

1971 ANNUAL MEETING PROGRAM



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MONDAY MORNING, APRIL 26, 1971

8:30 A.M. Business Session (Limited to Members) Phoenix Ballroom

8:45 A.M. Scientific Session: REGULAR PROGRAM Phoenix Ballroom

1. Frame Mounted Homografts for Mitral Valve Replacement

S. C. LENNOX* (Evarts A. Graham Traveling Fellow, 1964-65),
A. BLESOVSKY* (Evarts A. Graham Traveling Fellow, 1965-66),
V. P. CHANG,* W. P. CLELAND,* and P. E. GHADIALI,* London, England
Sponsored by Herbert Sloan

The fate of frame mounted homografts in the mitral area has not been fully established. To simplify the assessment we have selected only those patients who had a lone mitral valve replacement. Since October 1968 there have been 100 such patients, 65 women and 35 men. Their ages ranged from 14 to 69 with a mean of 46. Twenty-seven patients had from one to four previous mitral operations. Although experience led to minor modifications essentially four different types of valve were used. These were (1) formalin preserved aortic homografts (2) formalin preserved pulmonary homografts (3) aortic homografts stored in antibiotic solution at low temperature and (4) pulmonary homografts similarly prepared. The homografts were mounted on a dacron covered titanium frame. Initial results were good. The hospital mortality was 7% and there have been no known embolic episodes despite the absence of anticoagulants. A detailed follow-up of these patients will be given including some post-operative haemodynamic studies and the results will be correlated with the type of valve used. So far 41 patients have shown valve dysfunction ranging from symptomless systolic murmurs to severe mitral regurgitation requiring re-operation. The lesions of the excised valves which include thinning, tears, perforations and detachment of the cusps will be described in detail.

2. A Five Year Experience with the Cutter-Smeloff Mitral Prosthesis

BENSON B. ROE, L. HENRY EDMUNDS, JR., NOEL H. FISHMAN,*
and J. C. HUTCHINSON,* San Francisco, California

A 6 month to 5 year review of 119 consecutive adult patients who had mitral valve replacement with the Cutter-Smeloff prosthesis reveals a 10% operative mortality and a 12% late mortality. Of 62 patients over 3 years postoperative, 46 (75%) remain well. Thromboembolic complications of which 15 were cerebral vascular occlusion preceded operation in 44 (37%) patients. In 3508 patient-months of follow-up 10 patients have reported neurological symptoms of which 5 were transient. One late death was due to cerebral occlusion. All patients were anticoagulated, but recommended doses were frequently not maintained. Neither valve dysfunction, atrial thrombus nor peripheral emboli were found at autopsy in 12 of 14 late deaths. Paravalvular leak was demonstrated in 3 patients: twice clinically and once at autopsy. Possibly this experience compares favorably with other reports because of superiority of the prosthesis itself. During this study 21 patients had mitral replacement with Davila, Kay-Shiley, or Wada prostheses resulting in higher morbidity and mortality. Subannular placement of the prosthetic cuff may contribute to the low incidence of thromboembolic complications and paravalvular leak in patients with Cutter-Smeloff mitral valve prostheses.

3. Closed Valvulotomy for Calcific Mitral Stenosis

GORDON N. OLIXGER,* FRED W. Rio,* and JAMES V. MALOXEY, JR.,
Los Angeles, California

It is the consensus among cardiac surgeons that mitral stenosis with moderate or heavy calcification should be treated by prosthetic replacement of the valve by the open operative technique. It is the purpose of this presentation to provide objective evidence that this widely held view may be incorrect. Twenty-three patients with moderate or heavy calcification were operated upon by the closed method, and followed an average of 5.5 years (2 to 14). The results have been compared with all data available in the literature (2000 cases) on patients with prosthetic replacement. The closed method had a hospital mortality of 0% vs. 19%; probability of four year survival 0.89 vs. 0.60; and a lower incidence embolism and perivalvular insufficiency. Three patients who developed restenosis in the 7th, 9th, and 14th years have had a second valvulotomy by the closed method and are living and well (one other patient had a prosthetic valve replacement elsewhere in the 11th postoperative year). It is concluded that if the calcified, autogenous mitral valve can be made to function by the closed valvulotomy method, the immediate and long-term results are superior to those achieved by replacement with a prosthetic valve.

4. Open Mitral Commissurotomy: Results of 100 Consecutive Cases

SOHRAB GERAMI,* BRUNO J. MESSMER,* GRADY L. HALLMAX
and DENTOX A. COOLEY, Houston, Texas

The morbidity and mortality associated with early years of open heart surgery discouraged the use of mitral commissurotomy under direct vision, even though it was otherwise preferable to transventricular instrumental dilatation, which necessitated blind manipulation inside the heart. In a recent series of 100 consecutive cases of open mitral commissurotomy we had few complications and no deaths. Patients ranged in age from seven to 67 years. Thirty-six were functional class II, 62 were class III, and two were class IV. Fifty-one patients had calcification of the mitral valve, seven had thrombus in the left atrium, and six had fibrinous material on the valve. Operations were conducted at normothermia using disposable plastic bubble oxygenators primed with five percent dextrose in water. Only 13 patients received blood transfusion during operation (500 ml each). Average hospital stay was 12.6 days. Although follow-up has not been long, results are encouraging. Of 34 patients who have been followed two years or more, 32 are well and free of symptoms. We believe that "closed" techniques should be discontinued and that all mitral operations should be done under direct vision using temporary cardiopulmonary bypass.

5. Pericardiectomy for Recurrent Pericarditis

CHARLES R. HATCHER, JR., WILLIAM D. LOGAN, JR., P. N. SYMBAS,
R. BRUCF. LOGUE,* and OSLER A. ABBOTT, Atlanta, Georgia

Pericardiectomy is reserved traditionally for patients with constrictive pericarditis. In certain patients who exhibit episodes of recurrent pericarditis characterized by fever, pain, and recurrent pericardial effusion, pericardiectomy is indicated prior to the development of constriction. In the period 1963-1970, twenty-one patients underwent pericardiectomy for recurrent pericarditis at Emory University. During this interval pericardiectomy was performed in nineteen patients with constrictive pericarditis. This report details the etiology, previous medical therapy, indications for surgery, surgical technique, and follow up results obtained by pericardiectomy for recurrent pericarditis. Eighteen patients have had no further symptoms following pericardiectomy. Two patients have continued to manifest minor episodes of chest pain and fever responsive to steroids and in one patient the clinical course was unchanged by resection of diseased pericardium. A comparison is made with the operative and postoperative courses of patients in whom pericardiectomy was delayed until constriction had developed. Total pericardiectomy is a safe and effective treatment for recurrent pericarditis and in selected cases avoids the morbidity and mortality related to subsequent constriction.

6. Surgical Treatment of Mediastinal Tumors: A 40-Year Experience

ADAM R. WYCHTLIS,* W. SPENCER PAYNE, O. THERON CLAGETT, and
LEWIS B. WOOLNER,* Rochester, Minnesota

In the 40-year period, 1928 through 1968, 1,064 patients have undergone exploratory thoracotomy for the diagnosis and treatment of mediastinal tumor at the Mayo Clinic. Approximately 60% of the patients were found to have one of the commoner neoplasms: neurogenic (212), thymoma (206), or benign cysts (196). Another 30% were found to have malignant lymphoma (107), teratoma (99), granulomas (67), or intrathoracic goiter (56). The remaining 10% of the tumors proved to be some type of benign or malignant mesenchymal tumor, benign lymph node or thymic hyperplasia, meningocele, chemodectoma, parathyroid tumor, mesothelioma, or apparent primary mediastinal carcinoma. Approximately 75% of the mediastinal tumors were benign and were readily and permanently removed at operation. However, 25% of the tumors were malignant: lymphoma (107), thymoma (61), primary mediastinal carcinoma (25), neurogenic (14), mesenchymal (33), and teratoma (13). With the exception of patients with stage I (localized or unifocal) lymphoma, those with malignant mediastinal tumors had an almost universally poor prognosis. An analysis of tumors by decades indicates a progressive reduction in the size of the neoplasm encountered in more recent eras and a diminution in morbidity from huge benign neoplasms.

