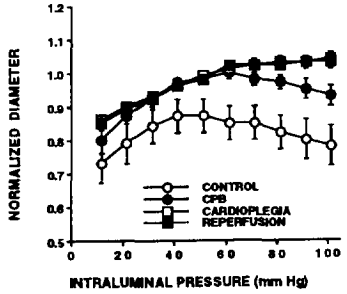
& 95%, reoperation = 90% & 83%; survival from all cardiac death was 85% & 77%. Pulmonary artery pressure, concomitant cardiac procedures, and associated coronary disease were predictive of late cardiac death by Cox regression analysis. Ten year freedom from reoperation was significantly better in nonrheumatic (90%) than in rheumatic patients (67%, $p < 0.001$). These data demonstrate durable long-term results and a continued low risk of late complications after mitral valve reconstruction using Carpentier techniques. This experience suggests that mitral valve reconstruction should be considered the procedure of choice for nonrheumatic patients with mitral valve insufficiency.

952-26 Myogenic Responses and Intrinsic Tone of Coronary Arterioles are Altered by Cardiopulmonary Bypass and Cardioplegia

Frank W. Sellke, Steven Y. Wang, Menachem Friedman, Robert G. Johnson, Ronald M. Weintraub. *Beth Israel Hosp. and Harvard Med. School, Boston, MA*

Cardiopulmonary bypass (CPB) and cardioplegia are associated with systemic hypotension and altered vascular responses. Myogenic properties and intrinsic tone of vascular smooth muscle are important mechanisms in the regulation of coronary blood flow and systemic vascular resistance. To examine if CPB and cardioplegic arrest alter myogenic reactivity and the intrinsic tone in the coronary microcirculation, pigs were placed on CPB. Selected hearts (n = 6) were arrested with a cold, hyperkalemic ($[K^+]$ = 25 mM) crystalloid cardioplegic solution for 1 hour. In another group (n = 6), hearts were arrested and then reperfused with warm blood for 1 hour, or pigs were placed on CPB without cardioplegia (n = 6). Coronary arterioles were studied in a pressurized, no-flow state with video-microscopy. Myogenic reactivity was examined to stepwise increases in intraluminal pressure from 10 to 100 mmHg. The vessel diameter was normalized to the diameter at 50 mmHg after application of papaverine (10^{-4} M). In vessels from non-instrumented control hearts (n = 6) and vessels in the CPB group, myogenic contraction was observed with pressures >40 mmHg. However, CPB significantly shifted the pressure-diameter relation upward ($p < 0.05$ vs control), suggesting a decrease in the intrinsic tone. Cardioplegic arrest, with or without reperfusion, decreased myogenic reactivity with an upward displacement of the pressure-diameter relation (both $p < 0.05$ vs control). Myogenic reactivity of the control vessel was not altered after mechanical denudation of the endothelium, or following pretreatment with N^G-nitro-L-arginine or indomethacin. However, blockade of the ATP-sensitive potassium channel by glybenclamide significantly attenuated the cardioplegia-induced decrease in myogenic reactivity ($p < 0.05$).

These results suggest that coronary microvascular myogenic reactivity and the intrinsic tone are reduced following hyperkalemic cardioplegia, and that CPB alone preserves myogenic reactivity but reduces the intrinsic tone of the vascular smooth muscle.



952-27 Truly Simultaneous Surgery for Carotid and Coronary Disease

Lawrence I. Bonchek, Mark W. Burlingame, Brad E. Vazales, Edward F. Lundy. *Mid-Atlantic Heart Institute at Lancaster General Hospital, Lancaster, PA*

Management of coexisting carotid and coronary disease has always aroused debate. Now, even more patients undergoing coronary bypass (CABG) will require consideration of carotid endarterectomy (CE), since randomized trials show that prophylactic CE benefits even certain asymptomatic patients with severe carotid stenoses. We propose a management plan and a unique operative strategy of truly simultaneous surgery.

All CABG patients with carotid bruits or cerebral symptoms undergo carotid doppler studies, then MRI or conventional angiography if appropriate. Severe stenoses are corrected during CABG as follows: cardiopulmonary bypass is begun and the left ventricle is vented. The carotid artery is exposed during systemic cooling to 23–25°C. (Lower temperatures may be used if deemed necessary — e.g. deficient communicating arteries etc.) CE is then performed without the time consuming distraction of a shunt, since profound hypothermia provides cerebral protection. Ventricular fibrillation is inevitable at these low temperatures and is ignored. After CE, systemic rewarming is begun while the cardiac procedure is performed with myocardial protection according to the surgeon's preference. The neck is closed after protamine is given.

