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# Proceedings of the Society of Thoracic and Cardiovascular Surgeons of Great Britain and Ireland

The Annual Meeting of the Society was held at the Ecole Polytechnique Federale de Lausanne on 19–20 September 1980.

**Closed valvotomy for critical pulmonary valve stenosis in the neonate**

G KEEN A series of 26 patients is presented, treated between 1966 and 1979. All these patients presented with cyanosis and severe heart failure in the first 10 days of life. All had cardiac catheterisation which confirmed the presence of very tight pulmonary valve stenosis with tricuspid regurgitation and right to left shunting at atrial level. The right ventricular pressure was invariably above 120 mmHg. In most patients some pulmonary artery perfusion was observed at left ventricular angiography via a patent ductus arteriosus. Although the majority of patients had a good-sized right ventricle, five had small ventricles. Twenty patients were seen at angiography to have a jet through the pulmonary valve orifice but six appeared to have a complete diaphragm. All patients underwent closed pulmonary valvotomy within hours of diagnosis, splitting the pinhole valve to a 6 mm diameter sound. Two patients required additional systemic pulmonary shunts. All patients survived the operation but six died within three days. Of the 20 survivors there have been no late deaths. Those patients with persistent right ventricular hypertrophy after the age of 3 years were reinvestigated (10). Five of these had persistent gradients (above 100 mmHg) and have all successfully undergone right outflow reconstruction using cardiopulmonary bypass. It is suggested that closed pulmonary valvotomy is the ideal procedure for this very sick group of patients presenting in the first few days of life.

**Anatomy of the tetralogy of Fallot**

SP ALLWORK, RH ANDERSON Although intraoperative heart block is a very rare complication of VSD closure much operation time may be occupied by measures to avoid it, particularly in Fallot's tetralogy. We have examined 90 hearts, both unoperated and operated, and have found a wide range of anatomical features. Review of 240 surgical operation notes accords with our findings. In most hearts the defect was perimembranous in position, so that the posterior margin of the defect was formed by the membranous septum and the septal tricuspid leaflet. Because the atrioventricular bundle is intimately related to the membranous septum, this structure is potentially at risk during closure of VSD. However, in approximately 25% of the hearts the defect was infundibular in position and so had wholly muscular margins. The membranous septum, with its related bundle was thus remote from the defect, lying posteroinferior to it. In some hearts this muscular defect extended to the pulmonary valve ring as a so-called "bulboventricular" defect. In these hearts the infundibular septum was absent. Pulmonary outflow tract obstruction was caused (except in the subpulmonary muscular defects) by anterior deviation of the infundibular septum. This obstruction was exacerbated by hypertrophy of the infundibular septal insertions and free, often multiple, anterior trabeculations hypertrophy or high origin of the trabecula septomarginalis. Often all these features coexisted. Dysplasia of the pulmonary valve was commoner than pure stenosis. The degree of aortic over-ride varied from 15%–95% and tended to be greater in hearts with infundibular muscular VSD; hence double outlet connection was more common than in those with perimembranous defect.

**Late results of radical surgical treatment of the tetralogy of Fallot**

HH BENTALL, WP CLELAND, SP ALLWORK Between 1958 and 1970, 244 patients had radical operation for Fallot's tetralogy at the Hammersmith Hospital. Hospital mortality was 15·6% (38 patients). So far there have been 10 late deaths (5%). Causes of late death were endocarditis, reoperation, epilepsy, cancer, and presumed arrhythmia. Of this last group one had a history of extra-systoles and all four had residual pulmonary outflow tract obstruction (POTO). Sixty-three patients (30%) had previously been palliated: 11 had had Brock infundibulectomy, 40 had Blalock-Taussig shunts (some bilaterally), and the remaining 12 had had both procedures. Where possible, the anatomical location of the VSD was categorised retrospectively. In most patients the VSD was patched either with "Teflon" felt alone, or with felt faced with pericardium. Some early patients had direct suture of the VSD. Most of this group had elective cardiac arrest by the Melrose technique. VSD persisted or recurred in 12 cases (16%) and needed reoperation in half, irrespective of the method of closure. POTO was relieved by infundibulectomy in most cases, but 40 patients (19%) needed outflow tract reconstruction. This was by aortic valve homograft (15 cases) or RV or transannular patch. None has required reoperation for aneurysm or graft failure or pulmonary regurgitation, but the last is present in about half the patients. Residual obstruction has needed reoperation in four patients. Complete heart block was an infrequent event, transient in all but one. One older patient developed intermittent block requiring a pacemaker 20 years after operation. Some have

developed disturbances of left-sided conduction and these patients are kept under close surveillance. The majority of patients, however, do not require frequent supervision; they take no medication and live normal lives. Twelve of the girls have become the mothers of normal children. One man has a daughter (now adult) with VSD.

### Surgical treatment of tuberculous constrictive pericarditis

PITT FENNELL In areas of the world where human tuberculous disease persists there will be cases of pericardial infection. Of those cases presenting as an acute illness with pericardial effusion, perhaps a third can be resolved with standard treatment. The remaining cases whose features of cardiac restriction do not resolve, will require surgical relief. One hundred and three cases were referred for surgical treatment of pericarditis. Two cases had septic pericarditis without constriction and were successfully treated by drainage. In 99 cases the constriction was considered to be due to tuberculosis. In the remaining two cases, one was considered to be a sequel to a known episode of uraemia and the other was thought to have been caused by a viral pericarditis. The 99 cases manifested the easily recognisable features of constriction which failed to resolve in spite of full antituberculous and diuretic treatment. Two of these cases were considered to be inoperable because of severe associated respiratory disease and another died before operation. In about half of the 96 cases treated by operation, the pericardial space was obliterated by fibrous tissue of varying thickness and maturity. In the remainder, areas of granulation tissue, collections of caseation and patches of calcification were found, generally increasing the difficulty of the procedure to free the myocardium. In one patient 2–3 mm sized tubercles persisted throughout the pericardium with a minor effusion and thin layer of fibrous tissue investing the heart. Of the 96 patients 92 left the hospital alive. Four patients died in hospital after operation, three of low output failure, two of whom were complicated by arrythmias and another died of respiratory insufficiency from severe coexisting bilateral pulmonary disease. In two-thirds of the 92 patients who left the hospital alive, there was complete or nearly complete resolution of the physical signs of constriction. The remainder were resolved at postoperative follow-up. Six cases required additional thoracic procedures. Four required preliminary right contra-lateral decortication and in two decortication was carried out simultaneously through the left-sided thoracotomy. One case had had a previous unsuccessful subxiphoid drainage and a further patient required a subsequent revision pericardectomy. Complete long-term follow-up was not possible because of the well patients' reluctance to reattend hospital.

