

# 1970 ANNUAL MEETING PROGRAM



## The American Association for Thoracic Surgery 1969-1970

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## MONDAY MORNING, APRIL 6, 1970

**8:30 A.M. Business Session (Limited to Members)**  
**International Ballroom Center**

**8:45 A.M. Scientific Session: REGULAR PROGRAM**  
**International Ballroom Center**

### **1. Cardiac Transplantation in Man. VIII. Survival and Function**

EDWARD B. STINSON,\* R. B. GRIEPP,\* D. CLARK,\* E. DONG,\*

and NORMAN E. SHUMWAY, Stanford, Calif.

Directly computed survival rates in 18 patients undergoing cardiac transplantation at Stanford University Medical Center show 53% survival at 3 months, 46% at 6 months, 40% at 9 months, and 29% at 1 year postoperatively. Maximum survival in this series is currently 14 months with good graft function. Allograft rejection was the cause of death in 3 patients; in one progressive AV conduction disturbances culminated in a fatal Stokes-Adams attack at 10 months. Histopathological examination of the heart showed occlusion of the AV nodal artery by obliterative arteritis, one of the organ-specific expressions of allograft rejection. In 3 other patients immunosuppressive therapy contributed directly to a fatal outcome through potentiation of infectious complications or metabolic toxicity. Four remaining deaths were due to separate causes, including the physiological complications of long-standing pulmonary vascular disease in 2. Hemodynamic evaluation of graft function has been performed in 5 patients, including 2 at one year postoperatively. Normal resting cardiac outputs were found in 4 patients on postoperative days 1 through 3. In one patient cardiac catheterization at 3 weeks showed normal pressures and low normal flows although atrial biopsy 2 days later revealed moderately severe rejection changes. In both patients studied at one year resting pressures and flows were normal with satisfactory responses to exercise. Correlation of these studies with serial exercise tolerance tests, electrocardiograms, and ballistocardiograms, as well as the results of late evaluation for cardiac reinnervation will be described.

### **2. Pulmonary Valve Autograft for Aortic Valve Replacement**

L. GONZALEZ-LAVIN,\* Chicago, Ill., M. GEENS,\*

and DONALD N ROSS,\* London, England

Sponsored by C. FREDERICK KITTLE

The main problem with aortic homograft replacement of the aortic valve at present relates to their long-term durability. Most of the late failures of the homograft valves have been due to degenerative changes related mainly to the methods of sterilization and storage. To overcome these problems the use of living valves has an immediate appeal. Since June 1967, 84 patients have undergone aortic valve replacement with a pulmonary valve autograft. This procedure has been electively performed in young patients the mean age was 35.6. Sixty-three per cent of the patients were in Class III or IV. The surgical technique will be presented in detail. Hospital mortality in the last half of the patients was 71%. Postoperative aortic regurgitation has been slightly less than with homograft valves. The majority of the patients with a diastolic murmur postoperatively are asymptomatic. In only 4.4% of the patients aortic regurgitation was moderately severe. These three instances were considered as definite valve failure. All three instances have been due to malposition of the valve. Two of these valves have been replaced, 4 and 13 months after surgery. Histopathology of these valves shows normal and living structures.

### **3. Autologous Fascia Lata for Heart Valve Replacement: Technique and Results**

MARIAN L. IONESCU,\* Leeds, England, and

DONALD N. ROSS,\* London, England

Sponsored by DWIGHT G. MCGOON

Heart valves made of fresh autologous fascia lata attached to a supporting frame are used for mitral, aortic and tricuspid replacement. The technique of preparing and inserting the grafts is described. Since April 1969, 100 patients have had one or several heart valves replaced with autologous fascia lata grafts. Except five, all patients were class III and IV before surgery. Of the total of 100 patients (9 to 73 years old) 12 died in the postoperative period of causes not related to the graft. 88 patients are alive and much improved. Thrombo-embolic complications have been completely absent although anticoagulants were not used. So far there have been no graft failures or late complications. Data concerning follow-up studies is presented to evaluate the results (clinical condition, catheter findings, angiography). Data concerning the structure and function of fascia is presented and the experimental and clinical uses of fascia in extracardiac and cardiac surgery are reviewed. The use of autologous, living fascia lata valves is considered to be a better approach for heart valve replacement.

because autovital fascia maintains its structure unchanged after transplantation, and being under mechanical stimulation it retains its functional properties.

#### **4. A New Central Flow Tilting Disc Valve Prosthesis: One Year Clinical Experience**

V. O. BJORK, Stockholm, Sweden

This aortic valve consists of a uniquely suspended free floating disc and a stellite cage (manufactured by Shiley Laboratories). The disc tilts 60° about an imaginary hinge, providing central flow. The pivot point of the disc shifts towards the center as the disc closes, greatly reducing closing impact velocity. The extreme low mass inertia of the disc contributes to the effectiveness of the valve, especially at high pulse rates. The disc is made of a thermoplastic material (acetal resin), which has the highest fatigue endurance limits and the highest abrasion resistance of any commercial thermoplastic. Accelerated pulse duplicator tests show that projected wear limits will easily exceed thirty years. Significantly lower gradients have been obtained, which is important in cases involving a narrow aortic root and calcine aortic stenosis. Blood trauma has been reduced to a minimum as well by the low gradient as by the fact that the disc does not hit the ring during diastole. In the first 45 cases operated there were 6 deaths. The mean systolic peak gradient at the end of the operation was 5.8 mm Hg. There was no significant regurgitation or hemolysis. Follow-up to one year has given excellent results.

#### **5. Pectus Excavatum: A 20 Year Surgical Experience**

J. ALEX HALLER, JR., GEORGE N. PETERS,\* MARK M. RAVITCH,

DAVID MAZUR,\* and J. J. WHITE,\* Baltimore, Md.

Surgical correction of pectus excavatum was performed in 166 children at the Johns Hopkins Hospital in the years 1949 through 1968. The two major indications for surgical reconstruction were cosmetic restoration of the anterior thorax and prevention of serious postural deformity. A basic operative procedure consisting of cartilage excision, sternal fracture and tripod stabilization without internal or external fixation was used in almost all cases. Several technical modifications of the operation have been introduced through the years. This series of patients was evaluated to determine the immediate morbidity and mortality and the long-term adequacy of the repair. Significant postoperative complications occurred in 5% and included mediastinal infections and wound separations. Except for these rare complications the postoperative morbidity in 95% was unremarkable. Long-term follow-up of these patients was accomplished in 92 cases with an average time of 8.25 years. The vast majority of patients and parents were pleased with their operative results and these were considered satisfactory by the examining physicians. Late partial recurrences were noted in 11%. A secondary operative correction was performed in 7% with satisfactory results. There were no deaths in the series. Our current approach to pectus excavatum including indications for surgery, technical features of the operative repair, management of complications and long-term results will be discussed in detail.

#### **6. Current Surgical Management of Pulmonary Tuberculosis**

WILFORD B. NEPTUNE, SAMUEL KIM,\* and JOHN BOOKWALTER,\*

Boston, Mass.

In the past five years, 168 patients had surgery for pulmonary tuberculosis at the Norfolk County Tuberculosis Hospital. Twenty-nine were readmission cases and 35 had previously had surgery. The indications for surgery varied but were primarily persistent cavity in 94 patients. Seventeen patients had drug resistant organisms, eight had diabetes; 20 had chronic alcoholism; and 16 had cardiac disease. There was only one postoperative death, no empyemas, no bronchopleural fistulas and no spread of disease. There were two late deaths unrelated to tuberculosis. All other patients had control of disease and were discharged. One patient was readmitted with reactivation after erroneously stopping drug therapy seven months following a pulmonary resection. Although statistics are favorable with drug therapy there are still patients with either uncontrolled disease or residual lesions with a poor prognosis. Surgery may favorably alter the immediate problem and offer future security. In any surgical program, however, the morbidity and mortality should be minimal, outcome should be predictable, and control of disease should be enhanced. A review of the indications, surgical procedures, and follow-up will be presented.

#### **7. Surgical Therapy in Neonatal Air Block Syndrome**

JAY L. GROSFELD,\* H. WILLIAM CLATWORTHY, JR., and

THOMAS R. FRYE,\* Columbus, Ohio

An experience with 179 newborn infants with air block syndrome is presented to evaluate mortality in relation to therapy and suggest a plan of management. Pneumothorax occurred alone or in combination with interstitial emphysema, pneumomediastinum, or pneumopericardium in 127 cases. Pneumothorax was unilateral in 96 patients and bilateral in 31. Interstitial emphysema occurred alone in 19 infants and with pneumomediastinum in 33. Therapy consisted of observation

alone in 121 patients, needle aspiration in two, and tube thoracostomy in 56. The overall mortality rate was 32.9%: 50% in bilateral pneumothorax, and 26% in unilateral pneumothorax. The mortality rate in the observed pneumothorax group and the tube treated group was similar (33%). Patients with unilateral pneumothorax or pneumomediastinum had a significantly lower (26%) mortality than cases of interstitial emphysema alone (50%). Air piercing the pleura appears to "protect" the infant's lung. Tube thoracostomy is recommended only in cases of tension pneumothorax, and in a deteriorating infant with partially collapsed lung due to loss of lung compliance from excessive interstitial emphysema. Careful selection of patients for tube thoracostomy, close monitoring of pH and blood gas measurements, serial chest x-rays, and assisted ventilation, when indicated, has diminished the mortality rate from 40% to 15% in the past five years.

