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American Association for Thoracic Surgery

53rd Annual Meeting

Scientific Program

MONDAY MORNING, APRIL 16, 1973

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

8:45 A.M. Scientific Session:
Regency Ballroom

1. Tubed Gastric Pedicle for Esophageal Replacement in placement in Children

KATHRYN D. ANDERSON* and JUDSON G. RANDOLPH,
Washington, D.C.

The standard operation for esophageal replacement in children has been interposition of the colon. A favorable response in a child treated with gastric tube after failure of colon bypass, and the recent report by Stephens and Burrington, led us to adopt this operation as the primary approach for esophageal reconstruction. The tubed gastric pedicle has been evaluated in seven children. The patients include four children with extensive lye strictures and three infants with esophageal atresia without fistula. Age range of the patients at the time of surgery was eight months to four years. Patients have been followed from six months to five years.

Results: There have been no deaths or serious complications. Three patients developed mild strictures at the cervical anastomosis requiring several dilatations. No gastric tube has required revision. One patient developed an ulcer in the tube which responded to conservative therapy. All tubes have functioned satisfactorily to meet the nutritional needs of growing children. On the basis of this experience, a wider clinical trial of this procedure seems justified in children who need esophageal replacement.

*By invitation

2. Intrauterine Production of Coarctation of the Aorta: Operative Technique and Newborn Hemodynamic Studies

J. ALEX HALLER, JR., I. J. SHAKER,* ROBERT GINGELL* and CHARLES HO,* Baltimore, Maryland

Clinical studies of coarctation of the aorta have contributed greatly to our understanding of this anomaly, but the high mortality of preductal versus postductal coarctation remains unexplained. Creation of these abnormalities in fetal lambs has provided an excellent opportunity to study the factors which affect survival, before and after birth, as well as the comparative differences in hemodynamic alterations.

Thirty ewes between 90-115/145 days gestation were operated upon and the fetal lamb was partially marsupialized to minimize amniotic fluid loss. Through a left thoracotomy, postductal coarctation was created in 13 lambs, and preductal in 17. Sixteen lambs were born alive either spontaneously or by C-section. The majority were studied angiographically to verify the site of coarctation and to demonstrate the extent of collateral circulation. Selected lambs received complete cardiac catheterization to assess the status of the ductus arteriosus and to measure the pressure gradient across the coarcted segment.

Operative techniques and data will be presented to show that intrauterine creation of preductal and postductal coarctation is possible with prolonged survival. Collateral circulation was remarkably similar in both groups and newborn survival was not affected by the location of the coarctation. We believe this is a useful model for definitive studies of altered hemodynamics in pre and postductal coarctation.

3. Surgical Repair of Single Ventricle

RICHARD N. EDIE,* KENT ELLIS,* WELTON GERSONY,* FREDERICK O. BOWMAN, Jr., and JAMES R. MALM, New York, New York

Single ventricle may occur with absence of the ventricular septum and two separate atrial ventricular valves associated with rotational variation in the origin of the great vessels. Four patients have successfully undergone repair of such an anomaly, two associated with Tetralogy of Fallot anatomy, one with double outlet in combination with pulmonary stenosis and one with D transposition and a pulmonary stenosis secondary to a pulmonary band. A technique of repair has been utilized to minimize residual shunting within the ventricle. The bundle of His is at risk in repair of this defect and direct mapping of its course has facilitated repair of the anomaly. The technique of His mapping will be presented in relation to single ventricle. Post operative studies are available on all patients. These demonstrate the complete prosthetic replacement of the ventricular septum can be carried out with near normal cardiac function post operatively.

*By invitation

4. The Fate of Reconstruction of the Right Ventricular Outflow Tract

SAMUEL KAPLAN,* JAMES A. HELMSWORTH, GEORGE BENZING, III,* DAVID C. SCHWARTZ* and J. TRACY SCHREIBER,* Cincinnati, Ohio

One hundred and thirty-eight patients with tetralogy of Fallot have been followed for 1-15 years after surgical correction. Reconstruction of the right ventricular outflow was accomplished with a pericardial patch in 45 patients and in another 11 instances an aortic homograft was used. In the remaining 82 patients, relief of obstruction was achieved by infundibulectomy alone with or without pulmonary valvotomy. Aneurysms of the right ventricular outflow developed in 19 patients, 18 of whom had pericardial patches. In all patients who developed aneurysms, residual significant defects were present. These consisted of (1) persistence of right ventricular hypertension because of inadequate relief of pulmonic stenosis or significant pulmonary arterial branch stenosis and/or (2) persistence of left to right shunt across the ventricular defect. It is concluded that right ventricular outflow patches or aortic homografts are well tolerated for many years after surgery (even in the presence of pulmonary valve incompetence) provided that the obstruction to right ventricular outflow has been relieved and the ventricular septal defect is closed.

5. Early Correction of Congenital Heart Disease with Surface Induced Deep Hypothermia and Circulatory Arrest

P. VENUGOPAL,* J. OLSZOWKA,* H. WAGNER,* P. VLAD,* E. LAMBERT* and S. SUBRAMANIAN* Buffalo, New York
Sponsored by John W. Kirklin

In the past three years we have done open correction of congenital heart defects in 110 children using the Kyoto technique which consists of surface cooling with ice packs, a short period of perfusion followed by exsanguination and circulatory arrest. Core rewarming was done after surgical correction. Thirty-seven infants were below six months of age, 29 were between 7 and 12 months, 26 patients between 1 and 2 years and 18 were over 2 years. Eighty-nine weighed less than 10 kg and 43 infants were below 5 kg in weight.

The lesions included:

a. Transposition—57 patients; 34 uncomplicated with 29 survivors. Twenty-three complex Transpositions with 15 survivors.
b. Twenty-four children had VSD and associated anomalies and in 15 infants with isolated VSD there were no deaths.
c. Tetralogy of Fallot in 10 infants with 2 deaths.
d. Nine infants with Total Anomalous Pulmonary Venous Drainage with 5 survivors.

The use of this technique has permitted us to carry out complete correction successfully as early as 7 days of age. Surgical palliation is performed at this institution only in exceptional circumstances.

*By invitation

6. Surgical Correction of the Transposition Complex in Infancy

JAMES W. KILMAN, THOMAS E. WILLIAMS, JR.,*
GERARD S. KAKOS,* JOSEPHA CRAENEN* and
DON M. HOSIER,* Columbus, Ohio

Twenty-five patients with transposition of the great vessels have had total correction of this anomaly using an intra-atrial baffle and a triangular patch to enlarge the new left atrium. Only one death has occurred in this series resulting in a mortality of 4.0% (1/25). Associated defects included seven ventricular septal defects and five patients with pulmonary stenosis. These twelve defects have all been corrected at the same surgical procedure. Surgery was done using normothermic, high flow cardiopulmonary bypass with a standard disposable bubble oxygenator. The mean body weight of these patients is 8.9 kilograms. Fourteen patients were under 10 kilograms and no deaths have occurred in this group. The mean preop PaO_2 was 42 mm Hg. and the mean postop PaO_2 in room air was 76 mm Hg. Arrhythmias have not been a serious problem with this modified Mustard repair. A new maneuver for the exposure and closure of the ventricular septal defect has been used. It is felt that after this experience that transposition of the great vessels can be surgically corrected with only minimal risk in infancy.

7. Repair of Ventricular Septal Defect with Aortic Insufficiency

G. A. TRUSLER, Toronto, Ontario, Canada

Over the past five years, 16 children with ventricular septal defect (VSD) and aortic insufficiency (AI) have been treated by repair of the VSD and valvuloplasty of the affected aortic valve leaflet. The valvuloplasty transforms the elongated prolapsed leaflet into a competent leaflet with a free margin identical in length to that of the other aortic leaflets. Success hinges on precise measurement of the leaflet margin, secure fixation of the excess prolapsed leaflet to the aortic wall and reconstruction of the adjacent commissure.