### Role of self-bouginage in conservative treatment of oesophageal stricture

S WESTABY, G WILSON, JW JACKSON The aims of treatment for hiatus hernia with reflux stricture of the oesophagus are to restore and maintain normal swallowing while preventing the troublesome sequelae of gastro-oesophageal reflux and peptic oesophagitis. Though recent reports have stressed an operative approach, many patients are elderly, obese, and atherosclerotic, and surgery is best avoided. It has been our policy to treat these patients by intermittent oesophagoscopy and dilatation combined with a medical anti-reflux regime. In addition, for patients with a tight fibrous stricture requiring frequent hospital admission for dilatation we advocate self-bouginage with Hurst's mercury weighted bougies. In this paper we examine the progress of 104 patients with reflux stricture of the oesophagus, 39 of whom use self-bouginage. Follow-up period varied from six months to five years with a mean 23 months. Three patients were unable to use their bougies properly and required three, six, and seven dilatations subsequently.

We conclude that for selected patients self-bouginage plays an important role in reducing the number and increasing the interval between admissions for oesophagoscopy and dilatation.

Table 1 *Number of hospital admissions for oesophagoscopy and dilatation*

| | *Number of patients* | *Total of dilatations* | *Average per patient* |
|---|---|---|---|
| Self-bouginage + medical regime | 36 | 10 | 0·27 |
| Medical regime alone | 65 | 259 | 3·95* |

*Five patients in this group subsequently required operative treatment.

Table 2 *Interval between admissions for dilatation*

| | *Number of patients* | *Period between admissions* |
|---|---|---|
| Self-bouginage + medical regime | 8 | 27 months |
| Medical regime alone | 63 | 5·75 months |

### Prophylactic antibiotics in oesophageal resection

G LITTLE, E ALVINS, HR MATTHEWS Operations which open the alimentary tract are frequently associated with bacterial contamination of the wound and postoperative wound infection. That this can be prevented by single-dose systemic antibiotics has been well shown in many general surgical situations but there is, to date, no information regarding the efficacy of such a regime in oesophageal resection. In this paper we report a recent blind, randomised study in which 61 patients who were possible candidates for oesophageal resection received either 1g of cefamandole nafate ("Kefadol") or a placebo, intramuscularly, immediately after induction of anaesthesia. Blood samples for cefamandole assay were taken at hourly intervals throughout the operation and swabs taken for bacteriological examination from the oesophagus, any other opened viscus and all wounds. Postoperatively all wounds were examined daily and any discharge examined bacteriologically. The oesophagus was actually opened in 47 of the 61 patients and 42 patients proceeded to oesophageal resection and anastomosis. Four wound infections occurred in the 30 patients (46 wounds) who received cefamandole, compared to 13 wound infections in the 17 patients (27 wounds) who received the placebo. This difference is highly significant ($p<0·001$). In the placebo group there was a significant correlation between organisms isolated from operative specimens and those subsequently cultured from infected wounds. These findings suggest that single-dose antibiotic prophylaxis with 1g of cefamandole intramuscularly at the start of operation is highly effective in preventing wound infection resulting from inoculation of endogenous organisms during oesophageal resection.

**Bilateral thoracotomy approach for resecting high oesophageal carcinoma**

JOHN F DARK Among a series of 449 resections carried out over a 15-year period by the author and one other surgeon (H Mousalli), for malignant lesions of the oesophagus and upper stomach, there were 30 instances where the deliberate policy was to make the approach by two separate thoracotomies at the same session. In each case the top of the lesion was judged to be higher than 30 cm from the upper gum. The cases and the method are detailed. The approach does not appear to have been described previously, and is offered as an alternative to the Ivor Lewis method, and the Belsey trans-hiatal route. There were three deaths (10%) including the single anastomotic leak, and there was no significant increase in postoperative respiratory problems. Nine out of a possible 17 patients lived for five years, and the predicted five-year survival rate for the whole series is 25%.

**"Spontaneous" intramural rupture and "spontaneous" intramural haematoma of the oesophagus**

WF KERR The literature contains reports of only 15 examples of these two variations on the same pathological theme. Four new cases are described and all 19 are reviewed. The dominant feature of every case was severe and constant retrosternal or epigastric pain with concomitant dysphagia mentioned in 11. In six the pain was preceded by or coincided with vomiting; it was related to other stresses in three and appeared to be truly spontaneous in 10. In approximately one-third the pain started suddenly but more often it began as discomfort worsening rapidly. Thirteen patients vomited blood after experiencing pain but only three (one on anticoagulants) were given transfusions. In contradistinction to complete rupture, none had surgical emphysema and plain chest radiographs were unremarkable. All had abnormal gastrografin or barium swallows which showed intramural filling defects and/or extralumenal contrast material closely applied to a wall of the oesophagus. Intramural haematomas with or without mucosal tears were seen in the 10 cases in which oesophagoscopy was performed. Fifteen patients made rapid and complete recoveries on conservative management. Of the three who did not respond satisfactorily, one had the oesophagus repaired and two had only drainage of the mediastinum after failure to find a false lumen. The only death in the whole series occurred nine months after a disastrous emergency exploration and subsequent total oesophagectomy, and was attributable to a complication of surgery.