7. Management of Persistent Bronchopleural Fistulas

WALTER L. BARKER, L. PEN FIELD FABER, WILLIAM E. OSTERMILLER, JR.,*
HIRAM T. LANGSTON, Chicago, Illinois

Persistent bronchopleural fistulas still represent a surgical catastrophe and therapeutic challenge. Although the incidence remains small, the morbidity and inordinate hospitalization associated with this problem demand a more aggressive approach when conventional measures have failed. The present report concerns 18 cases of persistent bronchopleural fistulas closed with pedicled muscle grafts. We feel that it is important to re-emphasize this technique as a means to close persistent leaks, to obviate the necessity of drainage tubes, to remove portals of infection, and to restore more adequate ventilatory function. The principles involved in muscle grafting are primarily control of active infection and reduction in size of the empyema space. The former is accomplished with adequate drainage and antibiotics; the latter, with appropriate timing and thoracoplasty when necessary. Preoperative evaluation and the technique of muscle grafting will be illustrated. The postoperative follow-up extends from one to ten years. Permanent closure of the fistula has been obtained in fifteen of eighteen cases. Improvement in ventilatory function and resumption of normal activities has been noted.

8. The Contribution of Cuff Volume and Pressure in Tracheostomy Tube Damage

NATHANIEL P. CHING,* STEPHEN M. AYRES,* ROLAND P. PAEOLE,*
and THOMAS F. NEALON, JR., New York, New York

Postmortem examination of the tracheas of 54 patients who died in our hospital following prolonged continuous ventilatory support demonstrated substantial tracheal damage in all cases. In several instances the damage was sufficient to have directly contributed to the death of the patient. Other authors have reported serious long-term complications following tracheal intubation with cuffed tubes. The first part of the study included laboratory models and in vivo dog studies. Using conventional readily available types of cuffed tracheostomy and endotracheal tubes the pressure within the cuff and the pressure exerted by the cuff against the lateral tracheal wall were measured following the insertion of different volumes of air into

the cuffs using a wide range of tube sizes. These demonstrated considerable differences between the pressures in the cuffed tube and the pressure actually exerted against the lateral tracheal wall. Every second day the tracheas of patients being ventilated continuously have their tracheas measured and photographed. The findings are assessed in the light of the pressures exerted and the type of management of the tracheostomy tube. It would appear that a high volume-low pressure cuff minimally disturbed is the more desirable method of occluding the trachea about the tube.

9. Surgical Implications of Pulmonary Aspergilloma (Fungus Ball)

ROBERT W. SOLIT,* JOHN J. MCKEWN, JR., STANTON N. SMULLENS,*
and WILLIAM FRAIMOW, Philadelphia. Pennsylvania

The surgical significance of an intracavitary "fungus ball" or mycetoma due to Aspergillosis is emphasized because of the high incidence of massive and often fatal hemoptysis in these patients. Thirty-two patients diagnosed with this entity have been followed at Jefferson Medical College Hospital. Of this group, 19 had pulmonary tuberculosis as their underlying disease, eight had sarcoidosis. In addition, there was one case each of chronic pyogenic lung abscess, bronchial cyst, lymphoma, and chronic pneumonitis. Hemoptysis was present in 69 per cent of the patients. Operation, usually a lobectomy, was performed in 13 patients, 10 with hemoptysis, without mortality and only minor morbidity. In the group of 19 non-operative cases, there were seven deaths. Five were due to massive hemoptysis and two due to progression of primary disease. Seven of the remaining 13 non-operative cases have had hemoptysis but due to medical reasons or patient's refusal have not had operation. Because of this high incidence of massive and frequently fatal bleeding, awareness of this entity in all forms of chronic cavitary lung disease, particularly tuberculosis and sarcoidosis, is stressed. In addition, prompt operative intervention is advised before the occurrence of hemoptysis whenever a mycetoma is recognized.

* By Invitation

MONDAY AFTERNOON, APRIL 26, 1971

2:00 P.M. Scientific Session: REGULAR PROGRAM
Phoenix Ballroom

10. The Simple Approach to Direct Coronary Artery Surgery: Cleveland Clinic Experience

DONALD B EFFLER, RENE G. FAVALORO and LAURENCE K GROVES
Cleveland, Ohio

Between May 1967 and October 1970, 1,310 patients have been treated by revascularization surgery: (1) 611 patients received vein grafts to the right coronary artery (hospital mortality rate 3.8%), (2) 434 patients received bypass grafts to left coronary artery (hospital mortality rate 3.1%) and, (3) 265 patients received multiple vein grafts (hospital mortality rate 3.6%); in category (3), 42 triple vein graft procedures were performed with one hospital death. Vein graft patency rates have risen from 80% in the first 220 vein grafts to a current figure of 90%. The following factors contribute to decreasing mortality and improved results: (1) High-quality coronary arteriography. (2) Methoxyflurane anesthesia. (3) Extracorporeal circulation with hemodilution technic at normothermic level. (4) Standardization of operative techniques: incisions, cannulations and methods that provide an ideal surgical field will be described in detail. Regional hypothermia and coronary arterial perfusion are not employed. (5) Coronary vasodilators are utilized during and after surgery. (6) Postoperative management emphasizes controlled ventilation, adequate sedation, prevention or correction of hypokalemia, rapid digitalization when indicated and simple monitoring procedures. Blood volume is controlled by central venous pressure and

left atrial pressure. Continuous improvement in direct revascularization results depends upon standardization and simplification of methods employed.

11. The Safety of Ischemic Cardiac Arrest in Distal Coronary Artery Bypass

GEORGE J. REUL,* GEORGE C. MORRIS, JR., J. F. HOWELL,*
E. STANLEY CRAWFORD, FRANK M SANDIFORD,*
and DON C. WUKASCH, Houston, Texas

Ischemic cardiac arrest accomplished by occlusion of the ascending aorta during total cardiopulmonary bypass was not utilized in 30 of the first 60 patients undergoing aorta to coronary artery bypass grafts. Significant differences in the clinical course, operative mortality, postoperative electrocardiogram, and enzyme levels were not seen. Early graft patency levels in the non-ischemic arrest group, however, was less satisfactory (4 of 30 occluded). Providing the advantage of a dry immobile operative field, aortic occlusion for periods of 12 to 107 minutes was utilized in the next 400 patients. Comparison of the two groups has revealed little difference. Operative mortality due to "pump failure" has remained less than 3%, and early fatal myocardial infarction has occurred in about three percent of each group. Even though postoperative electrocardiogram patterns diagnostic of acute myocardial infarction were present in about 11% of both groups, actual clinical manifestations of non-fatal myocardial infarction occurred in only 4% of both groups. Myocardial failure or infarction could not be related to aortic occlusion time (if less than 60 minutes), or severity of coronary artery, involvement. The techniques to safely accomplishing this procedure and further comparison of the two groups will be discussed.

12. Emergency Myocardial Revascularization for Impending Infarctions and Arrhythmias

CARY J. LAMBERT,* MAURICE ADAM,* GERALD GEISLER,*
EDUARDO VERZOSA,* MANUCHER NAZARIAN,*
and BEN F MITCHEL, JR., Dallas, Texas

An analysis of 250 patients undergoing aorto-coronary vein bypass grafts revealed that 45 of these operations had been performed as semi-emergency operations. Forty-two patients were operated for "impending infarctions"; three because of uncontrollable arrhythmias; in four other patients, a combination of uncontrollable arrhythmia and impending infarction constituted the indication. Sixteen patients had single vessel disease, ten had two vessel disease and nineteen had triple vessel disease. Ventricular function was judged as good in 35 patients, fair in eight and poor in two. There was one cardiac death and one central nervous system death. One late death was due to pulmonary embolus. Thirty-six patients (80%) are asymptomatic. Six patients are considered failures; 1-overt infarction; 1-residual angina with patent vein grafts; 1-EKG changes but without symptoms; 1-RC open, LAD closed; 1-failure, redone with good results and 1-late failure at 6 months. We conclude that: (1) cineangiography can be done safely in this group of patients; (2) semi-emergency surgery has not been associated with added mortality in our hands; (3) the "preinfarctional syndrome" can be abruptly and favorably terminated by appropriate revascularization.

13. Coronary Artery Bypass Grafts for Congestive Heart Failure

FRANK C. SPENCER, GEORGE E. GREEN,* DAVID A. TICE,
and EPHRAIM GLASSMAN,* New York, New York

Numerous reports have shown the early benefits from coronary bypass grafts for angina pectoris, but the value and hazards of such grafts for congestive heart failure are uncertain. In a group of 200 patients with bypass grafts inserted for coronary arterial disease (operative mortality 9%) 21 were operated upon for

congestive failure; angina was minimal or absent. Ventriculography showed impaired contractility, elevated end diastolic pressure (20-40 mm Hg), and localized aneurysms. Mitral insufficiency, pulmonary hypertension, and hepatomegaly were present in some patients. Operative procedures included double bypass grafts, excision of paradoxical myocardial scars, and correction of mitral insufficiency. Three deaths occurred, at operation, five days, and seven weeks respectively. Moderate improvement consistently resulted but many patients remain with some disability. One late death resulted from cerebral thrombosis. Catheterization two to four months after operation in five patients found patent grafts but continued impairment in ventricular function (contractility, cardiac output, and ejection fraction). These data indicate that bypass grafting may be done for congestive heart failure without a high operative risk and with immediate symptomatic improvement. However, the long term influence on cardiac function and longevity is uncertain and remains an important consideration in evaluating indications and contraindications for bypass grafting.