## **8. Comparative Results of Early Internal Stabilization and Other Methods for Treating Flail**

### **Chest**

ROBERT F. WILSON,\* and S. SANKARAN,\* Detroit, Mich.

Sponsored by RAYMOND J. BARRETT

Although many physicians now treat flail chest with early internal stabilization using tracheostomy and mechanical ventilators, there is little or no evidence that this method has significantly improved survival rates. In an attempt to more clearly define the benefits to be derived from early internal stabilization, a series of 89 patients with flail chest seen from January 1962 through July 1969 were reviewed. The treatment given during the first 48 hours was "none" in 7 patients, external traction in 9, tracheostomy in 9, tracheostomy and external traction in 25, and tracheostomy and respiration in 39. The mortality rates in these groups were 52%, 0, 22%, 32%, and 23% respectively. These figures in themselves, however, are somewhat deceptive. Of 59 patients with relatively uncomplicated flail chest injuries, only 6 (10%) died. Of the 9 with severe associated injuries, all 9 (100%) died. Although the type of treatment used made little or no difference in the above 2 groups, it was extremely important in the other 21 patients with injuries of intermediate severity. Of 9 patients treated with early tracheostomy and respirator assistance, only 1 (11%) died. Of the 12 treated differently, 8 (67%) died. This difference was statistically significant ( $P < 0.02$ ).

## **9. A Case of Clinical Lung Allograft Transplantation**

JAMES D. HARDY, FIKRI ALICAN,\* P. MOYNIHAN,\* H. TIMMIS,

C CHAVEZ,\* J. T. DAVIS,\* P. ANAS,\* and L. FABIAN,\*

Jackson, Miss.

This 66 year old man with chronic obstructive pulmonary emphysema had a  $P_{CO_2}$  of 80 mmHg and a  $P_{O_2}$  of up to 90 mmHg on the respirator but usually around 40 mmHg. He was admitted to our hospital on three previous occasions during the year 1968 with acute bronchitis and respiratory distress. When last admitted he was almost moribund and  $CO_2$  narcosis and hypoxia kept him somnolent. A light growth of *E. coli* and *pseudomonas* were present in his sputum. Following resuscitation and when the infection was cleared, the left lung of a cadaver was transplanted in January 1969. A catheter was left in the left pulmonary vein to measure function. Arterial blood gas values steadily improved over the weeks. At two weeks pulmonary arteriogram and lung scan were normal. His general condition was satisfactory until the 24th day when he abruptly developed *pseudomonas* pneumonitis in his right lung and expired on the 29th day. Autopsy showed that the transplanted lung had not been rejected. A detailed study of this case, a review of our 1963 case, a survey of the world's experience, and the special problems of clinical lung transplantation will be presented.

\*By Invitation

## **MONDAY AFTERNOON, APRIL 6, 1970**

**2:00 P.M. Scientific Session: REGULAR PROGRAM**  
**International Ballroom Center**

## **10. Ascending Aorta-to-Coronary Artery Saphenous Vein Bypass Grafts**

BEN F. MITCHEL, MAURICE ADAM,\* and GARY J. LAMBERT,\*

Ascending aorta-to-coronary artery saphenous vein bypass grafts provide an immediate increase in myocardial blood supply for patients with ischemic heart disease. Because of this immediate effect, surgery can now be extended to those patients who were previously denied a revascularization procedure because of multiple vessel disease and/or poor myocardial function. To date, 133 bypass grafts have been used to augment myocardial blood flow in 80 patients. Thirty-six single, 35 double, and 9 triple bypass grafts were used. The grafts were taken to the right coronary artery (44 times), to the left anterior descending coronary (70 times), and to the circumflex coronary (19 times). In the last 60 cases internal mammary artery implants into the circumflex distribution have been abandoned in favor of direct circumflex surgery. Hospital mortality has been 10%. Graft failure, indicated by recurrence of symptoms and confirmed by angiography, has occurred in 6 patients (7.5%). The remaining patients (82.5%) are definitely improved, most markedly so. More striking has been the improvement demonstrated by some patients in myocardial contractility. Myocardial infarction may have been prevented by early bypass surgery in five patients diagnosed as having impending myocardial infarction. The longest follow-up is now 21 months.

### **11. Severe Segmental Obstruction of the Left Main Coronary Artery and Its Divisions: Surgical Treatment by the Saphenous Vein Graft Technic**

RENE G. FAVALORO, DONALD B. EFFLER, LAURFENCE K. GROVES,

WILLIAM C. SHELDON,\* and F. MASON SONES, JR.,\* Cleveland, Ohio

Saphenous vein grafts have been used at The Cleveland Clinic Hospital since May 1967 Up to August 31, 1969 a total of 401 operations were performed. In 74 patients, there was severe localized obstruction in either the left main coronary artery, the anterior descending branch of the left coronary artery, or the circumflex branch of the left coronary artery. Bypass grafts from aorta to anterior descending or circumflex artery were used in almost all operations. In 12 patients, a simultaneous saphenous vein graft bypass was performed on the right coronary artery, and in 21 patients, a single internal mammary artery implantation was done. The hospital mortality was 6.5 percent. Postoperative coronary cineangiographic studies showed excellent perfusion of the coronary circulation through the graft. This new approach offers a solution for two lethal obstructions (1) severe narrowing at the main trunk, and (2) severe narrowing of the anterior descending branch above the first perforator branch. The previous technic (pericardial patch graft repair) was associated with an operative mortality of 65 percent when applied to the left coronary artery. Operative technic, indications, and pre- and postoperative selective angiography will be presented.

### **12. The Physiologic Parameters of Ventricular Function as Affected by Direct Coronary Surgery**

W. DUDLEY JOHNSON,\* ROBERT J. FLEMMING,\* and

DERWARD LEPLEY, JR., Milwaukee, Wis.

Direct reconstruction of coronary flow is now being accomplished in 97% of patients referred for surgery using single, double, or triple vein grafts. No "end-stage" patient has been refused on the basis of his heart condition alone. The recognition and correction of some pathophysiologic changes has allowed most "end-stage" patients to undergo surgery successfully. Blood volume deficiencies pre- and postoperatively are numerous, and the importance of an adequate volume and a normal hematocrit on ventricular function will be illustrated. To determine the physiologic changes induced by the increased coronary flow in an abnormal ventricle, a variety of studies have been performed on groups of patients pre- and postoperatively. These include ventriculography, atrial pacing, bicycle ergometry, cardiac outputs, measurements of ventricular contractility, and alterations in the ratio of the pre-ejection time to the total time of ventricular systole. These studies will be summarized and indicate that in addition to relief of angina, significant improvement in function in late stage coronary patients can often be achieved. While the long-term results of vein bypass grafts to coronary arteries is uncertain, we feel these studies lend support to our vigorous surgical approach to coronary disease.

### **13. Arterial and Venous Microsurgical Bypass Grafts for Coronary Artery Disease**

GEORGE E. GREEN,\* FRANK C. SPENCER, and DAVID A. TICE,

New York, N.Y.

From February 1968 to October 1968 coronary bypass grafts were attempted in 50 patients and completed in 47. The internal mammary artery was anastomosed to the anterior descending coronary artery (10 to 2.5 mm) in 25 patients, using a dissecting microscope (16 magnifications) and 9-0 nylon. In many of these patients the patent distal anterior descending artery could not be demonstrated by angiography but was found by dissection at operation. An aortic-coronary saphenous vein graft to either the anterior descending or the right coronary artery was carried out in the other 22 patients. Double grafts were performed in 22. Blood flow rates in the grafts averaged 50 to 65 ml/min. There were five hospital deaths. All but three of the surviving patients are virtually asymptomatic, and two of these three have thrombosed grafts. All of 11 mammary arteries studied by angiography 3 to 13 months after operation are patent. Two of four vein grafts, however, have been found

thrombosed, with prompt recurrence of angina. The importance of the dissecting microscope to expand the applicability of bypass operations will be emphasized.

#### **14. Complete Surgical Correction of the Totally Occluded and Diffusely Diseased Right Coronary Artery**

G. ROBINSON, M. J. KAPLITT,\* P. PHILIPS,\* and B. PATEL,\*

Bronx, N.Y.

In an attempt to provide immediate surgical relief to the ischemic heart attention has been directed to the aorto-coronary vein by-pass techniques in favor of endarterectomy. While the by-pass techniques appear to be successful in many instances they are often unsuitable because of inadequate runoff. Further, a long vein by-pass in fact by-passes a useful segment of artery, which if properly reopened might serve as a vast network for inter-coronary collateral formation. In the hope of effecting just such a complete surgical correction coronary gas endarterectomy was undertaken in the diffusely diseased right coronary artery. Six patients have been treated using this technique. In each instance a multibranched specimen measuring from 10 to 14 centimeters was retrieved. Postoperative angiograms demonstrate complete reconstitution of the entire coronary system with multitudinous side branches reopened. Operative time for the coronary surgery itself has not exceeded one hour. One patient recatheterized at one year demonstrates a patent 14 centimeter gas endarterectomy. It is our impression that coronary gas endarterectomy is the procedure of choice for total correction of the diffusely diseased right coronary artery.