Three of the 16 children had only slight to moderate relief of AI because the technique was inappropriate due to a bicuspid aortic valve in two and dilatation of the aortic ring in the third.

The other 13 children had a typical prolapsed leaflet (right 11, left 1 and non-coronary 1). The VSD was subcristal in 10 children and supracristal in 3.

Excellent results with no diastolic murmur, normal pulse pressure and decreasing heart size were obtained in 7 children. The other 6 children were improved but with mild to moderate aortic insufficiency.

Late studies, including angiocardiography, up to 4½ years after repair, show that improvement is maintained. AI due to a prolapsed valve leaflet can be safely and effectively repaired by this technique.

*By invitation

8. Progress and Problems in the Surgical Management of Congenital Aortic Stenosis

WILLIAM F. BERNHARD, DONALD C. FYLER,* KENNETH E. FELLOWS* and ROBERT E. GROSS, Boston, Massachusetts

During a fourteen year interval, 194 patients with valvar, subvalvar and supravalvar aortic stenosis were operated upon. One hundred forty-six underwent valvotomy, including 33 infants (under one year). Although there were 11 infant deaths, twenty of the last 24 babies survived. Two deaths occurred among the remaining 113 children. Among the survivors, 80 had no significant aortic regurgitation (AR); however, AR was severe in ten, and mild to moderate in 43 patients. Follow-up LV-aortic pressures (available in 50 patients) revealed gradients less than 40 mmHg in 35. Of the remaining 15, two died with residual stenosis and five had successful valve replacement.

Forty children underwent partial resection of a subvalvar ring (five deaths). Sixteen survivors were recatherterized: gradients less than 40 mmHg were found in 14; nine had appreciable aortic or mitral incompetence.

Eight patients presented with supravalvar AS (four with discrete lesions). The latter improved following operation; however, three with a hypoplastic ascending aorta and aortic annulus expired.

Conclusions: Valvotomy provides effective palliation in children with severe stenosis (including infants). Valve replacement was necessary in only five. Finally, left ventricular hypertension can be relieved in most patients with discrete obstructions below or above the valve.

11:15 A.M. Presidential Address

Frank Gerbode, San Francisco, California

COMPUTERIZED MONITORING IN THE SERIOUSLY ILL PATIENT

*By invitation

MONDAY AFTERNOON, APRIL 16, 1973

2:00 P.M. Scientific Session
Regency Ballroom

9. Diaphragm Pacing by Radiofrequency Transmission in the Treatment of Chronic Ventilatory Insufficiency: Present Status

W. W. L. GLENN, W. G. HOLCOMB,* J. HOGAN,* I. MATANO,* J. B. L. GEE,* E. K. MOTOYAMA,* C. S. KIM* and R. A. POIRIER,* New Haven, Connecticut

The indications for, complications of and long term results of diaphragm pacing in 15 patients with chronic ventilatory insufficiency will be reported. In 12 patients the respiratory center was affected (Ondine's curse); in 3 patients there was partial or complete severance of the upper cervical cord. The diaphragm pacemaker consists of a radiowave generator transmitting programmed signals via an antenna to a subcutaneous receiver connected to bipolar electrodes around one or both phrenic nerves. Receiver failure, initially troublesome, appears to have been corrected. Nerve fatigue is evident after 10-12 hours of continuous unidirectional stimulation but its onset may be delayed by utilizing a bidirectional stimulus.

In one patient pacing failed after 2 weeks. In the remaining patients adequate ventilation of the lungs, as evidenced by spirometry, normal blood gas concentration and Xenon^{133} diffusion studies, has been achieved up to 44 months without evidence of injury to the phrenic nerve; the phrenic nerve stimulation threshold rose initially but stabilized within 6 months usually at between 1 and 2 milliamperes. Right heart failure and pulmonary hypertension, when present, improved during diaphragm pacing. Evidence to date indicates that pacing of the diaphragm is an effective, practical and reasonably safe technique for long term partial or complete ventilatory support.

10. Development of an Implantable Artificial Lung

ARTHUR PALMER,* JOHN COLLINS* and LOUIS R. HEAD, Chicago, Illinois

A membrane oxygenator, which can be implanted in the chest, has been developed to function as an artificial lung. It operates at pulmonary artery pressure and requires no external power source for ventilation. Silastic capillary tubes function as the membrane surface. These are manifolded in parallel into modules containing 2288 to 6270 individual tubes. The modules are then sealed in a Silastic ventilating envelope which is connected to an artificial bronchus. Blood flows through the capillary tubes and the gas in the ventilating envelope is continuously changed by the normal motion of the dogs chest.

Ten artificial lungs have been implanted in dogs. Blood flow through the prosthesis ranged from 80-260cc/min at mean pulmonary artery pressures of 10-25mm. of Hg. Oxygen transfer ranged from 15-23cc/min/M^2 at physiologic levels of pO_2,pCO_2 and ph.

The major problem remaining is prevention of intravascular coagulation in the artificial lung. Regional heparinization is presently used and various antithrombogenic surface treatments are under investigation.

*By invitation

11. Delayed Sequelae of Penetrating Cardiac Wounds

P. N. SYMBAS, DAVID A. DiORIO,* D. H. TYRAS,*
R. E. WARE* and CHARLES R. HATCHER, Jr.,
Atlanta, Georgia

In order to determine the course and sequelae of penetrating cardiac wounds, the cases of 76 patients with such injuries treated at Grady Memorial Hospital from July 1964 through June 1972 were reviewed. Of these 76 patients, 56 survived the immediate postinjury period with no further mortality attributable to their injury during an average 19 month follow-up period. A variety of anatomic and physiologic sequelae of the cardiac wounds were encountered, including 5 ventricular aneurysms (3 pseudo, 1 true, and 1 undefined aneurysm), 3 ventricular septal defects, 3 instances of valvular incompetence (2 mitral, 1 pulmonic), 2 aortopulmonary fistulae and 2 instances of bullets retained within the interventricular septum. With the exception of the 2 patients with ventricular septal defects and both patients with aortopulmonary fistulae, none of these patients were more than mildly symptomatic and most were totally asymptomatic. Operative intervention has been carried out without mortality and with excellent results in the 4 patients with marked symptoms (2 VSD and both AP fistulae) and in 4 patients with ventricular aneurysms (3 pseudo and 1 true).

This experience re-emphasizes the need for close follow-up of patients sustaining penetrating cardiac wounds and repair of the delayed sequelae of such wounds when either hemodynamically significant or potentially dangerous to the patient.

12. Air Embolism Following Penetrating Lung Injury

ARTHUR N. THOMAS,* San Francisco, California
Sponsored by Benson B. Roe

The literature does not mention the occurrence of air embolism after penetrating lung injury. Nevertheless we have documented coronary air embolism after penetrating lung injury in three patients. We believe that this was responsible for difficulty in resuscitating the patient in one instance and resulted in death in two.

In order to evaluate the mechanism and significance of air embolism penetrating lung injuries were created in 14 anesthetized dogs. A polyethylene shunt between the aortic root and femoral vein was used as an air bubble trap and detector. The lung was penetrated with a #22 scalpel blade. Air immediately appeared in the shunt in 10 of 14 dogs. Airway, pulmonary artery, right ventricle, left atrial and femoral arterial pressures were measured in animals receiving controlled ventilation.

Air caused rapid death from coronary embolism in 6, and caused hemodynamic changes that spontaneously ceased in 4. Lung injury produced no detectable air embolism in 4 dogs. A communication between the airway, pulmonary artery and pulmonary vein was shown in all lung wounds. The sequential hemodynamic changes measured were left ventricular failure, left atrial hypertension, pulmonary arterial hypertension and systemic hypotension.

The conclusion is that air embolism is a potential hazard following lung wounds. It is most apt to occur in patients who are in shock and require positive pressure ventilation.