14. Assessment of Myocardial Contractility after Coronary Bypass Grafts

JAMES R JUDE, RICHARD M. RUBINSON,* DAVID D. MICHIE,*
HOOSHANG BOLOOKI,* and KATHLEEN BOCABELLA,* Miami, Florida

In 6 patients with severe occlusive disease of the right and left coronary arteries, myocardial contractility as expressed by the extrapolated maximal velocity of contractile elements (V_{max}) and the calculated contractile element velocity at end diastolic pressure (VCE/EDP) were obtained during surgery using a catheter tip pressure transducer. The VCE was calculated from the isometric segment of the left ventricular pressure curve and its first derivative (dp/dt KP, $K = 28$). The studies were done prior to, during and after occlusion of the bypass grafts. Within one hour after the bypass graft in 3 patients V_{max} increased an average of 20% over the preoperative value. The 3 patients with VCE/EDP value of less than 1.0 circumference/second prior to grafting did not show any postoperative improvement in V_{max} and VCE/EDP. During temporary occlusion (3-5 min.) of the graft, there was a significant decrease in V_{max} ($P < 0.05$) and VCE/EDP ($P < 0.025$) as compared to control (the measurements made prior to occlusion.) The largest decline was noted in patients with VCE value greater than 1.1 circ/sec. After return of blood flow through the graft these parameters returned to or exceeded the control levels. No appreciable changes in the left ventricular end diastolic pressure was observed during the time of these measurements. The method provides immediate evaluation of effect on myocardial function of the operation.

15. Selectivity in the Surgical Treatment of Bronchogenic Carcinoma

DONALD L. PAULSON and HAROLD C. URSCHER, JR., Dallas, Texas

The results of surgical treatment of bronchogenic carcinoma are predetermined largely by the natural history, the stage and the extent of the lesion and less on the procedure performed. The importance of complete pretreatment assessment of prognosis is illustrated in a review of the results of treatment in 2087 cases divided approximately equally into two ten year periods, 1950-59 and 1960-69. Improved selection of patients based on location, cell type, stage and extent of the lesion, particularly by means of mediastinal exploration, resulted in a reduction of the operability rate from 49% in the fifties to 45% in the sixties, but an increase of the resectability rate from 37% to 41% of the total cases (from 75% to 91% of operated cases). Exploratory thoracotomy rate fell from 25% of those operated upon to 9% (12% of the total cases to 4%). Operative mortality remained about the same, 5%. Survival at 5 years for the operable cases including exploratory thoracotomy increased from 18% in the fifties to 35% in the sixties. Total salvage for all cases increased from 9% to 16% in the latter period.

16. Coincident Active Pulmonary Tuberculosis and Carcinoma of the Lung

WILLIAM TUNELL,* and PAUL C. ADKINS, Washington, D.C.

Delays in the diagnosis of pulmonary carcinoma continue to contribute substantially to the poor prognosis of those patients whose carcinoma co-exists with active pulmonary tuberculosis. Forty cases of co-existing active pulmonary tuberculosis and carcinoma of the lung, seen during the years 1957 through 1966 at Glen Dale Hospital, the tuberculosis facility of the District of Columbia, were analyzed in an attempt to clarify the problem posed by these coincident conditions. The diagnosis of carcinoma was strikingly delayed when comparison was made between patients with carcinoma alone and those with co-existing tuberculosis and carcinoma (average 3.4 weeks versus 16.3 weeks). In addition, the 16.3 weeks diagnostic interval exceeded that (7.1 weeks) of a group of 14 patients admitted with a diagnosis of tuberculosis but found to have carcinoma and no tuberculosis. Excepting thoracotomy, no single diagnostic modality (Papanicolaou smears, bronchoscopy, bronchial biopsy and washing, and scalene node biopsy), delineated carcinoma in more than one-third of these patients. Diagnostic thoracotomy was performed in 14 patients. Carcinoma was diagnosed in all. This study suggests undue delays were caused by preliminary diagnostic studies and that more frequent, earlier diagnostic thoracotomy is most likely to improve the diagnosis and cure of carcinoma co-existing with tuberculosis.

17. Human Experience with Pulsatile Left Heart Bypass without Anticoagulation for Thoracic Aneurysms

JOHN E. CONNOLLY, AKIO WAKABAYASHI,* JUNICHI HIRAI,*
JOHN C. GERMAN,* EDWARD A. STEMMER, and
EDWARD J. SERRES,* Irvine, California

Recently we described animal experiments in which we employed a left heart bypass system for periods up to 30 hours without anticoagulation. It consists of a pulsatile bladder pump lined by dacron velour and employs xenograft aortic valves. It is connected to the patient with tubing coated with a nonthrombogenic material of graphite-polyurethane-polyvinyl. To date we have employed this pulsatile nonthrombogenic left heart bypass in nine patients undergoing resection of thoracic aortic aneurysms, including five fusiform, three dissecting, and one post-traumatic aneurysm. No heparin was used and bypasses were up to three hours in duration. Pressures in the proximal and distal aorta were easily equalized and the patients tolerated the procedure with dramatic operative hemostasis and absence of postoperative bleeding. In the immediate postoperative period there was no evidence of renal, neurological, or cardiac impairment. Successful clinical application of athrombogenic pulsatile left heart bypass as described appears to be safer and superior to currently used methods for surgery of the thoracic aorta.

18. Clinical Experience with the Unidirectional Dual-chambered Intra-aortic Balloon Assist

DAVID BREGMAN,* ROBERT H. GOETZ,* and
DAVID STATE, Bronx, New York

Intra-aortic balloon pumping (IABP) presently appears to be the best temporary mechanical method of assisting the failing heart. A new unidirectional dual-chambered balloon has been developed which effects maximal central movement of blood in diastole producing a 66%-100% greater increment in coronary blood flow over that obtained with a single-chambered balloon of equal displacement. Four moribund, anuric patients in medically refractory cardiogenic shock with an average cardiac index of 1.03 L/M² have been assisted and hemodynamically studied to date: one has been discharged and is well for 1 year; one was successfully assisted for 15 hours but extended his infarct and succumbed; the third was assisted for 16 hours, became hemodynamically stable, but died of pulmonary and renal complications 2 days post-assist; the fourth was assisted for 11 hours, survived and was well for 1 week, but expired

suddenly. In our comatose patients the sensorium cleared rapidly, central venous pressure fell promptly (average 10 cm H₂O), and the average free plasma hemoglobin was 2.7 mgs%. One additional terminal, oliguric patient with intractable left ventricular failure 2 weeks post-myocardial infarction was successfully assisted for 14 hours. Pumping produced a prompt diuresis and the cardiac output rose from an initial 3.5 L/min. to 5.3 L/min. After angiographic studies were obtained during balloon pumping, open heart surgery was performed with the resection of an extensive left ventricular aneurysm. We believe that IABP with the dual-chambered intra-aortic balloon is the supportive treatment of choice both in medically refractory cardiogenic shock and as an adjunct to the pre- and post-operative care of selected patients requiring open heart surgery or a myocardial revascularization procedure.

*By Invitation

TUESDAY MORNING, APRIL 27, 1971

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

Phoenix Ballroom

19. New Developments in the Design of Fabric-Covered Prosthetic Heart Valves

NINA S BRAUNWALD, CONSTANTINE TATOOLE,* MARKO TURINA,*
and DON DETMER,* San Diego, California

Further improvement in the design of fabric-covered valves are essential if maximum benefit is to be derived from their use. In clinical and experimental application, a tendency toward stenosis and tissue buildup at the apex of the cage have been noted. This led to the design of a new fabric-covered, ball-valve prosthesis with an open-ended cage, tapered struts, and an ultrathin polypropylene mesh fabric covering on the inflow ring to optimize the benefits anticipated from development of tissue coverings. In vitro hemodynamic assessment of the valve in a pulse duplicator indicated that the average gradient across the mitral model averaged <5 mm Hg at flows up to 15L/min, while that across the aortic valve was <10 mm Hg at flows up to 10 L/min. Examination of valves implanted in the tricuspid and mitral annulus, in a series of 10 calves electively sacrificed up to 6 months postoperatively, demonstrated that there was less tissue buildup than in conventional models of fabric-covered, ball-valve prosthesis and the valves were free of thrombotic deposit. Clinical trial has been initiated in a series of 10 patients followed up to 6 months, and the results are promising.

