A REVIEW OF CARDIAC SURGERY

IN SOUTH AUSTRALIA

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by

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SUMMARY

An analysis has been conducted of the outcome following cardiac valve surgery and coronary artery bypass grafting performed in the Royal Adelaide Hospital Cardiothoracic Surgical Unit over a 25 year period.

Pre-operative and post-operative data was collected on all patients undergoing surgery and a follow-up questionnaire sent to various patient groups to assess survival, symptomatic outcome, complications and current employment. In excess of 7000 individual patients were contacted with 98% complete follow-up being achieved. With acurate survival data, potential risk factors were analyzed and inter and intra group comparisons made.

Isolated aortic valve replacement occurred in 601 patients with 65% having a Starr-Edwards valve and 33% a Bjork-Shiley. Hospital mortality over the period of review fell from 8.6% in the first decade, to 2.9% in the second decade. Poor long term survival was significantly influenced by poor ventricular function, dyspnoea, cardiac pathology and atrial fibrillation. Haemorrhagic and embolic complications requiring hospitalization occurred at a constant rate. No evidence of significant valve superiority was found in the aortic position or mitral position. In a subsequent group the use of the aortic Bjork-Shiley Monostrut Valve in 315 patients showed comparable results to the preceding model without the complication of strut fracture.

Mitral valve replacement occurred in 534 patients with 94% of patients having a Starr-Edwards valve inserted. The mean hospital mortality fell from 4.8% in the first decade of surgery, to 3.6% in the second. Pre-operative predictors of long term survival found in the

aortic group pertained to the mitral patient as did the incidence of complications. Dyspnoea was significantly improved in both aortic and mitral valve patients at time of review.

The first 4001 patients to undergo coronary artery bypass grafting were also reviewed. Five year survival was 91% with an overall hospital mortality of 2%. Angina, dyspnoea and activity were all significantly improved post-operatively. A small "drop off" (4%) from the workforce occurred following surgery. The cost of the surgery in 1982 prices being $3,476.00 per patient. When patients who had undergone coronary artery bypass grafting at least 10 years earlier were reviewed, 16% had required re-operation, however the only predictor of a re-operation found was inadequate initial surgery.

Diabetic patients undergoing coronary artery bypass grafting had a significantly poorer short and long term survival than non diabetic patients. In particular, there was significantly poorer survival for diet controlled diabetic patients and this group may warrant closer post-operative surveillance.

When coronary artery bypass grafting was combined with another cardiac procedure such as valve replacement or aneurysm plication, although the addition of the coronary artery bypass grafting carried no additional risks, it did not appear to enhance survival.

A review of the first 1155 coronary artery angioplasties and the effect on emergency and elective coronary artery bypass grafting has also been assessed.

DECLARATION

I declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any University and that to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis. I further consent to the thesis being made available for photocopying and loan if applicable, if accepted for the award of the degree.

GUY MADDERN

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The design of the questionnaires was helped by the input of Dr. Robert Douglas and Dr. Helen Winefield from the Department of

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PREFACE

Part of the work described in this thesis has been published or accepted for publication. These publications are listed below in the order in which they were submitted.

1. Maddern GJ, Craddock D, Leppard PI, Ross IK, Stubberfield J, Waddy JL (1984). Twelve years of Coronary Artery Surgery in South Australia. *The Med J Aust* 140; 136-40.

2. Maddern GJ, Craddock D, Leppard PI, Ross IK, Stubberfield J, Waddy JL (1986). The cost of Coronary Artery Surgery to the Community. *J Cardiovasc Surg* 27: 469-76.

3. Maddern GJ, Craddock DR, Leppard PI (1985). Actuarial analysis of survival and complications in patients with prosthetic cardiac valves. *Aust NZ J Surg* 55: 295-6.

4. Craddock DR, Maddern GJ, Ross IK, Leppard J, Waddy JL, Stubberfield J (1985). Early and late results of multiple valve replacements. *Aust NZ J Med* 15: 505.

5. Craddock DR, Maddern GJ, Waddy JL, Ross IK, Stubberfield J (1986). The changing face of open heart surgery. The South Australian Experience (1960-1985). *Aust NZ J Med* 16: 558.

6. Maddern GJ, Paterson HS, Craddock DR, Ross IK, Stubberfield J, Picozzi S, Leppard PI (1990). A four year experience with Bjork-Shiley Monostrut Valve. *Texas Heart Institute Journal* 17: 216-8.

SECTION I

AIMS

1.1 FOR PATIENTS UNDERGOING MECHANICAL VALVE REPLACEMENT SURGERY

Answers to the following questions are sought:

(i) What trends in patient selection and operative details have occurred in twenty five years of valve replacement surgery in both the mitral, aortic and multiple valve replacements?

(ii) Have different prosthetic models altered the survival or complications for these patients?

(iii) What risk factors affecting longterm survival can be identified in these patients pre-operatively?

(iv) What is the symptomatic outcome following surgery?

(v) How does the Bjork-Shiley Monostrut Aortic Valve perform in the short term?

1.2 FOR PATIENTS WHO UNDERGO CORONARY ARTERY BYPASS GRAFT SURGERY

Answers to the following questions are sought:

(i) What trends in patient selection and operative detail has occurred in the first decade of coronary artery bypass surgery?

(ii) What is the hospital and longterm mortality for these patients? What risk factors can be identified?

(iii) What is the symptomatic outcome for these patients?

(iv) Is return to work and activity affected by the surgery?

(v) Is the surgery cost effective?

(vi) Why do patients present for redo surgery and can they be predicted at time of initial surgery?

(vii) Is the outcome for redo patients different than those presenting for initial surgery?

(viii) What is the likelihood of redo operation 10 years after initial coronary artery bypass graft surgery?

(ix) What effect does diabetes have on patients undergoing coronary artery bypass graft surgery? Does the outcome depend on the insulin dependent status of the patients?

(x) Does the addition of coronary artery bypass graft surgery to other cardiac surgery, alter the prognosis for these patients?

(xi) What is the risk of emergency surgery following coronary artery angioplasty?

(xii) How many patients undergoing coronary artery angioplasty require subsequent coronary artery surgery and when does this occur?

(xiii) How does angioplasty's ability to relieve symptoms compare with coronary artery bypass graft surgery?

SECTION II

INTRODUCTION

From antiquity until comparatively recent times, the heart has been considered outside the limits of surgery. As late as 1886, the usually perceptive historian Stephen Paget wrote:

"Surgery of the Heart has probably reached the limits set by nature to all surgery, no new method and no new discovery can overcome the natural difficulties that attend a wound of the heart" (Lyons, 1978).

Ironically, it was in that same year that Ludwig Rehn successfully repaired a laceration of the heart and a new era of cardiac surgery had begun (Rehn, 1913).

The advancement of cardiothoracic surgery has relied heavily on technical developments. It was Werner Forssmann who, while an Intern in a German hospital, first demonstrated cardiac catheterization, trying to devise a technique for emergency injection of drugs directly into the heart. He did this in 1929, while standing behind a fluoroscopic screen and looking into a mirror which enabled him to visualize a thin catheter which he threaded through an arm vein and successive venous channels into his heart (Forssman, 1929). It was not however until Cournard, a French Graduate working in New York, established cardiac catheterization in 1941, that this valuable technique opened the way for further advances in cardiac physiology and surgery. These two pioneers shared the Nobel Prize for Medicine in 1956 (Morris and Schirmer, 1990). In 1953, Seldinger of Stockholm popularized transarterial catheterization (Seldinger, 1953),

which was extended finally to successful coronary cine-angiography by Sones in Cleveland, in 1962. This was occurring concurrently with the construction by Gibbon of the Heart-Lung Machine (Gibbon, 1954), which led to Effler and his colleagues in Cleveland developing a vein by-pass technique for myocardial ischaemia (Favaloro et al, 1970).

2.1 CARDIAC VALVES

The first implanted artificial valve in the human circulatory system was performed by Hufnagel, in 1953 and heralded the beginning of a variety of prosthetic devices available for use in cardiovascular surgery. Improvements in design and construction were followed with many modifications often failing to demonstrate longterm advantages and indeed some have proven positively harmful.

CLASSIFICATION

Four functional categories of prosthetic valves exist: caged ball, caged disc, tilting disc and tissue valve. The original Hufnagel prosthesis was of the caged ball variety and was implanted in the descending aorta in patients with severe aortic insufficiency (Hufnagel et al, 1954). Harkin performed the first sub-coronary implantation of a caged ball valve in a group of patients with aortic regurgitation in 1960, but was unable to achieve survival for longer than three months, in 9 of 11 patients in his series (Harken et al, 1960; 1962). The first insertion of a caged ball valve in the mitral position was performed by Starr also in 1960 (Starr and Edwards, 1961). The caged disc valve was introduced between 1964 and 1965, by a number of investigators (Hufnagel and Conrad, 1965; Kay et al, 1966

a, b; Cross and Jones, 1966). Similar in design, but all attempting to offer the advantages of a lower profile, improved haemodynamics and lighter weight, than the caged ball valve. Beall in 1967, (Beall et al, 1968) further modified the design to diminish the valve's thrombotic potential. The tilting disc prosthesis was introduced in 1967 by Wadda, Bjork and Lillehei (Wadda et al, 1972; Bjork, 1969; Lillehei et al, 1974) providing a greater approximation of laminar flow than did the caged valves. The tissue valve made its first appearance in 1962, in the form of a fresh aortic valve homograft, used successfully for aortic valve replacements by Ross, Duran and Barratt-Boyes (Ross, 1962; Duran and Gunning, 1962; Barratt-Boyes, 1964), after previous trials in the descending aorta (Murray, 1956; Kerwin, 1962). Initial favourable results were tempered by reports of early degeneration, rendering the bioprosthesis a less attractive alternative at the time (Ross, 1972; Angel et al, 1972; Wallace, 1975; Moore et al, 1975).

The clinical introduction of the aortic heterograft in 1967 (Ionescu et al, 1967; Carpentier et al, 1968) and the subsequent development of a glutaraldehyde tanning technique that substantially increased the valve's durability, stimulated renewed interest in these valves (Carpentier et al, 1969). Glutaraldehyde preservation techniques were subsequently applied to valves constructed of fascia lata (Ionescu and Ross, 1969) and bovine pericardium with satisfactory results (Ionescu et al, 1972).

First introduced by Gott in 1968, the bileaf tilting disc valve was designed to provide entirely central flow. The most recent bileave prosthesis was devised by St. Jude Medical Incorporated and has been studied in clinical trials since 1977 (Nicoloff and Emery, 1979; Duncan et al, 1983; Horstkotte et al, 1983; Aurelio et al, 1984; Douglas et al 1985).

CHARACTERISTICS OF A GOOD PROSTHETIC VALVE

In a careful review of prosthetic heart valves (McClung et al, 1983) the eight characteristics of good valve replacements were stated to be:

i) Haemodynamics,

ii) Minimal thrombogenesis,

iii) Durability,

iv) Minimal haemolysis,

v) Ease of implantation,

vi) Patient acceptability,

vii) Low incidence and diminished severity of late prosthetic endocarditis and

viii) Anatomic suitability of the valve to its implanted location. There is presently little difference between any of the four types of prostheses in terms of ease of surgical implantation. In addition, none of the valves now in use are sufficiently noisy as to be unduly disturbing to the patient. The remaining six characteristics serve as a framework through which the various types of substitute separate valves may be evaluated.

STARR-EDWARDS CAGED BALL VALVE

The valve models that have been used in over 95% of patients in the Cardiothoracic Surgical Unit at the Royal Adelaide Hospital, are the Starr-Edwards caged ball valve and Bjork-Shiley tilting disc valve. The Starr-Edwards valve prosthesis is the most widely known and extensively studied caged ball valve. The original models 6000 mitral and 1000 aortic, were constructed of a heat cured silicon rubber ball housed in a caged structure made from Stellite 21 (an alloy of cobalt chromiummolybdenum and nickel) and anchored by a sewing ring of

teflon cloth (Starr and Edwards, 1961). While the valve provided adequate haemodynamics in both the aortic and mitral positions, haemolysis was a significant problem in the former. Anticoagulation was mandatory. The 1260 prosthesis was developed in 1965 and has continued to enjoy popularity. In this valve a teflon cloth covering was extended over the entire seat as a means of providing endothelialization about the orifice. This resulted in a significant reduction in the rate of thromboembolism from 34% in the model 1000, to 19% in the model 1260 (Starr, 1972). Ball variance in the model 1000 and 6000 resulted in both obstructive phenomena and the fatal poppet embolization. This problem was dealt with in models 1260 and 6120 by a minimal reduction in temperature of the curing process, as well as the addition of an extra 10% silicon dioxide or fluorosilicone filler. Additional alterations included an increase in the orifice to ball diameter ratio (88%), modification of the orifice configuration to reduce opening pressure and a decrease in the overall weight of the prosthesis by reduction in its metallic composition (Herr et al, 1968).

Series 2300 aortic and 6300 mitral prostheses eliminated ball variance by replacing the silicon rubber poppet with a hollow Stellite 21 sphere (Starr et al, 1967). Based on observations (Braunwald and Bonchek, 1967) that neo-intimal proliferation along cloth covered valve struts substantially reduced the threat of thrombus formation, these valves employ completely cloth covered struts. They were subsequently modified to include a "composite seat" that featured a ring of small metallic studs projecting through the teflon cloth of the valve orifice, that both increased the orifice to ball diameter ratio and reduced wear on the orifice cloth. In clinical trials thromboembolic phenomena were initially noted to be substantially reduced in both

the aortic and mitral positions, however continuous anticoagulation remained mandatory (Hodam et al, 1971; Bonchek and Starr, 1975).

Reports of cloth wear and pronounced haemolysis with the cloth covered valve particularly in the aortic position (Roberts et al, 1973), encouraged development of the series 2400 and 6400 composite strut "track valve" in 1972. The valve was virtually identical in construction to the composite seat cloth covered series, but incorporated strips of Stellite 21 on the inner surface of each strut, providing a metallic track that protected the teflon covering from trauma resulting from ball impact. Early studies on this model revealed substantial thrombogenesis in the absence of anticoagulation (Stein et al, 1976). Later reports suggested that there was no greater thromboembolic potential associated with the valve than with other valve prosthesis, if the patients were appropriately anticoagulated (Starr et al, 1977a). Haemolysis remained significant resulting in the abandonment of the cloth covered struts, entirely in favour of the earlier non cloth covered model 1260 aortic and model 6120 mitral valves.

RESULTS WITH THE STARR-EDWARDS VALVE

Aortic Replacement

Initially hospital mortality for aortic valve replacement with all the presently available prostheses, was reported to be between 5% and 8% in multiple series (Anderson et al, 1973; Thompson et al, 1979; Foreman et al, 1980; Bonchek, 1981). Subsequent data using cold cardiaplegia for myocardial preservation, revealed hospital mortality lower than 1% for isolated aortic valve replacement (Jacobs et al, 1980). Mortality is not a function of the type of valve used, but rather a combination of well known peri-operative complications such

as peri-operative myocardial infarction, left ventricular failure and ventricular dysrhythmia. Late mortality ranges from 15% - 20% at 5 years (Bonchek, 1981) and also appears independent of the type of prosthesis employed. Haemodynamics are generally similar in all models with average gradient varying from 10 - 19 mmHg in multiple trials (McHenry et al, 1967).

Thromboembolic conditions in anticoagulated patients also tend to be relatively similar, with 1.5% - 2% patients a year reported for Starr 2400 model (Starr et al, 1977b) and 5% over 4 years noted for the Smelloff-Cutter valve (Bloodwell et al, 1969). Bonchek and Starr in 1975 observed no thromboembolic events in 116 anticoagulated patients followed for three years with cloth covered (2310 - 2320) valves. In contrast they found 8.8% incidence over two years in patients who were not anticoagulated and 29.4% incidence in patients followed for two years who had discontinued previous anticoagulation. Haemolysis is noted in all types of mechanical prostheses, however, frank haemolytic anaemia has been associated with cloth covered aortic devices and in the presence of peri-valvular leaks (Santinga and Kirsh, 1972).

Mitral Replacement

Operative mortality for elective mitral valve replacement in New York Heart Association Class 3 patients is between 1% and 3% (Bonchek, 1981), although the figures become somewhat higher if Class 4 patients are included. Late mortality is virtually identical to that reported for aortic valve replacement (Bonchek and Starr, 1975), with only 10% - 15% of these related to complications of the prosthesis itself. Mean resting valve gradients have ranged from 5 - 9 mmHg although they have been observed to increase as much as three fold during exercise (Starr et al, 1977b). Thromboembolic

events are reported more commonly in mitral position than in the aortic, although haemolysis is less pronounced. The Starr-Edwards model 6400 composite strut valve was associated with a 3% per patient year rate of thromboembolism (Starr et al, 1976).

COMPLICATIONS

Flow Obstruction

Flow obstruction is an intrinsic feature of the caged ball valve by virtue of its design. Three sites of obstructive flow are immediately apparent:

i) the valve orifice itself,

ii) the outflow orifice defined by the oblique distance between the respective circumferences of the valve seat and the ball in the open position and

iii) the centrally obstructed channel defined by the distance between the circumference of the ball and the surrounding tissue. Centrally obstructive flow causes a substantial amount of turbulence, particularly in the aortic position where flow velocity is at least three times that across the mitral valve.

Thrombogenicity

While necropsy studies have demonstrated the presence of prosthetic thrombi, in the vast majority of patients with caged ball valves, only a minority of these have displayed clinical evidence of embolic events antemortem (Roberts et al, 1973). Location of the thrombus is variable and is in part dependent upon the type of valve employed. There is predilection for thrombus formation at the junction of the struts with the seat in non cloth covered valves, while it is more commonly found at the apex of the cage in non close clearance cloth covered models. Thrombus formation in a small group

of close clearance cloth covered aortic prostheses appeared primarily at the mid portion of the struts and was reported to be responsible for reduced forward exertion of the ball with consequent mortality.

A re-evaluation of actuarial thrombotic rates by McManus et al (1980), reveals that thromboemboli were significantly more common from aortic and mitral silicon ball valves during the first decade of cardiac valve replacement than they have been for the second, using identical valve models. This difference probably reflects diminished ball variance as a result of alterations in silicon curing techniques. Thromboembotic rates in the anticoagulated patient with the Starr-Edwards silicon ball valve appears equivalent to those as observed in patients with both tilting disc and tissue valve prostheses.

Some evidence has been presented suggesting that the use of acetylsalicylic acid in combination with anticoagulant therapy is more effective than anticoagulants alone, in the prevention of thrombotic episodes (Dale et al, 1977). Not withstanding the use of antiplatelet agents, in the absence of anticoagulation, it has been shown unequivocally to be not only inferior to anticoagulant therapy alone, but little better than no medication whatsoever for thromboembolism prophylaxis in patients with caged ball prostheses (Dale and Myhre, 1981).

Durability

Silicon ball variance was a persistent problem in prosthetic devices implanted prior to alteration to the curing technique in 1965, especially those mounted in the aortic position. Swelling of the ball was observed with frequent reports of impaction in the cage. Trauma inflicted by the valve struts upon a swollen lipid laiden poppet has been implicated in the pathogenesis of ball distortion, fracture, and embolization, all of which probably represent a spectrum of the same

phenomenon. The low reported incidence of ball variance in the mitral position appears to be related to a combination of factors. Not only is the mitral prothesis subject to diastolic pressures that are substantially lower than those in the aortic position, but the impact of the ball when subjected to the higher velocity of ventricular systole is directed towards the valve seat rather than the apex of the cage rendering it less likely to the grooving and distortion observed in aortic devices. Cloth strut wear in model 2310 and 2320 Starr-Edwards Aortic prostheses has been associated both with an increased incidence of haemolysis and a decreased longevity of the valve itself.

Haemolysis

Haemolysis is a complication of all mechanical cardiac valves, although it rarely leads to frank anaemia, unless the prosthesis is cloth covered and located in the aortic position or a peri-valvular leak is present. The increased turbulence associated with both intact and damaged cloth covered struts provides an environment particularly conductive to intravascular traumatic haemolysis. Post mortem examinations performed by Roberts et al (1973), have revealed not only a high incidence of renal haemosiderosis in patients with aortic valve replacement, but also a significantly greater severity of iron deposition than that found in patients with mitral replacement alone.

Endocarditis

The majority of clinical investigations of prosthetic endocarditis have been performed in patient populations with Starr-Edwards cage ball valves. There has been no evidence of any significantly greater predilection to infection in one model over another. Incidence is variably reported in the range between 1% and 4% (Slaughter et al, 1973), between 36% and 53% of these cases are documented within two months of surgical implantation and are designated as early

prosthetic valve endocarditis. The most common ethological organisms are *Staphylococcus aureus* and *epidermidis*, accounting for more than half the infections with the remainder due to *Streptococcus*, fungal species and gram negative organisms. Common sources include wound infections, urinary tract infections, intravenous infusion equipment and cardiopulmonary bypass pumps. The infection commonly involves the suture line and is highly virulent with reported mortality rate as high as 87%, regardless of the mode of therapy employed (Dismukes et al, 1973).

Late prosthetic valve endocarditis is a different patho-physiological entity, both aetiologically and prognostically. The pathogenic strain is noted to be *Streptococcus* species in 42%, a *Staphylococcal* organism in 25%, a gram negative in 16% and a Diptheriod in 10% (Karchmer et al, 1978). Only one case of late prosthetic candidiasis was documented secondary to an infected Ilio-condute. Sources of infection in the remaining cases were those commonly associated with endocarditis in the general population, e.g. dental manipulation, peri-odontitis, genito-urinary manipulation. Mortality rate has been reported to range from 35 - 53% (Karchmer et al, 1978). *Streptococcal* infections fare the best with the late survival rate of 61% in Karchmer's population, in comparison with 36% in the non *Streptococcal* group. In all series a significant number of cases were potentially preventable by antibiotic prophylaxis.

Roberts et al, (1973) have described inflammatory processes extending through the atrial septum into the atrioventricular junction, as well as deep into other contiguous structures in five patients studied at post mortem examination with late aortic prosthetic valve endocarditis. All five cases were observed to manifest massive aortic insufficiency secondary to partial, or complete detachment of the

valve from the aortic route. In a larger series of 22 patients, prosthetic valve ring abscesses were documented in all cases regardless of the site of the valve involved (Arnett and Roberts, 1976). Involvement of the entire circumference of the prosthesis leading to valve detachment was observed in 80% of patients with aortic prosthetic endocarditis and in 28% of patients with prosthetic mitral lesions. While prosthetic mitral valve endocarditis is commonly accompanied by valve dehiscence and regurgitation, mitral prosthetic infection is more frequently associated with valve obstruction caused by vegetative material (Watanakunakorn, 1979). Karchmer et al (1978) has confirmed the importance of prosthetic regurgitant lesions, clinically demonstrating a two-fold increase in mortality in patients developing insufficiency murmurs. Atrioventricular conduction abnormalities were universally associated with a fatal outcome. Increasing duration of a febrile course was also know to correlate with more extensive myocardial invasion at autopsy. *Candida* and *Aspergillus* species are responsible for nearly all reported cases of fungal prosthetic endocarditis. Mortality remains greater than 90% regardless of the therapeutic modality employed (Harford, 1974).

Anatomic Suitability

The prime anatomic disadvantage of the caged ball valve is its size. The spacial requirements for the prosthesis have been responsible for an extraordinary variety of post-operative complications more commonly seen in the mitral, than in the aortic position. The absence of ventricular dilatation in the patient with pure mitral stenosis has both haemodynamic and electro-physiological consequences following mitral valve replacements. Incomplete forward motion of a poppet has been reported as a result of

ventricular myocardium interposed between the struts of the cage, a phenomenon that has greatly enhanced biconcentric hypertrophy in the presence of co-existent aortic stenosis (Roberts et al, 1973). In the presence of a small ventricular chamber obstruction to ventricular emptying can occur with the Starr-Edwards valve in the closed position, because of its intrusion into the ventricular outflow tract. Erosion of the ventricular septum in the vicinity of the conduction system as well as trauma to the ventricular free wall, have been responsible for fatal dysrhythmia (Robicsek et al, 1967). Use of the valve in the tricuspid position has resulted in stenotic obstructive and thrombotic complications similar to, if not more frequent than those encountered in the mitral replacement (VanderVeer et al, 1971).

BJORK-SHILEY TILTING DISC VALVE

Evolution

The concept of a tilting disc prosthesis was introduced by Wada in 1968, when he designed a valve that allowed a teflon disc in a titanium housing to pivett open to an angle of 75^0-80^0 providing semi centralized flow. Although haemodynamically successful, the valve developed problems with early degeneration of the hinged teflon disc leading to its withdrawal from production. Complications included regurgitant flow through the prosthesis itself and severe disc variation with at least 13 reported cases of disc disengagement and embolization from both aortic and mitral positions (Bjork, 1970; Roe et al, 1975).