*By invitation

13. The Role of Bronchial Brushing on the Decision for Thoracotomy

J. J. FENNESSY* and C. F. KITTLE, Chicago, Illinois

More than 600 transcatheter or bronchial brush biopsies have been performed at The University of Chicago Hospitals between 1965 and 1972. Tissue thus secured was examined histologically and cytologically, and cultured for fungus and bacteria. In most of these patients the indication for the procedure was the presence in the lung of a lesion suspected to be malignant. Flexible fiber optic bronchoscopy has been done for the past 3 years in these patients.

This presentation is a retrospective analysis of the clinical and radiologic data available on patients subjected to bronchial brush biopsy and flexible bronchoscopy to determine to what extent, if any, the results of the procedure influenced the surgeon's decision to operate.

These patients have been analyzed by reviewing the clinical data pre-brushing to determine if the surgeon would advise thoracotomy. A retrospective analysis was also done by both authors to determine if brushing was helpful in the overall management.

Definite indications for brushing have been established: the possibility of inflammatory disease and a need for culture material, the question of metastatic disease with multiple nodules, and the opportunity of obtaining a tissue diagnosis for x-ray therapy when other conditions precluded operation. In many instances "brushing" has been of supplemental interest only without decision-making importance.

14. Parasternal Mediastinotomy—A Useful Adjunct in the Diagnosis of Chest Disease

PHILIP C. JOLLY,* LUCIUS D. HILL, THOMAS WEST*
and PETER LAWLESS,* Seattle, Washington

One hundred consecutive cases of parasternal mediastinotomy have been compared to 240 cases of mediastinoscopy. Distant metastases were not present in these patients to contraindicate thoracotomy or allow easy tissue diagnosis. There was no mortality and morbidity was low after both procedures. Sixty-eight percent of the patients had carcinoma of the lung. In those patients with lung cancer tissue diagnosis was obtained by mediastinotomy in 69% and by mediastinoscopy in 32%. Undifferentiated tumors yielded a higher diagnostic return in both groups. Mediastinotomy proved superior to mediastinoscopy in evaluating patients for resectability. Resectability rates at thoracotomy correlated accurately with the findings at mediastinotomy and mediastinoscopy. Of the malignant cases, thoracotomy was avoided in 62% by mediastinotomy and in 30% by mediastinoscopy.

Parasternal mediastinotomy is a simple, versatile procedure. Lung biopsies were obtained in 22 patients yielding a diagnosis in a variety of chest diseases. Therapeutic procedures such as pericardial window, excision of pericardial cysts and placement of epicardial electrodes for pacemaking are possible through this incision.

*By invitation

15. Delayed Cutaneous Hypersensitivity Reactions to Tumor Antigens and to Non-Specific Antigens: Prognostic Significance in Patients with Lung Cancer

SAMUEL A. WELLS,* Durham, North Carolina
JAMES F. BURDICK* and CHRISTINE CHRISTIANSEN,* Bethesda, Maryland, WILLIAM L. JOSEPH,* WALTER G. WOLFE* and PAUL C. ADKINS, Washington, D.C.

Oncogenesis is favored by an environment of depressed immunity, but there are few studies in humans correlating both general immunological status and reactivity to tumor specific antigens with the patient's clinical course.

Delayed cutaneous hypersensitivity reactions (DCHR) to bacterial antigens (mumps, candida and streptokinase-streptodornase) and to a previously unencountered antigen, dinitrochlorobenzene (DNCB), were evaluated in 100 ambulatory patients, 75 with lung cancer and 25 with benign lung disease. Eighteen cancer patients were also tested with membrane antigen extracts (MAE) of autologous tumor tissue.

Twenty-four patients with benign disease had positive DCHR to both bacterial antigens and DNCB. In the 75 cancer patients 72 developed DCHR to bacterial antigens, but reactivity to DNCB was markedly depressed with only 40 patients reacting and in 12 patients with non-resectable disease only 2 reacted. Eight of 18 patients developed DCHR to autologous MAE of lung tumor, but not to normal lung. Seven of these patients were well at eight months, while only 3 patients with negative DCHR to tumor MAE were alive without recurrent disease.

These data demonstrate that in lung cancer patients, a poor prognosis is associated with a depressed immune recognition of DNCB and negative cutaneous reactivity to autologous tumor MAE.

16. Segmental Resection for Lung Cancer—A 15-Year Experience

ROBERT J. JENSIK, L. PENFIELD FABER, FRANK J. MILLOY* and DAVID O. MONSON,* Chicago, Illinois

One hundred fourteen patients with primary lung cancer underwent segmental resective surgery over the past 15 years. The patients were placed in the following groups:

I. In 14 patients, previous contralateral resective surgery had been carried out;
II. In 26 patients, the procedure was done for palliation;
III. In 74 patients, the resection was considered as a definitive curative operation.

Four patients of Group I survived more than two years with the longest survivor still alive seven plus years later.

Only five patients survived more than two years in the palliative group, the longest attaining a five-year survival.

A 55% five-year survival calculated by actuarial method was achieved in Group III. This declined to 21% over the 15-year period.

Tumor histology and location, the type of segmental procedures, and factors influencing the decision for limited resection will be discussed.

An operative mortality of 5% to 6% with a 55% five-year survival suggests that segmentectomy may be the procedure of choice when indicated.

*By invitation

TUESDAY MORNING, APRIL 17, 1973

8:30 A.M. Scientific Session
Regency Ballroom

17. A New Technique of Treating Esophageal Varices

MITSUO SUGIURA* and SHUNJI FUTAGAWA,* Tokyo, Japan
Sponsored by John E. Connolly

The high incidence of encephalopathy and progressive hepatic failure following portosystemic shunts for esophageal varices led us to abandon this technique. From 1964 to 1967 26 patients underwent simple transection of the thoracic esophagus. Recurrence of variceal bleeding was noted in 4 and esophageal varices disappeared radiographically in only 15 patients. The excision of coronary veins plus esophageal transection in 14 patients did not improve the late results.

Our current technique has evolved from these earlier experiences and consists of extensive paraesophageal devascularization up to the tracheal bifurcation, transection of the distal thoracic esophagus, splenectomy, devascularization of the abdominal esophagus and cardia, selective vagotomy and pyloroplasty. Thoracic and abdominal operations are performed through separate incisions and can be done in two stages in poor-risk patients. Since 1967, 74 patients have undergone this new procedure, 14 emergency, 48 elective, and 12 prophylactic. The causes of esophageal varices were: cirrhosis 41, fibrosis 22, extrahepatic portal vein occlusion 7, hepatoma 3, and carcinoma of the pancreas 1. Overall operative mortality was 5.4%. A five-year followup study revealed that six patients died of hepatoma, the esophageal varices disappeared in all cases, and all 60 survivors were free from encephalopathy.

Although a longer follow-up is necessary, our preliminary results are encouraging and warrant further trial.

18. Surgical Management of Scleroderma of the Esophagus

R. D. HENDERSON* and F. G. PEARSON, Toronto, Ontario, Canada

Misconceptions persist concerning the origin, and treatment of dysphagia in patients with scleroderma. This report of current experience clarifies aspects of pathogenesis, and an approach to treatment is suggested.

In the past four years, we have studied 22 patients with scleroderma, 16 of whom had significant complaints of reflux and dysphagia. In 6 of the 16 symptomatic patients a diagnosis of scleroderma was first made following our clinical assessment and esophageal motility studies. Nine of 16 patients with dysphagia had typical peptic strictures.

Twelve patients were treated surgically: Gastroplasty and Belsey hernia repair—9, Belsey repair—2, Thal esophagogastroplasty—1. Cine barium studies were done in all patients before and after operation. Motility studies were done in all 12 patients pre-operatively, and in 7 patients post-operatively.

Good results were obtained in 10 patients: 5 are completely asymptomatic; 3 have slight pharyngoesophageal motor dysphagia; 1 has slight gastroesophageal

*By invitation

mechanical dysphagia; and 1 patient has symptomatic reflux, but relief of dysphagia. One patient was unimproved. There was one operative death.

There is no evidence that scleroderma results in esophageal stricture, other than by predisposing to reflux. Correction of reflux with dilatation of strictures gives good symptomatic relief. No healing problems were noted.