20. The Flexible Stent: A New Concept in the Fabrication of Tissue Heart Valve Prostheses

ROBERT L. REIS, WARREN D. HANCOCK,* JOHN W. YARBROUOH,*
and ANDREW G. MORROW, Bethesda, Maryland

Fresh autogenous fascia lata valves and porcine aortic valves fixed in gluteraldehyde were mounted on flexible, dacron covered polypropalene stents. Fascia valves were fabricated by placement of a rectangle of fascia on a fabrication tool. The application of suction orients the fascia producing uniform prostheses rapidly. Cusp design (deep cusps, large coaptive surface) permits closure with minimal motion of the stent (<2 mm at 300 mm Hg). This small amount of stent motion reduced closing stresses on the cusps 90% as measured by a miniature strain gauge attached to the cusp. Valves of this design were evaluated in the pulse duplicator and in 15 calves and sheep, and 17 valves were implanted in patients (aortic, mitral, and tricuspid positions). All patients survived, and no prosthesis malfunction has occurred (6 months). Anticoagulants were not used, and there have been no emboli. Measurements of transvalvular gradient and cardiac output in the basal state and at different flows and heart rates, as well as assessments for valvular regurgitation, were made in each patient. Continued clinical application is planned, and the results including a comparison with the ball valve prosthesis will be presented.

21. Viability of Connective Tissue Cells Following Storage of Aortic Valve Leaflets

HITOSHI MOHRI,* DENNIS D. REICHENBACH,* MURRAY P. SANDS.*
and K. ALVIN MERENDINO, Seattle, Washington

Connective tissue cells within aortic valve leaflets maintain the structural integrity of the leaflet by synthesis and turnover of elastin, collagen and ground substance. Therefore there should be an advantage in homograft aortic valves which contain viable cells capable of maintaining graft leaflet structure. Lack of availability of fresh homograft leaflets necessitates storage of specimens. A study of canine valve leaflets was performed to ascertain the conditions and the length of storage which maintain viable connective tissue cells. Specimens were stored for various periods in saline, Ringer's lactate, Hanks' balanced salt solution, or Waymouth's tissue culture media. Storage conditions included: refrigeration, 37° in closed containers and 37° in Petri dishes in an atmosphere of 95% air, 5% CO₂. Following storage, explants of leaflets were made and outgrowth of the cells was noted. Fibroblast-like cells grew from aortic valve leaflet explants following storage of up to five weeks in warm Waymouth's tissue culture media with viable cells evident following shorter storage periods (3-7 days) in the other media. Tissue culture media is a more suitable storage agent for maintaining viable stromal cells than are simple salt solutions, and cells remain viable for longer periods of storage in a warm environment than in the cold.

22. The Role of Rejection and Mechanical Trauma on Valve Graft Viability

WALLY S. BUCH,* and WILLIAM W. ANGELL,* Palo Alto, California
Sponsored by NORMAN E. SHUMWAY

Our 4 year clinical results with viable aortic valve homografts have been gratifying. However, the ultimate effects on graft architecture of host rejection, surgical injury and hemodynamic trauma remain controversial. To explore these questions, viable composite valves were constructed consisting of a cusp each from a porcine aortic heterograft, a canine aortic homograft, and a pulmonic autograft. The stented composite was implanted in the mitral position of the dog after repair of the pulmonary outflow tract. The resultant pulmonic insufficiency was well tolerated and immediate prosthetic function was excellent. Twenty implants were performed and all animals were sacrificed at intervals up to one year. A consistent pattern was observed. The autograft was thickened and hypercellular. The homograft, while always cellular and thickened, showed discrete areas of acellularity and necrosis. The heterograft was hypocellular, often thinned and occasionally totally acellular. We conclude that while donor fibro-blasts persist for long periods in all grafts, chronic host rejection plays the dominant role in their fate in heterografts and, to a lesser extent, in homografts. Routine surgical trauma is not detrimental to valve architecture, and hemodynamic trauma may be a stimulus to cellular growth in autografts and homografts.

23. Collagen-Derived Cardiac Valves I: Concept and Experimental Results

ALAIN CARPENTIER,* Paris, France
Sponsored by ALBERT STARR

A new type of valvular substitute made from biopolymers has been developed in our laboratory. The different macropoteins extracted from heart valves and purified or bounded to prosthetic groups were studied with respect to their biochemical properties, their immunological specificity and their thrombogenic activity in contact with blood. Then these biomaterials were used under various combinations and moulded in order to reproduce the shape, the structure and therefore the physiology of a normal aortic valve. The advantages of these bioprotheses seem to be as follows: (1) Excellent hemodynamics with central flow without transvalvular gradient. (2) Absence of thrombo-embolic complication (no anticoagulants are required). (3) No immunological reaction. (4) Availability,

standardization and security of use as good as for a mechanical prosthesis. This valvular substitute was tested in mitral and tricuspid position on 24 sheep operated upon under extra-corporeal circulation with results good enough to consider clinical application. (Follow up 2 to 10 months).

24. Cardiac Prosthesis Utilizing Biological Material

Y. NOSE,* Y. IMAI,* K. TAJIMA,* H. OGAWA,* M. KLAIN,*
and K. VON BALLY,* Cleveland, Ohio

Sponsored by DONALD B. EFFLER

Many cardiac prostheses utilizing plastics have been designed, fabricated and used. However, the clotting tendency of these plastic materials is one of the greatest problems. Aldehyde-treated homologous or heterologous tissue has been used clinically for intravascular implantation. In vitro kinetic clotting studies have indicated that aldehyde-treated aortic wall and pericardium showed 2 times better antithrombogenicity over Silastic. Therefore, aldehyde-treated aortic valve with aorta and pericardium were used to construct a cardiac prosthesis. A purified hydrophilic aldehyde-treated natural rubber developed in our laboratory was used to reinforce the outside surface of the biological materials. Twelve such devices after 10-14 days bypass implantation in calves showed no clot formation inside the heart, while five implanted conventional cardiac prostheses utilizing silicone rubber clotted within 2-5 days. Eight of these cardiac devices have been used to replace the total heart. The longest pumping time was 76 hours, but in all of these experimental animals there was no evidence of thromboembolus formation. Utilization of aldehyde-treated biological material and its combination with biolized (HATAR) natural rubber can be applicable for an antithrombogenic cardiac prosthesis.

25. Mesothelial Fibrinolysis

JOHN M. PORTER,* FRANK H. MCGREGOR,* and DONALD SILVER,
Durham, North Carolina

Blood clots in pleural, pericardial, and peritoneal spaces usually undergo progressive fragmentation, liquefaction, and absorption without producing significant fibrosis. This study was performed to determine whether mesothelial surfaces can induce fibrinolysis and to localize the site of the fibrinolytic activity. Pleural, pericardial, and peritoneal samples were obtained from 10 patients and incubated on heated and non-heated fibrin plates and fibrin slides to quantitate and localize the fibrinolytic activity. Prior to incubation, portions of these tissues were exposed in vitro to a variety of agents known to produce mesothelial fibrosis, eg., nitrogen mustard, formaldehyde, phenol, and mechanical sponge abrasion. Similar samples were obtained and incubated from 10 mongrel dogs. The chemical and mechanical traumas were induced in vivo in the dogs. Lysis zones of 350 mm² (average) were produced on the non-heated fibrin plates. No lysis occurred on heated plates. Mechanical abrasion reduced the measured fibrinolytic activity by 25%. Nitrogen mustard reduced the activity by 45%. Phenol and formalin eliminated all fibrinolytic activity. The fibrin slides showed zones of fibrinolytic activity at the mesothelial surface and around vessels in the sub-mesothelial tissue. This study indicates that mesothelial surfaces possess fibrinolytic activator(s). Various types of chemical and physical trauma known to produce fibrosis in the mesothelial spaces are associated with a significant reduction in the fibrinolytic activity of mesothelial surfaces.