#### **15. Correlation of Mean Pulmonary Arterial Pressure with Results of Surgery for Non-restrictive Ventricular Septal Defects**

ROBERT B. WAGNER,\* JAY L. ANKENY, and JEROME LIEBMAN,\*

Cleveland, Ohio

The operative mortality associated with closure of ventricular septal defects with systemic level pulmonary hypertension remains high. In an attempt to establish better criteria for operability, a retrospective study of 30 consecutive patients undergoing closure of non-restrictive ventricular septal defects was carried out. Thirteen patients were females and 17 males whose ages ranged from two to 25 years. Preoperative pulmonary-systemic resistance (Rp/Rs), flow (Qp/Qs) and pressure (Pp/Ps) ratios, EKG, and pulmonary arterial mean pressures were correlated with operative results. All 15 patients whose mean pulmonary arterial pressure was 60 mm. Hg or less survived surgery with only one poor result due to persistent shunt. In contrast, eight of the 15 patients with mean pressures greater than 60 mm. Hg. died with low cardiac output syndrome within 48 hours following defect closure. Only four of these eight had Rp/Rs ratio of 0.45 or greater. Of the seven survivors, two have persistent left to right shunts, one died suddenly 40 days post-operatively, three have progressive pulmonary vascular disease, and only one has done well. In this study, surgical results correlated best with preoperative mean pulmonary arterial pressure. Only one of 15 patients with a mean pressure greater than 60 mm Hg. benefited from closure of a non-restrictive ventricular septal defect.

#### **16. Late Cardio-dynamics Following Correction of Ventricular Septal Defects with Previous Pulmonary Artery Banding**

PAULA EBERT,\* RAMON V. CANENT JR.,\* MADISON S. SPACH,\* and

DAVID C. SABISTON, JR., Durham, N.C.

Pulmonary artery banding is an established technic for infants with refractory cardiac failure due to a VSD. Subsequent closure of the defect is also an accepted procedure, but little data are available concerning the *ultimate* hemodynamics which ensue. Twelve children with a VSD and previous banding have been corrected with a single death. The band was removed and a pericardial patch employed to enlarge the artery. Of significance are the late catheterization and cineangiography data obtained in eight patients. These show correction of the pulmonary stenosis with no significant gradient and demonstrate that the pulmonary-to-systemic resistance ratios remain unchanged from pre-banding levels (Pre-band 24 and post-correction 25). In addition, the results of four children with atrioventricular canal defects and banding will be discussed. The choice of an atrial or ventricular approach in the correction of these defects and the role of infundibulectomy will also be discussed in view of the postoperative results. The data show that pulmonary artery banding allows pulmonary resistance to remain unchanged until total corrective surgery can be performed. Ultimate results are quite favorable, and emphasis upon several points in the operative correction has proved of considerable importance.

#### **17. Cor Triatriatum, Clinical Presentation and Operative Treatment**

R.D. BRICKMAN,\* L. WILSON,\* J.R. ZUBERBUHLER,\* and

HENRY T. BAHNSON, Pittsburgh, Pa.

Cor triatriatum is an uncommon congenital cardiac anomaly in which the left atrium is divided by a fibromuscular septum into two chambers. The upper chamber or common pulmonary vein receives the pulmonary venous return, the lower chamber is the true left atrium and communicates with the left atrial appendage and mitral orifice. The membrane has one or more fenestrations which permit flow through this obstruction. The clinical presentation of this anomaly depends on the degree of pulmonary venous obstruction produced by this septum. Once thought a rare anomaly, it is now being recognized with much greater frequency. Diagnosis and definitive surgical correction of this defect depend on a high index of suspicion when a patient presents with a pulmonary venous obstruction. We have seen eight patients with this anomaly. The first five were either undiagnosed and untreated or misdiagnosed and unsuccessfully treated. The last three were both correctly diagnosed and treated with excellent results. Characteristics of the clinical presentation, physical signs, radiologic appearance, electrocardiographic findings, catheterization data, cineangiography, and correct surgical approach will be discussed. Representative examples from these cases will be used to illustrate this anomaly with appropriate slides and movies.

## **18. Late Results of Superior Vena Cava-Right Pulmonary Artery Shunt**

I. B. BORUCHOW,\* T. D. BARTLEY, L. P. ELLIOTT,\* M. W. WHEAT, JR.,

and G. L. SCHIEBLER,\* Gainesville, Fla.

Postoperative (PO) cardiac catheterization and angiocardiology was performed in eight long-term (more than three years) survivors of SVC-RPA shunt. All had cyanotic congenital heart disease with decreased pulmonary blood flow. Clinical improvement was reflected by decreased hematocrit and increased arterial oxygen saturation (3 to 68%) and exercise tolerance. SVC pressure increased 2 to 10 mm Hg. In two patients, mild SVC syndrome beginning in the PO period was associated with over-all clinical improvement. Three patients with severe pulmonic stenosis as part of their malformation developed a late progressive form of SVC syndrome and clinical deterioration one and a half to two years after surgery. Disappearance of signs of SVC syndrome and clinical improvement followed Blalock-Taussig anastomosis (two cases), or open heart surgery (OH-S) (one case), leaving the SVC-RPA shunt intact. Improvement following OH-S of tetralogy of Fallot persists in spite of severe PO pulmonary valve insufficiency, elevated mean pressure in the left pulmonary artery (LPA), and systemic systolic pressures in the right ventricle and LPA. This paradoxical result may be due to the SVC-RPA shunt which reduced systemic venous return into the right heart.

\*By Invitation

## **TUESDAY MORNING, APRIL 7, 1970**

### **8:30 A.M. Scientific Session: THORACIC SURGERY FORUM International Ballroom Center**

#### **19. Cardiopulmonary Homotransplantation**

GEORGE L. GRINNAN,\* WALTER H. GRAHAM,\* JAMES W. CHILDS,\*  
and RICHARD R. LOWER, Richmond, Va.

Orthotopic homotransplantation of the heart and both lungs was performed on 25 dogs to evaluate function and pathology. All had serial determinations of arterial pO<sub>2</sub>, pCO<sub>2</sub>, pH and ECG. The ventilatory responses, pulmonary resistance and cardiac output (C.O.) were studied in 3 animals breathing alternately 7% O<sub>2</sub> and 5% CO<sub>2</sub>. Immunosuppression consisted of methylprednisolone, azathioprine and antilymphocyte serum. All animals resumed spontaneous respirations and 10 survived between 1 and 10 days. Early deaths were primarily related to technical problems. Most animals initially demonstrated normal pO<sub>2</sub> and pCO<sub>2</sub> and spontaneously corrected a mild metabolic acidosis resulting from bypass. In the animals studied, pulmonary resistance was normal; hypercapnia and hypoxia produced appropriate increases in tidal and minute volumes despite denervation. Changes in C.O. were unpredictable due to the unstable condition of the early postoperative period. In animals surviving over 24 hours, pulmonary edema was a frequent pathologic finding with varying degrees of mononuclear cell infiltration. Hearts were normal clinically and showed less cellular infiltrate. Total cardiopulmonary transplantation appears technically and physiologically feasible. The denervated preparation is capable of adequate gas exchange and normal hemodynamic support of the animal. Prolonged survival is more difficult to achieve than with cardiac transplantation.

#### **20. Effect of Anticoagulants on the Transplanted Heart**

DONALD R. KAHN, EDWARD A. CARR,\* MARVIN M. KIRSH,\*  
HAROLD A. OBERMAN,\* WILLIAM Y. MOORES,\* JOHN H. DUFEK,\*  
and HERBERT E. SLOAN, Ann Arbor, Mich.

To evaluate anticoagulants in acute and chronic rejection, myocardial scans were performed after 33 pig heterotopic cardiac transplants and three human cardiac transplants. Recipient pigs received Cesium-131 chloride one to nine days after

transplantation followed by myocardial scans. Samples of myocardia were counted in a scintillation well-counter and examined microscopically. One group received heparin; the second group were controls. Control pigs showed the same uptake of Cesium in the transplanted hearts despite microscopic evidence of rejection. Pigs receiving heparin had two- to three-fold increase in the uptake of Cesium and histological delay in rejection. Human cardiac transplants received heparin and coumadin in addition to azathioprine and prednisone. In two patients without evidence of rejection for one year, myocardial scans showed good uptake. In one patient who had two acute rejection episodes reversed with drug therapy and was in chronic rejection at 6 months, myocardial scans showed decreasing uptake with diffuse "cold" areas. This study supports that ischemia is not of great importance in acute rejection but does accompany chronic rejection. Heparin increases blood flow and delays rejection in the transplanted heart but does not always prevent chronic rejection. Myocardial scans may be useful in diagnosing chronic rejection.

## 21. Functional Evaluation of the Preserved Heart

SIDNEY LEVITSKY,\* WILLIS H. WILLIAMS,\*,\* DON E. DETMER,\*  
CHARLES L. MCINTOSH,\* and ANDREW G. MORROW, Bethesda, Md.

Nineteen canine hearts were perfused with filtered plasma passed through a Kolobow membrane oxygenator for 3 to 24 hours at 8-IOC. in a silicone rubber air free chamber. Active and passive length-tension curves (LTC) were obtained with an isovolumetric balloon after re-warming to 37C. with blood pumped from a support animal. Coronary perfusion pressure and heart rate were held constant. Nine additional hearts were evaluated in the same manner immediately after removal. The active LTC was unchanged up to 18 hours of preservation and depressed at 24 hours. Diastolic compliance gradually decreased over the entire preservation period but myocardial edema never exceeded 5%. At a left ventricular end-diastolic pressure of 10 mm. Hg, maximum dp/dt was  $1310 \pm 109$  and  $1403 \pm 435$  mm. Hg/sec., tension time index was  $12.4 \pm .6$  and  $10.9 \pm 3.5$  g-sec./cm.<sup>2</sup> and peak pressure was  $126.3 \pm 9.5$  and  $119.9 \pm 31.0$  mm. Hg in controls and hearts preserved up to 18 hours respectively. During the period of preservation depressed myocardial function could be predicted by increases in perfusion pressure above 75 mm. Hg, inhibition of lactate uptake and increasing acidosis. These data show the value of the preservation system and provide a model to compare with other methods of cardiac preservation.