19. Reappraisal of Adjuncts to Avoid Ischemia in the Treatment of Descending Thoracic Aortic Aneurysms

E. STANLEY CRAWFORD, Houston, Texas

Paraplegia is a dreaded complication associated with excisional therapy of aneurysms involving the descending thoracic aorta. Various methods or adjuncts have been devised to prevent this complication, including bypass shunts of various types and hypothermia. These procedures and improved surgical techniques have reduced this complication to a minimum and it is difficult to determine which is more important. This paper is concerned with a consecutive series of 80 patients in whom descending thoracic aortic aneurysm were removed. Bypass shunts were employed in the first 38 patients. The last 42 patients were treated without special protective mechanisms. Paraplegia was present after operation in 3 of the former and in one of the latter patients. Of the 36 patients undergoing operation electively without shunts, none developed paraplegia and 94.5 per cent survived despite being over sixty years of age in most cases. This experience would tend to require reappraisal of need for shunts, and this paper will deal both with this and other parameters in the conduct of operation felt to be more important.

20. Patterns of Myocardial Metabolism During Cardiopulmonary Bypass (CPB) and Coronary Perfusion

O. WAYNE ISOM*, NEIL D. KUTIN*, EMILY A. FALK*
and FRANK C. SPENCER, New York, New York

Much uncertainty prevails about methods of coronary perfusion, tolerance for ischemia, and fibrillating vs beating heart. Therefore, in 35 patients undergoing CPB (30°C) myocardial metabolism was studied during operation and for up to 70 hrs. Paired samples of arterial and coronary sinus blood, obtained from indwelling catheters, were analyzed for P_{O_2}, P_{CO_2}, pH, lactate, and enzymes—CPK, LDH, SGOT. In 15 pts undergoing aortic valve replacement, coronary flow rates and myocardial oxygen consumption were also measured. The data, statistically analyzed for over 20 variables, were as follows:

Coronary blood flow (CBF) was 200-300 ml/min, oxygen extraction (ΔA-V) 2.5-3.0 vol %; MVO_2 6-8 ml/min, about 20 per cent of normal. The table shows little difference between fibrillating (F) and non-fibrillating (NF) hearts, except greater enzyme production in F hearts ($p < 0.05$). Lactate extraction occurred in about one-half of each group.

*By invitation

	# pts	MVO_2 ml/min	A-V O_2 vol %	EO_2	% pts ext. Lactate	CPK	LDH	SGOT
NF	9	7.96	3.05	25%	56	206	345	125
F	6	6.13	2.7	24%	44	339	644	127

Marked lactate production (ΔA-V 85 mg%) occurred with 15 min ischemic periods. Metabolic recovery from shorter ischemic periods occurred in 5-10 min, but longer periods caused permanent alterations of oxygen consumption. An "overperfusion" injury was identified, characterized by localized edema, normal lactate metabolism, and severe arrhythmias (1-3 hrs duration). Coronary perfusion exceeding 300 ml/min led to significantly greater enzyme production than did lower perfusion rates (CPK 344 vs 172, $p < 0.01$).

Limitations of metabolic studies were found in one patient with a short left main coronary who developed a fatal myocardial infarction. CPK production occurred (A-V CPK 125 units) but lactate metabolism was near normal. The relationship of these data to the pathogenesis of hemorrhagic subendocardial necrosis will be discussed.

21. Anoxic Cardiac Arrest: An Experimental and Clinical Study of its Effects

S. R. K. IYENGAR,* E. J. P. CHARRETTE* and R. B. LYNN Kingston, Ontario, Canada

"It is important to know not only the survival but also the quality of life after anoxic cardiac arrest," commented Dr. Gerbode in the Thoracic Surgery Forum of the last meeting of the Association. We have been engaged in the study of this problem for the past two years. During phase I of the investigation a correlation between the incidence of subendocardial hemorrhagic necrosis in dogs and anoxic cardiac arrest was established. Simple flushing of the coronary bed during anoxic arrest of 60-75 minutes with a balanced electrolyte solution, designated as "Beks" solution in our laboratory prevented the subendocardial lesions and there was no intraoperative death from low output. Impressed by these results, we have been routinely flushing the coronary bed with the "Beks" solution during aortic valve replacement. The results are being assessed.

In patients with aortic valvular stenosis, it is believed that in addition to left ventricular hypertrophy, the coronary blood flow is interfered with. In the second phase of our programme a canine model in which sub-coronary aortic stenosis was produced to simulate the situation in humans was produced to study the effects of anoxic arrest. The hypertrophied left ventricle was much more vulnerable to anoxic arrest. Whereas the lesions were subendocardial in the normal canine heart, they were extensive and deep in the hypertrophied left ventricle. At present investigation is in progress to study and improve the quality of myocardial function after anoxic arrest in long term canine survivors.

Myocardial damage incidental to anoxic arrest during open heart surgery adversely affects the quality of life and diminishes the maximum benefit that could otherwise be expected. Pharmacologic manipulation and intermittent flushing of the coronary bed during anoxic arrest offers a simple technique which deserves more extensive clinical trial.

*By invitation

22. Profound Local Hypothermia for Myocardial Protection During Open Heart Surgery

RANDALL B. GRIEPP,* EDWARD B. STINSON* and NORMAN E. SHUMWAY, Stanford, California

Between 7/71 and 6/72, 329 adults underwent cardiac valve replacement (153), or aortocoronary bypass grafting (133), or both (43). The aorta was crossclamped during valve replacement and during the performance of distal coronary artery anastomoses. Local profound hypothermia during aortic crossclamping was provided by a continuous infusion of normal saline at 4°C. into the pericardial cavity. Coronary artery perfusion was not used. Cardiopulmonary bypass times ranged from 40 to 200 minutes (average 105 minutes), and aortic crossclamp times ranged from 30 to 140 minutes (average 62 minutes).

Twelve hospital deaths occurred, yielding an operative mortality of 3.6%. Six patients could not be weaned from cardiopulmonary bypass; three died of low cardiac output postoperatively, and three died as the result of factors not related to myocardial function. Average stay in the intensive care unit was 2.5 days, and average hospital stay was 10 days. No correlation is evident between duration of aortic crossclamping and morbidity or mortality.

This experience suggests that profound local hypothermia during aortic crossclamping affords excellent protection of the myocardium during the performance of cardiac valve replacement and aortocoronary bypass grafting.

23. The Hazard of Ventricular Fibrillation in Hypertrophied Ventricles During Cardiopulmonary Bypass

CHRISTOF E. HOTTENROTT,* HENRY J. KURKJI,* JAMES V. MALONEY and GERALD D. BUCKBERG,* Los Angeles, California

We previously reported left ventricular ischemic damage occurs in most patients dying after cardiopulmonary bypass, and defined pre- and postoperative factors contributing to this injury. This study provides evidence that any form of ventricular fibrillation during bypass impairs coronary flow to the hypertrophied left ventricle and causes ischemia.

Seven dogs with left ventricular hypertrophy (aortic stenosis 3-5 months) were compared to fifteen normal dogs to determine how spontaneous ventricular fibrillation (60 minutes) during cardiopulmonary bypass affects: (1) myocardial function (Sarnoff curves), (2) regional coronary flow (radioactive microspheres), (3) cardiac biochemistry (pH, lactate, potassium) and (4) histochemistry (acid fuchsin).

In normal ventricles, spontaneous fibrillation raised left ventricular oxygen consumption and subendocardial flow and lowered vascular resistance ($P < .01$). It did not impair myocardial function and biochemistry nor cause histochemical damage. Conversely, when hypertrophied left ventricles fibrillated spontaneously, oxygen consumption failed to rise, vascular resistance progressively increased, and biochemical evidence of severe ischemia occurred (myocardial lactate production, decreased coronary sinus pH, and loss of intracellular potassium, $P < .01$). Post-bypass ventricular function was depressed and histochemical ischemia was demonstrated. Clinical studies during aortic valve replacement confirmed these experimental findings.