**Polynesian cardiac surgery**

PJ MOLLOY Since 1974 a cardiac surgical service has been provided from the Dunedin Cardiac Surgical Unit to the Government of French Polynesia. This has resulted in a number of cases coming forward for operation in Dunedin and these 88 will be reviewed to show an epidemiological study which is of some significance in the difference between Polynesian and Caucasian disease patterns. Twenty-four congenital cases and 64 patients with acquired disease came to operation. There was a high incidence of pulmonary hypertension. There was a high incidence of sinus rhythm in spite of severe symptomatic disease and the operation results although showing a high mortality, reflecting the mortality of earlier days in cardiac surgery, have improved as the reservoir situation has been dealt with. Some aspects of total patient care involving these patients will be discussed, including cultural differences, both physical and psychological, and conclusions which may be applicable to other less developed nations who come into the ambit of cardiac surgical units around the world will be drawn. The age group patterns of rheumatic disease will be discussed in particular as there are two peaks of incidence of presentation with clinically significant rheumatic heart disease and a philosophy of treatment has been evolved for the younger age group patients which is important in their management because of accelerated disease process in these young Polynesians.

**Clinical significance of the hypertensive lower oesophageal sphincter**

SW FOUNTAIN, FG PEARSON, JM NELEMS, JD COOPER During the performance of 1700 oesophageal pressure studies 28 patients were found to have lower oesophageal sphincter pressures of more than 30 mmHg. Previous reports have described this level of sphincter pressure as hypertensive and associated the condition with disorders of oesophageal motility or with hiatal hernia. In this group of patients, chest pain and dysphagia were the most common presenting symptoms. Radiologically, nine patients had hiatal hernias but only four patients showed evidence of a motor disorder in the body of the oesophagus. Pressure studies showed the presence of a motor disorder in 19 patients. Eight of these had classical manometric features of diffuse oesophageal spasm and in a further five these features were seen after parasympathetic stimulation with Bethanecol. There was poor correlation between symptoms and radiological findings and no relationship was established between the presence of a hiatal hernia and a hypertensive sphincter. Over two-thirds of patients had evidence of a motor disorder of the oesophagus, however, and five patients with intractable symptoms of chest pain and dysphagia were successfully treated by long oesophageal myotomy. Two patients who presented with dysphagia and who initially had no radiological or endoscopic abnormality were later shown to have carcinoma of the cardia.

**Results of the Belsey mark IV repair for gastro-oesophageal reflux**

K JEYASINGHAM, LINDA REILLY The widespread acceptance of any one repair for gastro-oesophageal reflux would depend on the reproducibility and the predictability of the results of such a repair. The published results in patients operated on by Belsey himself or by one of the junior members of his team, and followed up for a period of up to 15 years, do suggest that this technique yields some of the best results for the control of reflux. Based on a follow-up adhering to the same criteria as outlined in Belsey's publication, this report analyses the results of all the 76 patients operated on between May 1975 and April 1979, and followed up for one to four years after surgery. The postoperative assessment was performed clinically, radiologically, and, in symptomatic patients, with endoscopic and manometric studies. The operative mortality was nil. Among the postoperative morbidity recorded, phlebo-thrombosis contributed to three and pulmonary infar-

tion to two. One patient bled from a reactivated duodenal ulcer while on anticoagulation and required laparotomy and control of haemorrhage despite intravenous H2 receptor-antagonist therapy. Sixty-three out of the 70 cases continued to remain free of reflux, and have not shown radiological evidence of recurrent reflux. In other words, in 90% of the series the results were good to excellent. Four patients have been shown on clinical and investigational criteria to have had a recurrence. Studying these four patients carefully, in at least three of them, the outcome was predicted before the surgery was undertaken. The reasons for carrying out the mark IV repair in these four patients are discussed. The paper concludes that the excellent results of the mark IV repair are reproducible as well as predictable, and that if the criteria for case selection are adhered to, there may well be scope for even better results.

**Replacement of the anterior chordae of the mitral valve**

DARRYL F SHORE, SHLOMO GABBAY, EDWARD L YELLIN, ROBERT WM FRATER

Plastic repair of the mitral valve after rupture of anterior chordae by leaflet excision and ring plication is frequently unsuccessful. This experimental study was designed to examine a method for chordal replacement utilising glutaraldehyde preserved pericardium. The correct length of the new "chordae" was determined by the following anatomical rules: their length should be less than the distance from their papillary attachment to the mitral valve ring and should be such that their tension is the same as that of the remaining normal chordae. In applying these rules we adopt the hypothesis that the chordae are under tension throughout diastole, vortex formation and diastolic closure movements occurring in the mathematical model only when the chordae are under tension. The anterior chordae were replaced in eight dogs. There was no mitral insufficiency demonstrated after the discontinuation of cardiopulmonary bypass. Two dogs died before restudy because of the development of bacterial endocarditis, confirmed histologically. The remaining six dogs were restudied four months to two years after chordal replacement. No significant transvalvar gradients or evidence of mitral incompetence were found in any dog under conditions of varying inotropic state or volume loading. Histological examination of the chordae demonstrated both cartilage formation and calcification. The degree of degenerative change was not time related. Electron microscopy demonstrated excellent healing at both suture sites with ingrowth of native collagen fibres between the fibres of the preserved pericardium at the papillary muscle end. We conclude that excellent haemodynamic results can be obtained after chordal replacement and are maintained in spite of early degenerative changes. Early calcification is known to occur in biological materials implanted in dogs and does not necessarily reflect the situation in adult man.