Since January 1993, 29 patients have had combined CABG and CE by this protocol with no strokes and no deaths. This approach offers substantial advantages in outcome, efficiency, patient convenience, and cost, and we strongly recommend its wider use.

952-28 Monomorphic versus Polymorphic Ventricular Tachycardia After Coronary Artery Bypass Grafting

Leslie A. Saxon, Isaac Wiener, Paul D. Natterson, Hillel Laks, Davis Drinkwater, William G. Stevenson. *UCLA Medical Center, Los Angeles, CA*

We hypothesized that 1) ventricular tachycardia and fibrillation (VT/VF) developing after coronary artery bypass grafting (CABG) are due to either restoration of perfusion to a chronic infarction or to peri-operative ischemia/infarction and 2) that VT morphologic and electrophysiologic characteristics would depend upon which mechanism was causal. Records of 17 pts referred for electrophysiologic studies (EPS) whose first episode of VT/VF ocurred peri-operatively were compared to a control group of 119 consecutive CABG pts without VT/VF. *Results:* Pts with VT/VF had more depressed pre-operative ejection fraction (0.32 vs 0.49, $p = 0.0001$) and a higher incidence of peri-operative myocardial infarction (MI) (47% vs 8%, $p = 0.0001$) compared to control pts. The majority of VT/VF pts (88%) had a zone of prior infarction and placement of a bypass graft to an occluded vessel occurred more frequently in these subjects compared to controls ($p = 0.03$). The majority of pts having monomorphic VT (64%) did not suffer a peri-operative MI and 80% had inducible monomorphic VT at EPS. Only 37% of pts having polymorphic VT were inducible and 67% had a peri-operative MI. *Conclusion:* New onset monomorphic VT after bypass surgery is associated with an old infarct scar and may, in some cases, be due to revascularization of an area of prior infarction. Polymorphic VT/VF is usually associated with acute ischemia/infarction.

952-29 Long-term Follow-up of Surgical Repair of Ostium Primum Defects in Adults

Redmond P. Burke, Keith Horvath, Michael Landzberg, Nancy M. Kinchla, Pamela Hyde, John J. Collins Jr., Lawrence H. Cohn. *Boston Adult Congenital Heart Service, Brigham & Women's Hospital, Boston, MA*

The natural history of patients (pts) undergoing surgical repair of ostium primum atrial septal defects (ASD-1) in adulthood remains unclear. We followed 33 pts who underwent surgical correction of ASD-1 at our institution at ages 20–73 years (mean = 42), 12 of these patients were over the age of 50 at the time of surgery. Moderate preoperative exercise incapacity (NYHA Class >2) was present in 4 pts, and 6 were in atrial fibrillation. Preoperative mean pulmonary artery pressure >25 mmHg, pulmonary vascular resistance >4 Wood units, or moderate-severe mitral regurgitation was present in 8, 4, and 5 pts, respectively. Autologous pericardium was used to patch the ASD-1 in 30 pts (91%). Mitral valvuloplasty, consisting of cleft repair (n = 10) and mitral valve replacement (n = 2), were performed selectively. At a mean follow-up of 5.3 years (1 month–18.2 years), all 28 surviving pts are free of exercise limitation (NYHA Class 1). Late post-operative deaths have occurred in 5 pts (15%); related to myocardial infarction, stroke, hepatic failure, renal failure, or sepsis. Reoperation was required in 2 pts (6%); for a residual ASD-1 (n = 1), and severe mitral regurgitation (n = 1), both within the first postoperative year. The presence of advanced age at operation, symptoms, atrial arrhythmias, mitral regurgitation, or moderately increased pulmonary vascular resistance did not predict late postoperative mortality, complications or functional capacity.

Conclusion: ASD-1 can be repaired in adult pts with the expectation of excellent long-term results, independent of age at operation and preoperative mitral valve function; and despite the presence of atrial fibrillation, or moderately elevated pulmonary vascular resistance.

952-30 Left Ventricular Ejection Performance Improves Late After Aortic Valve Replacement in Patients with Aortic Stenosis and Reduced Ejection Fraction

Paul A. Robiolio, Vera H. Rigolin, Eric B. Lieberman, John S. Wilson, Steven E. Hearne, Katherine B. Kisslo, Cynthia H. Pierce, Thomas M. Bashore, J. Kevin Harrison. *Duke University Medical Center, Durham, NC*

To assess the time course and magnitude of change in left ventricular (LV) wall stress and ejection performance indices, 24 patients undergoing aortic valve replacement (AVR) for aortic stenosis were prospectively evaluated.