*By invitation

This study shows that while spontaneous fibrillation may be safe in normal hearts, it is hazardous in hypertrophied hearts.

24. Evaluation of Functional, Metabolic and Structural Alterations in the Myocardium During Aortic Cross-clamping

EDWARD A. STEMMER, PETER McCART,* WILLIAM E. STANTON,* WILLIAM THIBAULT* and JOHN E. CONNOLLY, Irvine, California

Inability of the myocardium to support satisfactory circulation is the most frequent cause of death after open heart procedures. Knowledge of the interrelationships between metabolism, structure and function of the myocardium can prevent deterioration of myocardial function and refractory myocardial failure.

The ability to maintain normal myocardial metabolism, function and ultrastructure was evaluated in 70 dogs undergoing cardiopulmonary bypass with sustained fibrillation, ischemic arrest, topical hypothermia, intermittent coronary perfusion or continuous coronary perfusion. Survival, arterial pressure, central venous pressure, left ventricular pressure, cardiac output, dp/dt, urinary output, myocardial oxygen consumption, myocardial potassium loss, lactate utilization, pyruvate metabolism, light microscopy and electronmicroscopy were studied in each animal during a baseline period, two hour test period and two hour recovery period.

The best survival with the least impairment of myocardial function was observed with continuous hypothermic coronary perfusion. The poorest survival with the greatest impairment of function occurred after normothermic anoxic arrest for more than 60 minutes. Topical hypothermic arrest without coronary perfusion produced good survival but significantly compromised myocardial function. Electronmicroscopy demonstrated that damage to the mitochondria was associated with poor survival, elevated coronary sinus lactate and poor recovery of myocardial function. Anoxia aggravated these changes while coronary perfusion minimized them.

11:15 A.M. Address of Honored Speaker

Sir Thomas Holmes Sellors
President, Royal College of Surgeons

THE GENERALITY OF SURGERY

*By invitation

TUESDAY AFTERNOON, APRIL 17, 1973

2:00 P.M. Scientific Session
Regency Ballroom

25. Drug Influence on Platelet Loss During Extracorporeal Circulation

C. H. MIELKE, JR.,* M. deLEVAL,* J. D. HILL,*
M. F. MACUR* and F. GERBODE, San Francisco, California

Thrombocytopenia, which develops during prolonged extracorporeal circulation, represents the major hazard to this procedure. The potential for serious hemorrhage during prolonged perfusion has led to investigations of the influence of various drugs on platelet loss.

Using labeled platelets (51 Cr) in dogs, we were able to show that the majority of this platelet loss occurs because of storage in the liver during bypass. Once bypass is discontinued, some of the sequestered, labeled platelets return to the circulation with a corresponding reduction in liver radioactivity. Circulating fibrinogen labeled with 125 I remains stable.

Using this animal model we have evaluated several drugs with known influences on platelet function in both the Temptrol bubble and Bramson membrane oxygenators. The influences of Persantine, Aspirin, Sudoxicam and Pluronic F68 were compared on platelet loss during and after bypass.

Persantine inhibited platelet adhesion but not aggregation. Platelet levels were only slightly diminished during and after bypass. Pluronic F68 was similar but less effective. Platelet microaggregation during bypass was effectively inhibited by both agents. Sudoxicam inhibited both platelet aggregation and adhesion. However, the post bypass level of platelets was lower than with the two other agents. Platelet consumption was increased by high doses of aspirin.

26. Electroencephalographic Changes and Cerebral Complications in Open-Heart Surgery

M. WITOSZKA,* H. TAMURA,* R. INDEGLIA* and
F. A. SIMEONE, Providence, Rhode Island

Cerebral dysfunction and behavioral disorders are not uncommon after surgical correction of cardiac lesions. In the past four years encephalograms (EEG) were continuously monitored during open heart surgery in 50 randomly selected patients who survived (Group I) and 50 patients who succumbed during (Group II) and after the procedure (Group III). These data were correlated with clinical evidence of neurological disorders and findings in the brain at autopsy.

*By invitation

Results:

Group	Total		Hypo-tension		Encephalo-pathy		Motor Changes		Total Neurologi-cal Changes	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Group I	50		5	10%	26	52%	12	24%	26	52%
EEG Changes	7	14%	3	42%	5	71%	3	42%	5	71%
No EEG Changes	43	86%	4	9%	22	51%	10	23%	22	51%
Group II	5									
EEG Changes	5	100%	5	100%						
No EEG Changes	0		0							
Group III	45		17	37%	28	62%	23	51%	36	80%
EEG Changes	25	55%	13	52%	20	80%	14	56%	23	92%
No EEG Changes	20	44%	4	20%	8	40%	9	45%	13	65%

Postmortem examinations of the brain were performed in 20 patients. Among 18 of these patients with significant EEG changes fifteen had abnormal findings upon histologic examination of the brain. Evidence of cerebral embolism was found in 60% of autopsy specimens. No correlation between hypotension and histologic abnormalities was observed.

Conclusions:

1. Neurological complications occurred in 52% of patients who survived open heart surgery and in 80% of patients who died.
2. These complications followed intraoperative EEG abnormalities in 28% cases and 35% in the absence of intraoperative EEG changes, postoperative encephalopathy or motor disorders occurred in 62% of the patients.
3. Neuronal degeneration was the most common pathological manifestation of the encephalopatlic syndrome, while frank cerebral necrosis (8 cases) was most often associated with cerebral embolism (80% of the cases).

27. Surgical Experience with Temporary and Permanent A-V Sequential Demand Pacing

JOSH FIELDS,* BAROUTH V. BERKOVITS* and JACK M. MATLOFF, Los Angeles, California

The hemodynamic advantages of the normal atrioventricular sequence can be maintained in patients with atrial bradytachy-arrhythmias and/or complete heart

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block by the temporary or permanent use of atrioventricular sequential demand pacing. This pacing modality is achieved with a two-catheter system utilizing a conventional bipolar ventricular catheter and a new, preformed J-shaped bipolar atrial electrode. Temporary use in 12 postoperative cardiac surgical patients with sinus or nodal bradycardia (with and without A-V block) yielded a 12-22 mm Hg increase in blood pressure over that achieved with ventricular pacing. In each case of escape tachyarrhythmia or ectopic activity, the use of A-V sequential pacing achieved capture and maintenance of a stable rate and rhythm *without* large doses of suppressant drugs.

Permanent A-V sequential demand pacemakers have been implanted for up to three years in 49 patients, 6 following prosthetic valve replacement and 43 with intermittent or constant atrial arrhythmias (17) and bradytachy-arrhythmias (26). Fifteen of these patients also had A-V dissociation. There was dramatic clinical improvement in 44 of these patients, manifest by relief of syncope, control of tachyarrhythmias and relief of congestive heart failure. This latter result was achieved by virtue of increased cardiac outputs. From this experience, it would appear that A-V sequential demand pacing provides the most comprehensive modality of pacing yet available.

28. Experience with Atrial Pacemaker Wires Implanted During Cardiac Operations

NOEL L. MILLS* and JOHN L. OCHSNER, New Orleans, Louisiana

Two-hundred and seventy-five patients had implantation of a pacemaker wire on the right atrium at the time of cardiac operation. The operations involved were repair of congenital heart defects and valvular and coronary bypass procedures. Forty-three patients had arrhythmias in the postoperative period—the most common being atrial fibrillation, ventricular premature beats, and atrial flutter. A unipolar wire was implanted in all except 8 patients. Bipolar wires were used for patients who had sinus bradycardia at the conclusion of the operation and left while being atrially paced.

The atrial wire was used also in the postoperative period as an exploring electrode to diagnose atrial arrhythmias. Connection of the atrial wire to the chest electrode of the standard electrocardiograph obtains such information that proper diagnosis and prompt treatment could be instituted. In addition, the electrode was used as an atrial pacer for conversion of flutter to normal sinus rhythm, for sinus bradycardia, and for evaluation of coronary bypass grafts.