**Gross functional tricuspid insufficiency (gross FTI): mechanisms and management**

ROBERT WM FRATER, RONALD M BECKER, JOEL STROM

Gross FTI is that producing pulsatile hepatomegaly and jugular veins. Gross FTI is variably related to pulmonary hypertension (PHT). Thirty-five cases with mitral valve disease (MVD) and gross FTI were compared with 20 contemporaneous cases with PHT and no evident TI.

| *Pressures (mmHg)* | *RA* | *RV system* | *PA* | *PCW* | *Total pulmonary resistance (dynes-cm$^{-5}$)* |
|---|---|---|---|---|---|
| Gross FTI | 13·8 | 65·5 (38–110) | 42·2 | 27 | 1050 (484–2285) |
| No TI | 10·5 | 74 (32–148) | 52 | 24 | 1145 (200–2548) |

Leaving gross FTI at surgery results in frequent persistence or recurrence despite good MVD correction sometimes with persistent PHT and sometimes despite resolution of PHT. Fifteen cases with MVD and gross FTI had TI ignored. Hospital deaths: 2. Late deaths: 2. Gross FTI: 4.

| *Pressures (mmHg)* | *RA* | *RV system* | *PA* | *PCW* | *Total pulmonary resistance (dynes-cm$^{-5}$)* |
|---|---|---|---|---|---|
| Rec gross FTI | 13·5 | 47 (33–75) | 34 | 17·8 | 619 (417–866) |

Since gross FTI responds unpredictably to MV surgery, tricuspid annuloplasty (TA) is always indicated. A modified de Vega TA is performed by making final adjustments of TV ring from outside atrium, off bypass using: (a) IVC electromagnetic flow probe; (b) saline contrast echocardiography, RV saline injection, echo probe over IVC; (c) simultaneous measurement of RV, RA pressure and cardiac output. TA stitch tightened to abolish evidence of IVC reflux by methods (a) or (b). Absence of significant gradient and adequacy of effective orifice area (EOA) was confirmed by (c). Twenty patients with gross FTI were given controlled TA: hospital mortality: 3, late mortality with persistent LV failure: 2 (1 with recurrent TI). Cardiac outputs before and after TA post bypass were uniformly raised. Mean EOA of TV was 2·25 cm. Fifteen long-term survivors have no recurrence of gross FTI. Controlled TA is a precise, reproducible operation that achieves its objectives easily, speedily, and without guesswork.

**Aortic homograft valves into the second decade**

WH WAIN, DN ROSS

The first biological heart valve replacements were aortic homograft valves. One major problem with non-living biological valves has been the inevitability of late onset degeneration requiring a reoperation to replace the malfunctioning valve. The inevitability of such degeneration cannot be argued, but it is not correct to assume that an increasing rate of degeneration at five to 10 years after implantation will result in reoperations to replace all the aortic homograft valves within 15 years. Forty-five aortic homograft valves, preserved by either freeze-drying or deep-freezing were implanted between 1964 and 1970 and were intact and functioning 10 years later. During the 10 to 16-year follow-up period for these valves, there have been 10 deaths, only two of which can be

directly attributable to a malfunction of the aortic homograft valve (95% survival from valve-related death). Only 15 of the 45 valves have presented with degenerative failure, 30 valves being free of proven degeneration. However, allowing for the time scale and the numbers of valves, only 20% of the valves are free of degeneration on an actuarial basis over 10 to 15 years. Seven of the 15 degenerated valves had atrophic attenuation and holes, while the other eight had calcific degeneration. The incidence of an early diastolic murmur within one year of implantation was equally distributed among the 23 valves still intact and functioning and the 22 valves which were not, including the 15 with proven degeneration. These results show that only 33% of these valves present with proven degenerative changes associated with valve malfunction during the second decade while more than half (51%) of the aortic homograft valves implanted more than 10 years ago continue to function satisfactorily.

**Use of intrathecal morphine in cardiac surgery**

ET MATTHEWS, LD ABRAMS Attitudes to pain: war time experiences: Crile's theory. Recent work includes (1) discovery of opiate receptors, (2) isolation of enkephalins and endorphins, (3) localisation of receptor sites, and (4) application to spinal cord of endorphins (natural and synthetic) and morphine and other narcotic analgesics. The application in cardiac surgery of this new concept of pain relief, previously applied in cancer patients can be summarised as follows. *Aims:* (1) to block transmission of "noxious impulses" arising during surgery; (2) to provide profound and longlasting pain relief in the postoperative period. *Patients:* routine list. Selection only on prothrombin time. *Method:* pre-op visit. Premedication. Monitoring. Induction. Maintenance. Positioning. Lumbar puncture. Injection of morphine. *Materials:* preservative-free morphine—specially prepared, ampoules autoclaved, disposable spinal needle. We have observed in 30 patients that there is: (1) before surgery—CVS stability; (2) during surgery—protection from "noxious impulses" or "stress responses"; (3) postoperatively—(i) immediate awakening; (ii) pain-free awakening; (iii) long duration of pain relief; (iv) spontaneous respiration; (v) when respiratory depression occurs, reversal by naloxone does not reverse analgesia; (vi) elective ventilation facilitated; (vii) absence of side-effects of large doses of narcotic analgesics; (viii) no postural hypotension; (ix) low incidence of post LP headache. Intrathecal morphine has been used as the main analgesia for open-heart surgery and to provide postoperative pain relief. The use of a single dose intrathecal injection avoids the hazards of indwelling epidural catheters in heparinised patients. The postoperative nursing workload is eased. It is inexpensive.

**Comparative study of rigid and fibreoptic bronchoscopy in the diagnosis of bronchial carcinoma**

MH ASHRAF, RK WALESBY, MP SHEPHERD, HC NOHL-OSER Since the introduction of the flexible fibreoptic bronchoscope in 1968 and its subsequent refinements, significant advances have been made in the diagnostic application of bronchoscopy. A high degree of success has been reported using this technique in both medical and surgical pulmonary diseases. Donald Zulva in 1975 reported 85% positive cytology on biopsy materials in 330 patients of bronchial carcinoma. However, there are some limitations in employing this technique routinely in the surgical management of bronchial carcinoma. In this paper we report a prospective study carried out in the Thoracic Surgical Unit at Harefield Hospital in 200 cases of bronchial carcinoma. A comparison of rigid and fibreoptic bronchoscopy under equal conditions is made with respect to the diagnostic yield and accuracy, assessment of operability and the time consumed (cost benefit). The results are statistically analysed and reported in detail.