Each patient underwent resting radionuclide angiography (RNA), echocardiography, and cardiac catheterization (high fidelity pressure) before AVR, then RNA and echocardiogram at one week and six months after AVR. Patients were stratified by preoperative ejection fraction (EF) into reduced EF (<50%) and normal EF (≥50%) groups.

Pre-operatively, peak positive dp/dt was lower in the reduced EF group (1300 vs 1700 mmHg/sec, $p = 0.035$), and wall stress was elevated similarly in both groups (p = NS).

Temporal Relationships of EF and Wall Stress

	Pre-op	1 Week	6 Mos
Normal EF (n = 14)			
Mean Ejection Fraction (%)	66	64	68
Mean Wall Stress (dyne/cm^2 x 10^3)	62	34	44
Reduced EF (n = 10)			
Mean Ejection Fraction (%)	38	37	57
Mean Wall Stress (dyne/cm^2 x 10^3)	78	52	61

Wall stress was reduced at one week post-operatively ($p < 0.005$) in both groups. Ejection fraction remained depressed in the reduced EF group. By six months, however, EF had dramatically improved in the reduced EF group ($p = 0.002$).

Conclusion: In patients with LV dysfunction, EF remains low one week after AVR despite rectification of afterload mismatch. At six months, however, ejection performance improves. Therefore, when measured by ejection phase indices, the surgical benefit from AVR is not evident until late post-operatively.

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Tuesday, March 21, 1995, Noon–2:00 p.m.
Ernest N. Morial Convention Center, Hall E
Presentation Hour: Noon–1:00 p.m.

953-31 Modified Ultrafiltration Reduces Myocardial Edema and Reverses Hemodilution Following Cardiopulmonary Bypass in Children

J. William Gaynor, Robert M.R. Tulloh, Clarence H. Owen, Ian D. Sullivan, Martin J. Elliott. *Duke University Medical Center, Durham, NC; Hospital for Sick Children, London, England*

Cardiopulmonary bypass (CPB) causes a significant increase in total body water (TBW) resulting in organ edema and dysfunction. Modified ultrafiltration (MUF) performed following CPB significantly reduces the increase in TBW. The effects of (MUF) on myocardial edema were investigated in 9 children undergoing CPB with cardioplegic arrest for the repair of congenital heart disease. The mean age at the time of surgery was 2.8 ± 3.7 years and the mean weight was 11.4 ± 9.1 kg. Five children were under 1 year of age and 5 weighed less than 10 kg. The myocardial short axis cross-sectional area (MYOCSA) measured by epicardial echocardiography pre-CPB, post-CPB, and post-MUF was used to assess changes in myocardial wall thickness. The filtrate volume removed by MUF was 470 ± 240 mls. The hematocrit (HCT) increased from 24 ± 4% post-CPB to 39 ± 8% following MUF ($p < 0.0001$). MYOCSA increased from 5.6 ± 0.7 to 6.5 ± 0.9 cm^2 ($p = 0.011$) during CPB. Following MUF, MYOCSA decreased to 5.9 ± 0.8 cm^2 ($p = 0.013$), which was not significantly different from control ($p > 0.1$). MUF performed following CPB in children reverses hemodilution increasing the HCT and reduces myocardial edema.

953-32 Controlled Hypoventilation Increases Pulmonary Vascular Resistance at the Expense of Increased Right Ventricular Work and Oxygen Consumption

Ira M. Cheifetz, Donald R. Black, Damian M. Craig, Frank H. Kern, Peter K. Smith, Jon N. Meliones. *Duke University, Durham, NC*

Controlled hypoventilation (CH) has been utilized to increase pulmonary vascular resistance (PVR) and limit pulmonary artery blood flow (Qpa) in conditions with pulmonary overcirculation and single ventricle physiology. The effects of CH, and subsequent hypercapnia, on the pulmonary circulation, right ventricular performance, and oxygen consumption (VO_2) are poorly described.