26. Effective Measures in the Prevention of Intraoperative Aeroembolus

G. HUGH LAWRENCE, HUNTER A. MCKAY,* and
ROBERT T. SHERENSKY,* Seattle, Washington

The danger of coronary and cerebral aeroembolus and its contribution to morbidity and mortality following cardiac surgical procedures has been emphasized. A Doppler ultrasonic sensor has been utilized for the recognition of cerebral arterial aeroembolus during 52 cardiac surgical procedures. This technique has permitted an immediate evaluation of those factors which contribute to the production of air emboli (oxygenator, cardiotomy suction design, location of cardiotomy and previous operation with adhesion) as well as those techniques which tend to decrease their occurrence (chamber venting, chamber filling, CO₂ insufflation, aortic needle venting, and elective ventricular fibrillation). As a result of these studies, which have had a direct correlation with postoperative electro-encephalographic patterns and neurologic status, certain preventive techniques have been emphasized so as to virtually eliminate aeroembolism from postoperative morbidity of intracardiac procedures during the course of the study.

27. Intracardiac Air Following Cardiotomy: Location, Causative Factors and A Method for Removal

RICHARD T. PADULA,* THEODORE E. EISENSTAT,*
 MERRILL H. BRONSTEIN,* and
 RUDOLPH C. CAMISHION, Philadelphia, Pennsylvania

Embolization of air which enters the heart during cardiotomy remains a significant complication despite the use of vents, induced cardiac asystole, and flooding the operative field with carbon dioxide. To determine the location of air bubbles, the factors which cause their retention, and a method for their removal, intracardiac cinephotography, a technique which has previously been described before this Association, was employed. Isolated dual coronary-systemic perfusion systems were established in anesthetized dogs. With vents in the left ventricle and ascending aorta, the mitral valve was either inspected or replaced through a left atriotomy. As the heart resumed systemic perfusion, high speed color motion pictures of its interior were taken. Careful review of the films indicated air may be retained by gravity and trapping by anatomic structures. This air was readily removed by the vents. However, many fine bubbles remained adherent to the valve leaflets, chordae tendineae, and the endocardium itself. Installation of dilute paraldehyde solution into the left atrium with aspiration via the ventricular vent was found to be effective in removing these bubbles. This appears to be due to the fact that this solution significantly decreases the surface tension of blood and thereby decreases the cohesiveness of bubbles.

28. Transvenous Stimulation of the Phrenic Nerves

SEYMOUR FURMAN,* SPENCER K. KOERNER,* DORIS J. W. ESOHER,*
 A. JOEL PAPOWITZ,* JAMES BENJAMIN,* and
 PETER TARJAN,* Bronx, New York
 Sponsored by GEORGE ROBINSON

Transvenous stimulation of the right phrenic nerve was accomplished in dogs with a soft, distensible loop catheter inserted via a larger straight lumen catheter, to assume a fully curved position in the low superior vena cava. The catheter electrodes pressed lightly against the vena cava wall and the catheter was axially rotated until the most sensitive and stable stimulating position was found. The pulse generator was uniquely versatile, capable of altering the impulse trains, their modulation, timing, amplitude, wave form, duration, polarity and respiratory rate. After rendering the animals apneic with morphine, their tidal volume (V_t) and minute ventilation (V) could be regulated with ease to almost any level. T_{1/2} figures for V_t and V represent the average maximum volumes that could be obtained.

	VT	V	PCO ₂	
Before Morphine	250ml	6.0 L/min.		42
After Morphine apneic	apneic	-		
During Phrenic Stimulation	800ml	16.9 L/min.		38

Minimal energy output and smoothest inspiration and expiration were obtained by increasing the modulation of the stimuli from 30 to 100 pulses/sec at a pulse duration of 0.5 msec with a respiratory rate of 16/minute. Permanently implant-able respiratory stimulators are being developed and, because of the relatively large energies required, conventional battery sources are being replaced by a 1 milliwatt nuclear source.

29. Influence of Ischemia and Hypothermia on the Ability of the Transplanted Primate Lung to Provide Immediate and Total Respiratory Support

WILLIAM L. JOSEPH,* and DONALD L. MORTON,* Bethesda, Maryland
Sponsored by PAUL C. ADKINS

Cadavers appear to be the only practical source for clinical lung allotransplantation. As a result, a period of ischemia of the donor lung will be unavoidable necessitating adequate organ preservation for maintaining pulmonary viability. Most studies of lung preservation in the dog and baboon have been performed with the contralateral lung intact. However, the ultimate test of a preservation technique is immediate and total respiratory function following transplantation. Thirty-six baboons underwent left lung autotransplantation and immediate contralateral PA hgation. Eleven out of 12 with varying periods of normothermic ischemia up to four hours survived with adequate gas exchange (mean pO₂: 88.6 mm. Hg) postoperatively, while six others failed to survive five or six hour ischemia. External cooling (at 10-15° C) or continuous ventilation (at 36° C) provided an additional hour of ischemia time in five out of six additional animals. Intermittent cold internal perfusion allowed only three hours of ischemia with consistent survival Those primates who died showed progressive infra-alveolar congestion and proteinogenous exudate in the transplanted lung with a decreased arterial pO₂, (mean < 50 mm. Hg) and elevated PA pressure (mean > 35 mm. Hg) postoperatively. The primate lung tolerates up to five hours of ischemia and still provides immediate and total gas exchange to insure survival.

30. Preclinical Testing of a Redundant Rechargeable Cardiac Pacemaker

G. FRANK O. TYERS,* R. A. FORESMAN, JR.,* E.H. LERNER,*
and J. A. WALDHAUSEN, Hershey, Pennsylvania

Implantable pacemakers provide the best treatment for patients with complete heart-block. Unfortunately, two failure modes necessitate frequent reoperation: 1. premature component failure - 20% in the first 18 months, 2. battery failure - inherent in the design of all internal pacemakers used clinically. A small redundant rechargeable pacemaker has been developed to eliminate frequent reoperation on pacemaker patients. Six units with high drains to maximize discharge-recharge stress have paced dogs with complete heart-block for 4-18 months (mean 11 months). Premature component failure was eliminated by high reliability stress tested components, bench testing, and redundancy - i.e. each implantable unit includes a complete reserve stimulator including power source and three cathodal cardiac leads. Battery failure was avoided by modifying to a rechargeable configuration the mercury silver cell (not Ni-Cd) used in all clinical units. Continuing battery bench tests at body temperature have simulated 12 years of pacing. Recharging and repair in case of failure are accomplished magnetically through the intact skin. Clinical units require five minutes charging daily to prevent battery rundown. Each circuit provides 18 months pacing without recharging. A biological life in excess of 10 years is projected for each circuit for a total pacemaker life (primary plus reserve circuit) approaching 20 years.

*By Invitation

TUESDAY AFTERNOON, APRIL 27, 1971

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

**3:30 P.M. Scientific Session: REGULAR PROGRAM
Phoenix Ballroom**

**Address by the President
Thomas H. Burford
St. Louis, Missouri
"FROM WHENCE TO WHITHER -
Some Reflections on Surgical Specialty Training"**

**Address by the Honored Speaker
Roger O. Egeberg, Assistant Secretary
for Health and Scientific Affairs,
Department of Health, Education and Welfare
Washington, D.C.**

31. Operative Management of Thoracic Aortic Aneurysms Due to Cystic Medial Necrosis

HARRIS B SHUMACKER, JR., Indianapolis, Indiana

This is a study of the author's personal experience during the past eight years. Eleven had operations upon the ascending aorta with cardio-pulmonary by-pass, three of them for unruptured aneurysms with aortic insufficiency, eight for ruptured aneurysms. Two of the former had ball-valve prostheses inserted, one a fascia-lata graft. Several of the latter had valve suspensions. All patients survived. One with a prosthesis died six years later of cerebral embolic episodes. The other has had a fascia lata replacement of the valve for more minor embolic difficulties. Of the group with rupture all have done well save one who died later from rupture of an arteriosclerotic abdominal aortic aneurysm. Twelve had operations upon the descending aorta, using an atrial-femoral by-pass in eleven, arch-femoral by-pass in one. One with an unruptured aneurysm did well. Three of eleven with rupture died in the hospital. Two died later. Possible reasons why there were no hospital deaths in all eleven with operations upon the ascending aorta while three of twelve with operations upon the descending died will be discussed as will the puzzling and fortunately uncommon case in which the dissection involves the entire thoracic aorta and arteriograms fail to disclose site of aortic tear.