In 1969, Bjork reported preliminary studies on a new valve consisting of a free floating Dell ringed disc suspended between two cccentrically positioned struts in a Stellite housing designed to tilt open to a maximum angle of 60^0. Incorporated into its design was the

facility of the disc to rotate on its axis, in a fashion similar to that of a phonograph record on a turntable, once every 180-200 cycles, thereby substantially diminishing the wear caused by the hinge struts. The Dell ringed disc proved to be relatively resistant to thrombosis, as well as durable. However, a propensity to absorb moisture during steam autoclaving was found to lead to swelling of the occluder, if it was not rigorously dried following sterilization. This potential problem was solved with the advent of a pyrolytic carbon disc in 1972 (McClung et al, 1983). Subsequently, a series of valves were devised utilizing a convex-concave pyrolytic carbon disc, that rises out of the housing somewhat when the valve is open, directing more flow through the lesser orifice. The design is intended to diminish the thrombogenecity and resistance to flow perhaps at the expense of a moderate increase in regurgitation.

Results

Operative and late mortality for the tilting disc valve is similar to that reported for other prosthetic implants (Lepley et al, 1977). Exercise gradients with the eccentric monocusp valves are not well documented, however Bjork has reported doubling of aortic resting gradient and tripling of mitral resting gradient on exercise (Bjork et al, 1973). Subsequent reporting of strut fracture (Lindblom et al, 1986) lead to the development of monstrut valve, made from a single cast with no welds included (Bjork, 1985). This did not, however, alter the fundamental performance of the original concaved-convexed valve (Ostermeyer, 1987).

COMPLICATIONS

Flow Obstruction

Flow dynamics for the tilting disc prosthesis are better than for

the Starr-Edwards prosthesis. Incomplete opening of the mitral eccentric monocusp prosthesis can occur in the face of massive aortic insufficiency however, this problem is quite rare unless encouraged by incorrect positioning of the valve.

Valve Incompetence

Studies of the original Bjork mitral prosthesis demonstrated regurgitant flow of up to 12%-15% in some patients, a phenomenon which was presumed to provide an antithrombotic "washing" mechanism by the manufacturer (Bjork and Olin, 1970). Regurgitant flow was eliminated by the introduction of the pyrolytic carbon disc, that fit the valve orifice more snuggly than did its predecessor.

Thrombogenicity

The thrombotic potential of the Bjork valve in the absence of anticoagulation is well known. A substantial risk of thrombotic and thromboembolic events remains in the patient who is not anticoagulated. There are multiple reports of thrombosis of the prosthesis itself in both the aortic and mitral position, usually in patients not receiving anticoagulation therapy. Necropsy studies performed by Roberts and Hammer (1976) demonstrated no obstructive prosthetic thrombosis in any patients treated with Warfarin sodium, unless there was co-existing prosthetic endocarditis. Similarly the overall incidence of prosthetic thrombosis associated with the Bjork valve was less than that observed in anticoagulated patients with caged ball valves. Thromboembolic events have been reported to average 1.9% per patient year with the Bjork-Shiley prosthesis (Lepley et al, 1977).

Haemolysis

Haemolysis in all tilting disc valves has been remarkably minimal with few reports of haemolytic anaemia. Post mortem

examination has reported the presence of renal haemosiderosis in 3 of 9 patients, however only one of these was noted to be severely affected (Roberts and Hammer, 1976).

Endocarditis

Endocarditis has been no more frequently observed in tilting disc prosthesis than in any other valve replacement, although it has been associated with increased incidence of prosthetic thrombosis (Lepley et al, 1977).

Anatomic Suitability

Reports of anatomic disproportion of tilting disc valves are rare. Roberts and Hammer (1976) observed two cases in which the size of the Bjork-Shiley prosthesis chosen for mitral valve replacement, was too large for the left ventricular cavity, leading to incomplete opening of the valve with result in prosthetic stenosis.

2.2 CORONARY ARTERY BYPASS GRAFT SURGERY

Coronary artery bypass grafting (CABG) for ischaemic heart disease was developed in the 1960's and has undergone refinement since. Its true role in the treatment of ischaemic heart disease has been the subject of considerable controversy (Silverman and Grossman, 1984; Spodick, 1982), despite numerous studies. Both medical and surgical treatment for myocardial ischaemic disease has progressed rapidly (CASS, 1983a). Medical advances include calcium channel blockers, thrombolysis and coronary angioplasty. Surgical advances include increasing technical skills resulting from experience, better peri-operative care and improved myocardial protection, which has resulted in a decrease in peri-operative injury and mortality (Kennedy et al, 1980; Miller et al, 1983b). The rates for operative mortality and peri-operative myocardial injury for isolated CABG are 1%-2% and 2%-5% respectively (Hall et al, 1983; Jones et al, 1980; Kouchoukos et al, 1980; McCormick et al, 1983; Najafi, 1983; Rahimtoola et al, 1981).

Coronary Artery Anatomy

In order to appreciate the rationale for CABG, a brief review is presented of coronary anatomy and physiology. Arising from the aorta just above the aortic valve ring, are the right and left coronary arteries, the initial portion of the left coronary artery is the left main coronary artery and it rapidly divides into the left anterior descending (LAD) branch and a circumflex branch. The LAD supplies more of the myocardium than any of the other coronary arteries, its area of distribution being the anterior wall of the left ventricle and the majority of the intraventricular septum. The circumflex coronary artery branches that supply the posterior wall of the left ventricle and the terminal portions may supply the inferior portion of the heart

also. The right coronary artery (RCA) primarily supplies the right ventricle, but its terminal portion ends in the posterior descending artery (PDA), which supplies the inferior surface of the left ventricle, as well as part of the interventricular septum. The RCA may continue to give other branches to the posterior wall of the left ventricle. The PDA may arise from either the right coronary artery or the circumflex coronary artery or there may be branches from both. The LAD, the circumflex and the RCA, compose the three major arterial systems that supply the left ventricle, these are the systems involved when references are made to single, double and triple vessel coronary artery disease. The LAD, the circumflex and to a lesser extent the PDA all give off branches that may be individually involved with atherosclerosis.

Although colateral channels between the coronary arteries are not prominent in the normal states, they do develop and become quite important when there are significant stenoses in any of the arteries. For example, a normal LAD can form colateral vessels that supply areas of the heart, that are normally supplied by an obstructed PDA and vice versa. The flow through the coronary arteries varies depending on the myocardial requirements, however the ability to increase flow is impaired by atherosclerosis. There is a large capability for reserve flow. In fact, only when 70% of the cross sectional area of a coronary artery is obstructed, does flow decrease significantly. This is equal to a 50% reduction in diameter as measured on angiography. As flow becomes impaired the clinical manifestations of ischaemic heart disease progress, from angina to infarction (Christian et al, 1985).

Progression of Atherosclerosis and Risk Factors.

Ischaemic heart disease caused by atherosclerosis is a complex

progressive disease (Haft and Bachik, 1984; Kramer et al, 1983) resulting from inherited and enviromental factors. The rate of progression of stenoses in an individual patient cannot be predicted easily (Shub et al, 1981) and occlusion due to thrombus formation at a stenosis, or due to spasm, is the usual cause of acute infarction. It occurs often without warning. Inherited factors play an important role in the development of atherosclerosis, but the variable expression of these factors complicates our ability to make predictions about the disease and little control can be exerted over them.

Control of specific, identifiable risk factors that accelerate atherosclerosis such as elevated lipids, hypertension and smoking, may decrease cardiac events such as angina and infarction. Control of these risk factors has been studied extensively (Stamler, 1983; Castelli, 1984). Results in general have been favourable, but not consistent or to the degree hoped for by the investigators and controversy still exists (Brett, 1984; Corday & Corday, 1983). Risk factor analysis and modification in patients with established clinical ischaemic heart disease are reasonable goals, but they have not predictably correlated with progression. In those who are followed with serial angiographic studies (Kramer et al, 1983; Moise et al, 1984) stenoses proximal to patent grafts, appear to progress more rapidly, than stenoses in ungrafted arteries (Cosgrove et al, 1981). The development of atherosclerosis in grafts correlates best with elevated blood lipids (Palac et al, 1982) and vein graft patency at ten years will probably be about 65% (Campeau et al, 1983). It is agreed that medical and surgical treatment does not alter the basic metabolic problems that cause the disease or its progression and that at present, its therapeutic interventions must be considered palliative.

Major Factors Affecting Prognosis

Prognosis in patients with ischaemic heart disease is predicted by left ventricular function and extent of coronary obstruction (Harris et al, 1979; Proudfit et al, 1983) not severity of angina pectoris. However, if the pain pattern becomes unstable, occurrence of non fatal infarction and death increases (Harris et al, 1980). After coronary artery bypass graft (CABG), the degree and duration of pain relief and survival are related to completeness of revascularization (Assad-Morrel et al, 1975; Buda et al, 1981), long term patency rates (Brower et al, 1983) and progression of atherosclerosis in native coronary artery (Laird-Meeter et al, 1983). The progressive nature of the disease combined with the unpredictable role of risk factors and modification, makes it extremely difficult to decide between medical and surgical therapy in the individual patient.

As important as it is to control angina pectoris for improved quality of life, it is essential that medical and surgical interventions be timed to preserve ventricular function and thus prolong life. Needless extension of medical therapy should not occur when non invasive studies continue to show myocardial ischaemia and invasive studies demonstrate proximal obstruction with distal vessels supplying viable muscle. CABG should not be denied if indications exist and if excellent surgical results can be obtained (1% mortality).

Indications for Surgery

The majority of patients undergoing CABG suffer from chronic stable angina. Symptoms maybe mild, moderate or severe. Patients with severe symptoms should have CABG for symptom relief. In most cases this will result in improved longterm survival (Christian et al, 1985). In the CASS Registry, 29% of patients had mild or moderate symptoms (CASS, 1983a) and has been the subject of greater

controversy primarily because symptoms are usually not disabling enough to warrant immediate CABG. Patients with single vessel disease (CASS, 1983a) had excellent 5 year survival rate regardless of medical or surgical therapy. The medical and surgical mortality rate per year in this group of patients was 1.4% and 0.7% respectively, with 10% of patients with single vessel disease eventually crossing over to surgery during the 5 year period, mainly because of progression of symptoms to severe levels.

Patients with LAD lesions proximal to the first septal perforator form a subgroup whose condition is more critical, because of a lack of perfusion to a larger area of myocardium, with more frequent occurrence of cardiogenic shock in patients who develop anterior infarctions associated with single proximal LAD lesions, than more distal lesions (Brooks et al, 1982). Survival at 5 years in medically treated patients with proximal LAD disease, is lower than those with distal disease (90% versus 98%) (Califf et al, 1983). Delaying CABG in patients with right, circumflex or mid LAD coronary lesions until symptoms become severe, seems reasonable. Survival rates in patients with two vessel disease and mild to moderate symptoms, also showed no significant difference among those randomized to initial medical or surgical therapy in the CASS study, and surgical mortality rates of 1.2% and 1.0% per year respectively. Some special combinations, including proximal LAD lesions, have a different outcome. Patients with three vessel disease had mild to moderate symptoms and seemed to have no survival advantage in the medical or surgical groups (CASS, 1983a). However, crossover to surgical therapy was 38% at 5 years. Again combinations involving LAD or left main stem are indicators for early surgery.

Asymptomatic Patients

The totally asymptomatic patients with known coronary artery disease should not be considered lightly (Cohn et al, 1981; 1983a). Thirty percent to sixty percent of patients suffer acute infarctions as their first sign of coronary artery disease (Gordon and Kannell, 1971) and 25% have no typical chest pain during infarction. Of patients sustaining sudden cardiac death, almost half had no prior angina (Gordon and Kannell, 1971). Asymptomatic patients have similar degrees of ischaemia upon exercise testing, as do symptomatic patients with equal degrees of coronary artery disease (Cohn et al, 1983b). Asymptomatic post myocardial infarction patients, in the CASS study had equal medical and surgical survival rates of 89% at 5 years. In a smaller randomized trial (Norris et al, 1981) of asymptomatic post myocardial infarction patients showed medical survival in patients with ejection fractions less than 0.50 after recovery from myocardial infarction. At 5 years no patient with ejection fraction greater than 0.50 died, but only 65% of those with ejection fractions less than 0.50 were alive. It appears that impaired left ventricular function and additional areas of jeopardised myocardium are good predictors of subsequent mortality and when found, CABG is recommended even if symptoms are absent or minimal (Christan et al, 1985).

Severe Left Ventricular Dysfunction

Those patients with ejection fraction less than 0.35 carry a high medical and surgical risk (Alderman et al, 1983). Operative mortality reported at 6.9%, with a five year post surgical survival of 68% compared with 54% for medically treated patients. Surgery improves ventricular function (Tchernenkov et al, 1985) and surgery is directed towards this end, often with associated procedures such as aneurysm

plication.

Left Main Coronary Artery Stenosis

In patients with left main coronary stenosis treated medically, only 71% were alive at 24 months compared with 93% for surgery (ECSS, 1982), similar result occurred in the CASS study. This group unquestionably are offered better longterm survival by surgery. The syndrome of unstable angina pectoris identifies a subset of patients, who have a different natural history than those with chronic stable pain patterns (Harris et al, 1980). The definition varies, but includes, patients with progressive anginal pain of recent onset that increases with severity, duration or frequency, despite medical therapy; anginal pain at rest who are admitted to a coronary care unit, but show no enzyme changes, or an acceleration of anginal pattern that has previously been stable and related to exertion. Readily identifiable in reversible ischaemia is the characteristic of unstable angina and CABG for unstable angina may provide even better longterm survival compared with CABG for chronic angina (Cobanoglu et al, 1984). In the CASS Registry of unstable angina, the one year mortality rate on those operated was 5% and the 4 year mortality rate was 10% (McCormick et al, 1983). It appears that properly performed CABG can reduce, by almost half, the overall 1 and 5 year mortality rates in this high risk group of patients.

Acute Ischaemic Situations

Because eventual survival relates best to preservation of ventricular function, increasing attention has been given to salvaging the acutely ischaemic myocardium. Irreversible necrosis of myocardium is time related (Pluth, 1983) and varies with the degree of laterals to the ischaemic region (Rogers et al, 1984). Reperfusion must occur in less than 6 hours to allow for functional recovery, which

is usually delayed for about 10 days (Charuzi et al, 1984). Current approaches to this problem include intracoronary thrombolysis, often followed either by angioplasty, if the anatomic situation is favourable, or by CABG if multi-vessel disease is present or if ischaemia persists despite thrombolysis and angioplasty. Immediate CABG during acute infarction can now be done safely, but resources must be well organized to provide this treatment. The concept of immediate CABG applies best to patients in whom infarction begins as part of diagnostic catheterization (Connors et al, 1982) or angioplasty (Murphy et al, 1982) and to those who have been catheterized and are in hospital awaiting surgery when infarction begins.

After infarction is complete patients may develop a variety of well described complications that are best managed operatively. These include post infarction angina with extension of infarction, the development of persistent cardiogenic shock caused by ischaemia of areas distant or adjacent to the infarction, ventricular septal defect, mitral insufficiency as a result of papillary muscle necrosis and free wall ventricular rupture. All of these complications carry a high medical mortality and surgical experience in their management is increasing. Intravenous thrombolytic agents which can be given immediately on arrival in the emergency room, may play a key role in allowing earlier perfusion, while cardiac catheterization resources are being readied (Ganz et al, 1984).

Combined CABG and Valve Replacement

Coronary artery bypass surgery combined with valve replacement surgery has increased as the technique of cardiac surgery and myocardial protection have enabled prolonged myocardial ischaemia (Lytle et al, 1983). The complexity of the patient related variables and the operation related variables presents

multiple issues regarding management, including the indications for revascularization, optimal techniques of intra-operative management, selection of valve prostheses, anticoagulant prophylaxis and the long term efficacy of surgery. Early results looking at aortic or mitral valve replacement with coronary artery bypass surgery suggested that patients undergoing such simultaneous surgery had a poorer survival than those who had only a valve replacement performed (Kay et al, 1984). Reports that were able to compare valve only patients with valve and CABG that had adequate myocardial protection with cardioplegia solutions have suggested that the risk is not increased (Lytle et al, 1983; Cohn et al, 1984).

Although the natural history of patients with aortic valve disease and significant coronary atherosclerosis managed non-surgically is unknown, some data exists on the survival rate of patients with coronary artery and aortic valve disease undergoing only aortic valve replacement. Miller et al (1979) and Copeland et al (1977) described an adverse influence on survival rate after aortic valve replacement that was exerted by uncorrected coronary artery disease. The results were based in part on a higher operative mortality for this subset of patients. Longterm data for patients undergoing simultaneous aortic valve replacement and bypass grafting show at a mean interval of 22.5 months (Richardson et al, 1979) and a 77% survival rate for survivors of surgery. Nunley et al (1983) reported a 69% 5 year survival rate, including death at surgery. Lytle et al (1983) showed an 80% survival rate at 5 years. In the same study they were unable to demonstrate any effect on survival exerted by the type of prosthesis used (ball or disc valve). They concluded that, it can not bc argued that revascularization concomitant with aortic valve replacement might increase operative

risk. Similar findings have also been reported when mitral valve replacement and coronary artery surgery are performed simultaneously (Christakis et al, 1985).

While other studies have shown an increased operative mortality when a coronary artery bypass is also performed, it is felt this effect was due to the poor ventricular function present in the group of patients needing CABG compared with those with mitral valve disease alone (Magovern et al, 1985). There is no unanimity about determinants of perioperative mortality for patients undergoing mitral valve replacement and revascularization. Studies comparing mortality for isolated mitral valve replacement with that for valve replacement and bypass grafting have shown higher operative mortality rates associated with the combined operation (Miller et al, 1978; DiSesa et al, 1982; Czer et al, 1984). However, it appears that the increased peri-operative risk is caused primarily by the coronary artery pathology, not by the coronary bypass grafting performed to treat that pathology (Lytle et al, 1985a). It has been noted that patients undergoing mitral valve replacement and revascularization were at increased risk, compared with patients without coronary disease undergoing isolated mitral valve replacement, but that patients with coronary disease who underwent mitral valve replacement without bypass grafting had the highest risk of any of the three subgroups (Czer et al, 1984; Chaffin and Daggett, 1979).

RE-OPERATION AFTER PRIMARY CORONARY BYPASS SURGERY

Following primary coronary operation, 3% of patients require re-operation in the first 5 years (Cosgrove et al, 1986), due usually to, early graft failure, graft stenosis or incomplete revascularization. Later, patients may experience, progression of atherosclerosis in the

native coronary circulation, late graft failure or a combination of the two, which places areas of myocardium in jeopardy of ischaemia or infarction. A study of the predictors of re-operation for 8,000 Cleveland Clinic patients who underwent primary myocardial revascularization from 1971 through to 1978, was conducted by Cosgrove et al (1986). A total of 2.7% of the original group had undergone re-operation up to 5 years post-operatively, however, after 5 post-operative years the annual incidence of repeat surgery began to increase dramatically and by the 12th post-operative year, approximately 4% per year of the original group were undergoing re-operation. Accumulative percentages of the original group who underwent re-operation were: 2.7%, 11.4%, and 17.3% at 5, 10 and 12 post-operative years respectively.

Patient related descriptors recorded at time of the initial procedure and variables related to the primary operation were tested with univariate, followed by multivariate analyses to identify predictors of re-operation. Significant predictors of the need for re-operation were young age ($p<.0001$), no internal thoracic artery graft ($p<.0001$), incomplete revascularization ($p=.0004$), NYHA functional class 3 or 4, symptoms ($p=.003$), normal ventricular function ($p=.003$), in one or two vessel disease ($p=.005$). Many of these variables are predictive for long survival after primary operation, since the longer the patient lives, the more likely a second operation becomes.

A more cogent index of untoward events after primary surgery, is re-operation free survival. Variables identified by multivariant testing as being associated with a decreased re-operation free survival rate have been listed by Lytle and Loop (1988) as: no internal thoracic artery graft ($p<.0001$), cigarette smoking ($p=.0001$), incomplete revascularization ($p<.0001$), moderate or severe left

ventricular impairment (p=.0001), left ventricular end-diastolic pressure >24mmHg (p=.001), systemic hypertension (p=.002), NYHA functional Class 3/4 (p=.002) advanced age (p=.007), cholesterol >300mg per/dL (p=.008), mild ventricular impairment (p=.008), three vessel left main disease (p=.02), and abnormal ECG (p=.03).

Significant variables exert their influences in a variety of ways. Some descriptors are indicative of unfavourable patient related factors present at primary operation (advanced age, left ventricular impairment, abnormal ECG, 3 vessel or left main stenosis, (Class 3 or 4 symptoms). Others are markers of increased rate of progression of atherosclerosis (smoking, hypertension, hypercholesterolaemia). Incomplete revascularization is an indicator of diffuse coronary disease and may also reflect surgical philosophy. However, the variable that has the strongest influence on decreasing re-operation free survival, is the lack of an internal thoracic artery graft, a variable that is physcian dependant. Studies of coronary bypass graft patency have shown that internal thoracic artery grafts have patency rates superior to those with saphenous vein grafts (Loop et al, 1976; Campeau et al, 1983; Frey et al, 1984; Lytle et al, 1985b; Singh et al, 1983; Tector et al, 1981). Up to 5 post-operative years there is 10%-15% difference in patency rate, with 95% of internal thoracic artery graft patent compared to 80%-85% vein grafts, however, more than 5 years after operation the attrition rate of venous grafts increases such that by 10 post-operative years 60%-65% of vein grafts remain patent and 15%-20% of those are still patent after angiographic evidence of stenosis.

Some late vein graft attrition is undoubtedly caused by progression of atherosclerosis in native coronary vessels, which decreases vein graft outflow and predisposes to subsequent graft

thrombosis. However, in the majority of vein grafts removed at re-operation, vein graft atherosclerosis is evident and in most cases, it is probably these intrinsic changes in the graft that lead to stenosis and subsequent occlusions. Internal thoracic artery grafts appear to be relatively immune to the development of intrinsic changes and the occurrence of internal thoracic artery graft attrition has been documented infrequently up to 10 years after operation.

The rate of occurrence of late vein graft stenoses or occlusion is associated with the presence of coronary risk factors. The susceptibility of saphenous vein graft to atherosclerosis and the association of vein graft failure and risk factors, contrasted with the immunity of the internal thoracic artery graft to artherosclerosis highlighted by comparing the determinants of re-operation free survival patients who had only 1 vein bypass graft, with those patients who had internal thoracic artery graft in addition to whatever vein graft they received. Smoking, hypertension and hypercholesterolaemia all decreased re-operation free survival for patients who had only vein grafts, but had no influence on re-operation free survival for patients who had internal thoracic artery grafts (Cosgrove et al, 1986).

Indications for Re-operation

Examination of the angiographic indications for re-operations in patients undergoing repeat surgery, looks at the same problem from another direction. In a study of the first 1500 patients who underwent re-operation for coronary bypass grafting at the Cleveland Clinic, patients were graded according to whether the angiographic indications for re-operation were: progression of the atherosclerosis in the native coronary circulation, bypass graft failure or both. When the patients were subdivided according to the year in which they

underwent re-operation, it was found that from 1967 through to 1978 only 28% of patients underwent re-operation solely because of graft failure. Furthermore, that represented early graft failure since the mean interval between operations was only 26 months.

Progression of the atherosclerosis in the native circulation alone generated the need for re-operation in 55% of patients and 17% had a combination of graft failure and progression of atherosclerosis. The predominance of progression of atherosclerosis in the native circulation was the cause of re-operation from 1967 through to 1978 occurred, because many patients in the early years of bypass surgery underwent primary operation for treatment of single vessel disease and thus were at risk of progression of atherosclerosis in coronary vessels that had not been grafted at the first procedure. In contrast, only 18% of the patients who underwent repeat surgery during 1982 to 1984 had progression of atherosclerosis in the native circulation alone, 44% had graft failure alone and 38% had both. Graft failure for patients in the later surgical period was usually late, that is the interval between operation was 66 months in the graft failure only group and 91 months in the group with combined indications (Lytle and Loop, 1988; Lytle et al, 1987).

Mortality Rates

The overall in-hospital mortality rates reported by Lytle and Loop (1988) is 3.4% for re-operation cases. In-hospital mortality appeared to be caused by factors related to myocardium in 74% of cases. Thirteen patients died intra-operatively, 16 died post-operatively of myocardial infarction, 7 died of apparent myocardial failure without documentation of myocardial infarction, 1 died suddenly and 1 died of ventricular arrythmias. Nine deaths were due to stroke and complications of mediastinotomy contributed to 3

deaths. Other investigators have also documented an increased risk associated with coronary re-operations. For 958 patients undergoing operations from 1970 to 1984, Hall and associates (1986) documented an early mortality of 88 (9.2%) compared with a 2.8% mortality for primary revascularization operations during the same time period and further noted that the cause of early mortality was cardiac in 80% of cases.