**Management of neonates with posterolateral diaphragmatic hernias**

NIGEL R SAUNDERS, JD O'CALLAGHAN, R CHATRATH, DR WALKER The mortality rate in neonates with posterolateral diaphragmatic hernia remains between 25 and 50% and pulmonary vasoconstriction combined with myocardial failure accounts for most postoperative deaths. Hypoxia and acidosis depress the myocardium and cause pulmonary vasoconstriction, with shunting in the persistent foetal circulation. Pharmacological manipulation of pulmonary artery pressure, ductus ligation, and membrane oxygenation have achieved very limited success. Since March 1978, six neonates (mean weight 3·2 kg) with left posterolateral diaphragmatic hernias have presented with respiratory disease within hours of birth, and each had severe acidosis and hypoxia. They were immediately intubated and ventilated, arterial and central venous lines were inserted and acidosis was corrected. Continuous monitoring of arterial and venous pressures, core and skin temperatures, blood gases and pH was instituted. Dopamine 5 $\mu$g/kg/min was started as soon as the central venous line was inserted. Diaphragmatic defects were repaired using direct suture in five, and in one the defect was too wide and a patch of Gore-Tex™ was inserted. The left lung in all cases was hypoplastic. Ventilation and inotropic support were continued for three to four days postoperatively, and close control of acid base balance was maintained. All survived and continue to thrive. We consider the key to survival is management of the dangerous combination of acidosis (by enhancing peripheral and renal perfusion with dopamine) and hypoxia (by prolonged assisted ventilation).

**Use of diaphragmatic pedicle grafts for reconstructive procedures in the chest**

S WESTABY, MP SHEPHERD, HC NOHLOSER In an emergency when defects of the oesophageal wall or trachobronchial tree require primary repair in a contaminated and potentially septic field, it is an advantage to cover the suture line or fill the defect with healthy well vascularised tissue. Intercostal muscle grafts and flaps of pericardium or pleura are commonly used but each has disadvantages. Petrovsky first described the use of diaphragm to close defects in oesophagus, heart, liver, and lung, but since then this method has gained little popularity outside the Soviet Union. In this paper we record the use of diaphragmatic pedicle grafts for repair after spontaneous oesophageal perforation, bronchopleural fistula and avul-

sion of the posterior tracheal wall. An extensive blood supply allows grafts based on the oesophageal hiatus or periphery to be mobilised to the arch of the aorta or azygos vein without difficutly and to the thoracic inlet if necessary. We have found diaphragm to be strong, elastic, and easy to handle. The residual diaphragmatic defect is easily closed without tension. Considering these factors we find diaphragmatic pedicle grafts to be ideal for plastic reconstructive procedures in the chest.

**Unusual fate of emphysematous bullae**

RA MCCLUSKIE Emphysematous bullae may remain unchanged for many years, progressively enlarge, rupture, sometimes reduce in size, or occasionally may disappear after developing a fluid level as a result of infection or haemorrhage into them. Five cases of bullae which became infected, developed a fluid level, then absorption of both fluid and bullae are described. Two other cases had haemorrhage into a bulla, one the result of anticoagulant therapy, the other of cytotoxic therapy, and both bullae were absorbed. In all these seven cases of disappearing bullae the patients' breathing was improved, suggesting that removal of a bulla whether by intracavitary drainage or by excision without loss of lung tissue is always worthwhile. Not all bullae filling with fluid or becoming solid pursue a benign course. Five cases are detailed where such bullae become malignant. One patient developed a fluid level then an adenocarcinoma in a bulla, another had two bullae filling with fluid then adenocarcinoma, and a third had an adenocarcinoma replacing a bulla. A fourth patient whose bulla had absorbed nine years earlier developed a squamous carcinoma at the same site. The fifth patient developed an adenocarcinoma in a bulla with invasion of pleura and chest wall within one year of iodised talc pleurodesis for pneumothorax. There was a sixth patient who after excision of several bullae and iodised talc pleurodesis also developed an adenocarcinoma invading the chest wall and pleura. It is not thought that emphysematous bullae predispose to cancer, but when a cancer develops it is likely to be an adenocarcinoma. The previous use of iodised talc pleurodesis is considered to be coincidental to the development of the cancer.

**Surgical treatment of bronchial carcinoma 1950–78**

M BATES This lecture is based on the personal experience of 2430 patients upon whom I have performed thoracotomy for bronchial carcinoma between 1950 and 1978. Two thousand, two hundred and twelve patients had resections, 218 thoracotomy only, a resectability rate of 91%. *Age and sex groups* Emphasis is placed on the aging population. The majority of patients now having resections are over the age of 60. The ratio of males to females is 9 to 1. *Symptoms* Thoracic—the significance of a single haemoptysis is stressed. Extrathoracic—examples are shown of the metastatic and non-metastatic. *Histology* Squamous 1462=66·1%; undifferentiated 308=13·9%; oat 240=10·85%; adenocarcinoma 188=8·5%; alveolar 10=0·45%; giant cell 4=0·18%. Examples are shown of the two uncommon varieties.

*1956* Introduction of sleeve lobectomy and trend towards conservation, 36 cases in this series and results shown.

*1959* Report by Belcher supporting a policy of lobectomy with five year survival rate of 37% for a series of 264 lobectomies. Ten year result of 917 lobectomies reported from this series.

*1972* Report by Le Roux of long-term results from segmental resections, 47 patients treated in this series and results shown. Results of eight patients treated for peripheral growths by middle lobectomy.

*Importance of age* Twenty-eight patients treated under the age of 40; results shown, and example of a 20-year survivor, aged 39 at the time of operation. Many patients now aged 70 and over being operated on successfully, preferably by lobectomy. Results shown in 213 patients of this group.