32. Left Ventricular Approach for the Repair of Ventricular Septal Perforation and Infarctectomy

HUSHANG JAVID,* JAMES A. HUNTER, HASSAN NAJAFI,
WILLIAM S. DYE* and ORMAND C. JULIAN, Chicago, Illinois

Emergency repair of ruptured ventricular septum was undertaken within six weeks following myocardial infarction in four patients. Profound cardiogenic shock six days following infarct in one patient and non-remitting congestive failure in the other three patients prompted surgical treatment. A review of the literature indicates that 40% of patients with post infarction ventricular septal defects also have a left ventricular aneurysm. In our series of four, repair of septal rupture and excision of the infarct concomitantly would have been justified in three patients. The only operative death in this group occurred in a patient whose septal defect was repaired through the right ventricle six days after myocardial infarction. This patient died in the operating room because of inadequately functioning left ventricle. The

late death three months after surgery was due to congestive failure caused by a large left ventricular aneurysm in another patient whose obvious infarct was not excised. The ease of ventricular septal repair through the opening in the left ventricle after excision of the infarct and the uneventful postoperative course prompted this report. The mere presence of a dyskinetic or akinetic left ventricular wall should justify excision of the infarct as well as the repair of the septal defect.

*By Invitation

TUESDAY EVENING, APRIL 27, 1971

7:00 P.M. Reception

Phoenix Ballroom

8:00 P.M. Dinner and Dancing

Phoenix Ballroom

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 28, 1971

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

Phoenix Ballroom

33. A New Technique for Rapid Saphenous Vein - Coronary Artery Anastomoses

GEORGE J. MAGOVERN, DAVID C. FECHT,* SANG BOCK PARK,*
GERALD E. MCGINNIS,* and F. BEACHLEY MAIN,
Pittsburgh, Pennsylvania

Coronary artery surgery utilizing aortico-coronary artery saphenous vein bypasses introduces many technical problems - sutures becoming entangled, the graft being difficult to handle, prolonged coronary artery occlusion, etc. Stimulated by these adversities, we developed a technique employing a new instrument which alleviates these problems. Essentially, it is a saphenous vein holder which allows the vein to be brought to the operative field mounted with the sutures pre-threaded through the graft by an assistant. Distal coronary perfusion during anastomosis is also easily achieved. The advantages of this instrument are outstanding. It accommodates any size saphenous vein beveled at any angle. Suture identification numbers eliminate the confusion attendant with multiple suture techniques. Of greatest importance, the anastomotic time is decreased to one-fourth to one-third of that required prior to the utilization of this instrument. We are presently using it routinely. It is especially useful in those cases where the artery is quite diseased; those hearts with borderline myocardial function; and those cases where multiple veins are used. A movie strip will illustrate its use. We feel this is a significant advance in coronary artery surgery and should be brought to the attention of those engaged in this field.

34. Intramyocardial Gas Tensions in the Human Heart During Saphenous Vein Coronary Artery Bypass

TIMOTHY J. GARDNER,* JOHN W. BRANTIGAN, AVIO M. PERNA,*
HARVEY W. BENDER,* ROBERT K. BRAWLEY,* and
VINCENT L. GOTT, Baltimore, Maryland

Intramyocardial pO₂ and pCO₂ are being continuously monitored in patients undergoing saphenous vein-coronary artery bypass at The Johns Hopkins Hospital using a new Teflon membrane-mass spectrometric technique developed here. Thus far, 25 patients have had this operation requiring anoxic arrest for periods up to 40 minutes. Initial myocardial gas tensions during cardiopulmonary bypass averaged pO₂ 31 and pCO₂ 74. At peak anoxia, pO₂ and pCO₂ were 2 and 249. Several minutes after the onset of saphenous vein flow, there is a period of reactive hyperemia with the pO₂ averaging 69 and the pCO₂ 57. Following the period of reactive hyperemia with a more stable myocardial perfusion, the pO₂ averages 50. Following cardiopulmonary bypass and with restoration of pulsatile flow, the pO₂ values average 78 and the pCO₂ 52. This is the first time that pCO₂ and pO₂ have been directly measured (nonpolarographic) in the human myocardium and the results of this study suggest that the myocardial pO₂ in patients with coronary disease is considerably improved by saphenous vein bypass.

35. Left Heart Bypass without Anticoagulation

RICHARD M. ENOELMAN,* EMERY NYILAS,* and
SAMUEL J. GODWIN,* New York, New York
Sponsored by FRANK C. SPENCER

A totally implantable, pulsatile bladder ventricle containing air driven inflow and outflow valves and especially designed tubing has been built entirely of Avcothane-51, a new nonthrombogenic blood compatible polymer. The inflow end of the pump is placed in the apex of the left ventricle. The pump lies in the abdomen with the outflow tube anastomosed end-to-side to the abdominal aorta. Synchronous bypass at a flow rate of 750 to 1500 ml per minute (50-100% of the cardiac output) was used in five dogs for periods of one to seven hours. Systemic, left ventricular, and right and left atrial pressures were monitored during bypass. The systemic systolic pressure was maintained between 80 and 160 mmHg (mean 50-130 mmHg) without vasopressor support while left ventricular pressures were reduced by 50-100%. Urine output remained between 5 and 20 ml per hour. Hematologic studies showed a decrease in the fibrinogen level from 455 to 378 mg% and an increase in partial thromboplastin time from 24.4 to 36.8 second after bypass. No significant changes were noted in either the thrombin or prothrombin time. Platelet and white blood cell counts were reduced by 25-50% and plasma hemoglobin rose from a control level of less than 1 to 8 mg% during bypass. At the completion of each bypass period, the pump was carefully inspected for any evidence of clotting, and none was found. The above data represents our initial experience with a hemodynamically satisfactory pump. Continued experimentation is being vigorously pursued.

36. Bi-Ventricular Bypass: Physiological Studies During Induced Ventricular Failure and Fibrillation

W. F. BERNHARD, C. G. LAFARGE,* M. BANKOLE,* and
W. BORNHORST, Boston, Massachusetts

Previous investigations in this laboratory demonstrated that either right or left ventricular bypass was possible for periods of 85 and 170 days, respectively at flows of 4.0 to 8.0 liters/minute. Experiments were performed using separate, implantable, pneumatically actuated, blood pumps each with a stroke

volume of 100 milliliters. This study was designed to assess the effects of simultaneous biventricular bypass, (7-42 days), in calves during induced myocardial failure and ventricular fibrillation. Physiological observations were made by cardiac catheterization and biplane cineangiography in 16 chronic animals: (1), control state (2), during electrically-induced ventricular fibrillation (3-4 hours) and (3) during cardiac failure induced by microsphere myocardial infarction. Under the: conditions, right and left ventricular pressures were reduced to 0 mm Hg, cardiac output and systemic arterial pressure were maintained at normal levels, end-diastolic volumes and pressures were reduced, and ejection fraction improved. Mean pulmonary artery pressure ranged between 10 and 30 mm Hg, and pulmonary compliance values were comparable to control animals (left thoracotomy alone). Summary; The physiologic abnormalities produced by chronic ventricular failure and brief intervals of induced ventricular fibrillation can be reversed by an implantable, circulatory support system.

37. Cardiac Function after Prolonged Storage in an Intermediate Biological Host

PHILIP H. WELLS,* SURIYA PHALAKORNKVL,* HOWARD W. RAMSEY*
and MYRON W. WHEAT, JR., Gainesville, Florida

The ready availability of healthy adequately functioning hearts is a necessary requirement for large scale application of cardiac transplantation. We have approached one aspect of this problem by attempting to "store" the heart of one goat (donor) in the abdomen of a second goat (host) and evaluating the function of the banked heart. This report concerns a heart which was stored, remained in normal sinus rhythm for 47 days and was evaluated in detail on the 35th and 43rd days of storage. Light and electron microscopic sections demonstrate a gradual return to normal of the cellular elements of the donor heart. At five weeks, the host heart recorded left ventricular (LV) and left ventricular and diastolic (LVED) pressures of 142 mm. Hg and 3-5 mm. Hg respectively compared to donor LV 110-120 mm. Hg and LVED 10-12 mm. Hg. Following isuprel, host heart dp/dt increased 6 percent, donor heart dp/dt increased 27 per cent. Cineangiocardio-grams demonstrate excellent contractility of the donor heart. Studies eight days later (43rd day) indicated some further decrease of myocardial contractility and loss of compliance in the donor heart. These studies suggest that a heart stored under these conditions can maintain its ability to function adequately as a pump for as long as six weeks.