In a review of data from the CASS study, Foster and associates (1984a) found re-operation carried an increased risk of in hospital mortality compared with primary surgery (5.3% versus 3.1%, $p<0.05$). A trend towards increased risk of peri-operative myocardial infarction for their 283 re-operation patients (6.4% versus 5.8% for primary surgery) was not statistically significant.

Long Term Results of Coronary Re-operations

In general the long term results of coronary re-operations are not as good as the results of primary procedures. Again in Lytle's review (Lytle and Loop, 1988) follow-up of the 1,449 in hospital survivors of the 15,000 patient series at a mean interval of 54 months and a range of 13 to 171 months, documented late survival of 90% and 75%, at 5 and 10 post-operative years respectively. Mean variant testing identified age, hypertension, and pre-operative left ventricular function as variables with significant independent association with late mortality. The influences of left ventricular function and hypertension become particularly evident more than five years after operation. Examination of the extremes of variables show that the 3 year survival of patients over 70 years of age was 85% and the 5 year survival of patients with severely impaired left ventricular function was 82% indicating that even for these high risk categories re-operation was worthwhile.

Left main coronary artery stenosis which had a profound effect on earlier risk and the number of coronary vessels with significant stenoses, could not be demonstrated with multivariate testing to influence late survival. The use of a single internal thoracic artery graft has been demonstrated to positively affect survival after primary operations for bypass grafting, but as yet has not had a demonstrable effect on late survival after re-operation. Follow-up of the patients who received bilateral internal thoracic artery grafts at re-operation, have so far only documented one late death, although much more extensive follow-up of this promising group of patients is needed.

Lytle (1988) found at 5 post operative years, approximately half of the patients were completely asymptomatic. This was not as good a result as for patients after primary surgery, 65% to 70% of whom were asymptomatic after five post operative years (Loop et al, 1979), but few patients in Lytle's re-operative series were severely symptomatic. Schaff (1983) also noted that a relatively high proportion of the re-operative patients had mild angina five years after re-operation, but that severe angina was uncommon.

2.3 METHODS OF ASSESSMENT AND THEIR LIMITATIONS

Health surveys are conducted all over the world every year using self-administered questionnaires, telephone interviews and personal interviews, yet there are few published comparisons of these methods. Further, data quality is often overlooked (Gordis, 1979) even when survey modes are compared, since the choice of mode is often dictated by other factors such as cost, time, questionnaire content and required response rates, and is often heavily influenced by the study population itself. In three published mode comparisons (Hochstim, 1967; Locander et al, 1976; Siemiatychi, 1979) which considered data quality reports of mode differences varied. Hochstim found that the 3 strategies of data collection were interchangeable when compared according to response rates, comparability of findings, and validity of responses, only costs varied.

Locander et al (1976) compared the three modes in asking questions of groups of Chicago residents about voting, library card ownership, bankruptcy and drunken driving and measured response distortion (proportion of responses known to be false from objective records) and found no mode differences. Siemiatychi 1979 found no differences between mail and telephone modes in relation to item omission (approximately 5% each), but so called sensitive questions (family income and medicare number) were more readily answered in the mail, than in telephone or home interview (face to face) mode. Mail mode showed less reporting of physcian consultations than telephone mode and no more than the face to face mode. A more recent study by O'Toole et al (1986), does not fully support the suggestion that data quality is affected by the mode of survey conducted. They found a low rate of response for their mail mode, however the poor response was confined mainly to questions about

enviromental exposure to hazardous chemicals or activities, but good reliability with medical questions and for these type of questions no mode differences could be found between telephone, personal interview and mail survey. Indeed, medical conditions which required a medical diagnosis for subjects to be able to report them, were more reliably answered, than conditions which required a broad description or lay terms.

Validity of answers to medical questions varied across modes and types of questions. Under-reporting of medical conditions was highest in the mail mode and was lowest for conditions requiring a diagnosis. Over reporting was lowest in the mail mode and highest for conditions requiring a diagnostic opinion. It is generally accepted that the occurrence of false negative responses constitutes a greater health survey hazard than false positive responses (Meltzer and Hochstim, 1970; Madow, 1973; Cannell et al, 1977). Indeed false positive responses are often ignored in published survey reports, even those in which responses are validated.

In a study by O'Toole et al (1986), a number of the false negative findings probably relate to the group being questioned, which included ex-servicemen and medical questions regarding the occurrence of venereal disease during their service history. It is known however, that the validity of reporting of medical events (hospitalizations, clinical physcians visits, chronic or acute conditions) varies with the time elapse between the event and when questions are asked (Cannell et al, 1977) with the impact or seriousness of the event and with the sensitivity of the questions asked (Mork, 1970). Issues regarding cardiac health and myocardial events tend to have a high impact on patients with little or no embarrassment and although the study has not been done, probably are reliably recalled and

reported.

Survey costs are incurred in four main areas: interviewing, mailing, coding and office. O'Toole et al (1986), measured the relevant contribution to costs of the three interview modes and found telephone and home interviewing to cost approximately 100% more than the mail mode. Much of this difference can probably be explained by the fact that the post office often has access to current addresses and is able to redirect mail appropriately, a cost borne by the postal service rather than the survey group.

Whatever method of follow-up is selected for patients following coronary surgery, it must by necessity represent a compromise between the available funds to follow-up such patients and a wish for precise scientific data. A blend of mail, telephone and face to face interviews offers the most realistic and cost-effective method of acquiring this information.

SECTION III

METHODS

3.1 INTRODUCTION

The data described in this study represents the data collected prospectively at the time of surgery for all patients undergoing surgery in the Cardiothoracic Surgical Unit of the Royal Adelaide Hospital over the preceding 25 years. This unit provides cardiothoracic surgical services to the population of South Australia and the Northern Territory with some patients also coming from Tasmania. The total population base is about 1.5 million persons. Further questionnaires were sent to all patients for whom follow-up data was sought. The results of the combined data base of pre-operative and post-operative information and long term follow-up was used to answer the questions posed in the aims of this thesis.

3.2 PRE-OPERATIVE AND POST-OPERATIVE QUESTIONNAIRE

This questionnaire was already in existence in the Cardiothoracic Surgical Unit and had been used for almost twenty years. Although much of the information it collected regarding pre-operative and post-operative variables remained essential information, a number of new and important variables were not included, as they could not be foreseen at the time of the original questionnaire design. For this reason, a new modified proforma was designed to incorporate the vital elements of the old form (e.g. age, sex, time on bypass etc.) and important new variables (e.g. model and design of prosthetic valve, post-operative atrial fibrillation, previous angioplasty etc.). Two

forms were designed, one suitable for all patients undergoing cardiac surgery, a "Cardiac Form" (Appendix I) and if a patient was also having coronary surgery a "Coronary Form" (Appendix II). Data from these forms was stored on a VAX computer in The University of Adelaide and retrieved by use of SIR (Scientific Information Retrieval) data base manager. All data from these forms was supplied by the anaesthetist and senior registrars at the time of the hospital admission and checked by a research secretary prior to coding. All data entry was performed by experienced key punch operators of the Computing Centre in the University of Adelaide and checked, by being doubly entered and cross verified, before being finally transferred onto the Data File.

3.3 FOLLOW-UP QUESTIONNAIRES

The period during which follow-up questionnaires were sent to patients spanned more than eight years. The initial design of the questionnaire was to provide a simple series of questions that would produce reproducible reliable results. It was found that both full response and fixed response formats were necessary. Initially a pilot questionnaire using the style of form chosen for isolated coronary artery bypass patients was sent to 100 patients, their responses were studied and slight modifications made to the original layout (Appendix III). Although the initial format did not permit free response a contact number was available for clarification of any questions and this was used by 2% of respondents.

Subsequent forms used for other surveys included a mixture of free responses (e.g. details of haemorrhage requiring hospitalization) and fixed responses. Free responses were subsequently coded with details such as date and nature of haemorrhage being catergorized

and checked with hospital records that were available. In the light of experienced gained with the coronary artery follow-up form, subsequent follow-up studies were confined to only two sides of A4 paper, as many of the patients were old and more questions proved too difficult. Greek and Italian translations were also provided when required.

Each form was sent with a covering letter from the Head of the Cardiothoracic Surgical Unit, explaining the purpose of the questions and contact personnel involved, with appropriate telephone numbers and a reply paid envelope was enclosed. An example is provided in Appendix IV. After approximately four weeks, if no reply had been received another questionnaire and covering letter was sent. If no reply subsequently appeared, then the patient or local doctor was contacted by telephone. If following these attempts no contact had been made, a check was made with the South Australian Death Register, Motor Vehicles Registration Department or Electoral Commission.

Patients known to be alive, but for whom no response could be obtained (e.g. overseas, senile or seen by the local doctor in the last month, but now untraceable) were included in follow-up as alive, but no further data included. Only questionnaires answered by the patient were included, no third party interpretation was permitted. The actual questionnaires sent for the coronary bypass follow-up study are seen in Appendix III; for the Valve Follow-Up, Appendix V; the Diabetic Patients Following Coronary Artery Bypass Surgery, Appendix VI and Patients Following Coronary Angioplasty, Appendix VII.

3.4 DEATHS

Patients who had died during hospitalization or subsequently, had details of their cause of death noted. This was usually based on the cause shown on the death certificate and only rarely associated with autopsy. While reported to be imperfect in 29% of cases, the recorded cause of death does provide some indication of the cause of death (Kircher et al, 1985). Date of death was accurately obtained for all cases in order to conduct precise actuarial analysis. No attempt was made to assess retrospectively the symptoms in those patients whom were found to be deceased. Symptomatic outcome represented in these studies relates only to those patients alive at time of follow-up.

3.5 STATISTICAL ANALYSIS

The statistical package BMDP-81 was used to analyze data utilizing programmes from the life table and survival functions within the BMDP-81 series. Survival analysis included a 'Generalized Savage' (Mantel-Cox) and 'Generalized Wilcoxin' (Breslow) both of which needed to obtain a $p< 0.05$ for significance to be claimed. The quoted significance levels were taken from the 'Generalized Savage' analysis. For the assessment of differences between groups a Pearson chi-square test was performed. All data was analyzed in close co-operation with the Department of Statistics, University of Adelaide.

SECTION IV

VALVE REPLACEMENT

4.1 AORTIC VALVE REPLACEMENT

Introduction

Standardized prospective pre-operative and peri-operative data was kept on all patients during the period of review (Appendix I, II). A follow-up questionnaire was sent to all patients whom had undergone isolated aortic valve replacements within the Cardiothoracic Surgical Unit, Royal Adelaide Hospital from 1963, until 1st January, 1983. The follow-up commenced mid 1983, so all patients had at least six months since their valve surgery.

Patient Group

Complete survival follow-up was obtained on 592 patients (98.5%) of the 601 patients who underwent surgery (77% Male, 23% Female). Figure 1 shows the age distribution of the patient group undergoing surgery.

Valve Inserted

Table 1 shows the valve types used during the period of review. The Starr-Edwards group was the predominant valve type used and was usually a non cloth covered caged ball valve, with the Bjork-Shiley valve group being made up of predominantly equal numbers of the monstrut and concavo-convex valves. Very few Hancock or St. Jude valves were used during this period.

Hospital Mortality

Figure 2 shows the hospital mortality for 3 year cohorts of patients during the period of follow-up with the last 3 years showing

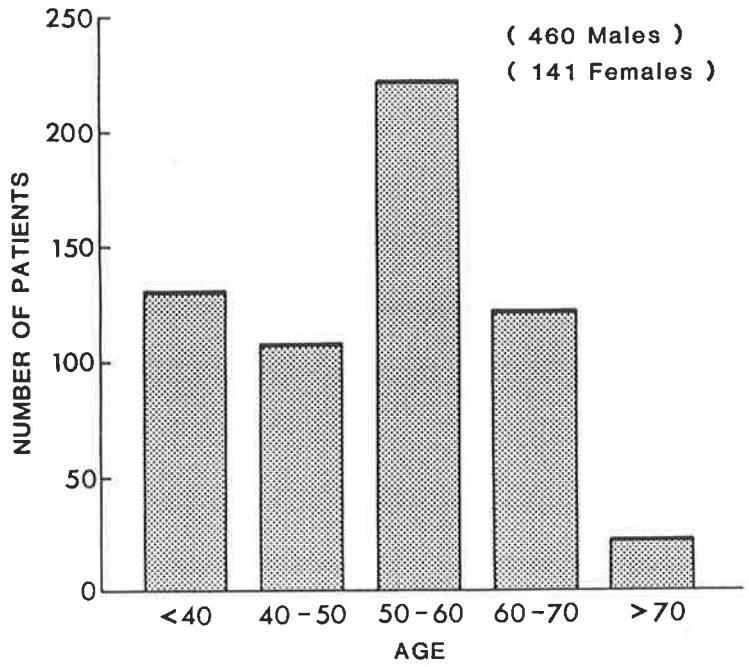

Figure 1: Age distribution of patients undergoing aortic valve surgery.

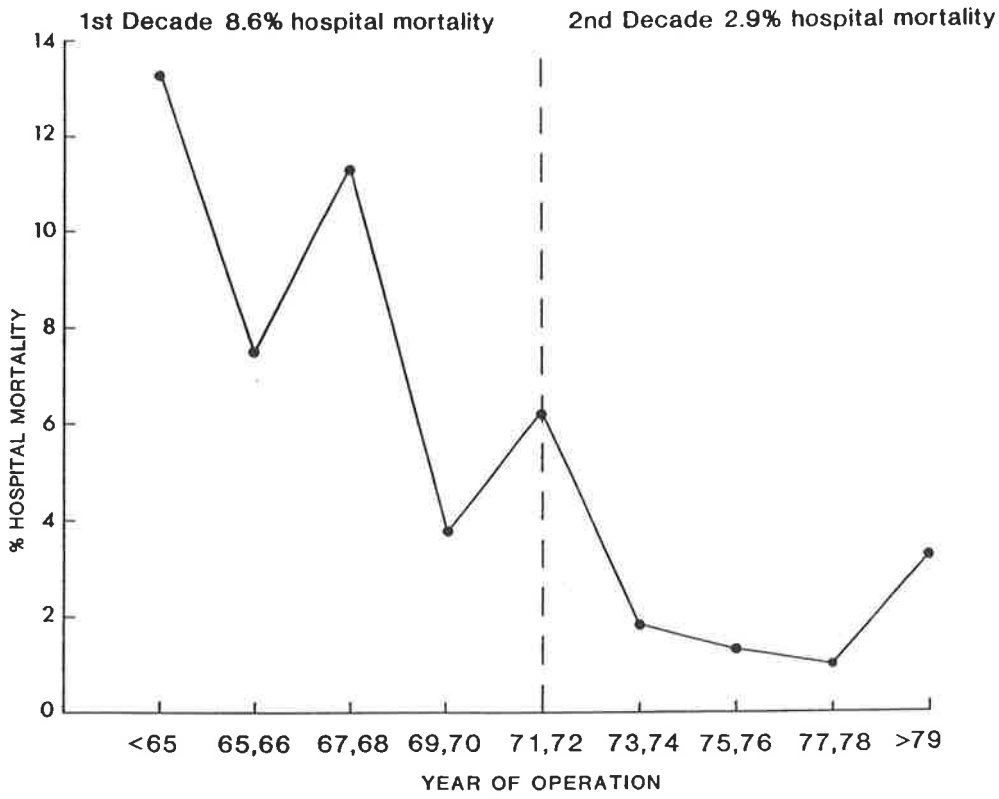

Figure 2: Hospital mortality in 2 year cohorts for patients undergoing aortic valve replacement.

TABLE 1

VALVE TYPE

Used In Isolated Aortic Valve Replacements

(601 Patients)

65% Starr-Edwards.

33% Bjork-Shiley.

1% Hancock.

1% St. Jude.

TABLE 2

CAUSES OF HOSPITAL DEATH

Aortic Valve Replacements.

(28 patients, 4.8%)

Cause of Death	No. of Patients
Other Cardiac	17
Non Cardiac	4
Cerebral	2
Renal	2
Infection	1
Post-operative haemorrhage	1
Respiratory Complications	1

a hospital mortality of less than 3%. The figure illustrates the dramatic fall from the first decade hospital mortality of 8.6%, to the second decade where the mean hospital mortality was 2.9%. Table 2 shows the cause of hospital death in 28 patients who died during their period of hospitalization.

Longterm Survival

The actuarial survival for the total aortic valve group compared with an age and sex match population is shown in Figure 3. The cause of death shown on death certificates is shown in Table 3. Longterm survival is significantly influenced by pre-existing aortic pathology ($p<.05$) (Figure 4), pre-operative dyspnoea ($p<.05$) (Figure 5) and cardiac rhythm ($p<.05$) (Figure 6). When crude survival over the period of review is analyzed by valve type inserted, the overall figure showed a significant difference ($p<.02$) in favour of the Bjork-Shiley valves (Figure 7). However, in Figure 8 when factors such as the time and learning curve associated with aortic valve surgery were removed by considering the last decade only (the period when Bjork-Shiley was used, ABC is the monostrut and ABP is the welded strut), no such difference was present.

Re-operation

Table 4 shows the post-operatively determined cause of re-operation in the total valve group. The main cause of re-operation in the Starr-Edwards and Bjork-Shiley group was endocarditis. Of particular interest, was the one ball variance that was found in the Starr-Edwards group. In all, only 8 Hancock valves have been inserted in isolation at the aortic position within the Cardiothoracic Surgical Unit, yet six of these have required replacement.

Complications

All patients with mechanical valves were placed on courses of

TABLE 3

CAUSE OF DEATH IN AORTIC VALVE PATIENTS (209 Patients)

Cardiac	61%
C.V.A.	13%
Hospital	7%
Unknown or Other	6%
Cancer	5%
Endocarditis	4%
Haemorrhage	3%
Non-Cardiac Thrombosis	1%

TABLE 4

CAUSE OF RE-OPERATION IN ISOLATED AORTIC VALVE PATIENTS

(601 Patients)

	No. of Patients
Starr-Edwards	
Ball Variance	1
Paravalvular leak	5
Endocarditis	9
Aortic aneurysm	1
Bjork-Shiley	
Paravalvular leak	1
Endocarditis	1
Hancock	
Endocarditis	4
Leaflet failure	2

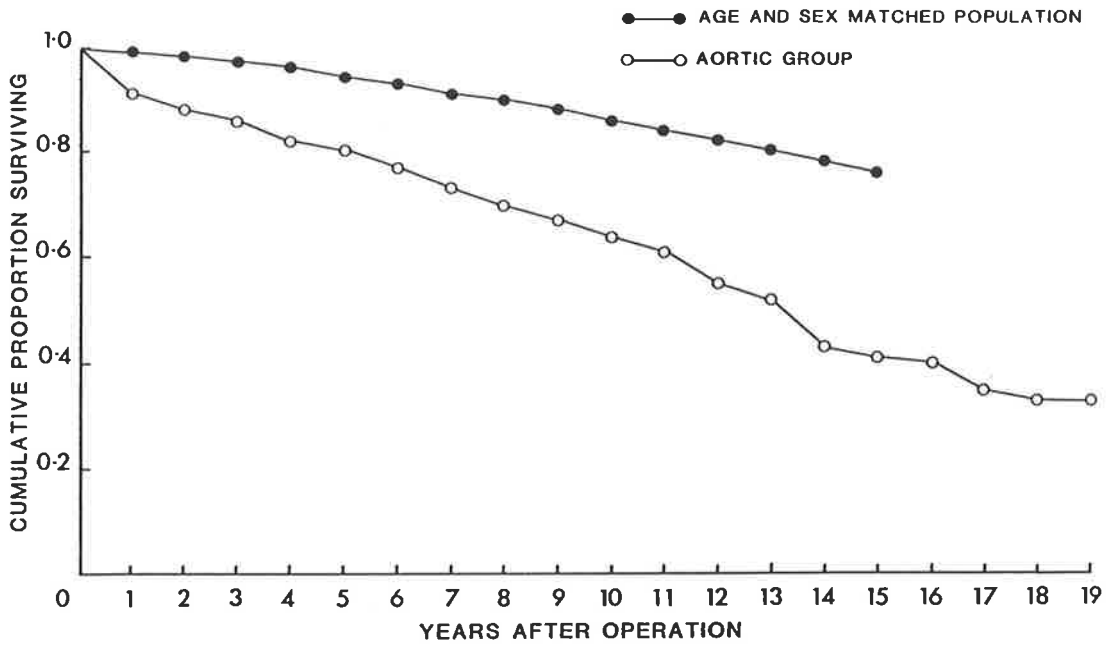

Figure 3: Survival of patients following aortic valve replacement compared with age and sex matched population.

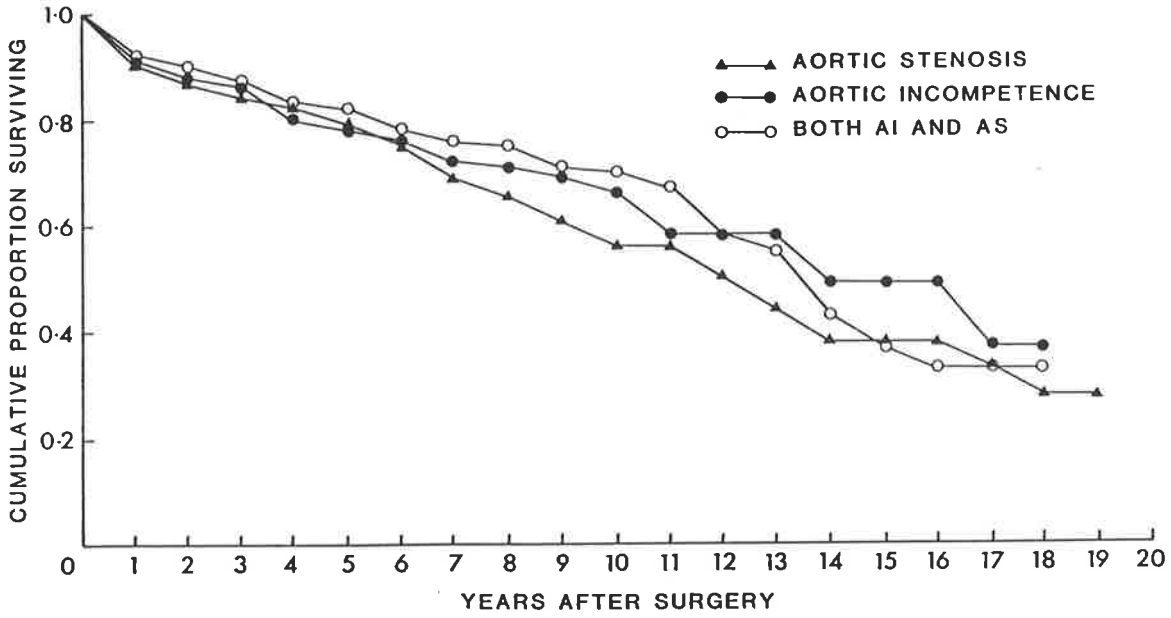

Figure 4: Pre-existing aortic pathology and longterm survival following aortic valve replacement.

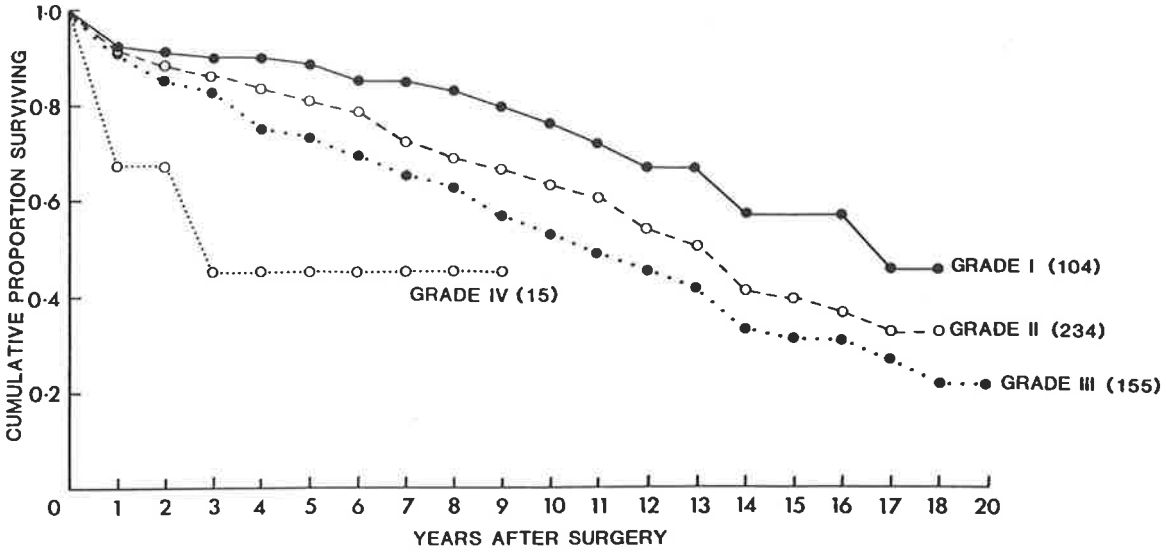

Figure 5: Pre-operative dyspnoea and longterm survival following aortic valve replacement.