*Patients having second thoracotomies* For recurrence on the same side, 17, with poor results. For metastases or second primaries, nine on the opposite side, with good results. Lung resections associated with operation on other conditions, ie hiatus hernia; results in seven patients shown.

*Hypertrophic pulmonary osteoarthropathy* Clinical demonstration with excellent immediate, but disappointing long-term results, 56 cases.

*Oat cell carcinoma* Poor results obtained up till 1966 by surgery alone. Since then, improved results by giving 1750 rads, without any increase in bronchial fistulae or empyema. The importance of preoperative liver, brain and bone scans realised.

*Resection for primary lung tumour and brain metastasis* Three cases in this series, one of whom is alive and well three years after brain surgery.

*Operations performed* Lobectomy 917; extra-pericardial pneumonectomy 649; intra-pericardial pneumonectomy 584; sleeve lobectomy 36; segmental resection 47; wedge resection 6.

*Hospital deaths* Extra-pericardial pneumonectomy 76 deaths from 649=11·4%; intra-pericardial pneumonectomy 88 deaths from 584=13·7%; lobectomy 51 deaths from 1006=5·1%.

*Causes of hospital deaths* Many different causes including: bronchial fistula and empyema, R 32, L 6, total 38; pulmonary embolus 25.

*Follow-up information to 1 March 1978* Alive and well 288; died from recurrence 1406; died from other causes 477; died from other cancers 34; lost to follow-up 7; total 2212.

*Survival rates* Twenty-three patients from a possible 433 survived 20 years (5·5%); 211 patients from a possible 1356 survived 10 years (15·6%); 429 patients from a possible 1815 survived five years (23·6%).

*Survival rates in relation to histology* The importance of a squamous cell growth with negative mediastinal nodes is demonstrated, and the poor long-term prognosis of both oat cell and adenocarcinoma.

*How can the treatment be improved* The importance of the CT scan is shown, and how, by demonstrating unsuspected metastases in the brain, lung, and mediastinum, unnecessary thoracotomies can be avoided. Surgery alone has been clearly demonstrated as giving the best long-term results for squamous cell growths. Preoperative radiotherapy, followed by pneumonectomy, has given improved results for oat cell carcinoma, and probably large cell undifferentiated carcinomas would best be treated in the same way. Adenocarcinoma has a poor prognosis with surgery alone, which probably should be associated with cytotoxic drugs.

### Heterotopic heart transplantation: the Cape Town experience

DKC COOPER, D NOVITZKY, P BERLOCO, M BONORIS, J HASSOULAS, MS BARNARD, CN BARNARD There are disadvantages to orthotopic transplantation which have led to the development of the heterotopic cardiac transplant which functions as a left and right heart assist device. The advantages and disadvantages of heterotopic, as opposed to orthotopic, heart transplantation will be detailed. To date 31 such transplants have been performed in 30 patients at Groote Schuur Hospital over the past six years with 15 patients surviving from four months to six years. The one-year survival has been 61%; three of six patients have survived for more than four years. Eight of nine patients whose initial transplant operation was performed during the past 12 months remain alive. One patient has undergone retransplantation but subsequently died of pulmonary infection and septicaemia. The possibility that certain myocardial pathology may spontaneously resolve, if enough time is allowed for the disease to run its natural course, has been confirmed in one terminally ill patient (with a probable viral myocarditis) whose own heart recovered completely three months after heterotopic transplantation allowing for removal of the donor heart. One other patient developed rejection severe enough to cause donor heart ventricular fibrillation, but survived on his own heart until increased immunosuppression and other measures brought about normal donor heart function again; he has now survived more than four years since transplantation and is leading a normal life.

### Recent experience with heart transplantation

R CORY-PEARCE, DKC COOPER, TAH ENGLISH Nine patients received heart transplants at Papworth Hospital between 14 January 1979 and 12 May 1980. Their ages ranged from 23 to 52 (mean=39 years). Four patients had cardiomyopathies and five ischaemic heart disease. During this period 142 patients were referred for consideration of transplantation. Twenty-one were accepted and seven died while awaiting operation. The ages of the donors ranged from 16 to 35 (mean= 22 years). The cause of brain death was cerebral trauma in seven and cerebral tumour in two. Donor hearts were brought to Papworth by road in five and by road and air in four instances. The total donor heart ischaemic time varied from 108 to 171 minutes (mean=148 minutes). Early graft function was satisfactory in all cases. Postoperative management has been directed towards the prevention of rejection and infection. Immunosuppression has consisted of equine anti-human thymocyte globulin, prednisolone, and imuran. Endomyocardial biopsy has been performed every 10 to 14 days during the early postoperative period. Fifteen rejection episodes (mean=1·7 episode per patient) have been treated. Major infectious complications have been uncommon. One patient died at 17 days; the remainder are well six days to nine months after operation. Five patients have returned home and three are still in hospital.

### Extracorporeal "interpulse" membrane oxygenator

DG MELROSE In 1976[1] Bellhouse and his associates described the design and performance of a prototype high efficiency pulsatile membrane lung employing secondary flow generation. It was designed to provide high gas transfer efficiency, to be simple to use and to meet sensible cost criteria. This ingenious design has now been developed and is in production as the extracorporeal "interpulse"™ membrane oxygenator. This paper describes the new unit and reports results of pre-clinical testing. Seven cows (100–115 kg body weight) were perfused for six hours at 5 litres/minute. The extra-corporeal circulation was from SVC–IVC to the aorta. Whole blood or blood-Hartmann's prime (2·3 litres) was used to maintain a haemoglobin level between 9 and 12 g%. Input oxygen saturation of 50–70% and $pCO_2$ 35–50 was achieved by ventilation of the animals with appropriate gas mixtures. Two hundred–300 ml/minute transfer of both $O_2$ and $CO_2$ was readily obtained, allowing output oxygen saturation to reach 88–98%. Despite small volumes of blood returned from the chest cavity by suction, the plasma haemoglobins were below 20 mg% throughout the perfusion period. All animals recovered and were without support and freely mobile within 24 hours. They were electively sacrificed after 72 hours for histological examination. The many qualities examined compare favourably with control perfusions carried out with the Travenol "TMO"™ membrane oxygenator. The results of these studies indicate that the "Interpulse"™ oxygenator in production form fully justifies design and performance criteria established by the small-scale prototype. We believe it to be now ready for clinical trial.