## 22. Bronchial Brushing

WILLARD A. FRY,\* and P. MANALO-ESTRELLA,\* Evanston, Ill.

Sponsored by JOHN M. DORSEY

Bronchial brushing has been the single most accurate procedure short of thoracotomy in diagnosing lung cancer in our series of 200 patients. It is a simple and economical diagnostic method which provides material for microbiologic as well as cytologic evaluation, and is one which any thoracic surgeon should be able to perform with ease. We have prepared a description of our technique demonstrating how it can be done in conjunction with bronchoscopy or as an isolated procedure. We compare the American technique with the current Japanese methods. A film strip demonstrates the use of the image intensifier in approaching peripheral indeterminate lung lesions. Recent modifications and refinements in technique are shown such as fine wire brushes which procure samples adequate for paraffin block section, and the handling of brush cultures so as to obtain the best results in patients with suspect, inflammatory disease.

## 23. Impedance Plethysmography, a Non-Invasive Means of Monitoring the Thoracic Surgery Patient

JOSEPH M. VAN DE WATER,\* ERIC N. C. MILNE,\* IAN T. MILLER,\*  
E. LAWRENCE HANSON,\* and KAREN S. KAGEY,\* Boston, Mass.

Sponsored by DWIGHT E. HARKEN

The Minnesota Impedance Cardiograph has been used to detect the accumulation of interstitial, pleural and mediastinal fluid. The impedance readings ( $Z_0$ ) are based on the changes in an electric field (4 ma, rms, 100 kHz) applied and monitored via circumferential electrodes and are inversely related to the total thoracic fluid content. In patients such as anephrics undergoing dialysis, changes in  $Z_0$  were found to correlate with clearing in the chest roentgenogram and decrease in the pulmonary extra-vascular water volume (PEWV), using tritiated water and Evans blue dye. With pleural effusion,  $Z_0$  correlated closely with the amount of fluid aspirated ( $r = 0.99$ ,  $p < 0.001$ ). This technique was then applied to the clinical monitoring of eight patients undergoing mitral valve replacement. Measurements were made preoperatively and continued post-operatively until discharge. During the immediate postoperative period the  $Z_0$  values were correlated with PEWV and the physiologic pulmonary shunt as well as with left atrial pressure, central venous pressure, blood volume and chest roentgenograms. Thoracic impedance was found to be a valuable means of following the patient's course. In addition it offers the advantages of being simple, non-invasive and adaptable to on-line monitoring systems.

## 24. Effect of Oxygen and Helium Mixtures upon Ventricular Fibrillation

ROQUE PIFARRE, T.K. RAGHUNATH,\* ROBERT M. VANECKO\*  
and WILLIAM E. NEVILLE, Hines, Ill.

The influence of oxygen and helium upon ventricular fibrillation has been investigated in 55 dogs. Routine pentobarbital anesthesia, endotracheal intubation and controlled ventilation with a Harvard respirator were used. The left circumflex artery was ligated at its origin, five minutes after ventilation with the gas mixture was begun. The study was divided in five groups: *Group I* (26 dogs) was the control group; dogs were ventilated with room air. *Group II* (10 dogs) 70% oxygen and 30% helium. *Group III* (12 dogs) 80% oxygen and 20% helium. *Group IV* (18 dogs) 10% oxygen, 20% helium and 70% room air. *Group V* (15 dogs) 30% oxygen, 20% helium and 50% air. The incidence of ventricular fibrillation was: *Group I (control)*: 54% *Group II*: 20%. *Group III*: 8%. *Group IV*: 16%. *Group V*: 0%. Oxygen and helium mixtures reduce significantly the incidence of ventricular fibrillation in acute myocardial infarction in dogs. The mechanism of protection is not clear. However, injection studies demonstrate faster development of collateral circulation with helium



ventilation, suggesting that helium mixtures increase blood supply in infarcted areas. Although further investigation is needed, its potential clinical application in mobile coronary care units is self-evident.

### **5. Evaluation of Dextrose, Insulin and Potassium on Ventricular Irritability in Localized Acute Myocardial Ischemia**

KENNETH S. DANIELSON,\* JAMES A. DEWEESE, and  
EARLE, B. MAHONEY, Rochester, N.Y.

Antiarrhythmic effects of dextrose (D), potassium (K) and glucagon-free insulin (I) on canine hearts following left anterior descending artery ligation has been analyzed by the technique of ventricular fibrillation threshold (VFT) as described by Wiggers. Serial VFT's were measured prior to and over a four-hour period following ligation in all groups. In test groups of ten dogs each receiving 500 ml solution of 1) D 50 g, 2) D 50 g K 40 mEq, or 3) D 50 g, K 40 mEq and I 40 u, the VFT returned to preligation levels after one hour of infusion whereas the VFT in a control group (ten dogs) and pancreatectomized D 50 g-treated group (five dogs) did not recover until the fourth hour. In the presence of the normally-functioning pancreas, concentrated dextrose alone has an antiarrhythmic effect on the acutely localized ischemic myocardium. It is not necessary to administer potassium or potassium and insulin to observe this effect. The mode of action appears to be release of a factor from the pancreas in response to dextrose.

### **26. Replacement of the Aortic Valve with Molded Autogenous Grafts Grown in Response to Implanted Silastic**

ALEXANDER S. GEHA,\* GUSTAVE L. DAVIS,\* and  
ARTHUR E. BAUE, St. Louis, Mo.

Preserved homologous aortic valves virtually eliminate thromboembolic complications following replacement of the diseased aortic valve, but their supply is limited and they have a high incidence of late degeneration and failure. The late results of easily available heterografts may be even less satisfactory. The advantages of autogenous tissue for aortic valve replacement are obvious, but tailoring of fascia lata or pericardium into a valve remains a difficult engineering problem. This report is an evaluation of a method designed to easily provide valve-shaped autografts and study their late results. Aortic cusp-shaped silastic molds are implanted subcutaneously, resulting in growth of a mature acellular thin fibrous host tissue response accurately molded to the geometry and configuration of the implant and histologically similar to the normal cusp architecture. When mature, this well-differentiated tissue is easily dissected and the new "cusp" is attached to the basal rim of the excised cusp with a single row of interrupted sutures placed prior to lowering the valve into position. Autograft aortic cusps have been inserted in a series of dogs, allowing functional, gross, and microscopic examination of the valves at regular intervals up to four months postoperatively. Clinical application of this method appears to be warranted.

### **27. Deterioration of Formalin-Treated Aortic Valve Heterografts**

WALLY S. BUCH,\* JON C. KOSEK,\* and WILLIAM W. ANGELL,\*  
Palo Alto, Calif.

Sponsored by NORMAN E. SHUMWAY

The superiority of fresh aortic valve homografts has been demonstrated by their low failure rate and lack of thromboembolic complications without adjunctive anticoagulant therapy. Difficulties in procurement and storage of this viable tissue prevent widespread use. Heterograft valves treated with 4% formalin have been used elsewhere with good initial results. We implanted supported formalinized porcine heterograft valves into the mitral position of 50 dogs. These valves functioned well initially. This prompted trial in 27 patients. Initial hemodynamic results were excellent; however, 25 percent failed during a 7-month follow-up, and were replaced successfully. They were weakened, thinned, stretched, and torn. Electron micrographs showed macrophage ingestion of portions of the otherwise acellular cusps. This correlated well with the late experimental results. Other methods of formalinization were therefore evaluated experimentally. Three separate heterograft cusps treated in different ways were reconstructed into a composite valve and placed in 60 dogs. Variations of formalin concentration (1/2, 4, 10%), pH (4.0, 5.6, 7.4), temperature (4°, 20°, 37°C), and storage time (2, 30, 60 days) produced no improvement in long-term function. We conclude that formalin is a weak, destructive, unreliable tanning agent for preservation of heterograft aortic valves.

### **28. Left Ventricular Akinesia: Experimental Production, Hemo-dynamic Effects, and Results of Excision**

P. C. PAIROLERO,\* B. D. MCCALLISTER,\* F. J. HALLERMANN,\*  
and F. H. ELLIS, JR., Rochester, Minn.

A technique of producing canine myocardial infarcts of predictable size has been developed which results in chronic survival and in left ventricular (LV) non-contractility as confirmed by cineangiography. Infarcts were produced in 28 dogs and were excised either 3 to 5 days later (8 dogs) or 4 to 6 weeks later (20 dogs). Hemodynamics were measured before and after excision of the infarct at rest (R), and during infusion of acetylcholine (Ac), angiotensin II (Ag), and isoproterenol (I). These findings were compared with normal values and with those from 5 dogs in whom a segment (3 x 4cm.) of normal myocardium was excised. Excision of normal myocardium was poorly tolerated, 4 dogs dying of pulmonary edema. Small infarcts (1 x 2cm, 8 dogs) produced no change in hemo-dynamics either before or after excision. Large infarcts (3 x 4cm., 20 dogs) resulted in a significant increase (P .001) in LV end-diastolic pressure which remained elevated after excision in the 10 survivors. The response of cardiac output to Ac and I was also abnormal (P .001) but remained so after excision. Neither early nor late excision of experimentally produced LV akinesia resulted in improvement of LV function as measured by the parameters analyzed in this study.