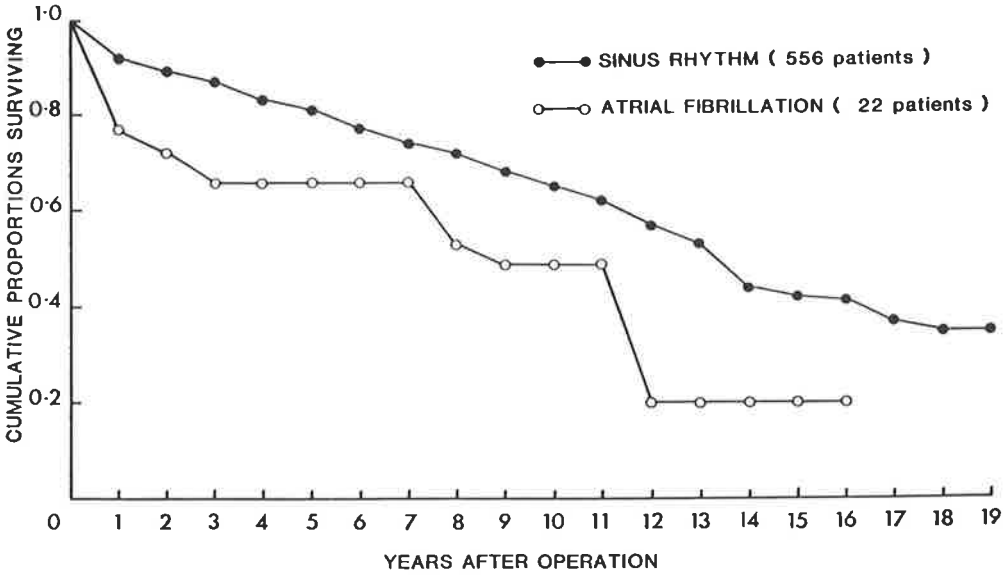

Figure 6: Cardiac rhythm and longterm survival following aortic valve replacement.

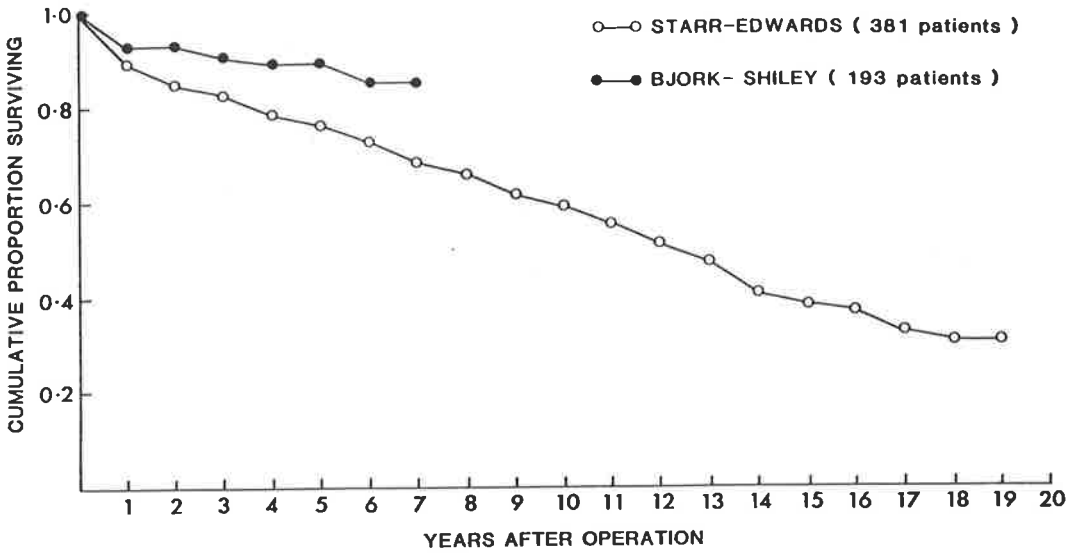

Figure 7: Survival for Starr-Edwards and Bjork-Shiley aortic valve replacements.

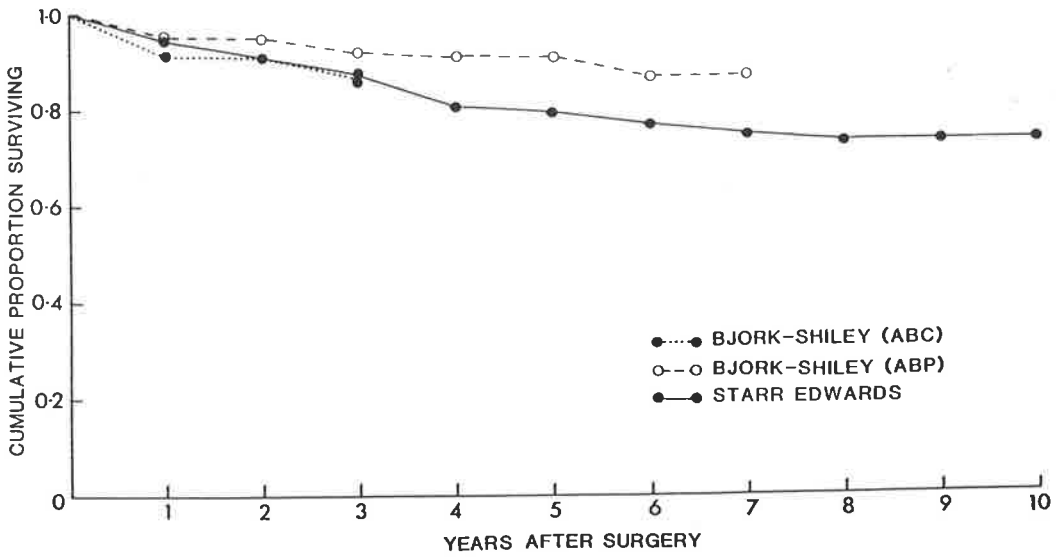

Figure 8: Survival for Starr-Edwards and Bjork-Shiley aortic valve replacements during last decade.

anticoagulation. Major haemorrhagic complications requiring hospitalization in survivors (376 patients) were assessed. In all, 33 patients required hospitalization and the cause of these hospitalizations are shown in Table 5, the dominant cause being gastro-intestinal bleeding. Haemorrhagic complications over the period of review occurred at a constant rate of 1.0% per annum and this was irrespective of the prosthesis inserted. Major embolic complications occurring in 32 patients (that is those requiring hospitalization in the 376 surviving patients), are shown in Table 6. Within this group the major cause of hospitalization was cerebral vascular accidents, which accounts for 42% of admissions and 33% of admissions being due to transient ischaemic attacks.

The overall rate of thromboembolic events was 1.1% per annum. When the rate of embolic events occurring over the period of review for the patients was assessed, a significant difference was found between the Bjork-Shiley group and the Starr-Edwards group, after allowing for time variables ($p<.01$) (Figure 9). The groups were not significantly different for age, sex and valve pathology at the time of replacement. "Other complications" were described by 44 patients (14%) and are listed in Table 7.

Discussion

Despite the continuously changing options available in prosthetic valves, the Cardiothoracic Surgical Unit of the Royal Adelaide Hospital, has tended to follow a conservative approach, preferring to use mechanical valves of the Starr-Edwards and Bjork-Shiley type. While modifications in these valves has occurred over the 20 year period of review, the basic design of both valves has remained relatively unaltered. In the comparison of the two valve types used, when no account of contemperaneous valve insertion was made it , showed the

TABLE 5

AORTIC VALVE REPLACEMENT PATIENTS REQUIRING HOSPITALIZATION FOR HAEMORRHAGIC COMPLICATIONS (33 Patients)

Causes	No. Patients.
Gastro-intestinal	15
Genitourinary	6
Upper Respiratory	5
Pulmonary	2
Stabilization	1
Cerebral	1
Trauma	1
Visual	1
Other	1

TABLE 6

AORTIC VALVE REPLACEMENT PATIENTS REQUIRING HOSPITALIZATION FOR EMBOLIC COMPLICATIONS

(32 Patients)

Causes	No. of Patients
C.V.A.	13
Transient-ischaemic Attack	11
Myocardial Infarction	4
Other	2
Renal	1
Visual	1

TABLE 7

OTHER COMPLICATIONS OCCURRING IN AORTIC VALVE REPLACEMENT PATIENTS REQUIRING HOSPITALIZATION

(44 patients)

Type of Complication	No. of Patients.
Arrthymia	18
Infection	12
Anaemia	10
Other	3
Congestive Cardiac Failure	1

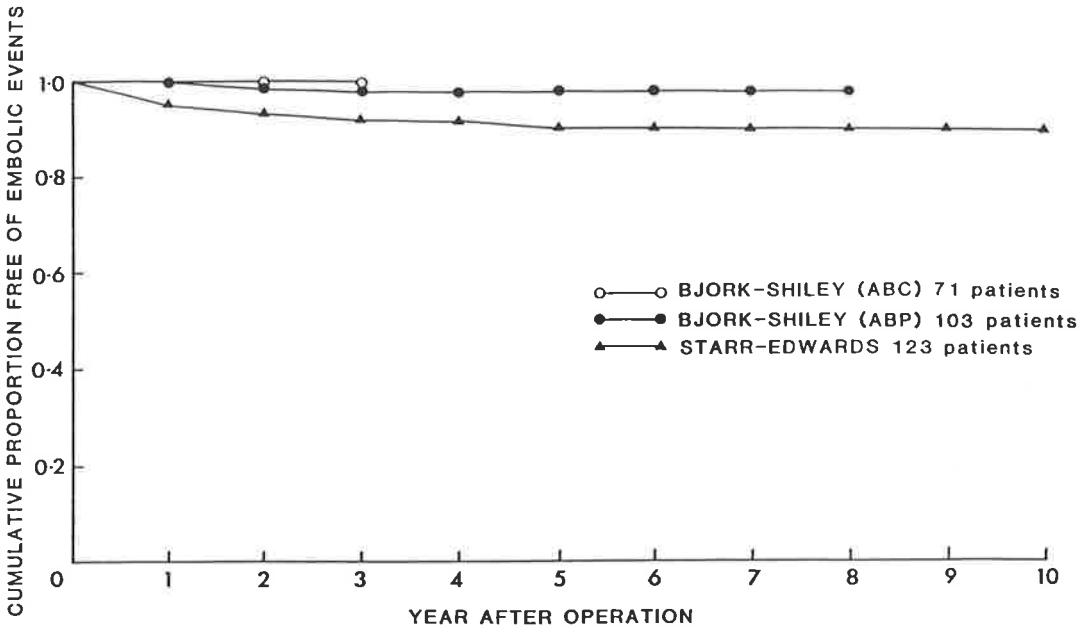

Figure 9: Embolic events occurring in patients following insertion of Bjork-Shiley and Starr-Edwards aortic valves.

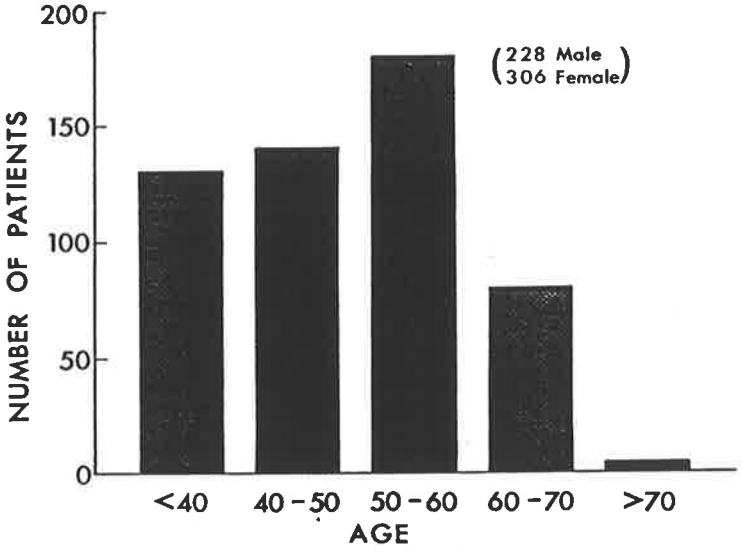

Figure 10: Age distribution for patients undergoing mitral valve replacement.

Bjork-Shiley to be a superior valve for longterm survival. However, when insertion of a valve in the same decade was considered, the difference was not significant. Of interest, was the improvement in the hospital mortality associated with aortic valve replacement, falling from 8.6% in the first decade, to 2.9% in the second decade and this has been inspite of the fact that older and less fit patients have undergone surgery in the second decade. The actuarial survival shown for this group of patients highlights the serious prognostic outcome for patients undergoing aortic replacement when compared with an age, and sex matched population.

Death certificates, while a poor substitute for autopsy data, showed that 4% of all deaths are contributed to by endocarditis, and emphasizes the seriousness of this complication in prosthetic valve replacement, particularly as it was the single greatest cause of re-operation in this group of patients. The study also illustrates that a poor longterm outcome is associated with patients who have a worse degree of breathlessness, are suffering from aortic stenosis, and in whom atrial fibrillation is present. Why patients with aortic stenosis and incompetence should have better survival than those with stenosis alone is not clear, but is probably due to the time at which they present, which with dual pathology may well be earlier than the stenosis alone group.

These risk factors need to be considered when advising patients for surgery. Assessment of post-operative complications, in particular haemorrhage and embolic complications, has been confined to those surviving. This avoids the problems of collecting retrospective data on deceased patients. By choosing major complications requiring hospitalization, it is possible to minimise problems of patient recollection of the major complications, or the time at which it

occurred. Hospitalization gives not only a documented record of complications but also an accurate timing, permitting annual rates to be determined. In this analysis, only the occurrence of the first haemorrhagic or first embolic complication has been included and at that point, the patients are removed from further analysis of subsequent complications of a similar nature. However, very few patients required subsequent admissions. By using this technique it was not possible to show any difference in the haemorrhagic complications associated with the two valves, however a significant difference did occur between the Bjork-Shiley group and the Starr-Edwards group for embolic complications. This has been reported by others (Murphy et al, 1983; Dale et al, 1980; Aris et al, 1974; Miller et al, 1983a) and may represent a significant difference between the valve types.

4.2 MITRAL VALVE REPLACEMENT

Prospective pre-operative and peri-operative data was kept on all patients. (Appendix I and II). A follow-up questionnaire (Appendix V) was sent to all patients whom had undergone an isolated mitral valve replacement from commencement of mitral valve surgery at the Cardiothoracic Surgical Unit, of the Royal Adelaide Hospital in 1963, until the 1st January, 1983. The follow-up commenced mid 1983, so all patients had at least six months of time lapsed since initial surgery.

Follow-up

Complete survival follow-up was obtained on 525 patients (98.3%) of the 534 patients who underwent surgery (median age 50 years, 43% Males, 57% Females). Figure 10 shows the age distribution of patients at time of mitral valve replacement.

Valve Inserted

The Starr-Edwards group comprised predominantly of non-cloth covered ball valve (314 patients) with 44 patients receiving a cloth covered ball valve and 176 patients a "track" valve (Table 8). The performance of these 3 groups of Starr-Edwards valves were initially considered individually, but as no difference was found between them for either pre-operative risk factors, complications or survival, they have been presented as one group.

Hospital Mortality

Figure 11 shows the hospital mortality for three year cohorts of patients during the period of review, with the last 3 years showing a hospital mortality of less than 2% (The period 1971-1973 did not have any deaths associated with it).

Longterm Survival

The actuarial survival for the Starr-Edwards group is shown in

TABLE 8

VALVE TYPE USED IN

ISOLATED MITRAL VALVE REPLACEMENTS

(534 Patients)

Starr-Edwards	94%
Hancock	3%
Fascia Lata	1.3%
Bjork-Shiley	0.8%
Carpentier-Edwards	0.4%
St. Jude	0.4%
Other	0.2%

TABLE 9

CAUSE OF DEATH IN

MITRAL VALVE REPLACEMENT PATIENTS

(257 Patients)

Cause	No. of Patients.
Cardiac	55%
C.V.A.	15%
Hospital	7%
Unknown or Other	7%
Endocarditis	6%
Cancer	5%
Haemorrhage	4%
Non-Cardiac Thrombosis	1%

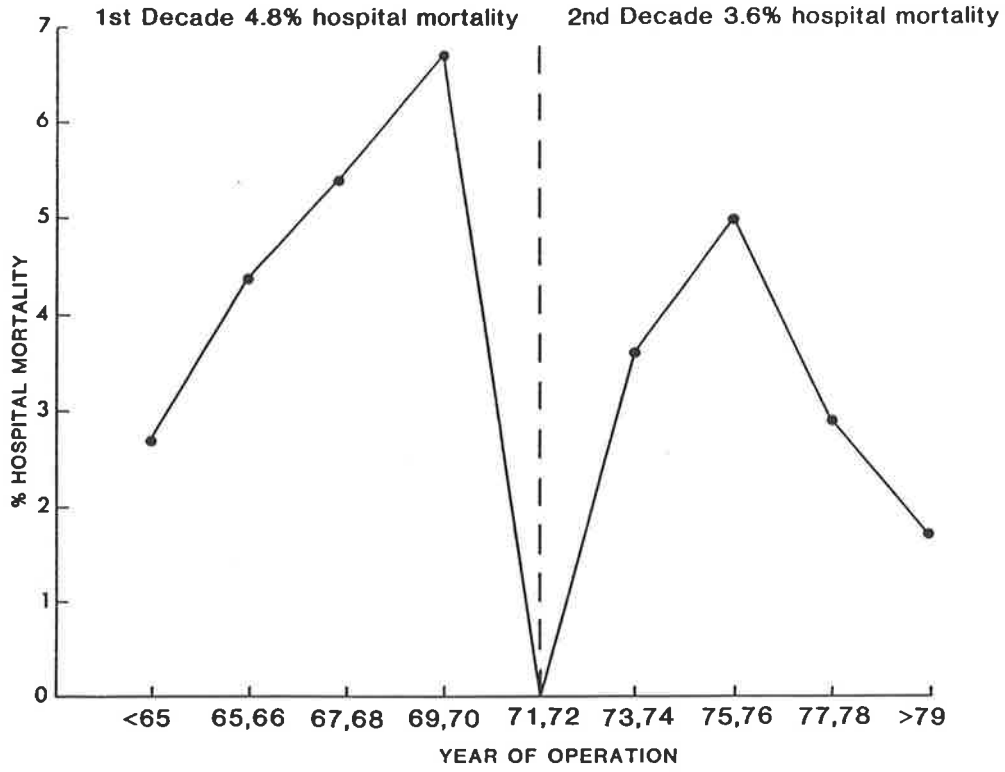

Figure 11: Hospital mortality in 2 year cohorts for mitral valve replacement shown as a percentage of total operative group.

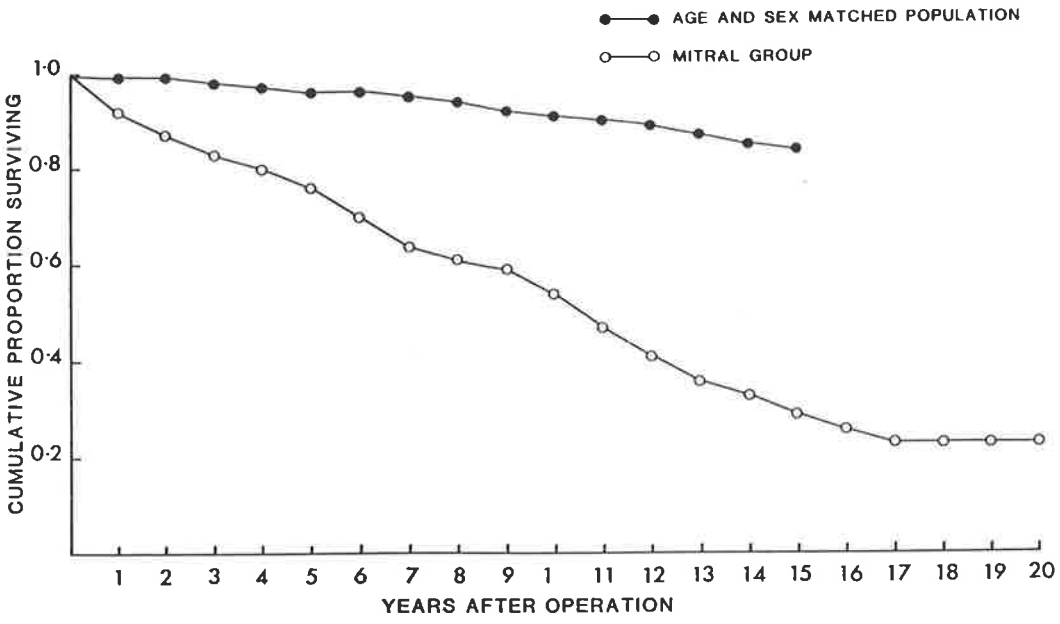

Figure 12: Survival for mitral valve replacement patients compared with an age and sex matched population.

Figure 12 with an age and sex matched population. The five year actuarial survival for the patient group is 77%, compared with the age matched group of the Australian population of 94% and the ten year figures of 54% for patients undergoing mitral valve replacement, compares with 86% in the general population. The death certificates of the deceased patients attributed cardiac death as the dominant cause of death (Table 9), with endocarditis accounting for 6% of all deaths. Survival was significantly influenced by pre-existing mitral pathology ($p<.05$) (Figure 13), pre-operative dyspnoea ($p<.05$) (Figure 14) and cardiac rhythm ($p<.0001$) (Figure 15). When survival over the period of review is analyzed by valve type inserted, the overall figure showed a significant difference ($p<.02$) in favour of the "track" valve. However, when the factors such as time and learning curve associated with the valves surgery were removed by considering the last decade only (the only period when track valves were in use), no such difference was present (Figure 16, 17).

Re-operation

Table 10 illustrates the post-operatively determined cause of re-operation in the total valve group. One unknown patient in the Starr-Edwards group, was a patient who underwent replacement of the valve overseas and details were not available from her or the hospital concerned. Six of the eight Hancock tissue valves required replacement.

Symptoms

The change between pre-operative dyspnoea and post-operative dyspnoea in surviving patients is shown in Figure 18 ($p<.0001$).

Complications

All patients with mechanical valves inserted received anticoagulation. Major haemorrhagic complications requiring

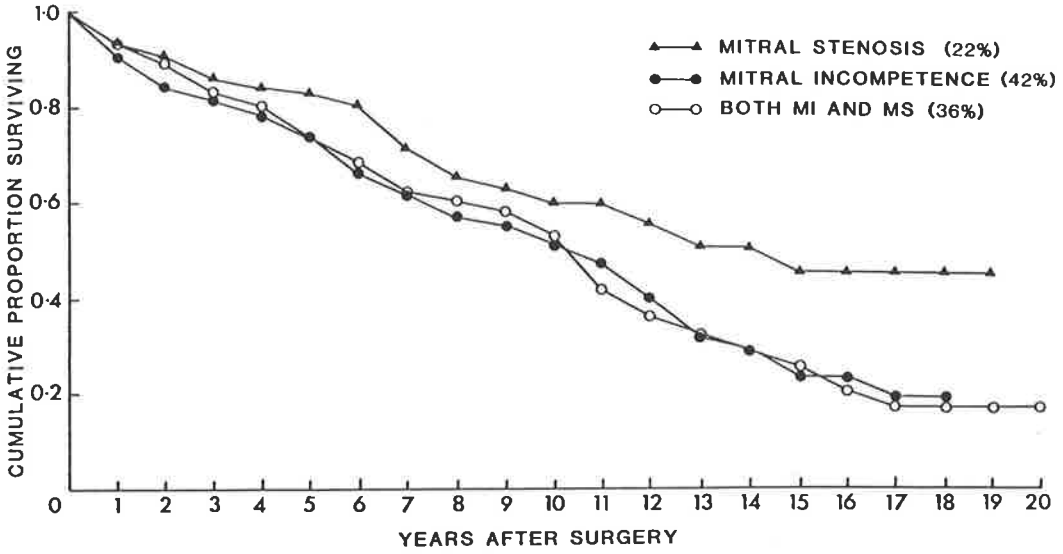

Figure 13: Pre-existing mitral valve pathology and longterm survival.