In 13 patients implantation of the wire was unsuccessful and in 4 the wires were broken on removal. No early or late sequelae were observed. From our experience we advocate the routine use of atrially implanted electrodes for diagnostic and therapeutic use after cardiac operations.

3:30 P.M. Executive Session (Limited to Active and Senior Members)
Regency Ballroom

*By invitation

TUESDAY EVENING, APRIL 17, 1973

7:00 P.M. President's Reception
Regency Ballroom

8:00 P.M. President's Dinner and Dancing
Regency Ballroom

Attendance open to all physicians and their ladies. Tickets must be obtained at the Registration Desk by 5:00 P.M. on Monday, April 16, 1973.

Dinner Dress Preferred

WEDNESDAY MORNING, APRIL 18, 1973

8:30 A.M. Scientific Session
Regency Ballroom

29. Liquid Membrane Oxygenator

HERBERT W. WALLACE,* MARC T. ZUBROW,* HELENE BROOKS,* WILLIAM J. ASHER,* NORMAN N. LI* and T. PETER STEIN,*
Philadelphia, Pennsylvania
Sponsored by William S. Blakemore

A new concept of blood oxygenation based on the encapsulation of gas bubbles within a thin film of inert fluorochemical avoids a blood-gas interface but allows adequate gas transfer. The encapsulated bubbles are passed countercurrent to the blood flow. Oxygen passes through the liquid membrane into the blood, and CO_2 takes the reverse course. The bubbles emerge from the blood phase and collapse, releasing CO_2. The fluorochemical is reused. *In vitro* experiments demonstrated the method's feasibility (estimated O_2 transfer $\geqq$ 100 cc/min/m2). The compalibility of fluorochemical and blood was evaluated with a device designed to generate a continuous blood-fluorochemical interface. There were no measured untoward effects of fluorochemical upon human blood (24 parameters studied) during 24-hour exposure of over 52 m2 of interface at 25°C. *In vivo* all ten dogs survived 4 hours of veno-venous perfusion (200 cc/min). No alterations of 24 blood parameters occurred acutely or during a four- to six-week period of follow-up. The animals were sacrificed, and no gross or microscopic alterations of organs were detected. A prototype oxygenator is now undergoing *in vitro* and *in vivo* evaluation. The initial results have been promising and will be discussed.

30. The Lande'-Edwards Membrane Oxygenator During Heart Surgery: Oxygen Transfer, Microemboli Counts and Bender Gestalt Visual Motor Test Scores

ROBERT G. CARLSON,* ARNOLD J. LANDE',* JAMES BAXTER,* RUSSELL H. PATTERSON, JR.,* and C. WALTON LILLEHEI,
New York, New York

In 130 patients, 7-103 Kg, the Lande'-Edwards Membrane Oxygenator provided simple, safe, total cardiopulmonary support (3M2 membrane/40 kg). Venous blood drained through the membranes into a reservoir by gravity only and was pumped back into the patient.

Maximum oxygen transfer was 52/ml/min/M2 of membrane, range 12-52 depending on temperature and body weight. At moderate hypothermia (30°C), venous saturation was 85% and arterial 100%. Partial support was provided during warming in larger patients to reduce the number of oxygenator units needed. At mild hypothermia (33-36°C) maximum oxygen transfer measured was 312 ml/min/6M2 membrane (range 35-53).

Decreased morbidity of the membrane compared with the bubble oxygenator was evidenced by decreased microemboli counts, e.g., comparable counts per minute with membrane were 1500 v.s. 18,000 with bubble oxygenator. Use of a

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microfilter (Pall) reduced these counts by 90% in both. Postoperative visula motor function (Bender-Gestalt) deteriorated in 9% (membrane) and 40% (bubble) patients. This membrane provided safe total cardiopulmonary support for heart surgery and is recommended for decreased morbidity particularly in complex operations.

31. Intraaortic Balloon Assist for Postcardiotomy Cardiogenic Shock

R. L. BERGER and V. K. SAINI,* Boston, Massachusetts

Intraaortic balloon pump (IABP) support was provided in eleven patients with cardiogenic shock following coronary artery bypass grafts, resection of left ventricle, mitral valve surgery or a combination of these operations. Nine of the eleven could not be weaned from cardiopulmonary bypass (CPB) as evidenced by a systolic pressure of less than 75 mm. of Hg. and a left atrial pressure of greater than 24 mm. of Hg. in spite of maximal volume and pressor therapy. Institution of IABP converted the nonpulsatile flow of CPB into a pulsatile one, raised the arterial and lowered the left atrial pressures and allowed discontinuation of CPB. Eight of the nine patients left the operating room and four became long term survivors. Aortocoronary bypass graft flow was measured with electromagnetic probes in one patient and IABP produced a 60% increase in flow. Two of the eleven patients sustained cardiac arrest on the first and second postoperative days and remained in deep shock following resuscitation. IABP support produced initial improvement but ultimately both died. Extensive documentation of clinical, hemodynamic and metabolic changes were obtained in all cases. This experience indicates that IABP can be instrumental in salvaging postcardiotomy cardiogenic shock patients.

32. Objective Assessment of the Effects of Aorto-Coronary Bypass Operation on Cardiac Function

HOOSHANG BOLOOKI,* LEONARD SOMMER,* STEVEN MALLON,* ABELARDO VARGAS* and MICHAEL GILL,* Miami, Florida
Sponsored by Gerard A. Kaiser

Controversy exists as to the actual effects of direct myocardial revascularization on cardiac function. In order to evaluate this subject more precisely, we have studied eleven parameters of cardiac function (as a pump and as a muscle) and left ventricular compliance in twenty consecutive patients before and within 4-10 months after successful myocardial revascularization. Eight patients were operated because of acute cardiac ischemia—preinfarction angina (Group A) and twelve had surgery because of chronic intractable angina pectoris (Group B). Postoperatively, all these patients were free of angina and had returned to work; also arteriograms had shown patency of all grafts. After surgery, cardiac index (CI), myocardial contractility (Vmax, dp/dt/Kp), left ventricular end-diastolic pressure (Edp) and compliance (dp/dv) among other parameters, showed insignificant changes in either group. Statistical analysis of data was carried out in a number of ways using various classifications. There was an increase in Vmax in 4 of 8 (50%) of patients in Group A as opposed to 3 of 12 (25%) of patients in

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Group B. Left ventricular compliance was unchanged in Group A, but had decreased by 50% or more in one-half of patients in Group B. CI had increased by 25% or more in 6 of 7 patients (in both groups) who had a control CI below 2.5 L/min/m2($P < 0.02$). In this group, however, the stroke volume remained unchanged. These results indicate that direct myocardial revascularization produces an excellent palliation of anginal symptoms, but the postoperative improvement in cardiac function is most likely to occur in that group of patients who are suffering from acute cardiac ischemia.

33. Preinfarction Angina Pectoris—A Surgical Emergency

R. R. GOODIN,* T. V. INGLESBY,* A. M. LANSING *
and M. W. WHEAT, JR., Louisville Kentucky

From November, 1971, to September, 1972, 19 patients with preinfarction angina pectoris, 11.3% of patients studied because of coronary atherosclerosis, were studied by cardiac catheterization and coronary arteriography. All patients were candidates for aorto-coronary bypass surgery if technically feasible.

Twelve patients had saphenous vein aorto-coronary bypass graft surgery with one death and good clinical results in the 11 survivors. Seven patients were not operated upon and in five of these patients there have occurred 3 deaths and 2 non-fatal myocardial infarctions during the first three months of follow-up.

From a clinical standpoint, severity and duration of pain, frequency of pain and EKG changes, the two patient groups could not be differentiated. Fifty percent of operated and 57% of non-operated patients had had previous myocardial infarctions. The average number of vessels with over 50% occlusion was 2.17% in operated and 2.85% in non-operated group. Sixty-seven percent of operated and 71% of non-operated patients had abnormal contractions by left ventricular cineangiography. These preliminary results suggest that once the diagnosis of preinfarction angina pectoris is established and appropriate studies carried out, the patient's best interests are served by immediate aorto-coronary artery bypass surgery.