38. Result of Total Artificial Heart Implantation in Calves

CLIFFORD KWAN-GETT,* J. KAWAI,* N. EASTWOOD,* and
W. J. KOLFF,* Salt Lake City, Utah

Sponsored by RICHARD K. HUGHES

We developed a new pneumatically powered total artificial heart which pumps 10 liters per minute. It has two hemispherical Silastic ventricles. Pumping diaphragms cannot touch the housing. Mechanical crushing of blood cells is eliminated. Filling and therefore stroke volume and cardiac output is proportional to atrial pressure. Atrial pressure autoregulation is obtained without pressure transducers, feedback loops or electronic control. In 14 calves weighing 68.0 to 90.7 kg, average survival time after total mechanical heart replacement was 30 hours; 8 exceeded 24 hours (average 49, maximum 92 hours). Postoperatively, animals could eat, drink, move and stand unsupported. Pulmonary artery pressures in long survivals were normal despite abnormal pressure waveforms. Hemolysis production was low. Plasma hemoglobin always fell from post pump-oxygenator levels. Twice it fell to 2 mg% from 36 mg% and 34 mg% in 63 and 36 hours. With serial determinations in 3 experiments, fibrinogen levels were low after bubble oxygenator support, rose towards normal, then fell rapidly prior to termination. Platelet levels at termination were extremely low (1,500 to 75,000 per cmm). Plasma protein levels fell gradually. The fall in fibrinogen, platelet, and hematocrit levels with increase in Lee-White clotting time at termination, suggests that consumptive coagulopathy limits survival times.

39. Transvenous Pulmonary Embolectomy by a Catheter Device

L.J. GREENFIELD, M. E. REIF,* E. R. MUNNELL, and
T.A. BRUCE,* Oklahoma City, Oklahoma

The high mortality rate associated with open pulmonary embolectomy has prompted a search for other approaches to the problem, and a new catheter technic has been used successfully in both experimental and clinical studies. The vacuum-cup catheter device is attached to a 12 Fr. double-lumen balloon-tipped catheter which can be introduced through a large extremity vein. In a total of 38 large mongrel dogs, acute massive pulmonary embolism has been produced using autologous thrombi, muscle strips, and human thrombotic material. Extraction of embolic material was possible with the catheter device under fluoroscopy in 83% of the animals and was associated with reduction in pulmonary vascular resistance and improved cardiac output. Arterial blood gases did not improve for 24-48 hours. The technic has been applied to two patients with pulmonary embolism in whom emboli were removed successfully under local anesthesia. Both patients showed immediate hemodynamic improvement, improved perfusion by angiography and lung scan, and are asymptomatic at three months follow-up. Rapid extraction of pulmonary emboli is possible without total cardiopulmonary bypass or general anesthesia and this technique should broaden the indications for pulmonary embolectomy.

40. A Low Pressure Tracheostomy Tube Cuff to Minimize Tracheal Injury: A Comparative Clinical Trial

JOEL D. COOPER,* HERMES C. GRILLO, BENNIE GEFFIN,*
and HENNING PONTOPPIDAN,* Boston, Massachusetts

Conventional tracheostomy tube cuffs may cause pressure necrosis which results in tracheal stenosis, tracheomalacia, tracheo-esophageal fistula or innominate artery erosion, since such cuffs require high inflation pressures, are relatively rigid and deform the trachea when a seal is obtained for ventilatory support. To obviate such necrosis a new compliant cuff was designed which provides a seal by conforming to the shape of the trachea and has low intracuff pressures. Randomized trial of the new cuff in comparison with standard cuffs was made in 46 unselected patients who required tracheostomy for ventilatory assistance. Damage to trachea was evaluated by telescopic examination after removal of the cuff or by postmortem examination. Tracheal injury was classified into four groups, ranging from absent or minimal damage to severe ulceration with cartilaginous slough. Half of the patients with new cuffs showed absent or minimal damage. No patients with standard cuffs were in this group. Most patients in severe damage categories had standard cuffs; few patients with new cuffs demonstrated severe damage. Results were highly significant statistically. Intracuff pressures in experimental cuffs averaged only 25 mm. Hg in comparison with 250 mm. in the standard. These clinical observations in man are consistent with prior experimental data in dogs.

41. Prepulmonary Oxygenation by Peripheral Cannulation for Respiratory Distress

A. B. IBEN* D. F. PUPELLO,* T. N. GREHL,* and
E. J. HURLEY, Davis, California

Venoarterial pump oxygenator support for patients with respiratory insufficiency is an inefficient method. It decreases preload, increases systemic resistance, and unfavorably alters forward cardiac output and tissue perfusion. Most present methods use roller pumps and peripheral application resulting in nonpulsatile flow. By the use of two triple lumen catheters introduced from the jugular vein above and the femoral vein below, up to 95% of the systemic venous blood can be removed, oxygenated and returned to the right atrium. Side openings in the large lumened catheter removes blood from the patient to the

oxygenator. Another lumen within the catheter returns blood to the right atrium. The third lumen connects to an inflatable balloon, which when inflated in the caval atrial junction, separates the two systems. The heart continues to function as a pulsatile pump. The entire system including the lungs receives oxygenated blood. Methods of catheter application are described as well as serial arterial blood gas determinations carried out in 24 canine laboratory subjects. The pathological findings of serial pulmonary biopsies removed during the period of perfusion are presented. With the advent of membrane oxygenators, which can be used for extended periods of time, this method of cannulation and prepulmonary oxygenation shows great promise as a useful clinical tool for the treatment of acute respiratory insufficiency in any age group.

42. A New System for Computerized Automated Blood Gas Analysis

L. GEORGE VEASY,* JUSTIN S. CLARK,* A. LARRY JUNG,*
JARRELL L. JENKINS,* and CONRAD B. JENSON,*
Salt Lake City, Utah
Sponsored by RUSSELL M. NELSON

An automated system for on line, real time computerized determination of arterial PO₂, PCO₂, and pH has been developed (CABAS). The determinations are made from a total of 0.3 ml sample of blood withdrawn automatically under computer control from an indwelling arterial catheter, which is not limited to CABAS function. The results are displayed within four minutes in alpha-numeric terms on a memory scope at the cribside. System sterility tests in 10 consecutive experiments having a total of 40 cultures had no positive growth. Accuracy of CABAS determinations compared with the ASTRUP technique showed a mean difference of 1.3 mm Hg with a standard deviation of 4.6 mm Hg in 60 measurements of PO₂ 0.4 mm Hg with a standard deviation of 1.5 mm Hg in 18 measurements of PCO₂, and 0.018 pH units with a standard deviation of 0.031 in 69 measurements of pH. The shorter time required for results, minimal amount of blood required for analysis, no disturbance of infant for sampling, and automated and scheduled sampling have helped in the management of many problems before they were clinically apparent in 9 cases of respiratory distress syndrome.

43. Surgical Techniques for Replacement of the Interventricular Septum

SHUJI SEKI,* and DWIGHT C. MCGOON, Rochester, Minnesota

An operative technique has been developed for replacing the interventricular septum, which may prove useful in correction of single ventricle and provide a way to study the function of the septum. The septum is resected at the free wall and atrioventricular valves and is replaced with a Teflon felt patch. The tricuspid valve is replaced with a prosthesis, and rhythm is maintained by an implanted pacemaker. Operative techniques were investigated in 15 dogs and effects of size and positioning of the patch were studied in 45 others. Anchoring stitches to the free wall must be tied outside the ventricle. A ball valve was not suitable because the patch bulged toward the right. Size of the defect and positioning of the patch were not important because the primary function of the patch was to divide the single ventricle into two cavities, volumes of which were in the normal range. If the patch size was equal to the defect size in diastole, the patch was too large and bulged toward the right ventricle. The patch must be smaller than the diastolic defect; 5 of 9 dogs with patches 22% smaller survived longer than 1 month.

44. Surgical Correction of Complete Atrio-ventricular Canal Utilizing Ball Valve Replacement of Mitral Valve: Technical Considerations

ALDO CASTANEDA, DEMETRE NICOLOFF,* JAMES MOLLER,*
and RUSSELL LUCAS,* Minneapolis, Minnesota

Operative correction of complete atrio-ventricular canal (CAVC) has been associated with both a high mortality and a high incidence of residual abnormalities, particularly mitral regurgitation. To improve the operative results, we now resect the malformed and malpositioned mitral valve. An hour-glass shaped Teflon patch is fashioned and one portion of this sewn in the ventricular component of the defect. A ball valve prosthesis is sutured into the mitral annulus until its medial aspect is reached. The valve is fixed to the patch about two centimeters above its ventricular septal attachment and at the level corresponding to the true A-V plane. The atrial segment of the patch is used to close the remaining primum defect. Finally the septal leaflet of the tricuspid valve is relocated in the appropriate A-V plane on the right side of the patch. Four children with CAVC, from 2V4 to 5 years of age, have been operated upon by this technique. Two had previous operations but required re-operation because of significant residual ventricular shunts and mitral insufficiency. In each of the four patients, massive mitral insufficiency was present preoperatively. The average mean pulmonary arterial pressure was 80 mm Hg and pulmonary vascular resistance was 1250 DSC5. One child (who developed complete heart block following the first operation) died 24 hours after the second. Each of the remaining patients is well and has no residual murmur. A-V block has not occurred.