## **29. Myocardial Metablism in Acute Regional Ischemia**

HENDRICK B. EARNER,\* GEORGE C. KAISER, MAX JELLINEK,\*  
AKIRA TAIRA,\* and VALLEE L. WILLMAN, St. Louis, Mo.

Regional myocardial ischemia was studied in ten anesthetized dogs using the right heart bypass preparation so that cardiac output, heart rate and aortic pressure could be independently controlled. A snare was placed on the left anterior descending coronary artery for occlusion. The coronary sinus was catheterized and arteriovenous levels of oxygen, lactate and pyruvate and glucose were measured every 15 seconds using an automated system during one, five and 15 minute periods of LAD occlusion. One minute of LAD occlusion resulted in a fall in total coronary flow (TCF) and a comparable fall in substrate utilization. Longer LAD occlusion was associated with slowly rising TGF, oxygen and pyruvate uptake and gradually diminishing lactate utilization. Release of the snare caused reactive hyperemia with increased TCF, oxygen and pyruvate uptake and washout of lactate from the ischemic myocardium. Consumption of lactate was rapidly restored while pyruvate utilization fell. Although lactate production is a well recognized sign of severe myocardial ischemia its detection may be extremely difficult during regional ischemia, even under relatively ideal experimental conditions. Absent lactate production does not exclude the presence of severe local ischemia.

## **30. Mapping of Epicardial and Intramural Activation of the Heart: A Technique for Localization and Extent of Chronic Infarction During Myocardial Revascularization**

THOMAS M. DANIEL,\* JIMMY L. COX,\* DAVID C. SABISTON, JR.,  
and JOHN P. BOINEAU,\* Durham, N.C.

Areas of chronic infarction in coronary artery disease may be multiple and difficult to recognize by visual examination or palpation of the epicardium. In addition, coronary arteriograms do not define the site or degree of myocardial infarction. By the direct recording of unipolar and bipolar potentials from the epicardial surface at operation, the underlying areas of infarction can be delineated with accuracy. This information assists in the determination of sites for revascularization. Mapping of activation is regarded as a potential aid for other surgical procedures on the heart and as a technique for estimating the amount of intrinsic heart disease present and thereby increasing the predictability of postoperative results. Eight human subjects were studied at the time of revascularization procedures. Comparative epicardial data was also obtained from normal hearts during thoracotomy for pulmonary disease, and the normal variations in Q-wave duration were determined for the human epicardial surface. Similar variations in epicardial activation time were also determined. Abnormal prolongation of either Q duration or activation time, or both, were used to delineate areas of underlying chronic infarction. The significance of these changes was validated by detailed anatomic-electrophysiologic correlations in a canine model with chronic experimental myocardial infarction. The technic has been of considerable clinical usefulness at the time of operation.

## **31. Operative Assessment of Ventricular Aneurysm and Adynamic Myocardium**

TED A. CALINOG,\* V. S. MEHTA,\* S. TJONNELAND,\* FRANK BEGG,\*  
W. CUSHING,\* EDWARD KENT, and GEORGE J. MAGOVERN,  
Pittsburgh, Pa.

Preoperative evaluation of the extent of damaged myocardium is difficult even with present-day techniques of cardioangiography and electrocardiography. The operative assessment of ventricular aneurysm and akinetic areas is a difficult task for the surgeon faced with preserving functioning myocardium vital to the hemodynamic workload of the ventricle. We have found two valuable intraoperative procedures which can easily be applied. (1) Creating an intraluminal negative pressure in the ventricle and (2) electrophysiologic technique utilizing epicardial electrogram with unipolar and bipolar electrodes. The patient is placed on cardiopulmonary bypass and a vent inserted in the left ventricle through the left atrial appendage. A negative pressure of 30 mm. of Hg. is applied. Gross collapse of the aneurysmal and adynamic areas can be appreciated with clearcut delineation of its margins. Epicardial electrogram with unipolar and bipolar electrode probes are applied at these margins. A precise line of resection can be shown, thus preserving viable functioning tissue. Techniques, experimental assessment, development, and clinical application will be presented. Seven patients to date have had successful resection based on this method. The use of the epicardial electrogram has further extended to selection of a vascular areas for myocardial revascularization. The technique and results, likewise, will be shown.

\*By Invitation

## TUESDAY AFTERNOON, APRIL 7, 1970

**2:00 P.M. Executive Session (Limited to Active and Senior Members)**  
**International Ballroom Center**

**3:00 P.M. Scientific Session: REGULAR PROGRAM**  
**International Ballroom Center**

*Address by the President*

**Hiram T. Langston Chicago, Illinois**  
**" - Of Cabbages and Kings"**

*Address by the Honored Speaker*

**Leo Eloesser**  
**Tacambaro, Michoacan, Mexico**  
**"Milestones in Chest Surgery"**

*Milestones that have marked new paths in chest surgery, impulses and landmarks that guided their finders, and incidents of their discovery.*

### **32. A New Reconstructive Operation for Correction of Mitral and Tricuspid Insufficiency**

ALAIN CARPENTIER,\* Paris, France

Sponsored by DWIGHT C. MCGOON

The palliative nature of the reconstructive procedures actually used for the treatment of mitral or tricuspid insufficiency, is probably responsible for a somewhat high percentage of recurrent systolic regurgitation. A systematic attack of this problem was undertaken by careful analysis of the anatomical and functional disorders observed in such diseases, and a reconstructive operation to correct them was devised, using prosthetic rings suitably shaped and sized. This "semi-prosthetic" repair of the valve corrects the triad of defects that usually exists in a pure mitral insufficiency: (1) Backward position of the aortic leaflet (2) Enlargement of the commissure (3) Dilatation of the mitral annulus. This can be automatically achieved without reducing the normal orifice area nor altering the leaflet motion. In addition the use of a semi-rigid prosthetic ring prevents the risk of persistent dilatation of the annulus which is generally responsible for the recurrent insufficiency frequently observed in patients operated upon with usual techniques. Anticoagulant therapy is not required since the prosthetic ring is extremely thin and cloth covered. The same concept has been extended to the treatment of the tricuspid insufficiency and the mitral insufficiency due to ruptured chordae, or associated with mitral stenosis. Since October 1968, 30 patients were operated on using these techniques. Clinical results and hemodynamics findings will be presented.

### **33. The Comparison of Late Results of Reconstructive and Replacement Procedures for Acquired Mitral Lesions**

WILLIAM J. KERTH, GIRIDHARI SHARMA,\* J. DONALD HILL,\*

and FRANK GERBODE, San Francisco, Calif.

From 1957 to 1969, 430 open heart operations have been performed for acquired mitral valve lesions at this center. Before the availability of prosthetic valves, 76 valvuloplastic procedures were done for predominant mitral insufficiency. After 1962, 354 operations consisting of 211 valve replacements and 143 reconstructive procedures were performed. Early hospital mortality and the late results of surgery have been compared by the actuarial method after a follow-up up to 11 years for reconstructive procedures and seven years for mitral valve replacement. Hemodynamic data are available in 27 patients after valvuloplasty and 41 patients who had valve replacement. Comparison is also made with regard to the findings at 51 reoperations, (28 for reconstructive and 23 for replacement procedures), the incidence of early and late complications, and the functional status of patients after surgery. Valvuloplasty is the procedure of choice for mitral insufficiency due to ruptured chordae of the posterior leaflet and in cases with a significant cleft in the posterior leaflet as the cause of insufficiency. It still has a good deal of merit in other selected cases of pure mitral insufficiency in absence of stenosis, calcification and fibrosis. Long-term survival was better with reconstruction than with mitral replacement with the prostheses available at the time of these replacements.

\*By Invitation

## TUESDAY EVENING, APRIL 7, 1970

### 7:00 P.M. Reception

International Ballroom Center

### 8:00 P.M. Dinner and Dancing

International Ballroom Center

Attendance limited to Members of the Association and their ladies, Invited

Speakers and their ladies, Invited Guests and their ladies

Dinner dress preferred

## WEDNESDAY MORNING, APRIL 8, 1970

### 8:30 A.M. Scientific Session: THORACIC SURGERY FORUM

International Ballroom Center

#### 34. Synthetic Blood

LELAND C. CLARK, JR.,\* SAMUEL KAPLAN,\* and FERNANDO BECATTINI,\*

Cincinnati, Ohio

Sponsored by JAMES A. HELMSWORTH

The discovery by Clark that silicone oils and certain perfluorinated liquids can transfer enough oxygen and carbon dioxide to sustain the life of animals breathing them suggests that they may serve in some form as valuable intracorporeal gas transfer agents. Such preparations may be useful in organ preservation, perfusion experiments, and even as emergency blood because, besides being able to contain at least 20 volumes % oxygen, they may be stored and they can be autoclaved. Emulsions of inert perfluorinated organics prepared by sonication of the fluorocarbon in Ringer's and other isotonic solutions containing surfactants, separately proven to be non-toxic, were shown to be excellent substitutes or adjuvants for natural blood. It is theoretically and experimentally demonstrable that such emulsions increase mixed venous and tissue oxygen tensions and are able to sustain life. The fate and half-life of the artificial blood will be reported together with experiments where these emulsions were given to mice, cats, and dogs while blood gas, tissue oxygen tension changes, and survival were tested. There was no problem with carbon dioxide transport and mixed venous  $p\text{CO}_2$  tensions as high as 300 mm. could be obtained.