To more precisely define the effects of CH on the cardiopulmonary circulation independent of cardiac shunting, seven swine (30–46 kg) with normal cardiac and pulmonary anatomy were studied. The swine were placed on volume control ventilation with ventilator rates adjusted to maintain $PaCO_2$ at 35–45 mmHg for normocapnia (NC) and 55–75 mmHg for CH/hypercapnia. Set tidal volume (15 cc/kg), PEEP (3–4 cm H_2O), and I-time (1 sec) were kept constant. Measurements in both conditions included pulmonary artery pressure (P_{pa}) by micromanometry and Qpa by ultrasonic flow probe. Right ventricular stroke work (SW) was determined by sonomicrometry. Transpulmonary vascular efficiency (TVE), a sensitive indicator of the efficacy of pulmonary blood flow, was calculated by Qpa/total power where total power is the energy the right ventricle imparts in moving blood through the pulmonary vasculature. Measurements were compared by Student's paired t-test with $P < 0.05$ considered significant.

	$PaCO_2$ (mmHg)	P_{pa} (mmHg)	P_{pa}/P_{sys} (%)	PVR (d-s/cm^5)	TVE (L/W-min)	SW	VO_2 (ml/min)
NC	39	15.6	27	689	25.5	159	69.6
CH	62*	20.1*	33*	907*	21.0*	201*	90.5*

* significant vs. normocapnia

CH significantly increases PVR but accomplishes this at the expense of increased right ventricular work, decreased TVE, and increased oxygen consumption. The potentially detrimental effects of CH on cardiorespiratory performance must be appreciated when applying this therapy to clinical conditions with unstable physiology.

953-33 Modified Venovenous Ultrafiltration in Infant Cardiac Surgery

Carlos M. Li, George M. Alfieris, Michael J. Walker, Renee L. Oakes, Fred Totzek, Gregory K. Sorensen, J. Geoffrey Stevenson, Flavian M. Lupinetti. *The University of Washington, Seattle, Washington*

Modified arteriovenous ultrafiltration has been used in pediatric cardiac surgery to reduce tissue edema and improve organ function. Arteriovenous filtration may be problematic in hemodynamically unstable patients and those with univentricular cardiac anomalies. To avoid problems that may occur during arteriovenous filtration, a technique of modified venovenous ultrafiltration (MVU) has been developed. From May through August, 1994, 20 neonates and infants (mean age 61 days, mean weight 4.5 kg) underwent open cardiac surgical procedures followed by 20 minutes of MVU after separation from cardiopulmonary bypass. Diagnoses included ventricular septal defect (4), complete atrioventricular septal defect (3), transposition of the great arteries (3), hypoplastic left heart syndrome (3), tetralogy of Fallot (2), total anomalous pulmonary venous connection (2), truncus arteriosus (1), and anomalous left coronary artery (1). MVU removed a mean volume of 98 ml/kg body weight and increased the hematocrit from 24 to 33% ($p = 0.0001$). Effects of MVU on systolic and mean arterial pressure (SAP, MAP) and on echocardiographic measurements of left ventricle wall thickness (LVT) and mitral velocity-time integral during the first third of diastole (VTI 1/3) are shown:

	Prefilter				Postfilter			
	SAP	MAP	LVT	VTI 1/3	SAP	MAP	LVT	VTI 1/3
Mean	62	45	6.0	2.7	76	57	4.8	4.7
S.D.	11	9	1.7	1.7	17	12	1.3	2.0
			P vs. Prefilter:		0.0002	0.0001	0.001	0.014

Filtered patients were compared to age- and diagnosis-matched controls operated on by the same surgeon within the same year. Days ventilated (Vent), days in intensive care (ICU), and postoperative hospital days (Hosp) were analyzed:

	MVU			Control		
	Vent	ICU	Hosp	Vent	ICU	Hosp
Mean	3	5	9	7	10	15
S.D.	2	3	4	8	9	11
			p vs. MVU:	0.086	0.040	0.067

MVU results in improved hemodynamics and a more rapid recovery in infants undergoing open heart operations. MVU can be used in a wide range of patients, including those with univentricular cardiac malformations.

953-34 Pulmonary Vascular Endothelium is Capable of Producing Nitric Oxide After Cardiopulmonary Bypass and Circulatory Arrest

Paul M. Kirshbom, Steven S.L. Tsui, Louis R. DiBernardo, Jon N. Meliones, Debra A. Schwinn, Ross M. Ungerleider, J. William Gaynor. *Duke University Medical Center, Durham, NC*

Cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest (DHCA) can lead to clinically significant pulmonary dysfunction and increased pulmonary vascular resistance (PVR). Endothelial production of nitric oxide (NO), a vasodilator, is an important mediator of pulmonary vascular tone. Endothelial injury during CPB and DHCA with loss of NO production may result