)4 rose from 2780 ± 222 ng/mL at 5 min to 6338 ± 767 ng/mL after 2 h, indicating extensive platelet release. In contrast, with CK2130 (n = 3), although platelet counts dropped to only 60 ± 9% at 5 min, platelets were similarly insensitive to ADP, and PF4 rose from 1012 ± 510 ng/mL at 5 min to 3689 ± 898 ng/mL after 2 h. With dipyridamole (n = 4) platelet counts fell to 50 ± 10% but PF4 rose from 861 ± 122 ng/mL at 5 min to only 2157 ± 346 ng/mL after 2 h and platelets responded to ADP.

In conclusion, both CK2130 and dipyridamole significantly preserved the circulating platelet count and reduced release of PF4 with dipyridamole preserving function as well. Thus, PDEIs may play a promising role as platelet inhibitors during CPB.

1826 The Woods II, Cherry Hill, NJ 08003

Does Plasma Sequestration Reduce Post-Operative Bleeding?

Charles Wacker*, Sidney Fuller, Anthony J DelRossi, Roger Vertrees

A clinical evaluation of the Haemonetics Plasma Saver was undertaken to try to determine whether plasma sequestration affords some protection against post-operative bleeding during cardiac surgery, concentrating platelets in the plasma, and protecting them from bypass.

Twenty consecutive patients were identified and divided into 2 groups. Group A, the control group, was analyzed for platelet levels (platelet concentration × Hematocrit^{-1}) and the values recorded. In Group B, patients were subjected to plasma sequestration pre-bypass; these platelet values were also analyzed as in Group A.

According to manufacturers' recommendations, blood was aspirated from the patients through the 7.5 Fr. Cordis introducer sheath, processed as per instructions, stored at a warm temperature and reinfused after heparin reversal with protamine. Platelet counts for both groups are:

	Pre-op × 10^5	Cold × 10^5	Warm × 10^5	Post × 10^5	Day No. 1 × 10^5	Day No. 2 × 10^5
GROUP A	7.8±2.3	5.9±1.6	6.9±1.9	5.4±1.1	6.3±2.3	4.7±1.6
GROUP B	6.9±2.1	4.3±0.5	6.0±1.3	6.0±0.8	4.8±1.1	4.2±1.3
Sign	NS	NS	NS	NS	NS	NS

after anesthesia (pre-op), during stable hypothermic bypass (cold), during stable normothermic bypass (warm), post bypass (post), 24 h post-op (Day No. 1) and 48 h post-op (Day No. 2). Additionally, a platelet count was performed on the sequestered volume.

It is apparent from this study, that this technique, while allowing 9% of the total platelet volume to be sequestered, had little effect on the above platelet levels, or post-operative blood loss.

School of Perfusion, 310 Sarah Cooper Building, Cooper Hospital/University Medical Center, University of Medicine & Dentistry of New Jersey—Robert Wood Johnson Medical School at Camden, Camden, NJ 08103

FEMORO-FEMORAL, EMERGENCY BYPASS

Percutaneous Cardiopulmonary (Bypass) Support in the Cardiac Catheterization Laboratory: A New Application of Perfusion

T Lowinger*, F Shawl, G Difee, J Richmond

Percutaneous cardiopulmonary bypass support (PCPS) has been introduced in the catheterization laboratory (CL) to support high risk coronary angioplasty (CA), as well as in emergencies. We report the safety and feasibility of PCPS in 45 patients from the perfusion standpoint.

Thirty-seven patients (Group I) were elective and 8 were emergencies (Group II). Group I (ages 41–82) were high risk CA, Group II (ages 40–80) were in cardiogenic shock (CS) due to myocardial infarction (MI) with 2 in cardiac arrest (A). While cannulation using 20F cannulae through femoral vessels was in progress, priming of the system with 1400 mL of normosol was achieved in 5–7 min. Cardiopulmonary bypass was then instituted using Bard CPS system after full heparinization using 300 U/kg. Flows ranged from 2.8–6 L/min (mean = 3.8) and pulmonary diastolic pressures were 0–4 mm Hg. Two patients in A regained consciousness while still in ventricular fibrillation or asystole. The ACT ranged from 317–880 s (mean = 498). Mean bypass time was 37 min (range 10–73) in Group I and 66 min (range 44–120) in Group II. Total infusion volume of normosol during and prior to coming off bypass was 0–2500 cc (mean = 338).

There were no intraprocedural complications associated with PCPS. We conclude that PCPS can be used safely in selected patients who are considered high risk for PTCA, acute MI complicated by shock or A, and therefore adds a new dimension in perfusion medicine done in the CL.