#### 35. Negligible Hemolysis in Lande'-Edwards Membrane Oxygenator, Especially at Physiological Gas Tensions

ALBERT VERVLOET,\* MILES J. EDWARDS,\* and M. LOWELL EDWARDS,\*

Portland, Ore.

Sponsored by ALBERT STARR

Blood damage has limited the use of external gas exchangers. Blood and gas are separated by membranes of silicon rubber in the Lande'-Edwards oxygenator. We tested a small prototype of this oxygenator at flows of 250 ml/min using 250 ml of fresh heparinized human blood at 37°C for 24 hours *in vitro*. We compared three gas mixtures: (1) 21%  $\text{O}_2$  and 6%  $\text{CO}_2$  ("PHYS"  $\text{O}_2$ - $\text{CO}_2$ ); (2) 94%  $\text{O}_2$  and 6%  $\text{CO}_2$  (HIGH  $\text{O}_2$ ); (3) 21%  $\text{O}_2$  and 0%  $\text{CO}_2$  (LOW  $\text{CO}_2$ ). At 8 hours, the per cent hemolysis was (mean  $\pm$  S.D.): "PHYS"  $\text{O}_2$ - $\text{CO}_2$  =  $0.36 \pm 0.09$  (n = 4); HIGH  $\text{O}_2$  =  $0.59 \pm 0.15$  (n = 4); LOW  $\text{CO}_2$  =  $0.69 \pm 0.16$  (n = 3). Hemolysis with "PHYS"  $\text{O}_2$ - $\text{CO}_2$  only slightly exceeded the 0.28% expected *in vivo* and was significantly less than with either HIGH  $\text{O}_2$  or LOW  $\text{CO}_2$  ( $P < 0.01$ ). On microscopy, there was much greater damage to both erythrocytes and leukocytes with HIGH  $\text{O}_2$  or LOW  $\text{CO}_2$  than with "PHYS"  $\text{O}_2$ - $\text{CO}_2$ . This oxygenator causes little apparent blood cell damage. Prolonged exposure to either high  $\text{O}_2$  or low  $\text{CO}_2$  damages blood.

### **36. Partial Cardiopulmonary Bypass Lasting up to Seven Days in Alert Lambs with Membrane Lung Blood Oxygenation**

THEODOR KOLOBOW,\* ROBERT L. SIGMAN,\* WARREN M. ZAPOL,\*

and JOSEPH PIERCE, Bethesda, Md.

Sponsored by ROBERT L. REIS

Alert, unsedated, tethered 7-12 kg. lambs were subject to continuous 5-7 day veno-arterial perfusion with membrane lung blood oxygenation, with survival. Blood was drained from the inferior vena cava and right atrium into a closed reservoir through a non-kinking, large bore polyurethane catheter; it was then pumped by a non-occlusive roller pump through a fixed prime volume spiral silicone membrane oxygenator and returned to the common carotid artery. Heparin was infused at 1.5 mg/ (kg)(hr). Extracorporeal blood flow averaged 35-65 cc/(kg) (min). Plasma free hemoglobin remained below 5 mg%. Blood hemoglobin decreased by 1 gm% per day due to blood sampling. Platelet counts averaged 400,000/mm<sup>3</sup>. WBC counts averaged 13,000/mm<sup>3</sup>. Venous pH, pCO<sub>2</sub> and pO<sub>2</sub> remained at control values throughout. Cardiac output with pump temporarily off remained at control values of about 200 cc/(kg) (min). LVEDP after prolonged pumping ranged between 5 and 10 mm. Hg. Central venous pressure was always less than 5 mm. Hg. Institution of bypass slowed the heart by 20-30% with a transient 10-20 mm. Hg. rise in mean BP. Heart, lungs, and other internal organs of perfused animals grossly appeared normal. We conclude that in alert lambs continuous partial non-pulsatile long-term cardiopulmonary bypass with silicone membrane blood oxygenation is possible without producing cardiac, pulmonary, or hematologic impairment.

### **37. Prolonged Partial Cardiopulmonary Bypass and the Integrity of Small Blood Vessels: Role of Serotonin and of Platelet Transfusion**

PETER WISSELINK,\* MARIO FEOLA,\* CLARENCE P. ALFREY,\*

MINORU SUZUKI,\* J. N. ROSS, JR.,\* and JOHN H. KENNEDY,

Houston, Texas

While short-term circulatory support by means of a heart lung machine may be useful, prolonged perfusion is usually attended by increasing vascular resistance, rising perfusion pressures, decreasing flow rates, and edema. This is caused by obstruction of the microcirculation by cellular aggregates and emboli. Gimbrone et al. have demonstrated that vascular resistance and fluid accumulation were significantly lower during perfusions with platelet-rich plasma than with platelet-poor plasma in isolated organ perfusion. Preliminary experiments by one of the authors (JHK) have suggested that the Serotonin-binding capacity of platelets may be involved in their nurturing effect on vascular integrity. In 32 dogs Cardiopulmonary bypass for five hours with platelet-rich plasma and with platelet-poor plasma was carried out in normal and in splenectomized dogs. The parameters studied were: platelet counts, blood Serotonin, peripheral vascular resistance, light and electron microscopy of kidney and skin vascular endothelium. Thrombocytopenia of 50% after one hour was regularly seen in bypass controls, but not in anesthesia controls, and was accompanied by a rise in systemic vascular resistance, but a progressive decrease in Serotonin. Platelet transfusion reversed these effects. The possibility that platelet transfusion may be of benefit for clinical assisted circulation or for organ perfusion is considered.

### **38. Peristaltic Bypass-Type Heart Assist Device**

HISATERU TAKANO,\* HIROYUKI TAKAGI,\* CHARLES A. FARISH,\*

and TETSUZO AKUTSU,\* Jackson, Miss.

Sponsored by JAMES D. HARDY

In order to eliminate thrombus formation, a new bypass-type heart assist device has been designed without using a conventional type valve. The device consists of six-air driven chambers which function like a moving valve. This device can be filled simultaneously as it pumps. Synchronized pumping was done being triggered by the R-wave of the EGG. The device was implanted between the left atrium and the descending aorta. Eleven consecutive acute experiments demonstrated that this device effectively changed left ventricular pressure, femoral arterial pressure, left atrial pressure, the bypass flow, aortic root flow, and left ventricular work. Maximum bypass flow was 4.24 liters/min. The maximum decrease in aortic root flow was 105.4 per cent of control measurements. The left ventricular work, expressed by the tension-time index, was dramatically decreased. The maximum decrease was 100 per cent, being indicated by completely flat left ventricular pressure curve. Regulation of bypass flow was achieved either by changing the trigger ratio from 1:1 through 5:1 or by changing the number of pumping chambers used from six through three. When all six chambers were used at 1:1 trigger ratio, complete atrialization of the left ventricle was achieved.

### 39. Physiological Observations During Partial and Total Left Heart Bypass

WILLIAM F. BERNHARD, C. G. LAFARGE,\* M. HUSAIN,\* N. YAMAMURA,\*

and T. C. ROBINSON,\* Boston, Mass.

A previous report from this laboratory indicated that prolonged left heart bypass was possible in calves at flows up to 3.0 liters/minute. Subsequent investigations, using a larger pump (stroke volume 100 mls), were undertaken at higher flow rates (4.0-8.0 liters/minute) and continued for periods of one to four months. Prior to surgical implantation, the pump lining was primed with bovine collagen and seeded with cultured, fetal (bovine) fibroblasts. Physiological observations in these animals were made by cardiac catheterization: at rest, in left ventricular failure, and during treadmill exercise. At rest, left ventricular pressure could be reduced to zero mmHg., and end-diastolic volume decreased; in addition, cardiac output, left ventricular stroke volume, and ejection fraction were increased. Similar results were obtained during transient left ventricular failure induced by balloon-cuff coronary occlusion. During exercise, implanted electromagnetic flow probes reflected a doubling of cardiac output, with maintenance of bypass at eight liters/minute. Erythrocyte survival studies (D.F.<sup>32</sup>P.) returned to normal in 12 calves after one month of by-pass, and examination of the blood-pump interface (by light and electron microscopy) disclosed viable fibroblasts and abundant collagen fibrils (up to 130 days).

### 40. A Comparative Study of Arterio-Arterial and Intra-Aortic Balloon Counterpulsation in the Therapy of Cardiogenic Shock

WILLIAM H. FLEMING,\* and GENE V. AABY,\* Washington, D. C.

Sponsored by JUDSON G. RANDOLPH

Cardiogenic shock was produced in 30 dogs by ligation of coronary artery branches to the left ventricle, with decreases in aortic, left ventricular and coronary perfusion pressures, cardiac output by the direct Fick technique, and left ventricular work as measured by tension time index. Left ventricular end diastolic pressure and total peripheral resistance, increased. In all ten control animals these changes became increasingly severe until death within 20 hours. Treatment for one hour with arterio-arterial counterpulsation produced a reversal of all of these changes, both immediately and for 30 days thereafter. Counterpulsation by intra-aortic balloon showed the same reversal of the shock process, and the magnitude of change was very similar. This model was uniformly fatal without therapy, but there was marked improvement in pressures, cardiac output, and survival following therapy by counterpulsation by either the arterio-arterial or intra-aortic balloon technique, with most animals surviving for over 30 days.