34. Surgical Treatment of Ventricular Irritability

E. D. MUNDTH, M. J. BUCKLEY, R. W. DeSANCTIS,*
W. M. DAGGETT and W. G. AUSTEN, Boston, Massachusetts

Myocardial revascularization and/or resection of a ventricular aneurysm appears to be an effective method of treating persistent and medically refractory ventricular irritability (VI) following acute myocardial infarction (AMI). Nine patients with medically refractory VI, varying from 2 days to 6 weeks post-AMI, have undergone cine coronary arteriography and left ventricular angiography and surgical treatment. Five of the nine patients were less than 2 weeks post-AMI. They were all hemodynamically unstable and 3 were in cardiogenic shock. All 5 had institution of intra-aortic balloon pump assistance (IABPA) with hemodynamic improvement but had persistent VI despite antiarrhythmic drug therapy and appropriate electrical pacing. The other four patients demonstrated intractable VI 2 to 6 weeks post-AMI. IABPA was used in one patient in this group to facilitate management during diagnostic study and induction of anesthesia as well as postoperatively. Seven of nine patients had a demonstrable left ventricular

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aneurysm. Aneurysmectomy was carried out in 7 patients and was combined with 1, 2 or 3 vein bypass grafts in 3. Revascularization alone was carried out in 2 patients. Six of nine patients have survived. VI was improved and readily manageable in all 6 survivors. In 4 of the 6 survivors postoperative VI was managed with minimal antiarrhythmic therapy. Left ventricular function has been good or excellent in all 6 survivors.

35. Serial Angiographic Evaluation of Aortocoronary Vein Grafts in Sixty Consecutive Patients, Two Weeks, One Year, and Three Years after Operation

CLAUDE M. GRONDIN,* JEAN-PAUL MARTINEAU,* CLAUDE MEERE* YVES R. CASTONGUAY,* GILLES LEPAGE* and PIERRE R. GRONDIN, Montreal, Quebec, Canada

Although early results in aortocoronary vein grafts (ACVG) have been promising, critical appraisal must await long term studies.

Serial angiographic studies were conducted in 60 consecutive patients who underwent ACVG at the Montreal Heart Institute. All patients were studied two weeks, one year, and three years after operation. Occlusion occurred in 7 of the 91 grafts on the initial study and in 8 additional grafts on the second study. On this second study, most grafts displayed diffuse reduction in caliber—average reduction: 30 percent. In 3 grafts, reduction in caliber was greater than 75 percent. Two years later, all 3 grafts were occluded.

Except for these 3 grafts and 2 additional grafts which became occluded, there was no further attrition rate or reduction in caliber—segmental or diffuse—after one year in the remaining 71 grafts. The overall patency rate was therefore 92.3 percent after two weeks, 82.5 percent after one year, and 77 percent after three years. Hence the occlusion rate of ACVG after one year was only 5.5 percent.

These results indicate that the initial enthusiasm for ACVG was not unwarranted.

36. Coronary Bypass Grafting in 376 Consecutively Operated Patients with Three Operative Mortalities

JOHN E. HUTCHINSON, III,* GEORGE E. GREEN, HAROUTUNE A. MEKHJIAN* and HARVEY G. KEMP,* New York, New York

In the twenty-one month period from January, 1971, to September, 1972, 376 patients had coronary bypass grafts performed for coronary atherosclerosis. Three hundred and seventy-three patients were discharged from the hospital (alive) and three patients died. The operative mortality in this consecutively operated group was 0.8%. Four late deaths have occurred to date, two of them (being) due to pulmonary emboli, one due to hepatitis, and the fourth to myocardial infarction.

In this series, single grafts were performed in 60 patients, double grafts in 185, triple grafts in 121 patients, and quadruple grafts in ten patients. Included in this consecutive series are twenty-four patients with threatened infarction syndromes and twenty patients with diffuse scarring of the left ventricle.

*By invitation

We feel that the major factors accounting for this low mortality are (1) Increased experience in the performance of small vessel anastomosis. (2) Total avoidance of endarterectomy. (3) The performance of the distal coronary anastomosis with ventricular fibrillation rather than anoxic cardiac arrest. (4) The use of the internal mammary arteries and small veins from the lower legs as the bypass conduits of choice.

The specific details of these factors will be discussed.

WEDNESDAY AFTERNOON, APRIL 18, 1973

2:00 P.M. Scientific Session
Regency Ballroom

37. Pneumothorax Complicating Continuous Ventilatory Support

MICHAEL STEIER,* NATHANIEL CHING,* ENRIQUE BONFILS ROBERTS* and THOMAS F. NEALON JR.,
New York, New York

There has been a 35 per cent increase in the incidence of pneumothorax in our hospital in the last 3 years. The increase has been due to iatrogenic causes related to improvements in the care of critically ill patients—external cardiac massage, central venous pressure monitoring and continuous ventilatory support. The factors associated with continuous ventilatory support seemed appropriate for presentation before the Association.

In the period from January 1, 1968 to December 31, 1971, 61 patients at our institution developed pneumothorax during continuous ventilatory support. The significant factors leading to the occurrence of this complication include:

1. volume-controlled ventilation
2. large tidal volumes
3. high inspiratory pressures
4. positive end expiratory pressure
5. history of chronic obstructive lung disease and previous rib fractures.

These factors will be discussed in detail.

The importance of early diagnosis based on physical findings allowing immediate treatment will be stressed. Eight per cent of patients so diagnosed and treated succumbed as compared to 38 per cent of those in whom diagnosis waited confirmation with a chest x-ray due to the hazard of pressure ventilation in patients with pneumothorax.

38. Electronmicroscopy and Physical Chemistry of Healing in Prosthetic Heart Valves, Skirts, and Struts: Modification by Electrochemically Clean, Physiologic Surfaces

P. N. SAWYER, B. STANCZEWSKI,* N. RAMASAMY,* G. W. KAMMLOTT,* J. G. STEMPAK* and S. SRINIVASAN,*
Brooklyn, New York

Repeated attempts have been made to decrease the incidence of valve thrombosis, infection, embolism, fibroblastic overgrowth, with orifice occlusion and/or poppet sticking. Sequential studies from this laboratory have revealed various solutions to these problems. The first problem, valve thrombosis, can be prevented by use of "electrochemically clean" oxide free negatively charged non-thrombogenic metallic surfaces. Aluminum, Starr-Edwards stellite 21, titanium and a recently developed metal surface from Howmedica seem to provide this antithrombogenic characteristic along with appropriate uniform net negative surface potentials.

*By invitation

Light electron and scanning electron microscopic studies of the surfaces and composition of healing characteristics of 100 valves implanted in the mitral and tricuspid annuli of calves for periods as long as 765 days have been completed. The scanning electron microscope and transmission electron microscope pictures have proven of real value in developing insight into the pathologic processes found in dysfunctioning valves.

The use of cloth around struts leads to abnormal fibrin deposition in the cloth interstices covering the metallic valve surfaces with invasive fibroblasts followed by abnormal collagen production, sequential platelet deposition and significant repetitive onion layering of fibrin on strut surfaces. This results in increasing strut diameter, poppet sticking, and increased trans-valvular pressure gradients.

Infection, fibroblastic overgrowth on the cuff, and orifice occlusion can be prevented by use of the dacron reinforced autogenous venous skirt which heals as normal autogenous tissue to the valve orifice. The remaining problems are obviated by the use of clean surfaces and appropriately designed valves as shown by flow, electrochemical, and valve surface studies before and following implantation. The characteristic photographs and surface phenomena changes found using the new techniques will be presented along with related interfacial potentials and characteristic light, electron, and scanning electron microscopic histology.