9530 Many Mile Mews, Columbia, MD 21046

In-Vitro Analysis of the Physical Characteristics of Femoral Bypass Cannulae

T Pope*, MA Noe, AK Litzie, SW Soronen

The physical dimensions and flow characteristics of arterial and venous femoral cannulae were evaluated. An in-vitro femoral bypass simulator was employed to measure pressure drop across various O.D. arterial and venous cannulae from Cook Inc, CR Bard Inc, DLP Inc, Shiley Inc and Biomedicus Inc. Thirty degree Centigrade, 39% hematocrit bovine blood was employed with a Biomedicus BP-80 vortex pump. Pressure drop, peak flow velocity, shear rate, and Reynold's numbers were statistically compared. The maximum "safe" flow rate for each cannula was determined.

The blood flow rate that yielded a pressure drop greater than 200 mmHg for the arterial cannulae, and the blood flow rate achieved at −300 mmHg Bio-pump inlet pressure for the venous cannulae are:

Arterial Cannula	Blood Flow L/min @ 200 mmHg
16 Fr. Biomedicus	3.5
19 Fr. Biomedicus	5.0
20 Fr. Cook	6.0
20 Fr. CR Bard	>7.0
21 Fr. DLP	>7.0

Venous Cannula	Blood Flow L/min @ −300 mmHg
18 Fr. Biomedicus	3.0
20 Fr. Bard	6.5
21 Fr. DLP	6.5
24 Fr. Biomedicus	>7.5
29 Fr. Cook	>8.0

For the smallest Fr. O.D. to facilitate insertion and to yield the maximum safe blood flow rate, the 20 Fr. CR Bard arterial cannula in tandem with the 20 Fr. CR Bard, or 21 Fr. DLP venous cannula, appear to be the optimal choice for full-flow femoral bypass.

16818 Via del Campo Court, Rancho Bernardo, San Diego, CA 92127

A Convertible Cardiopulmonary Bypass System for Emergency Support Using a Hard-Shell Membrane Oxygenator

William Gil*, Tamara Sakert, Glen Laub

Recently, several emergency cardiopulmonary bypass (ECPB) systems have been designed for the support of the arrested patient refractory to resuscitation. We have developed a compact ECPB system utilizing a Bio-Medicus centrifugal pump and a Bentley BCM-7 membrane oxygenator featuring rapid set-up and prime.

In contrast to other systems, our design provides a choice of configurations for ECPB which allows its continued use from initiation of membrane assist throughout any operative intervention.

The safety and efficacy of this system has been tested using a canine model. Five animals were cannulated via the external jugular vein and the femoral artery, placed on ECPB (mean flow 70 cc/kg/min), and monitored for 6 h. Arterial and venous pressures and blood gases were easily maintained by standard manipulations. Serum hemoglobin, BUN creatanine, and urine output remained stable at levels normal for bypass. Platelets, fibrinogen, and hemoglobin exhibited dilutional decreases at 1 h, then stabilized.

In summary this system safely provides short-term emergency metabolic and respiratory support while offering unique advantages in mobility, flexibility, and ease of use.

**Division of Cardiopulmonary Specialties, Department of Surgery, Allegheny General Hospital, 320 E North Ave, Pittsburgh, PA 15212*

Hemodynamic Management During Closed Circuit Percutaneous Cardiopulmonary Bypass

George A Justison*, William Pelley

The development of self-contained portable cardiopulmonary bypass (CPB) systems and percutaneous cannulas has prompted new applications for CPB therapy. One indication has been for support of elective high risk Percutaneous Transluminal Coronary Angioplasty (PTCA) procedures. Management of closed circuit CPB systems relys on interrelationships between desired blood flow, cannula selection/placement, and patient volume status.

Ten patients considered high risk for elective PTCA were supported using the Bard CPS system. Ideal support was defined as achieving a predetermined cardiac index 2.4 L/min/m^2 with no drop in mean arterial pressure, pulse pressure reduction of 50%, and no change in coronary sinus saturation of hemoglobin or lactate levels. Mean patient data is summarized below.

BLOOD FLOW		PULSE PRESSURE			SvO_2		LACTATE	
calc.	act.	Pre	Full CPB	%Reduction	Pre	Full CPB	Pre	Full CPB
4.8	4.1	64.4	32.2	50	28.5	31.8	0.82	0.73

The authors will present an algorithm for making hemodynamic decisions during supported PTCA procedures delineating problems in cannula position, patient volume control, blood flow selection, and manipulation of systemic vascular resistance.

**3036 Debra Court, Auburn Hills, MI 48057*