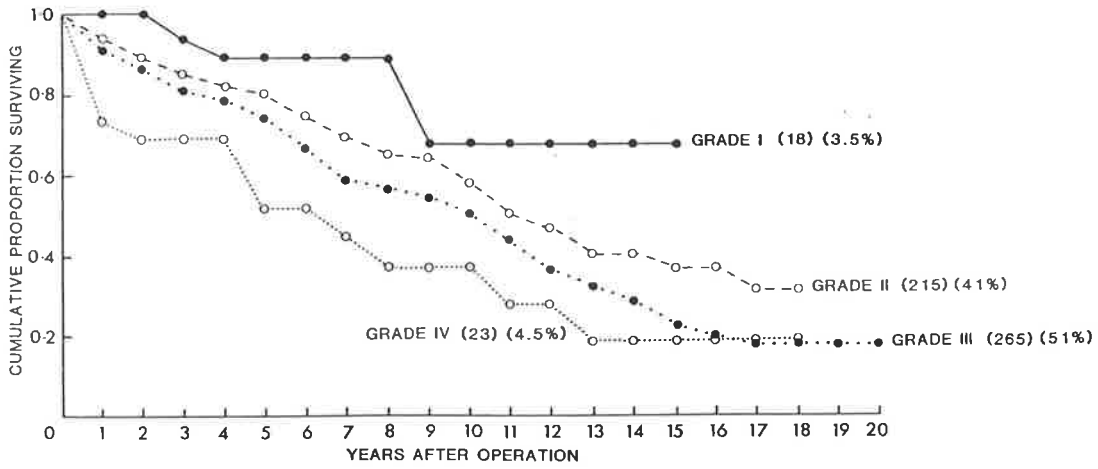

Figure 14: Pre-operative dysponea in mitral valve replacement patients and long term survival.

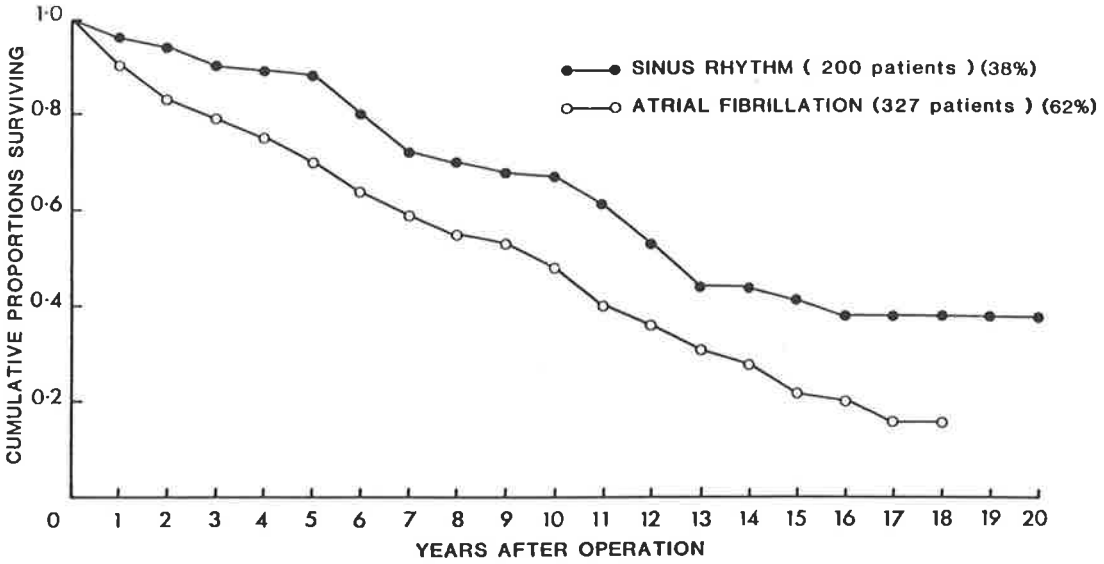

Figure 15: Pre-existing cardiac rhythm and longterm survival in mitral valve replacement patients.

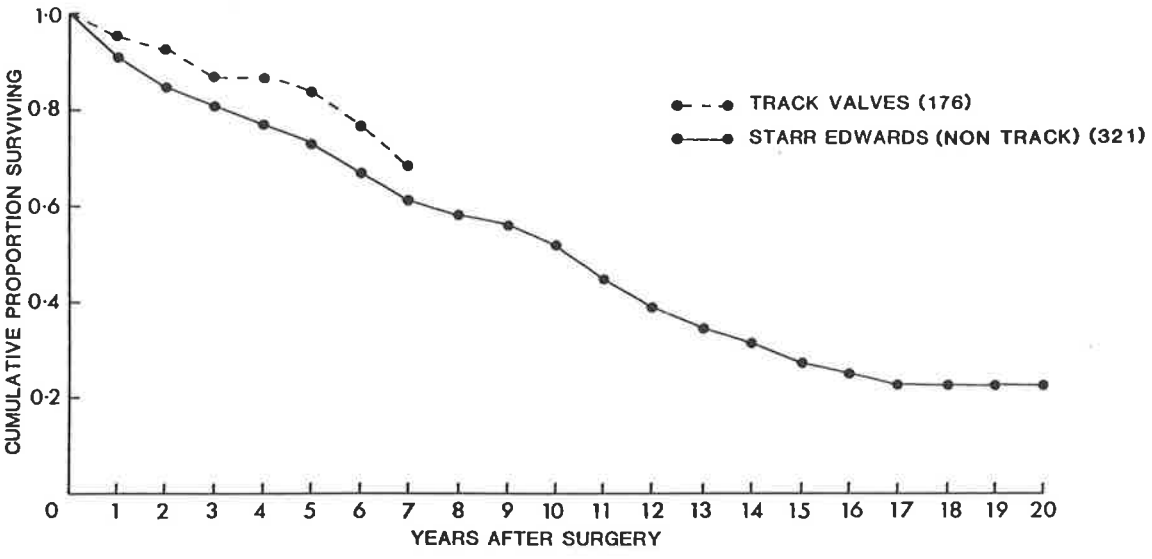

Figure 16: Survival of "track" versus "non track" mitral valve replacement over total period of review.

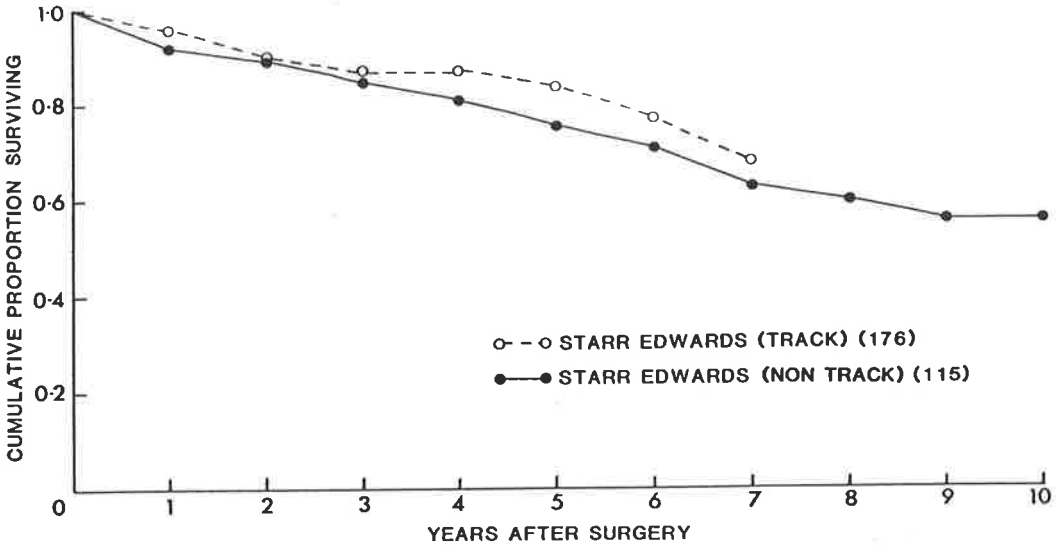

Figure 17: Survival of "track" versus "non track" mitral valve replacement performed only during the last decade.

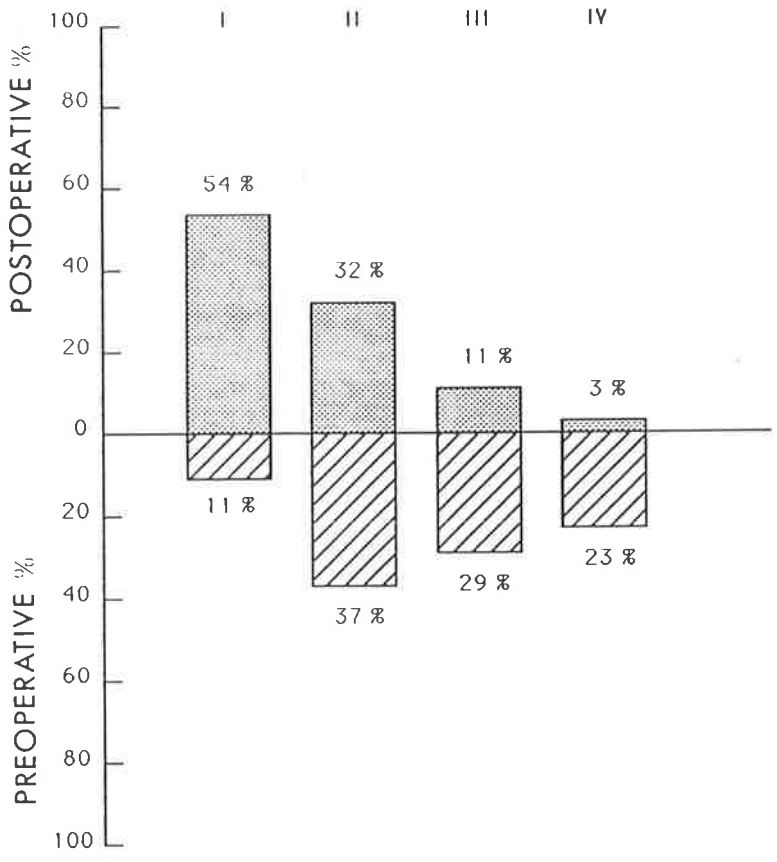

Figure 18: Pre- and post-operative dysponea following mitral valve replacement.

TABLE 10

CAUSES OF RE-OPERATION IN ISOLATED MITRAL VALVE PATIENTS

(534 Patients)

Valve Type	No. of Patients
Fascia Lata	
Leaflet Failure	3
Paravalvular leak	1
Starr-Edwards	
Endocarditis	4
Paravalvulvar leak	1
Unknown	1
Hancock	
Leaflet Failure	1
Bjork-Shiley	
Small Valve for child	2
Shumway Ring	
Leaflet Failure	1

hospitalization in survivors (283 patients) occurred at a rate during the period of review of 1.2% per annum. Haemorrhagic complications requiring hospitalization in the 31 patients involved is shown on Table 11.

Major embolic complications (requiring hospitalization) in survivors (283 patients) is shown in Table 12. All myocardial infarctions were included in this group as were cerebral vascular accidents (unless specifically diagnosed as haemorrhagic). Again the rate of major embolic complications remained constant at 1.4% per annum. Other complications were described by 61 patients (22%) and are listed in Table 13. All major complications observed failed to show any significant difference with respect to type of valve inserted, or the sex of the patient.

TABLE 11

HAEMORRHAGIC COMPLICATIONS REQUIRING HOSPITALIZATION IN MITRAL VALVE REPLACEMENT PATIENTS

(31 patients)

Causes	No. of Patients.
Gastro-intestinal	9
Trauma	5
Genitourinary	4
Upper Respiratory	4
Cerebral	4
Other	4
Visual	1

TABLE 12

MITRAL VALVE REPLACEMENT PATIENTS REQUIRING HOSPITALIZATION FOR EMBOLIC COMPLICATIONS

(37 of 283 patients)

Cause	No. of Patients
CVA	17
Transient-ischaemic Attacks	8
Myocardial Infarctions	5
Other	4
Visual loss	2
Renal	1

TABLE 13

OTHER COMPLICATIONS OCCURRING IN MITRAL VALVE REPLACEMENT PATIENTS REQUIRING HOSPITALIZATION

(61 Patients)

Type of Complication	No. of Patients
Arrthymia	21
Congestive Cardiac Failure	15
Anaemia	13
Infection	10
Drug Reaction	1
Hepatitis	1

4.3 MULTIPLE VALVE REPLACEMENTS

Double Valve Replacements

A group of 119 patients who have undergone aortic and mitral valve replacements were also analyzed. All of these patients were successfully followed-up. The pre-operative parameters for these patients were similar to the individual aortic and mitral groups. Hospital mortality occurred in 11 patients (9%). Of significance is the longterm survival of these patients shown in Figure 19. It can be seen that the addition of a double valve replacement does not significantly diminish the longterm survival of these patients, when compared to that of mitral valve only replacement patients. Further analysis of valve type combination used, also failed to show a significant effect on outcome (Figure 20). The effect on breathlessness following aortic and mitral valve replacement is shown on Figure 21. Eight patients underwent a mitral and tricuspid valve replacement, with 2 hospital deaths due to ventricular fibrillation (day 5 post-operative) and cardiac failure (day 1 post-operative). Two further deaths had occurred at time of review, at 18 months post operation due to myocardial infarction, and at 33 months post surgery from septicaemia.

Triple Valve Replacements

Five patients underwent triple valve replacements involving aortic mitral and tricuspid valves with no hospital mortality. Two patients were dead at time of follow-up, one at 49 months post surgery due to multiple emboli and the other at 62 months due to multi-system failure.

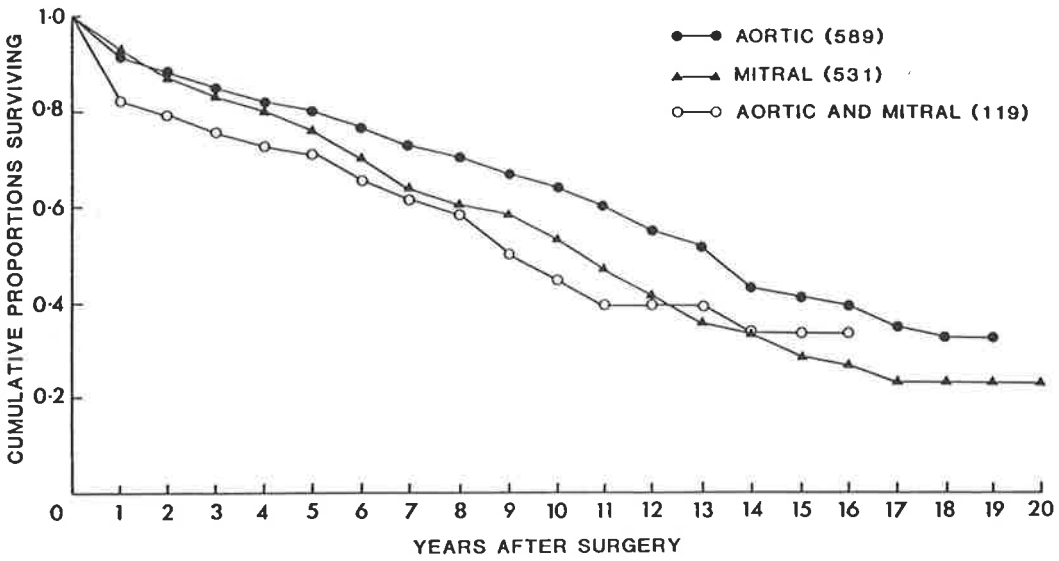

Figure 19: Survival for aortic, mitral and double valve replacement patients.

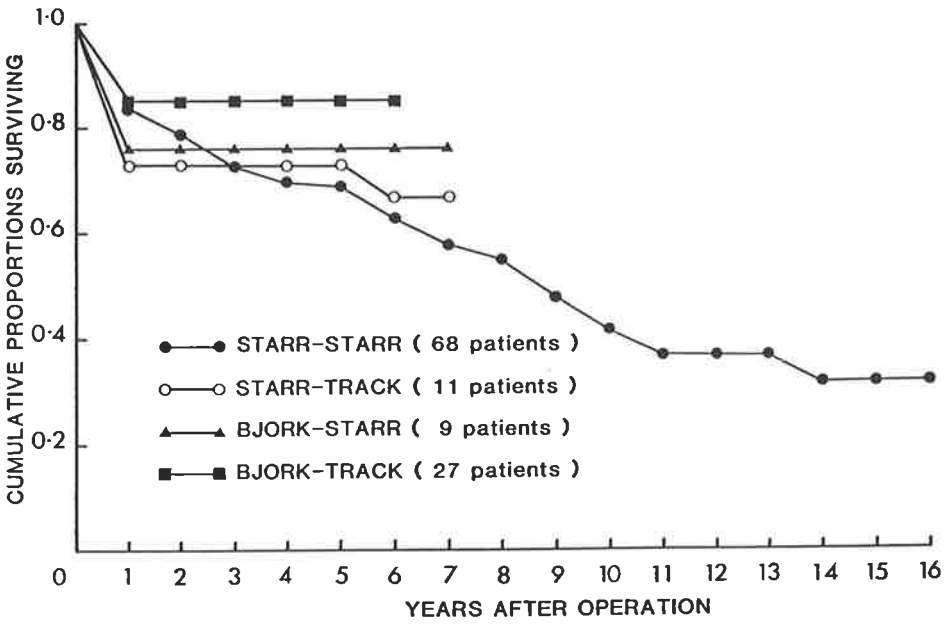

Figure 20: Survival by combination of double valve type used.

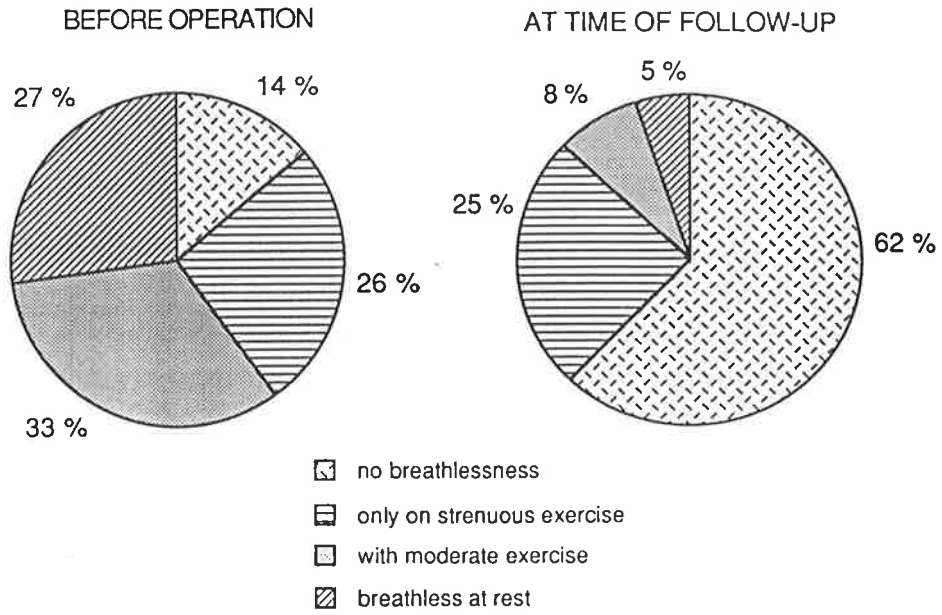

Figure 21: Change in dysponea following insertion of double valve replacements.

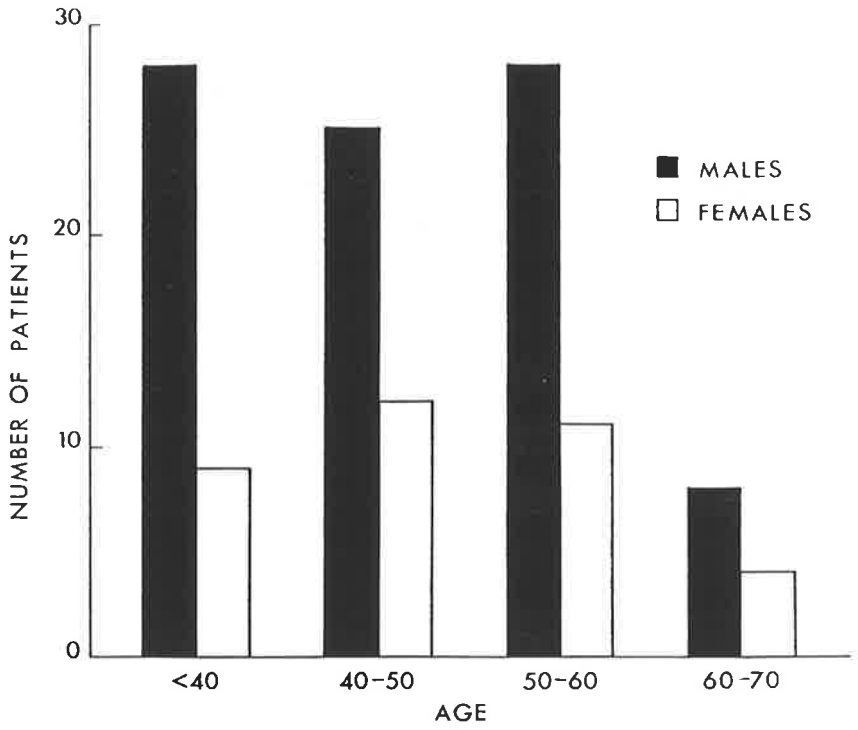

Figure 22: Age and sex distribution for patients undergoing Bjork-Shiley monostrut valve replacement.

4.4 BJORK-SHILEY MONOSTRUT VALVE IN THE AORTIC POSITION

A specific review was conducted of 315 consecutive patients who had a Bjork-Shiley Monostrut inserted into the aortic position over a four year period. The questionnaire sent to these patients is included in Appendix V. The median time to follow-up was 23 months, range 0-46 months since operation, with 98% follow-up being achieved. The patient groups comprised 70% males and 30% females (mean age 60 years, range 5-83 years) with 297 (94%) patients receiving only an aortic prosthesis and 18 (6%) having an aortic monostrut valve plus a mitral Starr-Edwards valve. The age and sex matched population is shown on Figure 22.

Survival

At the time of review there had been 20 (6.3%) deaths, with 10 (3.2%) of these being hospital deaths. Figure 23 shows the overall survival for the valve group. Valve endocarditis accounted for one late death only. The cause of death in the 20 patients is shown in Table 14. There were no deaths in the group receiving double valve replacements.

There was substantial improvement in breathlessness following valve replacement, as indicated by the NYHA Assessment ($p<.0001$) (Figure 24). Thromboembolic events that required hospital admissions occurred in 2% of patients (Figure 25) and haemorrhagic complications associated with anticoagulant therapy occurred in 5% of patients (Figure 26). Post-operatively, only 1 patient required insertion of an additional prosthesis. This was due to a peri-prosthetic leak secondary to infection, there had been one further leak which was repaired without replacement.

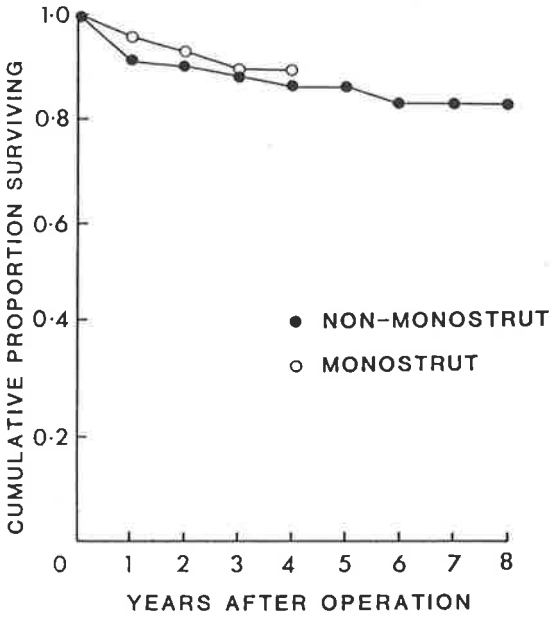

Figure 23: Overall survival of Bjork-Shiley Monostrut valve replacement group.