### 41. Prosthetic Tracheal Replacement

JOHN BORRIE,\* Dunedin, New Zealand

Sponsored by HIRAM T. LANGSTON

Principles governing tracheal reconstruction are reviewed against a 15-year experience of replacing long tracheal defects (5 cms or more). Such methods as (1) excision and suture alone, (2) suturing with lateral relieving incisions, (3) using ribbed Dacron or (4) Marlex mesh prostheses have all been tested and rejected. The first method produced strictures, the second usually necrosis and strictures. Dacron or Marlex prostheses either collapsed or developed fatal tracheo-prosthetic suture line stenosis, usually within 28 days. A 5 cm long Silastic and Dacron mesh prosthesis, with terminal Dacron suturing cuffs, gave an average of 42 days survival before fatal stenosis occurred, again at the tracheo-prosthetic suture line. As clinically, tracheal strictures in infants can be successfully held dilated by indwelling polythene stents, the Silastic prosthesis was modified by recessing the Dacron suture-cuff one centimeter from each end of the prosthesis. Of six experiments, all survived beyond 100 days. There were two late deaths, (1) after 108 days - peri-prosthetic abscess, (2) after 152 days - intratracheal haemorrhage. Two developed some granulation at one end of the prosthesis, controlled by bronchoscopy and silver nitrate cauterisation. Two remain uncomplicated. Further prostheses, 10 cm. cuff-to-cuff, are now being tested. This 'Dunedin-Model' Silastic prosthesis, with sub-terminal Dacron suturing cuffs has been the most promising 'Ersatz-trachea' yet tested.

### 42. Experimental Evaluation of a Radioisotope-Powered Cardiac Pacemaker

ANDREW G. MORROW, SIDNEY LEVITSKY,\* CHARLES L. MCINTOSH,\*,

VICTOR PARSONNETT,\* and PETER L. FROMMER,\* Bethesda, Md.

With the cooperation and support of the Atomic Energy Commission a nuclear-powered pacemaker has been constructed. It has a potential operating life of 11 to 20 years. The fuel, <sup>238</sup>plutonium, serves as a heat source (250C.). A thermopile, consisting of glass tapes incorporating metallic thermocouple wires, provides direct thermo-electric conversion; 200 microwatts are supplied to the pacemaker circuit. The fuel itself is triply encapsulated, and provided with thermal and radiation shields; there is insignificant heat and radioactivity externally. The entire unit is enclosed in an evacuated, hermetically-sealed titanium case, which is the anode. The unipolar stimulating electrode (cathode) is connected via a

ceramic-to-metal feedthrough. The unit weighs 100 g., and is comparable in size to conventional pacemakers. Three prototype units have been implanted in dogs for periods up to 6 months. There have been no changes in rate or stimulus artifact amplitude and configuration, and pacing has been maintained continuously. Early clinical application of the device is anticipated.

#### **43. Quantitation of Red Blood Cell Destruction Associated with Valvular Disease and Prosthetic Valves**

HERBERT W. WALLACE,\* and WILLIAM S. BLAKEMORE, Philadelphia, Pa.

A new technique of quantitating intravascular and extravascular hemolysis was applied to a study of 21 patients with aortic valvular disease who underwent open heart surgery. This method involves measurements of endogenous carbon monoxide production ( $V_{co}$ ), which has been correlated quantitatively with heme catabolism. Plasma hemoglobin concentrations do not reflect true RBC destruction. Of 11 patients studied preoperatively, nine patients with aortic stenosis had a mean  $V_{co}$  of 0.91 ml/hr (normal  $\approx$  0.5 ml/hr), and one of two patients with severe aortic insufficiency had an elevated  $V_{co}$  (1.02 ml/hr). Postoperative studies were performed on four patients with malfunctioning aortic prosthetic valves and 11 patients with normally-functioning prosthetic valves. Without exception, the patients with malfunctioning valves had a markedly elevated  $V_{co}$  (mean, 1.88 ml/hr), but only one had an elevated plasma hemoglobin. Six or more months postoperatively, the mean  $V_{co}$  of the patients with normally-functioning prostheses was 0.5 ml/hr, although three had above normal values. Carbon monoxide production may be related to pressure gradient or stroke volume/systolic emptying period. Thus malfunctioning valves can induce marked RBC destruction, which may be detected by this technique. This methodology should also be helpful in evaluating new designs for prosthetic valves and artificial hearts.

#### **44. Replacement of Pulmonary Artery with a Pulmonary Arterial Homograft**

S. SEKI,\* J. L. TITUS,\* and G. C. RASTELLI,\* Washington, D.C.

Sponsored by DWIGHT C. MCGOON

Truncus arteriosus, transposition of the great arteries with subpulmonary stenosis, and pulmonary atresia have been successfully corrected using aortic homografts. Calcification in the elastic tissue of these homografts has developed postoperatively. Alternative grafts with which to replace the pulmonary artery and in which calcification might not occur are being investigated. The rationale of using a pulmonary homograft is that the pulmonary artery seldom becomes calcified from age or disease and that it contains less elastin and calcium than does the aorta. The pulmonary artery was ligated and excised in 25 dogs and replaced with a homograft consisting of the pulmonary valve, the main pulmonary artery, and right and left branches which were split longitudinally and sutured together so as to produce a tubular graft of the required length. Seventeen fresh grafts and eight frozen, irradiated grafts were implanted under cardiopulmonary bypass. Fifteen dogs are currently alive 2 weeks to 6 months after operation. Histologically these homografts are free of calcification 6 months after operation. This contrasts with the fate of aortic homografts which were used to replace the canine pulmonary artery and in which medial calcification had occurred by this time. Follow-up studies including hemodynamic data will be presented.

#### **45. Immediate Function with Survival Following Left Lung Autotransplantation and Contralateral Pulmonary Artery Ligation in the Baboon**

WILLIAM L. JOSEPH,\* and DONALD L. MORTON,\* Bethesda, Md.

Sponsored by PAUL C. ADKINS

Until recently there have been no survivors after lung transplantation in the dog followed immediately by Contralateral pneumonectomy or ligation of the opposite pulmonary artery (PA). However, in clinical transplantation immediate function of the grafted lung will be necessary. Recently, Veith has reported a few survivors in dogs with angioplastic reconstruction of the pulmonary artery anastomosis to prevent subsequent PA hypertension. Left lung autotransplants *without* angioplastic reconstruction of the PA and with immediate Contralateral PA ligation were performed in 16 baboons. Postoperative differential bronchspirometry showed good function on the left; none on the right. Four died postoperatively while 12 are still alive at up to 10 weeks. Systemic arterial blood gas studies following transplantation (average:  $P_{O_2}$  87 mm.Hg;  $pCO_2$  35 mm.Hg.) showed little change from preoperative values. Serial PA pressures showed a minimal rise in 6 baboons (average: 31/11 mm.Hg.) but all returned to normal within 14 days. Six had almost no change (average postoperative value 24/11 mm.Hg.). Lung autotransplantation with immediate function and survival is possible without the development of a sustained elevated PA pressure. The baboon appears to be a better animal for use in physiologic lung transplantation studies since it is probably more representative of man than the dog.

#### **46. The Significance of the Bronchial Arterial Circulation in Lung Transplantation**

NOEL L. MILLS,\* ARTHUR D. BOYD,\* and CHARUN GHERUNPONO,\*

New York, N.Y.

Sponsored by FRANK C. SPENCER

This study was prompted by the uncertain consequences of interrupting the bronchial circulation at the time of lung transplantation. In reported experimental series without reconstitution of the bronchial arteries, the bronchial anastomosis complication rate has been 20 per cent or higher. If the incidence of significant bronchial complications in human lung allografts is as high and unpredictable as in dogs, bronchial circulatory reconstitution will be needed. In 50 postmortem dogs the anatomic patterns of the bronchial arterial supply to the left lung were classified by location and injection studies were performed. With this background, left lung allotransplantation was performed in 21 dogs in whom rejection was suppressed with Imuran. In 10 animals the bronchial circulation was reestablished while in 11 control animals it was not. In 82% of the control group bronchial complications, including ulceration (64%), stenosis (9%), and disruption (27%) occurred. This included disruption of the anastomosis in one animal (bronchial artery occluded) and ulceration in another. A review of the experiences with human lung transplantation with reference to bronchial complications will be included in the report.

\*By Invitation

## **WEDNESDAY AFTERNOON, APRIL 8, 1970**

### **2:00 P.M. Scientific Session: REGULAR PROGRAM**

#### **International Ballroom Center**

#### **47. Prognostic Significance of Tumor Doubling Time in Evaluating Operability in Pulmonary Metastatic Disease**

DONALD L. MORTON,\* WILLIAM L. JOSEPH,\* and PAUL C. ADKINS

Washington, D. C.

Although arbitrary criteria have been suggested for evaluating operability in metastatic pulmonary disease, the results after resection based on these criteria are often disappointing. A more uniform and precise method is needed in predicting survival. Tumor doubling time (TDT) was measured in 92 patients with pulmonary metastatic lesions after control of their primary. Sixty-eight had no treatment for their pulmonary spread, while 24 had some type of resection. In 58 individuals whose TDT was less than 20 days, the median interval between resection of the primary and the appearance of pulmonary metastasis was 4.5 months; 68% survived 6 months, 9%, one year. In the remaining patients with a TDT greater than 20 days the median interval between the primary lesion and onset of metastasis was 1.2 years; 90% were alive at 6 months, 76% at one year. Those patients with a TDT greater than 40 days had an unusually good result following pulmonary resection even when bilateral thoracotomy was necessary. Tumor doubling time appears to be an accurate method for quantitation of tumor growth and an important criteria for evaluating operability. This study suggests a more aggressive approach should be used in patients with metastatic pulmonary disease having prolonged doubling times.