1 Proceedings ESAO (1976), III, 123.

### Critical appraisal of antibiotic prophylaxis in cardiac surgery

GH PERCIVAL The problems facing prophylaxis in cardiac surgery are stated. The significant benefit of short-course, that is pre, peroperative, and 48 to 72 hours post-operative wide-spectrum antibiotic prophylaxis in general surgery, particularly major procedures in the upper abdomen is discussed. The 80% incidence of demonstrable chest complications in these cases and 9% occurrence of severe pulmonary infections are stated. Controversial papers concerning the value of peroperative antibiotics, in one case irrelevant to prophylaxis are critically examined. The benefit of prophylaxis against deep prosthetic infections in orthopaedic and vascular surgical trials is established and rates of deep infection of 1·3% and 1·9% are acknowledged. Early and late prosthetic valve endocarditis (PVE) are defined. Mayo Clinic, Massachusetts General Hospital, Vanderbilt (Nashville) and other large reports using antibiotic cover are discussed and an overall PVE rate of 1–4% established. In the absence of certainty because of loss to analysis of late cases, probably less than half of this is early PVE. The antibiotic trial of penicillin with flucloxacillin (600 mg and 500 mg IV six-hourly), against cefamandole (1 g IV six-hourly) short-course prophylaxis performed on 140 sternotomy patients in the Trent Sub-Regional Cardio-Thoracic Centre is reported.

### Investigation of distal sapheno-coronary artery bypass anastomosis stenosis

AL PRIOR The distal sapheno-coronary anastomosis is probably the most critical technical procedure in coronary artery bypass surgery. The anastomotic difficulties relate to the small diameter and

often disease of the native coronary arteries, coupled with sapheno-coronary diameter disproportion and often difficult exposure all associated with myocardial ischaemia time limitation. Unsatisfactory sapheno-coronary anastomoses occur and can be responsible for low graft flow, early or later graft occlusion and myocardial infarction. Clinically, this can produce operative death, postoperative low output states and later recurrent angina pectoris or myocardial infarction. The concept that a significant number of these complications are the result of technically unsatisfactory anastomoses and, therefore, avoidable, implies that continued improvement in surgical technique will give better results. Investigation of sapheno-coronary anastomoses has been performed by various techniques in fresh cadaver hearts; (1) resin corrosion casts, (2) in situ dissection of elastomer casts, (3) bariotrop gelatin casts, and (4) gas angiography. By these methods performed using different techniques the anatomy of the sapheno-coronary anastomoses could be detailed. Studies using pulsatile perfusion in vitro established the haemodynamic significance of the stenoses. The clinical significance of these stenoses was shown by correlating the postoperative Thallium scintiscan with the angiographic findings on 20 patients who were investigated for recurrent angina pectoris after coronary artery bypass grafting.

**High protein pulmonary oedema**

MV BRAIMBRIDGE, M ROSIN, B BUXTON Three cases are described with the syndrome high protein pulmonary oedema after open-heart surgery. The syndrome is characterised by severe pulmonary oedema occurring half to one hour after discontinuation of bypass, the oedema having a high protein content and containing the same constituents as the serum of the patient at the time. The packed cell volume (haematocrit) rises rapidly to 60% and the chest x-ray shows marked widespread pulmonary oedema. In the last patient an intravascular complement fixation reaction was shown to have occurred with pulmonary vascular leucostasis and damage to the capillary membranes making them permeable to protein. The cause of this reaction is unknown but protamine has been suggested with patients being sensitised at the time of cardiac catheterisation. One of our patients was sensitive to protamine on skin testing. Further investigations will be reported. Treatment includes adrenalin, steroids, plasma, expanders, and IPPR.

**Myocardial infarction related to open heart surgery**

CGA MCGREGOR, AL MUIR, AF SMITH, HC MILLER, RJM MCCORMACK, PR WALBAUM, DJ WHEATLEY Recently available techniques for the diagnosis of operative myocardial infarction include serum cardiac specific isoenzyme estimation, technetium $^{99m}$Tc pyrophosphate scanning and non-invasive assessment of ventricular function by radionuclide ventriculography and now supplement electrocardiography and measurement of non-specific enzyme release. We have applied these various techniques in parallel to 95 patients undergoing cardiac surgery. Group 1: 50 patients undergoing coronary artery bypass graft surgery; Group 2: 25 patients undergoing aortic valve replacement; Group 3: 20 patients undergoing mitral valve replacement. Clinical and operative data including techniques of myocardial protection have been documented. The incidence of myocardial infarction in group 1 patients was 14%. Good correlation existed between $^{99m}$ technetium (Tc) scanning and isoenzyme release with the electrogram proving a less sensitive indicator of myocardial injury. In group 2 the incidence of myocardial infarction was 20%. Again there was good correlation between $^{99m}$Tc pyrophosphate scanning and isoenzyme release. The electrogram appeared relatively insensitive in this group of patients. In group 3 evidence of myocardial infarction occurred in one patient, an incidence of myocardial infarction of 5%. These studies indicate that the routine methods of diagnosing operative myocardial infarction such as the electrocardiogram are not sufficiently sensitive. The diagnostic criteria applied to the problems inherent in the new techniques employed in these studies are described. Accurate assessment of the incidence of operative myocardial injury is necessary, not only to define the magnitude of the problem, but to assess the effectiveness of measures taken to protect the heart from such operative injury.