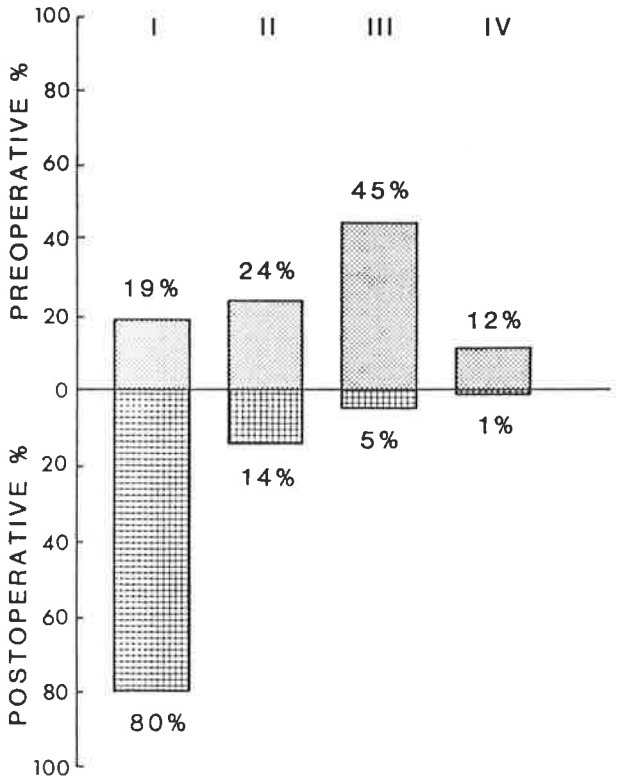

Figure 24: Change in dyspnoea following insertion of an aortic Bjork-Shiley Monostrut valve.

TABLE 14

CAUSE OF DEATH IN MONOSTRUT GROUP

Cause	No. of Patients
Hospital Death	7
Unknown (? Non Cardiac)	5
Congestive Cardiac Failure	3
Cerebro-vascular accident	1
Died During Re-operation	1
Endocarditis	1
Brain Tumour	1
Myocardial Infarction	1

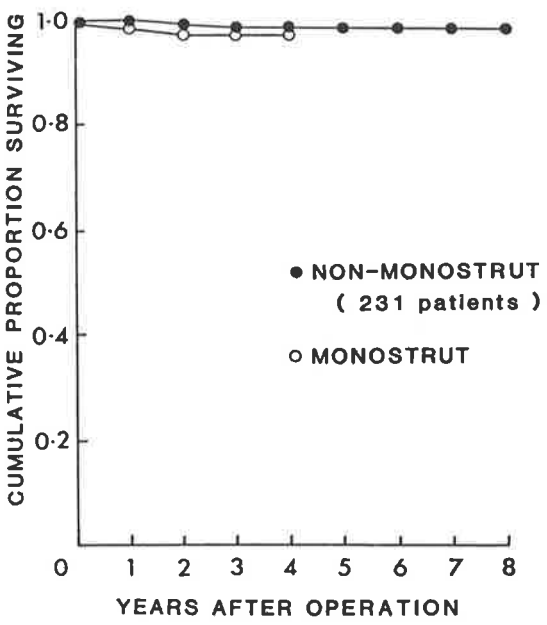

Figure 25: Thromboembolic events occurring in Bjork-Shiley Monostrut valve replacements.

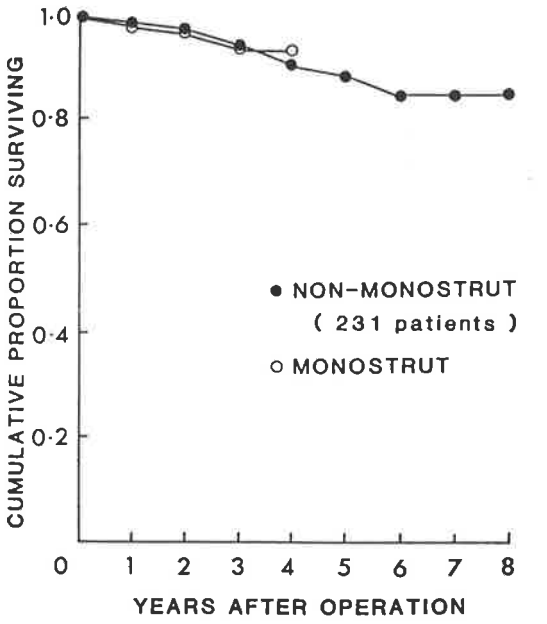

Figure 26: Haemorrhagic events occurring in Bjork-Shiley Monostrut valve replacements.

Discussion

The Bjork-Shiley 60^0 convexo-concave tilting disc valve released in 1976, remains a commonly used prosthesis and improvement in flow characteristics has been achieved by increasing the opening angle to an optimal 70^0 (Bjork, 1987). The 70^0 convexo-concave model was released in 1980, but subsequently withdrawn due to outlet strut fractures (Ostermeyer et al, 1987). The monostrut model became available in 1982 and incorporated the advantages the convexo-concave disc, a 70^0 opening angle and a stronger outlet strut fashioned, as an integral part of the valve ring. No strut fractures have been reported in over 5,000 valve replacements for this model (Thulin et al, 1988). Its longterm success will depend on close follow-up of all patients in whom it is inserted. Embolic complications and haemorrhagic complications appear to occur at a similar rate to the non monostrut predecessor.

4.5 TRENDS IN VALVE SURGERY IN SOUTH AUSTRALIA 1960-1985

A 25 year experience of open heart surgery at the Cardiothoracic Surgical Unit at the Royal Adelaide Hospital was assessed. The unit serves a largely homogenious caucasian population of approximately 1.5 million people. From 6 operations in 1960, the number rose to 1,256 in 1984, with a total of 12,165 open heart procedures being performed in the 25 year period. Valvular surgery has shown a small but steady increase throughout the period of review, from 229 mitral valve replacements in the first 10 years, up to 362 during the last decade (Figure 27). A similar trend is shown with aortic valves, although an increasing proportion of aortic valves inserted have been in combination with coronary artery bypass grafting, with 33% of aortic replacements in 1984 also having a coronary artery bypass graft (Figure 28).

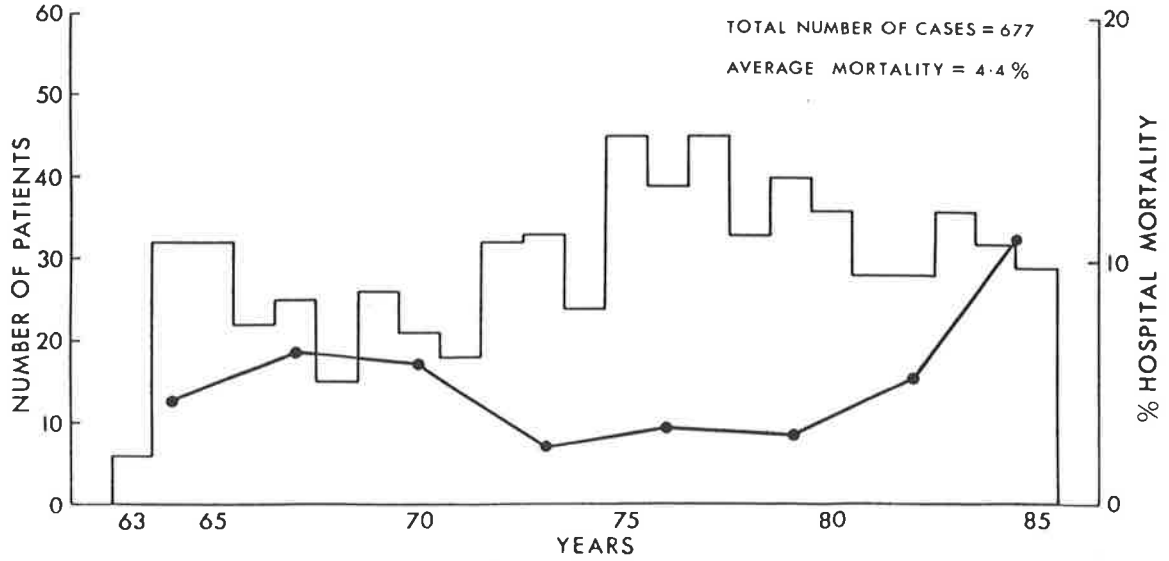

Figure 27: Change in the number of patients undergoing mitral valve surgery over 25 years.

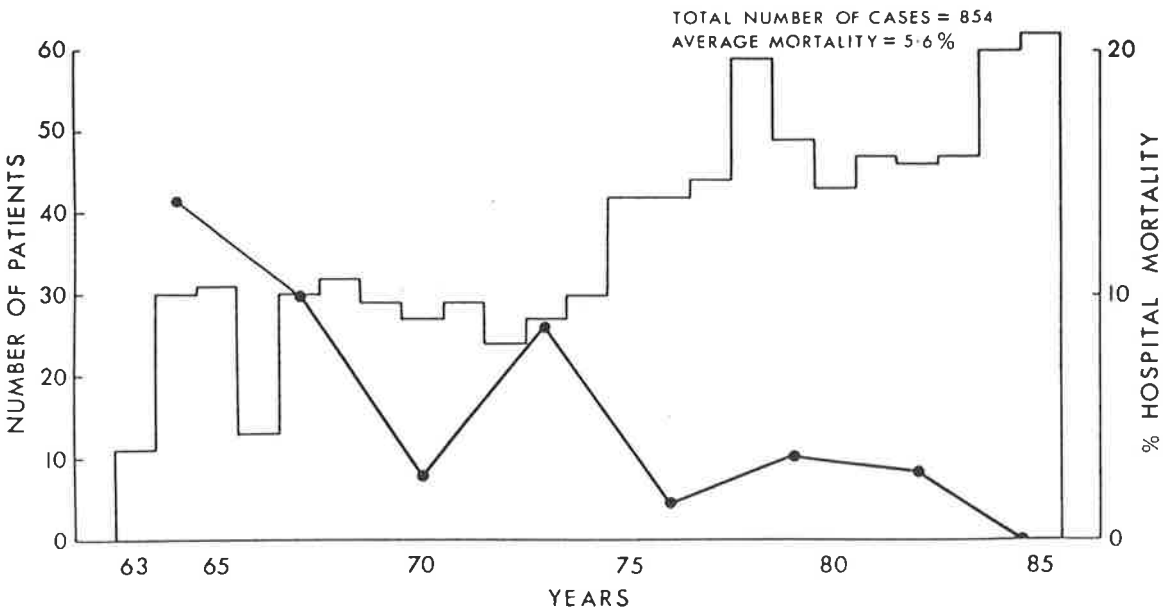

Figure 28: Change in the number of patients undergoing aortic valve surgery over 25 years.

SECTION V

CORONARY ARTERY VEIN GRAFT SURGERY

5.1 THE FIRST TWELVE YEARS

Coronary artery bypass grafting is now the most common major surgical procedure performed in Australia. It is therefore important that the efficacy of the operation is kept under review. This review covers coronary artery bypass grafting performed in South Australia over a twelve year period to December 31st, 1981. Previous reviews of such operations in South Australia were conducted in 1976 and 1979 (Craddock et al, 1977; 1980). The first coronary artery graft operation in this State was performed in December, 1970 and 4,001 patients have undergone isolated coronary artery grafting to December 31st 1981. Patients who have had valve replacements or resection of left ventricular aneurysms in addition to coronary artery grafting have not been considered in this study. No patient in this study or subsequent studies described in this thesis have undergone internal mammary artery bypass grafting. South Australia has a population of 1.35 million people and the Royal Adelaide Hospital has the only Cardiothoracic Surgical Unit in the State. A small number of patients were referred for treatment from other States of Australia and the total population served by the Unit is probably close to 1.5 million.

Follow-up

An overall follow-up rate of 98.8% was achieved with only 48 patients being untraced at time of review in June, 1982. These patients had either moved interstate and could not be located, or had

changed address and failed to continue with any medical supervision after surgery. Patients who underwent a second operation were considered as two separate patients. In the first instance, follow-up ceased at the time of the second operation, the second operation was then taken as the time of commencement of follow-up of the "second patient".

The mean period of follow-up is 3.1 years for the total group, the age and sex distribution of the patients undergoing coronary artery grafting is shown in Figure 29. The percentage of women presenting for surgery has gradually increased from 5% in 1972, to 17.6% in 1981. Women comprising 14.8% (592 patients) of the total operative group. There has been a steady increase in the average age of patients undergoing surgery during the 12 years of review. In 1971, the mean age was 44 years, but by 1981 it had risen to 57 years (Figure 30). Of the 4,001 patients, 3,852 (96.3%) had undergone the operation for chronic or unstable angina.

The differentiation between these classifications is not always easy and depends on the definition of unstable angina, however, 10% of the patients in this group had recurrent pain at rest before the operation. The remaining 148 (3.7%) patients were operated on for other reasons, of these, a small group of 49 (1.2%) had no symptoms. They had been investigated after an infarction and their angiograms were considered to be sufficiently abnormal for an operation to be recommended on prophylactic grounds. A further 84 (2.1%) patients had a second operation because of recurrent symptoms, this left 15 (0.7%) patients with indications such as tachyarrhythmias (5 patients) or acute myocardial infarction (10 patients). It was not a general policy of the Unit to operate for acute infarction, but these were patients who had previously undergone angiography and who were

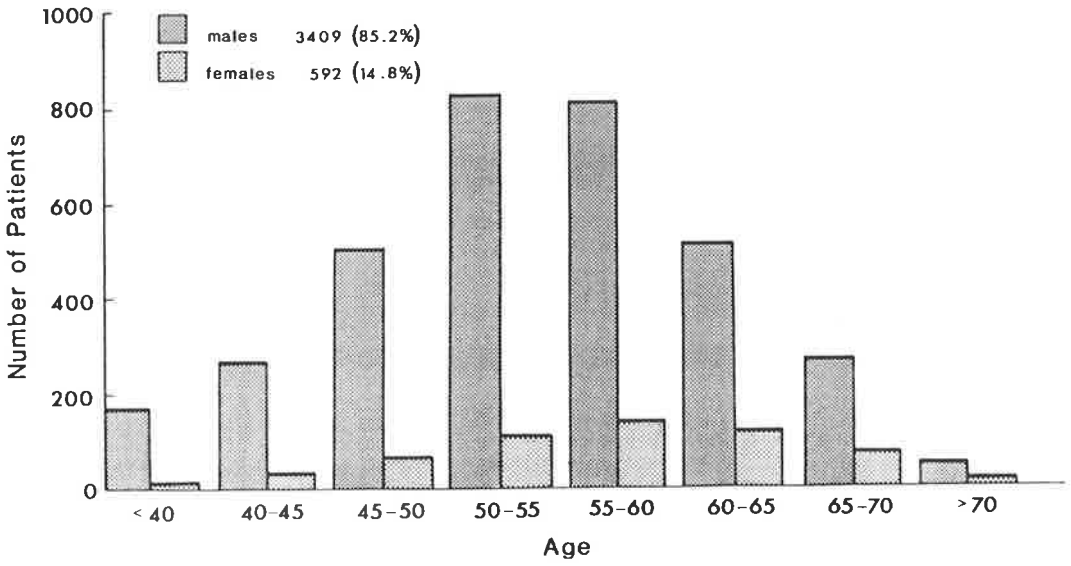

Figure 29: Age and sex distribution of total coronary artery bypass graft group (4,001 patients) at time of operation.

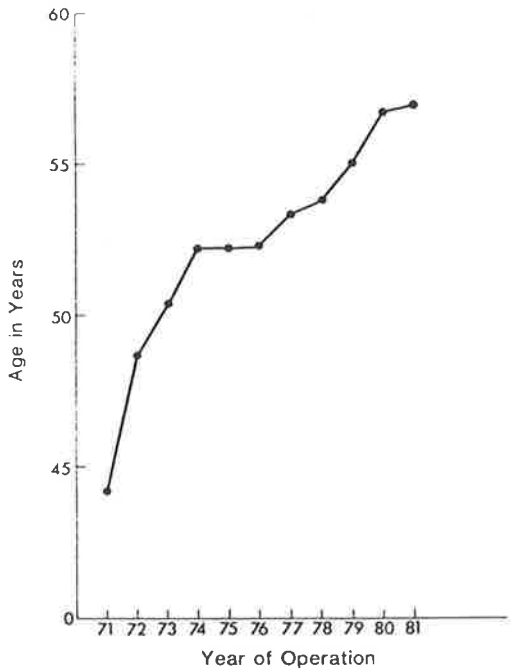

Figure 30: Mean age of patients at the time of operation for each year of review.

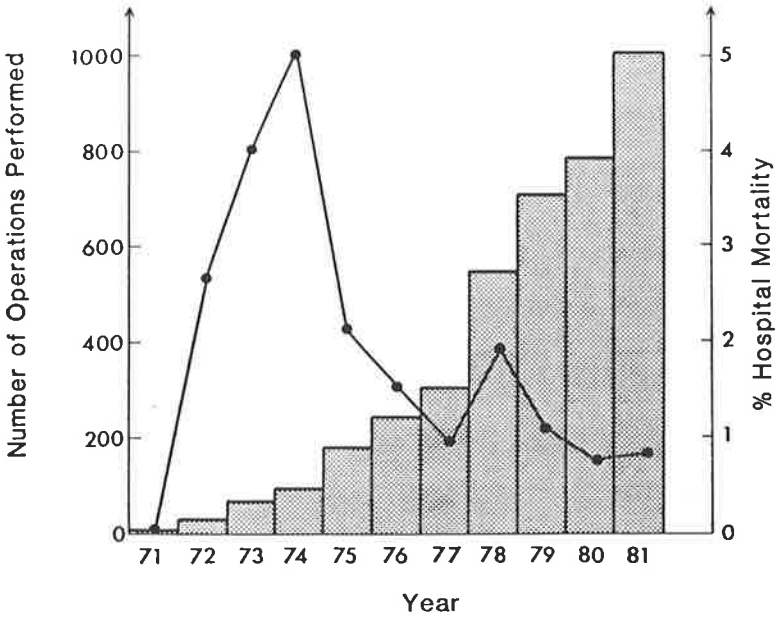

Figure 31: The number of operations performed each year of review shown by the columns, with the corresponding hospital mortality rate indicated by the dots.

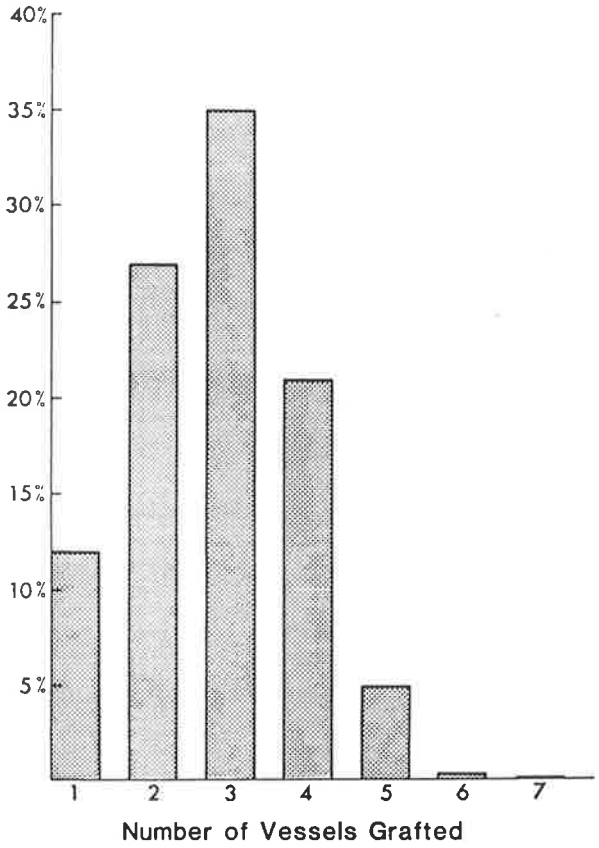

Figure 32: The number of grafts inserted for each patient in 1981. Triple vessel grafting was the most commonly performed procedure.

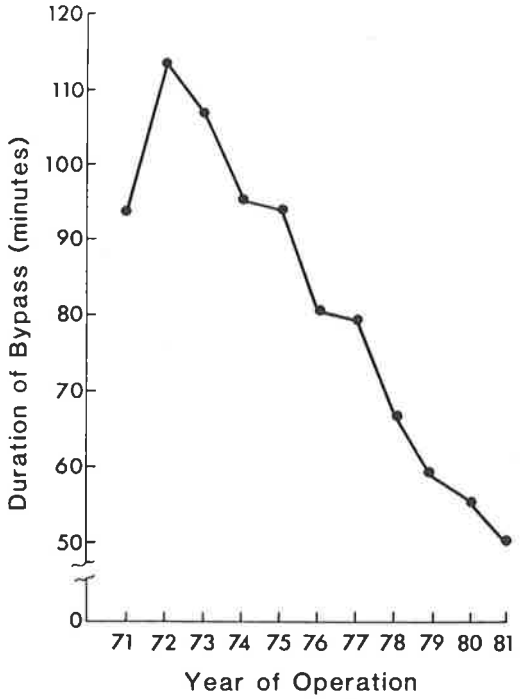

Figure 33: Mean duration of cardiopulmonary bypass for the patient group by the year of operation.

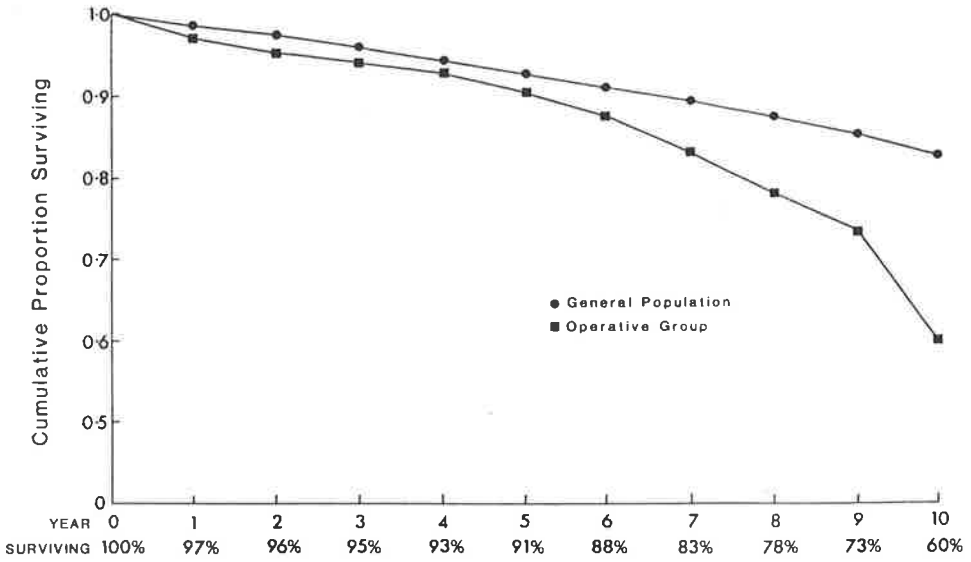

Figure 34: Survival pattern of the operative group compared with an age and sex matched group for the Australian population. The percentage of patients surviving at the end of each 12 month period are shown on the bottom line.

suitable for emergency operation.

The total number of procedures has increased each year (Figure 31). The associated hospital mortality has fallen from 5% in 1974, to less than 1% for the years 1980 to 1981 (Figure 32). The hospital mortality for the total group was 1.4%. The number of grafts inserted per patient has increased from a mean of 1.3 in 1971, to a mean of 3.1 in 1980 and 1981. Triple vessel grafting (Figure 32) was performed most frequently in 1981, with quadruple grafting being next in frequency. Despite this increase in the number of grafts per operation the mean duration of cardiopulmonary bypass fell from 113 minutes in 1973 to 51 minutes in 1981 (Figure 33). Peri-operative infarction was defined as the appearance of the new Q waves in the ECG in the immediate post-operative period. In the total operative group peri-operative infarction by this definition occurred in 2.6% of patients and in 2.4% of the 1028 patients who had undergone operation in 1981.

Survival

There were 48 patients with whom no specific contact could be made, these were presumed to be alive as no record of death was found in South Australia or other Australian States. However, survival time was calculated only until the last documented visit to a local medical officer or cardiologist, the remaining 3,953 patients were either known to be alive at the time of follow-up, or the dates of death were known.

The one year survival figure for the total group of patients was 97% and the five year figure was 91%. Figure 34 shows the survival for the total operative group compared with an age and sex matched population drawn from the lifetables of the Australian population (Australian Bureau of Statistics, 1981). The small number of patients operated on in the early part of the series makes the interpretation of

survival analysis for those years difficult. Potential risk factors which may have influenced survival were analyzed. The risk factors which did not reduce longterm survival in this study were: age (in women), sex, the year in which the operation was performed, the number of grafts inserted, the presence of moderate impairment of left ventricular function, diabetes, hypertension, unstable angina or the use of cardioplegia. The factors which did produce significantly reduced survival time were: poor left ventricular function (as diagnosed by chest x-ray films, left ventricular angiography or marked elevated left ventricular end diastolic pressures), increasing age (in men), peri-operative infarction or multiple pre-operative infarctions, a second operation and a prolonged period on cardiopulmonary bypass.