#### **48. Primary Sarcoma of Lung**

NAEL MARTINI,\* STEVEN I. HAJDU,\* and EDWARD J. BEATTIE, JR.,

New York, N.Y.

From 1926 to 1968 there were 42 primary sarcomas of the lung seen at the Memorial Hospital. In this interval 5714 new lung tumors were seen, indicating the sarcoma to be 0.74% incidence. Twenty patients had lymphoma confined to the lung and 22 had a variety of soft tissue sarcomas (leiomyosarcoma, rhabdomyosarcoma, spindle cell sarcoma and angiosarcoma) also confined to the lung. No patient was lost to follow-up. Ten of 22 lymphomas had no recurrence of disease after treatment. Seven of these were free of disease for 6 ½ to 27 years. Three of seven leiomyosarcomas were well for 14, 16 and 20 years respectively, but none of 13 other soft tissue sarcomas remained free of disease. Review of this material is interpreted to show: 1. One cannot be certain from limited histologic material as to the primary site. The correct diagnosis is confirmed by thorough study of the patient and careful observation of his course. 2. In lymphoma the prognosis is not accurately predicted by the histologic examination alone. 3. In contrast, the histologic cell type of soft tissue sarcoma can be recognized and is of the utmost importance for prognosis. 4. Complete surgical excision is the treatment of choice.

#### **49. Primary Pulmonary Cryptococcosis**

CHARLES R. HATCHER, JR., JAGJIT S. SEHDEVA,\* VICTOR SCHULZE,\*

WILLIAM D LOGAN, JR., P. N. SYMBAS, and OSLER A. ABBOTT,



Atlanta, Ga.

Human infection with *Cryptococcus Neoformans*, once thought to be a rare disease, is being recognized and treated with increasing frequency. Although the portal of entry is most likely the lungs, the isolated pulmonary forms of the disease account for only 10% of proven cases. The best opportunity for rapid and permanent cure of cryptococcal infection lies in the diagnosis and treatment of the primary infection of the lungs. Experience with twenty-four cases of primary pulmonary cryptococcosis diagnosed and treated at Emory University between 1952 and 1969 forms the basis of this report. Epidemiology, clinical and laboratory diagnosis, differential diagnosis, and results of medical and surgical treatment are presented. A high index of suspicion and diligent diagnostic efforts are required to make the diagnosis of cryptococcal infection without thoracotomy. Local and disseminated forms of pulmonary infection required a variety of surgical procedures. Amphotericin B is of value in the management of certain forms of infection and in prevention of dissemination. With an aggressive medical-surgical approach, pulmonary cryptococcosis was controlled in all cases with ultimate survival of these patients.

## **50. Gastroplasty: An Operation for the Management of Peptic Stricture with Acquired Short Esophagus**

F. G. PEARSON, B. LANOER,\* and R. D. HENDERSON,\*

Toronto, Ontario, Canada

The optimal correction of peptic stricture with acquired short esophagus requires restoration of normal swallowing and prevention of gastro-esophageal reflux. Sufficient esophageal shortening precludes control of reflux by standard techniques of hernia repair. Esophageal resection and interposition of bowel is accompanied by significant mortality and morbidity, and in our experience a normal swallowing mechanism is not usually achieved. In 1957 Collis described the operation of gastroplasty, in which normal esophageal length is restored by creating a tube from lesser curve of stomach in continuity with distal esophagus. Effective hernia repair is now possible, and further reflux prevented. Esophagitis resolves and stricture is well managed by dilatation. During the past six years at Toronto General Hospital, 16 patients with peptic stricture and acquired short esophagus were managed by gastroplasty combined with a Belsey hiatus hernia repair. Results of treatment were assessed by history, cine-barium esophagograms, esophagoscopy and esophageal manometry. There was no operative mortality. No patient has symptomatic or radiologically demonstrable reflux, and the esophagogastric "valve mechanism" was competent by manometric analysis. Esophagitis and stricture resolved to the extent that 12 of 16 patients now experience normal swallowing and require no further dilatation. 4 recent patients still require postoperative dilatation.

## **51. Correction of Heart Disease in Infancy Utilizing Deep Hypothermia and Total Circulatory Arrest**

D. H. DILLARD, HITOSHI MOHRI,\* and K. A. MERENDINO,

Seattle, Wash.

Correction of cardiac lesions in infancy results in a greater salvage of life and reduces emotional and financial stress for the family. During the past four years 14 critically ill infants with complex cardiac lesions were totally corrected utilizing surface induced deep hypothermia to 17° to 20°C with total circulatory arrest for 20 to 57 minutes. Management is simplified by avoidance of perfusion and heparin. Infants ranged from 3 days to 19 months and 2.2 to 8.8 kilograms. A total of 30 patients were operated, 25 of which were potentially correctable. Of these 6 of 7 patients with transposition of the great arteries (86%) and 5 of 8 patients with total anomalous pulmonary venous drainage (62%) were salvaged. Other lesions treated successfully included pulmonary atresia and ventricular septal defects. There were no failures and no nervous system damage thought to be related to the technic of hypothermia. All corrected patients resuscitated without ventricular fibrillation. We believe that the procedure of choice in infants dying with correctable lesions is an attempt at total correction under surface hypothermia. The use of a surgical palliative procedure requiring a second corrective procedure at a later date is often needless and inappropriate.

## **52. Surgical Correction of Congenital Pulmonary Atresia with Ventricular Septal Defect**

NICHOLAS T. KOUCHOUKOS,\* ALBERTO BARCIA,\*

LIONEL M. BARGERON,\* and JOHN W. KIRKLIN,

Birmingham, Ala.

Seven patients with congenital pulmonary atresia and ventricular septal defect have been operated upon by us since April, 1964. Five patients have survived. In this entity, the infundibulum of the right ventricle is absent or severely underdeveloped, there is no connection between right ventricle and pulmonary artery, and the ventricular septal defect is large. The pulmonary artery may arise from aorta (truncus arteriosus) from ductus arteriosus (pseudotruncus) or it may be absent with right and left pulmonary arteries (or simply collateral vessels) arising directly from the aorta. The operation consists of closure of the ventricular septal defect, interruption of the major aortico-pulmonary connections, and interposition of a conduit between the right ventricle and pulmonary arteries. In the first four patients, the conduit was a

tube of pericardium or woven Teflon without a valve. In the last three patients, it was an aortic homograft with its valve or a Dacron tube with an aortic homograft valve within it. The latter is presently preferred. Naturally occurring or surgically created aortico-pulmonary anastomoses may make operation difficult. Precise angiographic definition of the anatomy is essential. Late results have been excellent except in one early case in which the conduit did not contain a valve.

### **53. Pulmonary Atresia with Intact Ventricular Septum**

FREDERICK O. BOWMAN, JR., JAMES R. MALM, CONSTANCE J. HAYES,\*

WELTON M. GERSONY,\* and KENT ELLIS,\* New York, N.Y.

In the neonatal age, results of surgery for pulmonary atresia with intact ventricular septum have been generally poor up to the present time. Pulmonic valvulotomy has produced only occasional success. More rewarding results have been obtained by systemic-pulmonary artery shunts to increase pulmonary blood flow. Recently, an operative approach has been used which allows both pulmonic valvulotomy for right ventricular decompression and an aortic-pulmonary artery (Waterston) shunt to increase pulmonary flow. In the past five years, 15 patients under two weeks of age with pulmonary atresia and intact ventricular septum have been admitted to Columbia-Presbyterian Medical Center. Surgery was performed on 12 patients with 7 survivors. Six of 7 patients on whom a shunt was performed, with or without valvulotomy, survived. The single patient who survived valvulotomy alone required a shunt before one year of age. Late total correction was attempted in 2 patients with one survivor. The variable anatomy encountered should influence the operation performed. Abnormal right ventricular function and abnormal tricuspid valvular function must be considered in addition to the pulmonary valve atresia.

### **54. Repair of Transposition of Great Vessels by Transposition of Venous Return: Surgical Considerations and Results of Operation**

GORDON K. DANIELSON, DOUGLAS D. MAIR,\* PATRICK A. ONGLEY,\*

ROBERT B. WALLACE, and DWIGHT C. MCGOON, Rochester, Minn.

Sixty-nine patients underwent correction of transposition of the great vessels (TGV) by venous transposition (Mustard procedure). Ages ranged from 8 months to 19 years (median 4 years), and 29 had prior palliative operations. Operative mortality was 12% to 25 patients without ventricular septal defect (VSD), 54% for 28 patients with large VSD, and 40% for 15 patients with large VSD and severe pulmonic stenosis (PS). One patient with severe PS and intact ventricular septum also died. In patients without severe PS, absolute pulmonary vascular resistance (APVR) and pulmonary vein-to-artery oxygen content difference (PVAD) were useful criteria for determining operability. Twenty-six of 38 patients (68%) with an APVR of 10 units or less and a PVAD of less than 2.4 vol % survived operation, whereas all patients with higher values died. Three late deaths occurred; 95% of the survivors are clinically well. These data indicate that TGV without PS can be repaired satisfactorily in patients with or without VSD if the above criteria of operability are met. Patients with VSD and severe sub-valvular PS are best treated by diversion of the left ventricle to the aorta and aortic homograft reconstruction of the right ventricular outflow tract.

\*By Invitation

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