*By Invitation

WEDNESDAY AFTERNOON, APRIL 28, 1971

2:00 P.M. Scientific Session: REGULAR PROGRAM Phoenix Ballroom

45. Long-term Results of the Mark IV Operation for Hiatal Hernia and Analyses of Recurrences and their Treatment

MARK B. ORRINGER,* and DAVID B. SKINNER, Baltimore, Maryland
and RONALD H. R. BELSEY, Bristol, England

From 1955 to 1965 approximately 900 Mark IV operations for hiatal hernia and/or gastroesophageal reflux were performed at Frenchay Hospital, Bristol, England. Followup evaluations of clinical results, radiographic, and endoscopic findings in patients operated upon more than five years previously revealed recurrences of hiatal hernia, gastroesophageal reflux, or both in approximately 12% of patients followed more than five years, 14% in patients followed more than seven years, and 18% in patients followed more than ten years. Causes of recurrences were found to be due to attempting reduction of the hernia in the presence of severe esophagitis and esophageal shortening, diaphragmatic or esophageal sutures cutting through, or inadequate operative reconstruction. Recurrences were further related to age of the patient and experience of the operator. Details of management for the recurrent reflux problem will be discussed including indications for repeat Mark IV operations, pyloroplasty, a resection and colon interposition. Results of treatment for recurrent hiatal hernia will be presented.

46. The Nature and Surgical Treatment of Lower Esophageal Ring (Schatzki's Ring)

CONRAD R. LAM, RODMAN E. TABER and EDUARDO ARCINIEGAS,* Detroit, Michigan

In 1953, Schatzki and Gary published a paper entitled "Dysphagia due to a diaphragm-like localized narrowing in the lower esophagus" ("lower esophageal ring"), and the description was so good that the senior author's name is commonly used to describe the lesion. In 1955, Bugden and Delmonico reported two cases cured by removing wedges from the diaphragm through an esophagotomy. In principle, this operation appears logical, but it has not been universally adopted. The lesion has been called a "semantic and surgical enigma" in the surgical literature, with the suggestion that dilatation is an acceptable form of treatment. We have operated on 18 patients with symptomatic Schatzki's with hiatus hernia. The ring has been excised or eliminated by radial cuts through gastrotomy before reduction of the hernia. We were convinced that any attempt to dilate or rupture the ring by endoscopic methods would be unsatisfactory. A case of rupture of the esophagus after such an attempt is being treated for mediastinitis and empyema. The patients treated by direct approach have remained asymptomatic. Histologic study of the excised portions of the ring invariably showed esophageal mucosa on one side and gastric mucosa on the other.

47. Management of Carcinoma of Cervical Esophagus

WALTER J. BURDETTE and RICHARD H. JESSE, JR.,* Houston, Texas

The outlook for carcinoma of the cervical esophagus was found to be more favorable than for carcinoma of the thoracic esophagus among 507 cases of the esophageal carcinoma seen at the M. D. Anderson Hospital. Principles found useful in management of this disease are careful preoperative evaluation, radical resection of the cervical lesion and surrounding tissues involved, repair by interposition of ileocolon, and use of irradiation therapy when indicated. The segment of bowel found most useful for interposition has been terminal ileum attached to ascending and right half of transverse colon with pharyngoileal and cologastric anastomoses. Epiglottis can be used as a portion of the anastomosis in the neck. Very careful approximation of pharynx and ileum, testing of suture line with hydrostatic pressure, and use of a broad cuff prevents an annoying leak which otherwise occurs fairly frequently. Limitations imposed by invasion of contiguous organs is greater within the thoracic cavity and possibly explains the more favorable prognosis in carcinoma of the cervical esophagus. The experience with specific cases will be utilized to illustrate problems and procedures characteristic of the methods adopted for managing a very difficult problem.

48. Implications of the Urokinase Study Concerning Surgical Treatment of Pulmonary Embolism

RICHARD D. SAUTTER, WILLIAM O. MYERS,* and
FREDERICK J. WENZEL,* Marshfield, Wisconsin

In a randomized national cooperative trial, urokinase with subsequent heparin therapy, when compared with heparin therapy alone, significantly accelerated the resolution rate of pulmonary thromboembolism at 24 hours. Patients were separated into four categories (I-S, I-M, II-S, II-M) based on the severity and massivity of their pulmonary embolism. In the series of 160 patients, there were 11 who had massive pulmonary embolism with shock (II-M). In this group, there were only two deaths for a two week fatality rate of 18%. Six patients in this group received urokinase and five received heparin only. During the trial, the mortality rate in 11 patients undergoing pulmonary embolectomy at the participating institutions was 73%. It appears that pulmonary embolectomy is a procedure which should have a very limited application. Consideration has been given to the use of lytic therapy in those patients usually recommended for caval ligation. In light of the recurrence rate for the two groups of patients, at present this cannot be recommended. Comparison of the hemodynamic data, pulmonary scans and arteriograms

of the patients treated with urokinase versus those treated with heparin will be presented. Complications of lytic therapy will also be reviewed.

49. Open Heart Surgery Using Deep Hypothermia: The Development and Current Method Using a No Blood, No Oxygenator Technique for Open Heart Surgery

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Sponsored by JAMES A. KEY

Since 1959, 841 cases of mixed pathology have been operated on by open heart techniques at St. George's and Westminster Hospitals in London using modifications of the technique first described by Drew. The modifications of these techniques are described, together with a report on 100 consecutive recent cases studied prospectively. There were 36 cases of acquired heart disease and 64 cases of congenital heart disease. The over-all mortality of 13% occurred predominantly in the acquired cases. The results suggest the value of this technique, particularly for use in very young children. Advantages in the technique will be outlined which would recommend its use as an alternative to standard cardiopulmonary bypass, particularly for early total correction of lethal lesions in the neo-natal period.

50. Reconstruction of the Right Ventricular Outlet with a Fascia Lata Composite Graft

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Sponsored by FRANK GERBODE

For the complete correction of congenital cardiac abnormalities with hypo-plastic or absent right ventricular outlet, a technique of making a composite fascia lata graft has been developed. The graft comprises a conduit for right ventricular outflow tract and pulmonary artery reconstruction, and an inner three cusp valve which provides the conduit with a one-way flow mechanism. The technique of preparing and inserting these grafts is described. Since November 1969 the composite graft has been used in 23 patients. There have been 16 patients with Pallet's tetralogy, 2 with double outlet right ventricle, one with corrected transposition and V.S.D., one with corrected transposition and absent ventricular septum, one with truncus arteriosus type II, one with Fallot's trilogly and one with single ventricle and mitral atresia. All 23 had had pulmonary atresia or hypoplasia and 16 had had previous shunt procedures. There have been 4 hospital deaths. Early results have been very good. No late deaths or clinically detectable complications have occurred. Only 4 patients have had post-operative haemo-dynamic and angle-graphic investigations performed and these show excellent results. The follow-up is too short (5 to 12 months) to draw any conclusions concerning the advantages and drawbacks of this method.

51. The Mustard Operation as a Palliative Procedure

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Our current series of corrective operations on patients who had transposition of the great vessels with favorable anatomy and physiology for total correction now includes thirty cases. There has been only one death in this group and the clinical improvement in the survivors has been startling. The ease with which this operation can be performed upon these favorable candidates and the satisfactory low mortality rate has prompted us to use this procedure in less favorable circumstances. We have had seven patients in this category. The group of patients with transposition of the great vessels associated with severe pulmonary hypertension, usually with ventricular septal defect, has been of particular interest. The Mustard operation

converts the cardiopulmonary physiology in these patients to one more favorable for long term survival. The arterial oxygen saturation and the clinical performance of these patients have shown marked improvement. We also have used the Mustard operation for patients whose defects made the risk of total correction seem prohibitive. On the basis of this experience we believe that the Mustard operation is a satisfactory palliative procedure.

*By Invitation

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