Symptoms

The mean follow-up period was 3.1 years at the time of review. Seventy percent of surviving patients reported complete relief of symptoms and 23% reported partial relief. Angina was therefore absent or substantially reduced in 93% of surviving patients at time of review. This is a similar figure to that found in patients who survive 5 years after operation, when 93% of survivors were either free of angina or substantially improved (Figure 35). When angina did recur, it recurred in 59% of patients within the first post-operative year.

An attempt was made to assess shortness of breath in the same way as angina. This is a more subjective symptom than angina, it is not always possible to differentiate between cardiac and pulmonary disease as a cause of shortness of breath. A total of 77% of the patients suffered from shortness of breath before operation, but only 43% of patients complained of this symptom at follow-up. In the latter group, shortness of breath was less in 59%, the same in 21% and

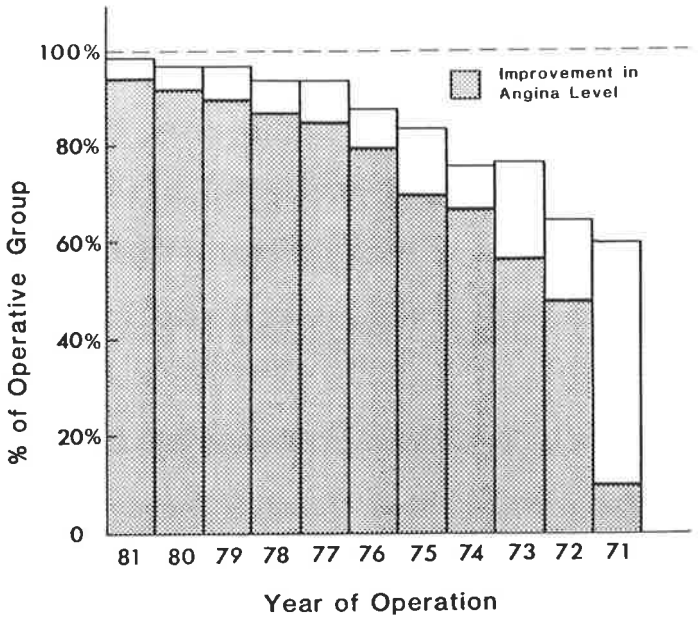

Figure 35: Recurrence of angina. The broken line at the top of the figure corresponds to 100% of the patients undergoing operation. The column represents those surviving at the time of review, with the hatched areas representing those patients with a decrease in their original symptoms.

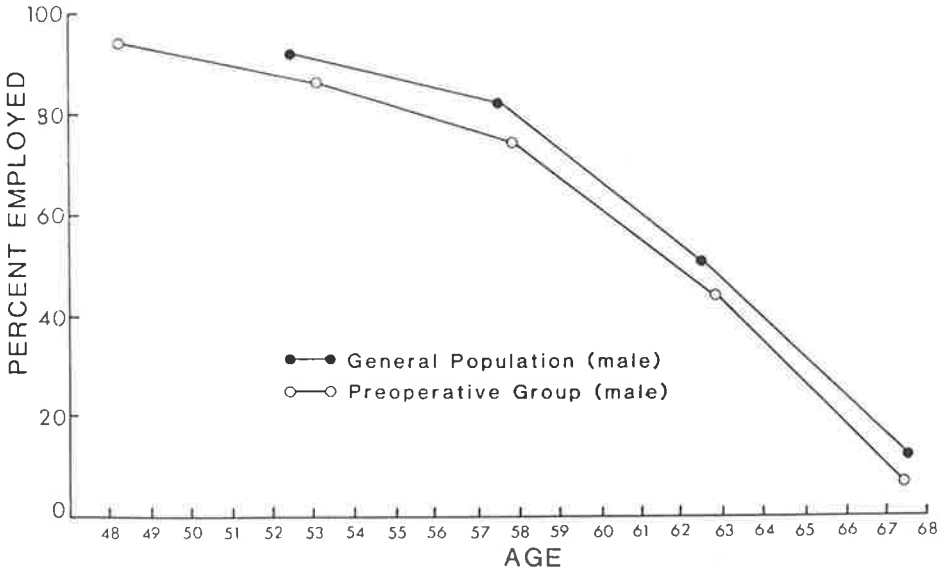

Figure 36: The number of male patients employed full time at time of surgery shown with the Australian male employment curve.

worse in 20% of patients. When shortness of breath recurred after the operation in the majority of patients (68%) it recurred within the first post-operative year. The pattern of subsidence of symptoms of breathlessness was therefore similar to the pattern of decrease in anginal pain. Activity was the third parameter used to gauge the symptomatic outcome. Of the 3,722 responses received, 71% of patients described their level of activity after the operation as improved, 21% thought their level of activity was the same and 8% thought that their level of activity was less. There was a significant association between improvement of activity and decrease in angina ($p<.001$).

Visit to the Doctor

Forty-four percent of patients stated that they visit their doctor less often after the operation, 6% have not seen a doctor at all, 20% required more frequent visits, and 30% visit the doctor as frequently as before the operation. No attempt was made to classify the causes of the patients visits to the doctor into cardiac and non cardiac categories.

Smoking

Reported smoking patterns changed dramatically after the operation, whereas 50% of patients smoked before the operation, only 21% of patients smoked after the operation. Of the total patient group 16% smoke less, 4% smoke the same amount and 1% have increased their consumption of tobacco. A significant association exists between smoking before operation and recurrence of angina ($p<.05$), however, no significant association was found between smoking after the operation and the recurrence of anginal pain.

Discussion

A number of interesting trends were revealed by this 12 year

review. A steady increase in the mean age of patients undergoing surgery, probably indicates a liberalization of selection criteria as the procedure has become accepted and established. A fall in hospital mortality has been associated with an increased number of patients proceeding to surgery. The unusually high mortality in 1974 (5 of 105 patients), was due in part to 3 deaths from pulmonary embolism and action taken to overcome this problem produced an immediate reduction in hospital mortality. Shorter periods on cardiopulmonary bypass, despite an increased number of grafts inserted in each operative procedure, may have contributed to a falling rate of hospital mortality. An increase in the number of grafts in each patient has not altered the mortality rate of the operation, it is expected that increasing the number of grafts in each patient will reduce the number of recurrences. Consideration of survival after coronary artery surgery is difficult, as appropriately matched medical control groups are not obtainable because of great symptomatic benefits provided by operation. Other studies have attempted to match medical and surgical groups (Varnauskas et al, 1980; Hammermeister et al, 1979b), but this study has confined comparison to life tables of the Australian population. These tables include not only persons free of heart disease, but also those suffering from terminal conditions, a factor which may introduce some bias.

It has been suggested that a truly comparative group would be those granted insurance policies which excludes those terminally ill people (Chait, 1982). In contrast to earlier reports (Craddock et al, 1977; Craddock et al, 1980) which assessed hospital mortality against risk factors, the sex of the patient was not found to be a fact in longterm survival, however, this may well reflect the relatively small number of female patients included in this study. The year in which

the operation was performed also failed to influence the survival rate. Increasing surgical experience probably compensated for the selection of older patients in more difficult cases in the latter years reviewed. The age of female patients was not a significant survival factor, but there were relatively small numbers of these patients in each 5 year cohort analyzed. It is reasonable to suppose that the age at time of operation would have some bearing on length of survival and this is true in elderly male patients who have a significantly shorter survival than do other patients. As has been shown in other series (Crossgrove et al, 1982; Zubiate et al, 1977) poor left ventricular function, significantly reduced post-operative survival regardless of the method of assessing left ventricular function. The occurrence of multiple pre-operative infarctions similarly reduced survival. In some series peri-operative infarction has not been associated with a decreased longterm survival (Codd et al, 1978). This was not the case in this study and other published studies confirm this finding (Namay et al, 1982). The definition of peri-operative infarction as the presence of a new Q wave may explain these apparently contradictory findings, such a definition selects a more severely affected group of patients than those in series which use enzyme changes and other minor ECG abnormalities, as criteria for the diagnosis of infarction. The rapid recurrence both of breathlessness and of angina in those whose symptoms recur after operation, may be explained by failure to revascularize the myocardium adequately, either because of poor distal arteries or technical problems, the former reason seems more likely to apply in more experienced units.

One of the alleged advantages of coronary artery grafting as opposed to medical management is that the patient no longer requires the same degree of medical supervision after surgery. This study

supports such a view, especially as the data would tend to underestimate the improvement in the condition of these patients, because no account has been taken of other medical problems which might require medical supervision after the operation. A somewhat inexplicable finding on these results is the lack of effect of diabetes on the outcome following coronary artery surgery. This is at variance with other reports (Salomon et al, 1983; Devineni and McKenzie, 1985; Johnson et al, 1982b; Lawrie et al, 1986) and was a stimulus to further study reported elsewhere in this section.

5.2 COST AND BENEFIT TO THE COMMUNITY OF CORONARY ARTERY BYPASS GRAFT SURGERY

With the emergence of coronary artery bypass grafting as an established procedure to treat myocardial insufficiency, there has been a dramatic increase in the number of cases performed annually in centres in Australia (Figure 31) as elsewhere in the world (Loop et al, 1981). This change has carried with it, an increasing initial cost to the community in general and governments in particular. There have been some attempts to assess the financial implication of such surgery in the USA, England and Australia and these studies have suggested the procedure is extremely cost effective. Such assessments are complex and should include consideration of the cost of the procedure, impact on employment (Love, 1980), extent of ongoing medical supervision and the associated mortality and morbidity (Oberman and Kouchoukos, 1979; Niles et al, 1980; Russell et al, 1980; Anderson et al, 1980; Barnes et al, 1977; Symes et al, 1978; Smith et al, 1982; Oberman et al, 1982; Hammermeister et al, 1979a; Johnson et al, 1982; CASS, 1983b).

All of these parameters have now been assessed in 4,001 patients who underwent isolated coronary artery venous grafting over a 12 year period defined in the previous section. The questionnaire sent to these patients was the one shown in Appendix III. Specifically, surviving patients, were asked to categorize their employment prior to surgery as either working full time, working part time, retired, government supported pension, unemployed or independant, and then under the same heading their employment at the time of follow-up. In order to include performance of home duties a question was designed to ask housewives, not otherwise employed, to describe the level of home duties they performed as full

home duties, part home duties, no home duties, both prior to operation and at time of follow-up. Patients who were not employed prior to their operation were asked to categorize the reason, using the options of either age, heart problems, other medical reasons, employment redundancy, voluntary retirement, community attitudes to their heart disease, poor job opportunities. A similar question was also required to be answered at time of follow-up if they remain unemployed.

Procedure Cost

To obtain some indication of the cost of coronary artery grafting within the hospital, the aid of Finance Division and the relevant departments serving the Cardiothoracic Unit, were contacted to itemize costs incurred by the Unit during the 12 month period corresponding to the financial year 1981 to 1982. This information along with the total number of patients admitted to the unit, was used to determine the average cost of coronary artery grafting per operation (Table 15). This technique makes it impossible to build in depreciation costs of buildings and major equipment although items of equipment purchased during the relevant financial year are included. Details of this financial data appear in Appendix VIII.

Employment

The impact of coronary artery grafting on employment is complicated by the fact that the mean age of the group was 54 years. The largest 5 year cohort for males was the 50 to 54 age group (834 patients) and for the females the 55 to 59 age group (140 patients). Figure 30 shows the age and sex distribution for the total group. The older age group encompasses a large proportion of patients more likely to retire from the work force irrespective of the cardiac disease. Therefore to consider those patients employed before operation with

TABLE 15

COST OF C.A.B.G./PATIENT (1981-1982)

Hotel Costs	
power, water, meals, etc.	$1,110.00
Unit Costs.	
pharmacy, medical and nursing salaries, consumables, clerical, etc.	$1,408.00
Theatre Costs.	
nursing staff, anaesthetic, consumables	$ 821.00
X-Ray.	
(based on 100 consecutive patients)	$ 137.00
	$3,476.00

those employed at follow-up would not take into account the normal attrition from the work force with age. The retirement data for the general male Australian population is only available for 5 year age groups of 50-54 years, up to 60-65 years (Australian Bureau of Statistics, 1982). For the purpose of comparisons the male patients who underwent coronary artery grafting were divided into similar groupings. Figure 36 demonstrates how the full time male pre-operative employment pattern relates to the full time male Australian employment.

By calculating the mean period of follow-up for each age group in each cohort of patients and assuming the male Australian employment pattern was unchanged during the period of review, the pattern of full time employment at time of follow-up is shown in Figure 37. The change in full time employment as a percentage of the total male operative group shows a consistent downward trend of about 4% when compared with the post-operative pattern (Figure 38). However, the shape of the pre- and post-operative full time employment curves are similar for both the operative group and the general Australian male population.

When home duties are used as an index of employment the improvement between pre- and post-operative employment is marked. Of the 430 females who responded, 37% were on full home duties, 55% on part home duties and 8% on no home duties pre-operatively. At the time of follow-up, 68% had returned to full duties, 30% could manage part home duties and only 2% were on no home duties.

Pattern of Employment

Figure 39 outlines the changes in unemployment and the reasons given for these changes in 866 patients prior to surgery and

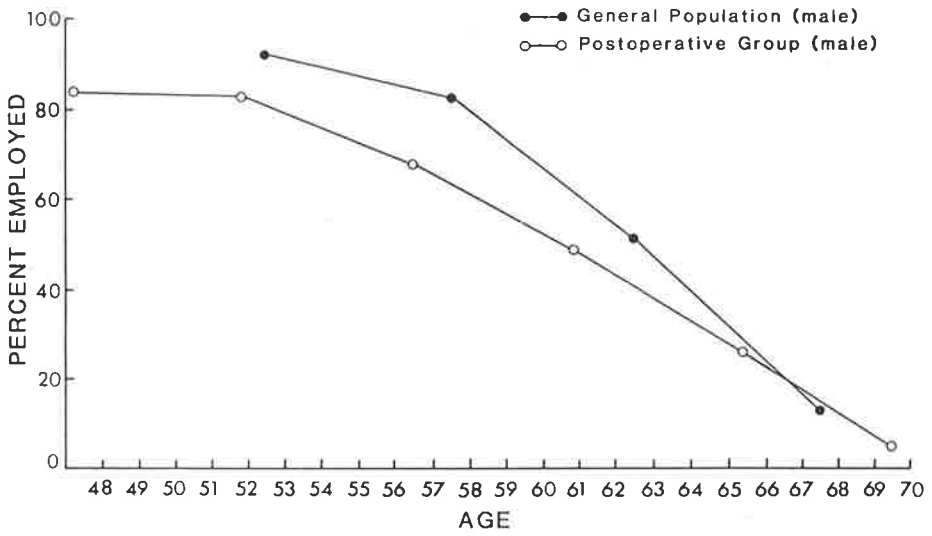

Figure 37: The number of male patients employed full time at time of review shown with the Australian male employment curve.

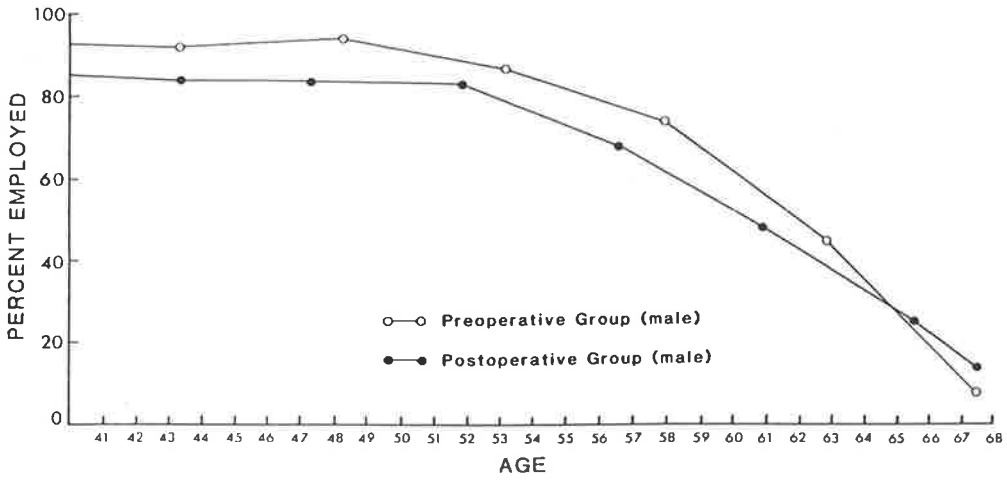

Figure 38: Pre- and post-operative employment shown together.

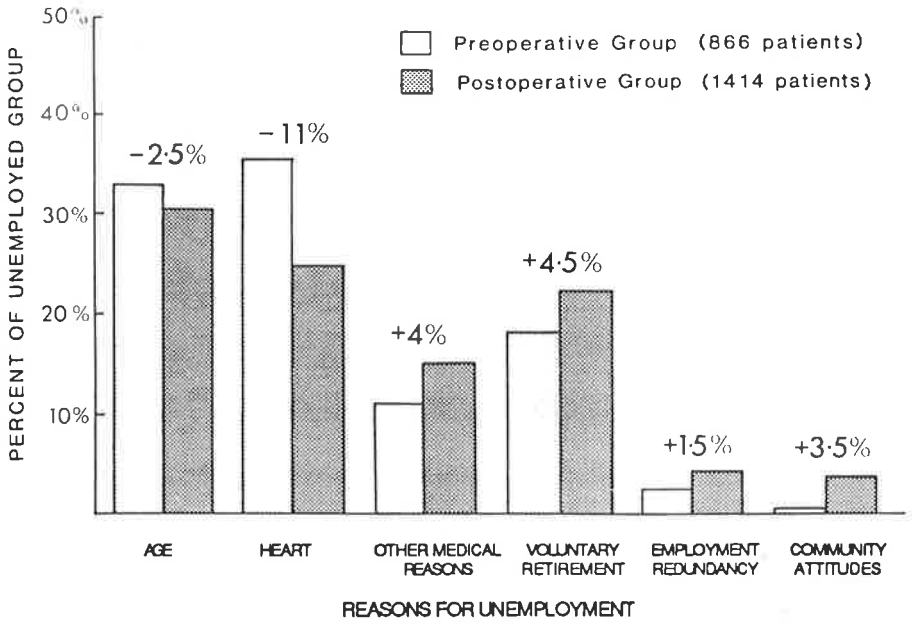

Figure 39: Reason given by patient for unemployment before and after surgery. The percentage change is shown over the respective column.

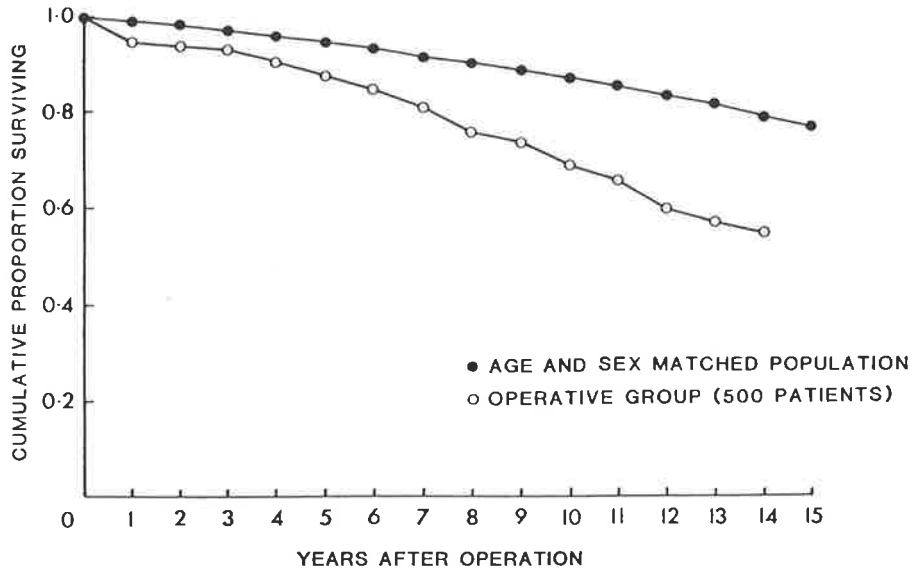

Figure 40: Survival curve for the first 500 coronary artery bypass patients compared with an age and sex matched population.

1,414 patients at time of follow-up. A significant shift has occurred in "Heart" with an 11% fall. However, poor job opportunity and community attitudes show a 5% rise. Voluntary retirement and other medical reasons accounted for 8.5% drop. Figure 39 also illustrates how a distorted view of the operation can be obtained if unemployment figures are not corrected into the normal retirement patterns. Thus there was an overall increase of 163% in unemployment at follow-up when compared with the pre-operative group.

Average Cost of Operation

The determination of this figure is based on a number of assumptions. Where possible the costs of running the wards and theatres used by the Cardiothoracic Unit have been added and divided by the number of patients admitted per year. Since items such as X-rays and anaesthetics cannot be costed in this fashion they have therefore been allocated on the basis of "typical" patient. Table 15 shows the breakdown for the contributing sections of the cost. No cost has been attributed to angiographic investigation and its attendant expense, as these are usually performed some weeks earlier, but could be added to give the total cost.

Discussion

Few previous studies have attempted to address the issue of the cost to the community and individuals of coronary artery bypass surgery (Love, 1980; Oberman and Kouchoukos, 1979; Niles et al, 1980; Russell et al, 1980). Changes that occur before and after surgery are more controversial. The questionnaire used was simple and involved a fixed format. However, patients did have a contact telephone number they could use to resolve problems, but only 2% of respondents made use of this facility. The overall pattern of male

pre-operative employment is similar to that of the general male Australian full time employment pattern. Unfortunately the details of Australian female employment are not available. In our group, however, only 15% of patients were female. Only working women were missed and this represents less than 4% of the total group. The post-operative employment pattern again showed the male patients to follow a similar pattern to the general population group, but with a downward translation. This downward translation is clearly illustrated in Figure 38, where the pre-operative pattern was approximately 4% more employed than the equivalent age corrected post-operative group.

One possible bias with this data was that pre- and post-operative information was obtained on survivors only at the time of follow-up. No retrospective assessment was made of employment behaviour of non survivors. It seems reasonable however, that those currently living are a representative sample of those leaving hospital, as the study includes longterm and short term patients. Reports have appeared showing no significant difference in patient employment pattern after surgical and medical treatment (Hammermeister et al, 1979a), as well as significant differences (Russell et al, 1980). It is not possible to answer this in this study, as no appropriate control group exists. However, this study confirms that coronary artery bypass grafting has a slight effect on work performance.

Justification of intervention on symptomatic grounds should therefore not be weighted by dropout from the workforce. The main reason for giving up work was given as "heart" pre-operatively and "age" post-operatively. The percentage of patients unable to work due to "heart" post- operatively fell by more than one third. Of greatest concern was the group of patients who thought their

unemployment was due to "community attitude". They represented 4% of the post-operative group, which was a rise of 3.5% from the pre-operative group percentage. This group possibly could be helped by improved employer and community education.

One aspect of the cost differential between coronary artery bypass grafting and medical management that should not be ignored is the ongoing dependence on the medical profession of the patients concerned. This study clearly shows that 50% patients see the doctor less than before surgery. This has savings not only in consultations, but also in pharmaceutical dispensary and laboratory investigations that frequently attend medical consultations. Further, the age group under consideration has not infrequently concommitant medical problems unrelated to their cardiac disease. We have not asked the patient to judge whether the visit is related to cardiac disease however, it would be reasonable to assume that many visits may have a non cardiac basis on the basis of the high percentage cure of the cardiac complaint by coronary artery bypass grafting, which is indicated by the improvement of angina and breathlessness.

Others have shown that following discharge from hospital, costs for surgical patients are more than for medical patients (CASS, 1983b), however, their study group had admission to hospital routinely in the first 12 months, a routine that was not a feature of our patients. The cost of the operation at about $3,500 (1981 prices), has been possible due to a considerable economies achieved because of the high surgical throughput. Although, it must be noted that depreciation has not been calculated. To put this cost into context the average male full time wage in Australia in 1981-82 was $15,934-10 which would incur a Federal Income Taxation in excess of the operative cost, thus if a male is able to return to work for one year

following operation then operative costs are recouped.