39. Evaluation of Aortic Valve Homograft Failures

ROBERT B. WALLACE, STEPHEN P. LONDE* and
JACK L. TITUS,* Rochester, Minnesota

Between May 1965 and June 1972, 229 patients (163 males and 66 females) had replacement of their aortic valve with an aortic valve homograft. The hospital mortality rate was 4.8% (11 patients). Of the 218 patients dismissed from the hospital, 22 have required reoperation for homograft failure 3 to 73 months after the initial operation, and 16 others have died during the follow-up period.

Valves removed at reoperation or autopsy were studied grossly and morphologically, and factors possibly related to the status of the homograft were evaluated. These factors included valve preparation (92 of the valves used in this series were sterilized with β-propiolactone and 137 were sterilized by irradiation), age and sex of the donor, condition of graft and recipient valve at time of insertion, function of graft at the time of hospital dismissal, and the relationship of graft function to the cause of death. Correlations were done in an attempt to define better those patients in whom the operation might be most appropriate and to delineate those factors that may be important in the long-term results of this procedure.

40. Surgical Management of Acquired Tricuspid Valve Disease

A. CARPENTIER,* A. DELOCHE,* A. HANANIA,* A. PIWNICA,*
Cl. FARGE* and Ch. DUBOST,* Paris, France
Sponsored by Dwight C. McGoon

Acquired tricuspid valve disease (A.T.V.D.) raises two questions which continue to challenge the surgeon. (1) In what circumstances the tricuspid disease

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should be corrected? (2) and if so, by what means? A four years experience with the Carpentier tricuspid annuloplasty (C.A.) allows us to bring new answers to these questions.

From May 1967 through September 1972, 375 A.T.V.D. have been treated at Broussais Hospital with correction of severe mitral (271) or mitroaortic (104) diseases.

Kay annuloplasty (K.A) was used in 103 cases with an hospital mortality of 39% (1967-1969). C.A. has been used in 137 cases with a mortality of 9.5% (1969-1972). Starr prosthesis has been used in 135 cases with a mortality of 37% (1967-1972).

In the first 62 C.A., follow up study (1 to 4 years) including cardiac catheterization in 30 patients has shown constant effectiveness of the repair, no recurrent insufficiency, no A.V. block, no thromboembolic complications at the site of the tricuspid valve.

These results led us to a shift in our policy concerning the treatment of A.T.V.D.:

1. All A.T.V.D. clinically detected and operatively confirmed have to be corrected.

2. The C.A. is the only method capable to physiologically correct the disease and prevent the recurrent dilatation of the annulus. It can be used either isolated or combined with a commissurotomy in 90% of the A.T.V.D., as shown by our experience.

41. Closed Mitral Commissurotomy on Cannulated Pump Standby Through A Sternal Split Incision—An Alternative to Routine Open Commissurotomy

VINCENT L. GOTT, ANTONIO REVILLA,* JAMES S. DONAHOO,* EDWARD H. KLOPP,* and ROBERT K. BRAWLEY,*
Baltimore, Maryland

Open mitral commissurotomy offers several advantages over closed commissurotomy, including greater patient safety on pump bypass and easier conversion to prosthetic replacement if necessary. In some patients, however, fibrous obliteration of the commissures makes direct incision somewhat imprecise and the surgeon, in turn, may use a transventricular dilator to accomplish the commissurotomy. Engineering analysis demonstrates that a dilator used this way in the flaccid heart applies equal stress to the leaflets and commissures and not infrequently produces leaflet fracture, whereas in the beating heart, the stresses appear to be concentrated at the commissures because of the teathering mechanism of the chordae. All patients having mitral commissurotomy at this hospital since 1965 have been reviewed. One hundred patients had a standard closed commissurotomy (93% successful commissurotomies, 2% mortality) and 25 patients had open commissurotomy (40% requiring prosthesis, 4% mortality). In an attempt to combine the mechanical advantages of closed commissurotomy with the best features of open commissurotomy, we have more recently carried out all mitral commissurotomies as a "closed" procedure through a median sternotomy on cannulated pump standby with a newly designed "right angle" transventricular dilator. Eighteen patients have had this new procedure. One patient had a valve unsuited for commissurotomy and was easily converted to open cardiotomy for prosthetic replacement. The remaining 17 patients obtained

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excellent commissurotomies with no morbidity or mortality. This technique for mitral commissurotomy appears to offer several advantages over other currently used methods.

42. The Open Approach to Mitral Commissurotomy

JAMES O. FINNEGAN,* HORACE MacVAUGH, III, DENNIS C. GRAY,* CLAUDE R. JOYNER* and JULIAN JOHNSON,
Philadelphia, Pennsylvania

Of the 1005 operations on the mitral valve (380 open) done at the Hospital of the University of Pennsylvania from 1961 to 1971, 592 (317 open) consisted of mitral commissurotomy only.

As the first half of the 10 year period progressed the closed technic was used less and less, being reserved for the more favorable valves, but still constituted 50% for the period. For that 5 year period the mortality was 4% closed and 11% open—combined 7.5%. During the second 5 year period, the open technic was used exclusively, with a single death—less than 1% mortality.

The improved results for mitral commissurotomy in the second 5 year period was no doubt due to better selection of patients for the procedure, the freer replacement of the badly diseased valves, and improvements in postoperative care. These will be described, along with pre and postoperative complications.

The operative and late (5.3%) deaths in the open group have been analyzed. Of the surviving patients all but one have been followed and 73% have been restored to Class I (NYHA).

43. Mitral Valve Replacement with Beall Mitral Valve Prosthesis

N. P. ROSSI, C. KONGTAHWORN* and J. L. EHRENHAFT,
Iowa City, Iowa

To evaluate the function of the Beall valve, 100 consecutive cases of single valve replacements in the mitral position with a Beall prosthesis were analyzed. The procedures were performed from November 1967 to January 1972 allowing a followup of at least one year and up to five years. Eighty percent were performed for rheumatic disease and 20% for mitral incompetence due to nonrheumatic causes. Sixty-five percent of patients were in New York Heart Association Class IV, 26% in Class III and 9% in Class II. We found a 2% incidence of thromboembolism, 2% of paravalvular leak, and 19% of hemolysis. The problems relating to hemolysis were encountered early and were resolved within six months. Twenty-four percent had a previous mitral commissurotomy. Mortality was confined to patients in functional Classes III and IV (17% hospital and 7% late). Of 65 patients who were in functional Class IV, 59 showed improved functional classification, 25 out of 26 patients in functional Class III had changed to Class I or II postoperatively, and six out of nine patients in functional Class II had improved to Class I.

The results of analysis suggested satisfactory clinical improvement after replacement with Beall valve mitral prosthesis. There was a low incidence of thromboembolism but a high initial incidence of hemolysis.

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44. Mitral Valve Replacement with Cloth-Covered, Composite Seat Prostheses: The Case for Early Operation

LAWRENCE I. BONCHEK* and ALBERT STARR, Portland, Oregon

Operative and late complications of prosthetic valves have usually limited mitral valve replacement (MVR) to functional class (FC) III or IV patients refractory to medical management.

146 patients have undergone MVR with cloth-covered, composite seat prostheses (models 6310, 6320). 129 were FC III or IV. Operative mortality was 2% (3/146), and late mortality was 9% (13/146). Only two late deaths were valve related (one leak, one infection). Nine patients had emboli (6%) two with significant residuals, in 2,216 months of patient followup.

110 patients were FC I or II postoperatively. Since this improvement did not correlate with preoperative FC, a new *prognostic* classification was introduced to correlate preoperative *duration* of symptoms and *response* to medical therapy with postoperative result. 75% (15/20) survivors with unsatisfactory functional results postoperatively were in the worst prognostic classification (C2).

The striking reduction in *valve related complications*, and the minimal operative mortality, indicate that MVR with the current prosthesis should be offered early to patients with recent deterioration who respond to medical treatment (prognostic class A1). The poor functional results seen after MVR for neglected mitral disease may thus be avoided.

THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

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1974	April 22-24	Las Vegas Hilton Las Vegas, Nevada
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*By invitation

The American Association for Thoracic Surgery, 1972-1973

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