**Prostacyclin: influence on blood loss after cardiopulmonary bypass**

A FAICHNEY, JF DAVIDSON, KG DAVIDSON, ID WALKER, DJ WHEATLEY Haemorrhage remains a major problem in patients undergoing cardiopulmonary bypass and it has been suggested that the inhibitory effects of prostacyclin ($PGI_2$) on platelet aggregation may reduce thrombocytopenia and platelet dysfunction which are features of the postoperative phase. A double-blind study on 44 patients undergoing either coronary artery vein grafting or valve replacement was designed to investigate the effects of a constant intravenous prostacyclin infusion, before and during bypass, on the blood losses and platelet function after bypass. In the 13 graft patients and nine valve patients who received prostacyclin, there was no statistically significant reduction in the amount of blood lost after bypass compared with the controls. Similarly, the need for blood replacement did not differ between the prostacyclin and control groups. The weight increase in the arterial line filters (40 micron) was smaller in the prostacyclin group ($p < 0.05$). The changes in platelet numbers and their activity during and after bypass are currently being analysed. These results suggest that while prostocyclin may preserve platelet function and limit aggregation on filters, it has little influence on postoperative bleeding or the demands for blood transfusion.

**How safe is cardiopulmonary bypass?**

DR WHEELDON, RD GILL, DW BETHUNE, TAH ENGLISH Reliable information on the safety of cardiopulmonary bypass is sparse. After a recent survey in the USA of 375 000 perfusions during the years 1972–77, a similar analysis of perfusion practice in the United Kingdom during the years 1974–79 was undertaken. Returns were duly received on 43 262 perfusions, representing about 80% of total perfusions performed during this period. The surveys reveal that a fatal perfusion accident occurs once per 1000–1500 perfusions and a serious incident once per 300–400 perfusions. The United Kingdom survey showed that the following aspects of perfusion (expressed as number of incidents per 1000 perfusions) represent particular hazards: electrical failure (0·88); arterial line embolism (0·56); oxygenation failure

(0·46); mechanical failure (0·23); disseminated intravascular coagulation (0·16); vent air embolism (0·09); inadequate perfusion (0·09); and donor blood accidents (0·02). The commonest causes of fatal perfusion accidents were gross air embolism (0·16); disseminated intravascular coagulation (0·12); and inadequate perfusion (0·09). Methods for improving the safety of cardiopulmonary bypass include the establishment of agreed perfusion protocols with provision for regular emergency drills, the use of alarm systems to help prevent gross air embolism, and more effective monitoring of heparin therapy during bypass. Most important, however, is a continuing critical analysis of "systems performance" to identify failure modes of existing systems and to predict hazards from the introduction of new components.

**Evaluation of synthetic, biosynthetic and biological conduits used for aorto-pulmonary shunt in growing animals**

G NUNN, V KETHARANATHAN, D GUERREIRO, SC LENNOX Aorto-pulmonary shunts were constructed in four-week old pigs using one synthetic, two biosynthetic, and three biological conduits of 6 mm diameter. These grafts produced maximum tolerable left to right shunts. Four weeks later when the pigs were eight weeks old they were fully restudied. The left to right shunt had variably diminished in size according to the type of graft used. An impermeable waterproof graft with dispensability performed better than the others.

**Brachial plexus injury from median sternotomy**

TOM TREASURE A small proportion of patients who had undergone median sternotomy complained of numbess and weakness in one or both hands. These symptoms have been noted sporadically in other units and various explanations have been given. The deficit is usually mild and transient but occasionally complete paralysis of the hand may occur. We studied a consecutive series of 200 patients. Their hands were examined preoperatively and any postoperative symptoms were investigated with electromyography (EMG) and nerve conduction studies. Nine patients developed clinically evident neurological changes and in three cases the changes were bilateral. The symptoms were found to result from a lesion in the lower cord of the brachial plexus causing motor and sensory deficits in the distribution of the C8-T1 nerve roots. The lesions could be accurately localised because the pectoralis major muscle showed evidence of denervation on EMG. This places the lesion proximal to the medial pectoral nerve. The injury must therefore be in the lower trunk in that part related to the first rib. Postmortem room dissections confirmed that spreading the chest during median sternotomy brought localised pressure to bear on the plexus at that site. There was thus a close correlation between the anatomical and electrophysiological evidence obtained. The presentation, natural history, and avoidance of the injury will be discussed.

**Peter Allen Essay Prize Abstract**
**Quantification of cardiac cachexia and its relationship to the results of surgery**

ROBIN K WALESBY The incidence of cardiac cachexia in patients undergoing cardiac surgery was assessed both by peripheral markers of nutritional depletion and indirectly from the lean body mass (the energy utilising component of the body) derived noninvasively from total body potassium measurements. Total body water, which is also directly related to total lean body mass, was measured by a tritiated water dilution technique ($^3H_2O$). The incidence of calorie-protein depletion was approximately 50% of all the patients, being more common in valvular heart disease than in coronary artery disease. There were no deaths among the nutritionally normal and nine deaths during the first 28 postoperative days among the depleted patients. The difference is significant (Fisher's exact $p<0·01$). Of the survivors the median postoperative stay of nutritionally malnourished patients was 17 days as compared with 27 days for those in a nutritionally replete state (Wilcoxon $p<0·01$). The metabolic response to surgery as assessed by changes in lean body mass, was a mean net negative loss of 9·8 g of nitrogen a day over seven postoperative days. The incidence of the requirement for inotropic support, prolonged ventilation, and wound sepsis was significantly higher in the two groups using non-parametric statistics. The probability of death related to lean body mass depletion rose from approximately 10% in the nutritionally normal, through 50% at 15–25% depletion, to 100% in patients undergoing cardiac surgery with a preoperative depletion in excess of 25% of that predicted. The regressions of lean body mass derived from total body potassium against lean body mass derived from total body water measurement and fat-free measurements, were 0·93 and 0·85 respectively. Repeat measurement of the lean body mass at three years showed the mass to have significantly increased after successful surgery (analysis of variance $p<0·01$). Total body potassium therefore indexes the lean body mass and from this a quantification of cardiac cachexia and the relative risks of surgery may be evaluated.