5.3 THE TEN YEAR OUTCOME FOLLOWING CORONARY ARTERY SURGERY

The first 500 patients to undergo coronary artery bypass graft surgery were followed up at least 10 years after initial surgery to assess their current level of health, to determine factors that influence long term survival, to identify the risk factors that may influence re-operation and to assess outcome for those patients requiring re-operation. The group comprised 500 patients, 453 males (91%) and 47 females (9%), with a mean follow-up of 11.5 years (range 10-15.5 years) with a 98% follow-up. The overall group survival is shown in Figure 40 compared with an age and sex matched general population. The time at which surgery was performed did not significantly alter outcome (i.e. first 100 cases cf last 100 cases) (Figure 41). Similarly, male and female patients had similar long term survival with no significant difference although the number of female patients was small (Figure 42). The survival obtained for male and female patients compared with an age and sex matched population is shown in Figures 43 and 44. Factors which did significantly alter long term survival were previous myocardial infarction ($p<.0001$) (Figure 45), diabetes ($p<.01$) (Figure 46), hypertension ($p<01$) (Figure 47) and abnormal myocardial contraction ($p<.01$) (Figure 48).

Symptoms

In 315 patients surviving at time of review, 64% described their present level of activity compared with their pre-operative level of activity as "better", in 19% "the same", and "worse" in 17%.

In the same surviving group, 48% described "no" breathlessness after surgery, 27% said it was "less" than prior to surgery, 13% "the same" and 12% now felt it was "worse" than pre-operatively.

Pre-operative angina and post-operative angina were compared

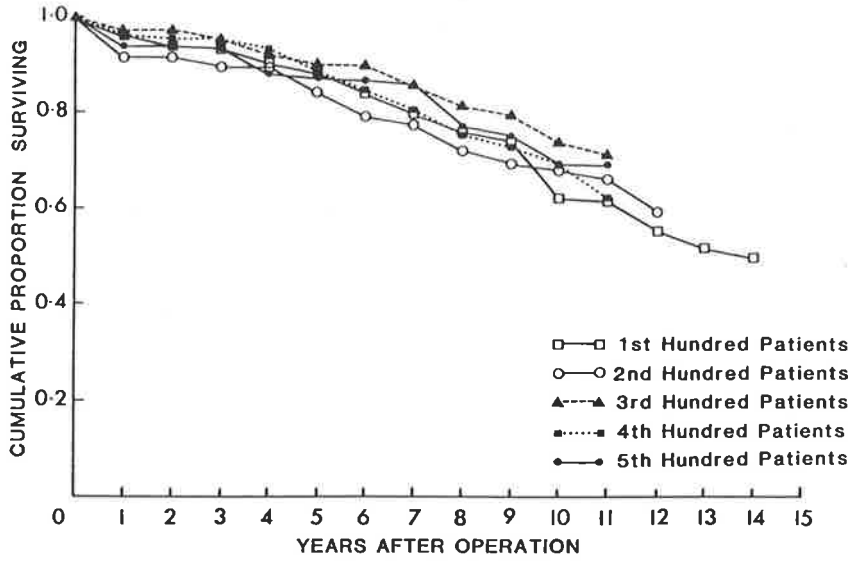

Figure 41: Effect of time of surgery on longterm survival in the first 500 coronary artery bypass patients.

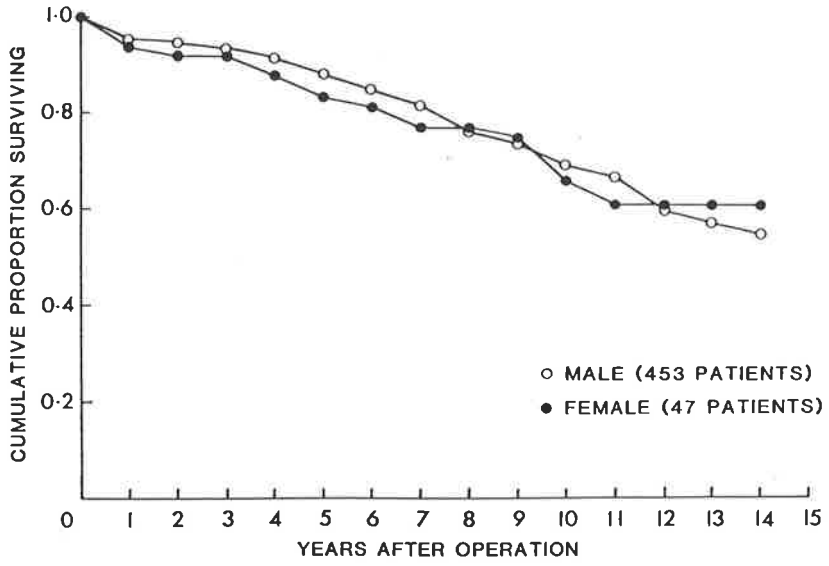

Figure 42: Influence of sex on survival for the first 500 coronary artery bypass patients.

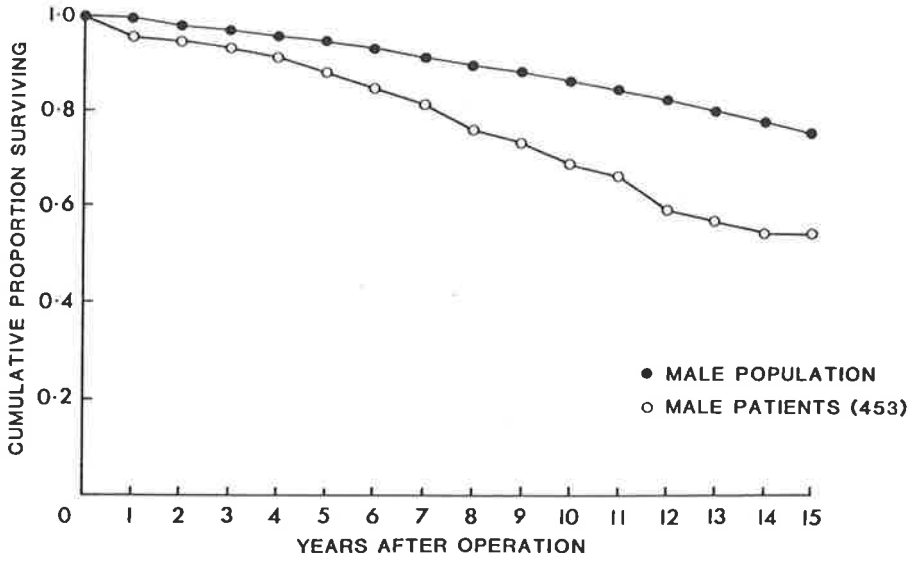

Figure 43: Male longterm survival compared with the general population in the first 500 coronary artery bypass cases.

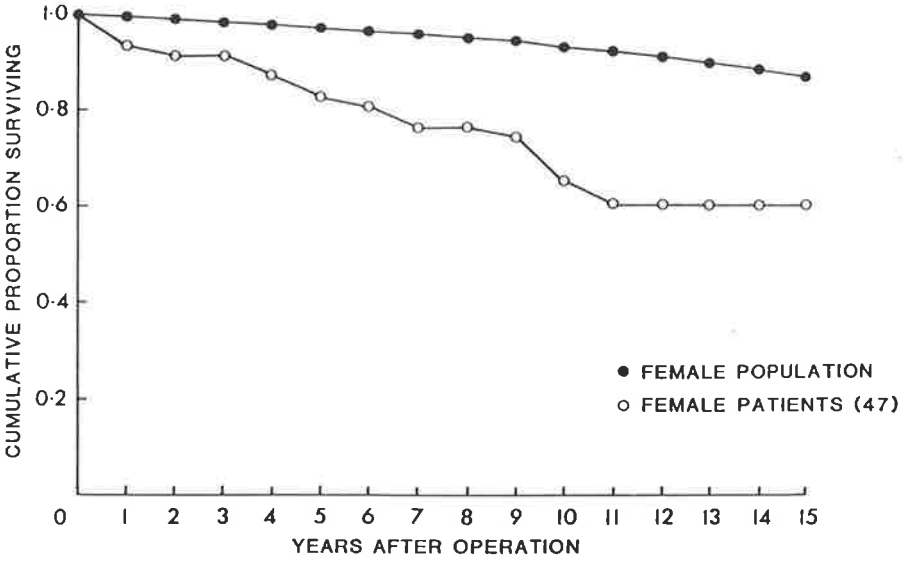

Figure 44: Female longterm survival compared with the general population in the first 500 coronary artery bypass cases.

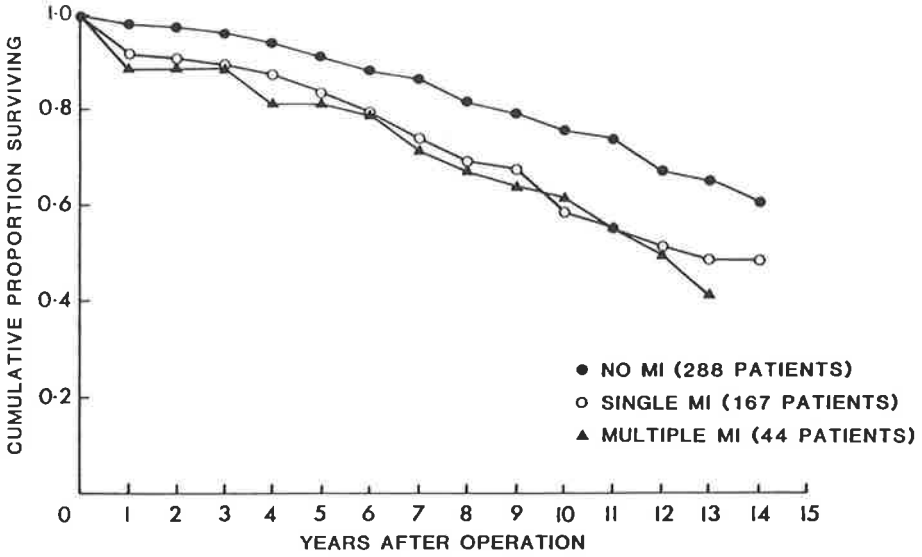

Figure 45: Influence of previous myocardial infarction on survival in the first 500 coronary artery bypass cases.

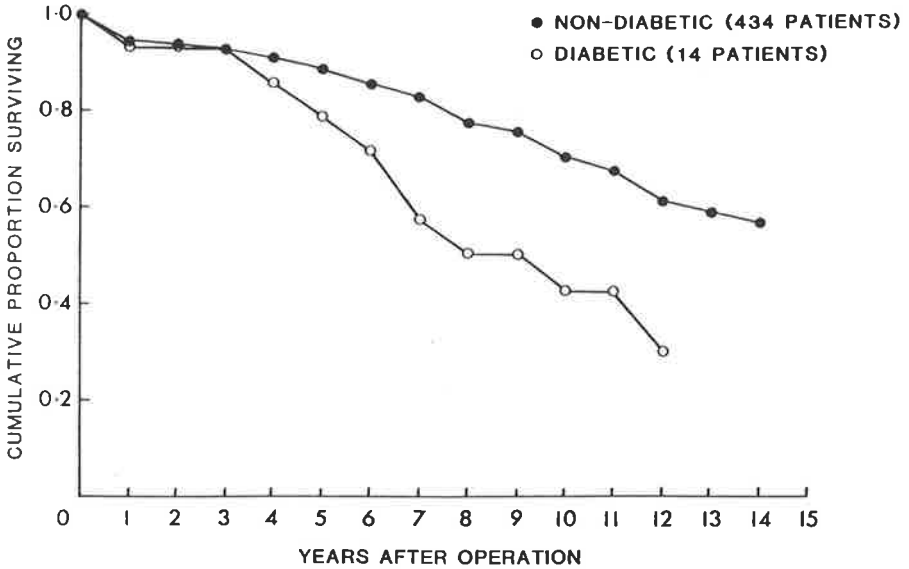

Figure 46: Influence of diabetes on survival in the first 500 coronary artery bypass cases.

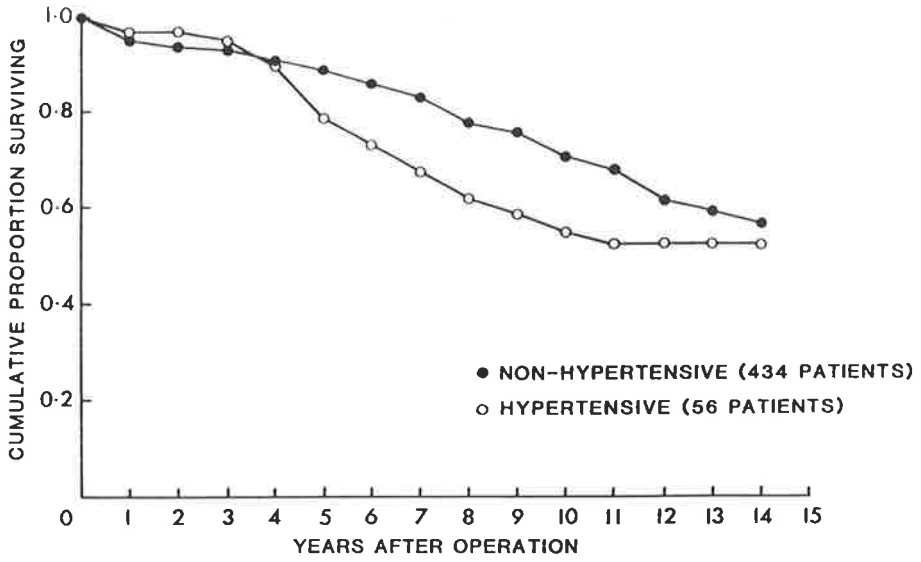

Figure 47: Influence of hypertension on survival in the first 500 coronary artery bypass cases.

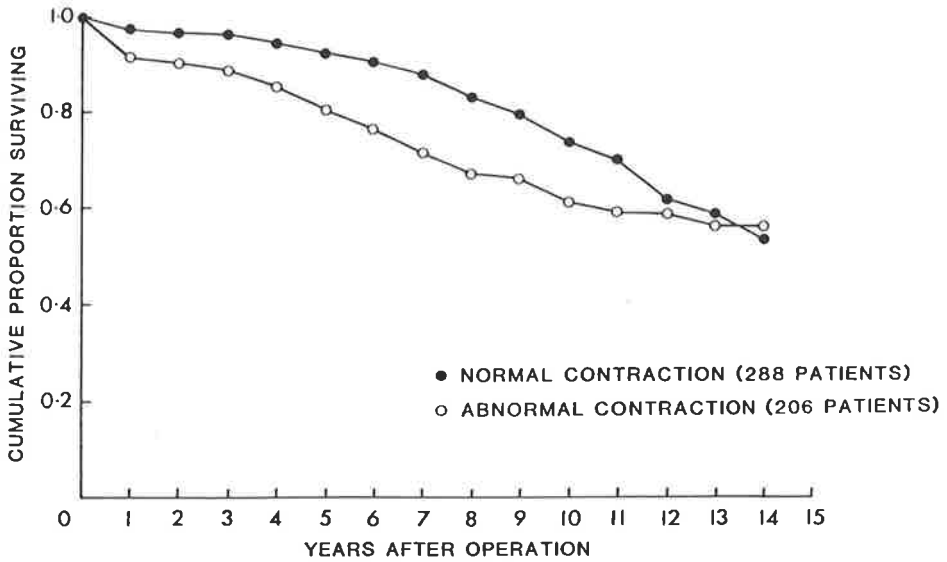

Figure 48: Influence of myocardial contraction on survival in the first 500 coronary artery bypass cases.

by 316 surviving patients: 41% had no angina, 40% had "less" angina, 12% "the same" and 7% now had "worse" angina.

Redo Patients

Within the first 500 cases, 81 patients had required a further operation when followed up. In the first 100 cases 20% had further surgery, 19% in the second 100, 13% in the third 100, 16% in the fourth 100 and 13% in the last 100 cases. When the overall survival for re-operative and non-reoperative patients is considered, re-operative patients appear to have a survival advantage (Figure 49) ($p<.001$). However, this probably represents the fact that they had a return of symptoms that warned recurring myocardial insufficiency and were fit enough for further surgery and therefore represents a highly selected group. However, when survival from time of redo surgery is considered, compared with survival from the initial group who did not have redo surgery, a significant difference emerges ($p<.02$) (Figure 50). When the hospital mortality is removed from the analyses (Figure 51) no such difference occurs. This indicates that if the peri-operative and hospital mortality is reduced then redo patients have the same longterm survival outcome as patients undergoing only their first operation.

Other factors analyzed that may have led to the occurrence of redo surgery (sex, diabetes only 1 patient, hypertension, previous myocardial infarction and impaired myocardial contractility), failed to be more prevalent in the redo than in the non redo group however, the redo group is a small sample and it was unlikely that any single factor would be a predictor in this group.

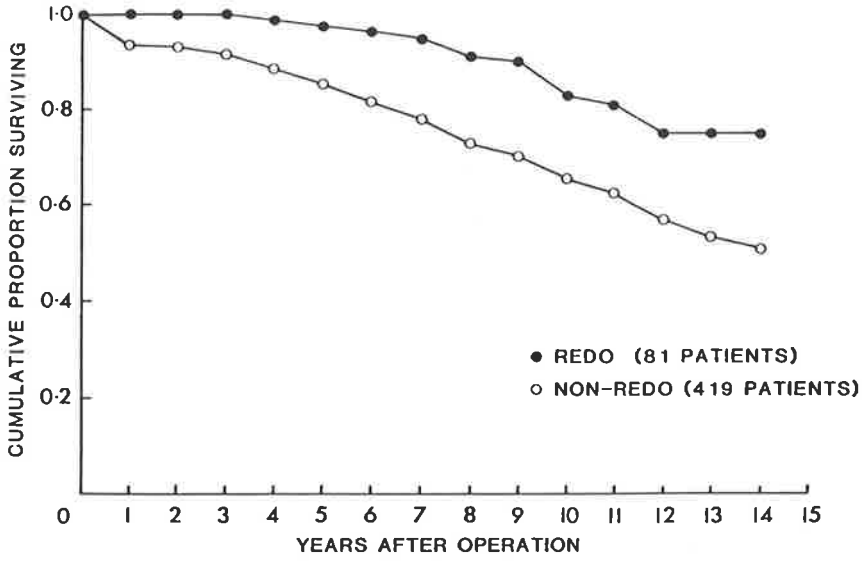

Figure 49: Longterm survival for patients requiring re-operation from those operated on in the first 500 cases of coronary artery bypass surgery compared with those not requiring re-operation.

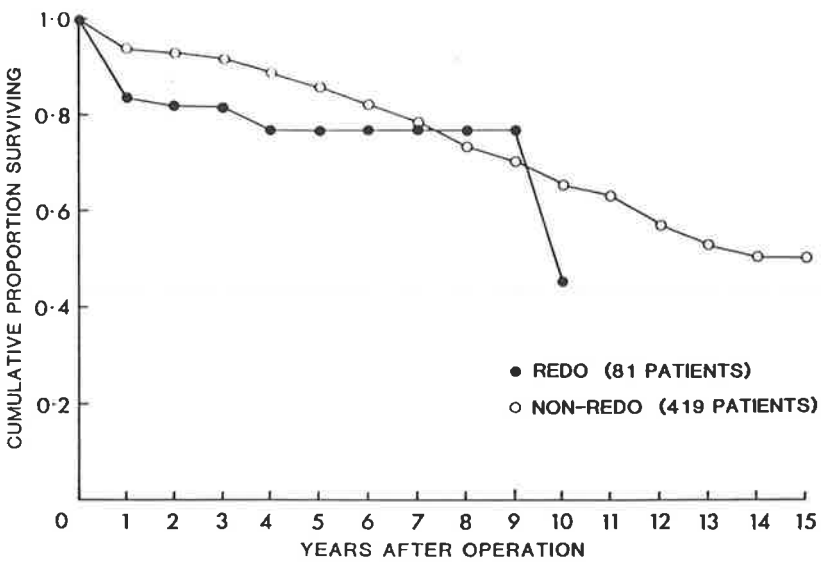

Figure 50: Survival for re-operation patients when second operation is taken as commencement of survival period and compared with the first 500 cases of coronary artery bypass grafting.

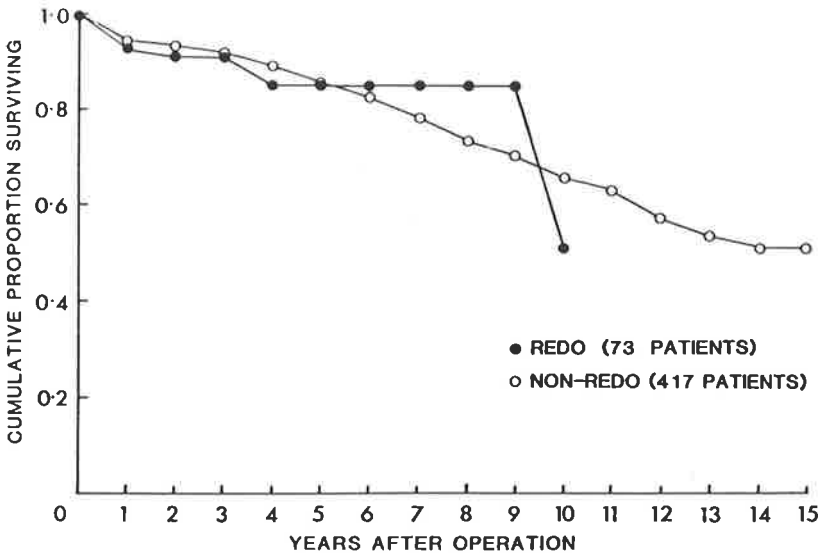

Figure 51: Re-operative group survival compared with non re-operative group survival after hospital mortality has been excluded.

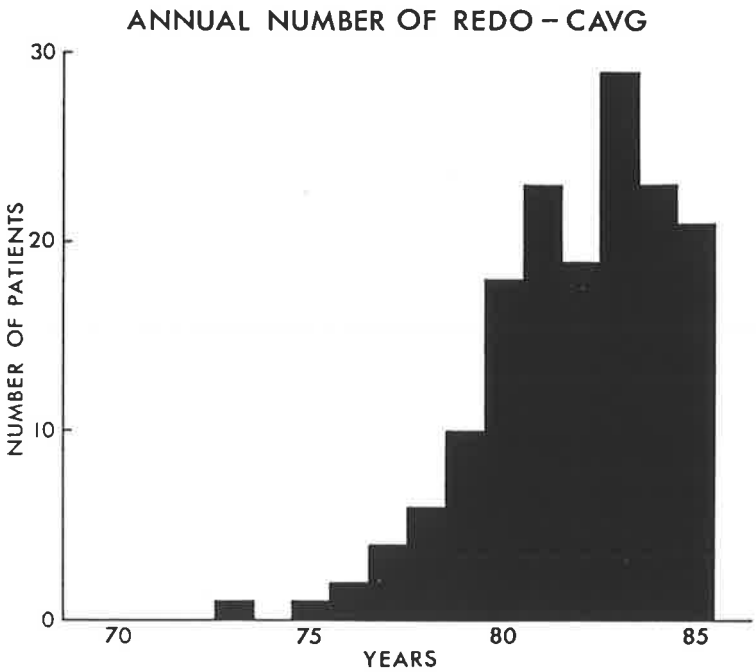

Figure 52: Annual number of redo coronary artery bypass graft cases performed at the Royal Adelaide Hospital.

5.4 RESULTS OF RE-OPERATION FOLLOWING CORONARY ARTERY SURGERY

Re-operation for coronary artery disease is becoming an increasing and difficult challenge (Figure 52). Over the first 14 year period, 136 patients underwent redo surgery within the Cardiothoracic Unit of the Royal Adelaide Hospital, representing an overall rate of 2%. The mean interval between operations was 56 months (range 0-138) (Figure 53) and between the second operation and follow-up 32 months (range 2-120). Hospital mortality for the second operation was 5% (Figure 54), with an overall mortality at follow-up of 13% (8 cardiac, 8 hospital, 1 CVA). This compares poorly with the total operative group mortality of between 1-2%, but is consistent with other early reported results for redo CABG (Winkle et al, 1975; Tyson et al, 1978; Reul et al, 1979; Thomas et al, 1976; Norwood et al, 1977; Oglietti et al, 1976; Wukasch et al, 1977; Culliford et al, 1979). The number of grafts inserted initially was 2.5/patient and at time of subsequent surgery 1.9/patient compared with 3.1/patient for the total group. Between the two operations 24% of patients underwent a myocardial infarction. All patients developed recurrent angina prior to redo surgery.

Amongst the survivors of the second operation, at the time of follow-up angina was improved in 90% and shortness of breath in 84%. Activity was described as better in 61% and the same in 20%. Further hospitalization for cardiac problems was required in 29% following the second operation and 61% of patients required cardiac medications at time of review. Prior to the initial operation, 54% smoked compared with 23% at time of second operation and only 9% at the time of follow-up after the second operation.

Pre-existing diabetes and hypertension did not predispose to re-

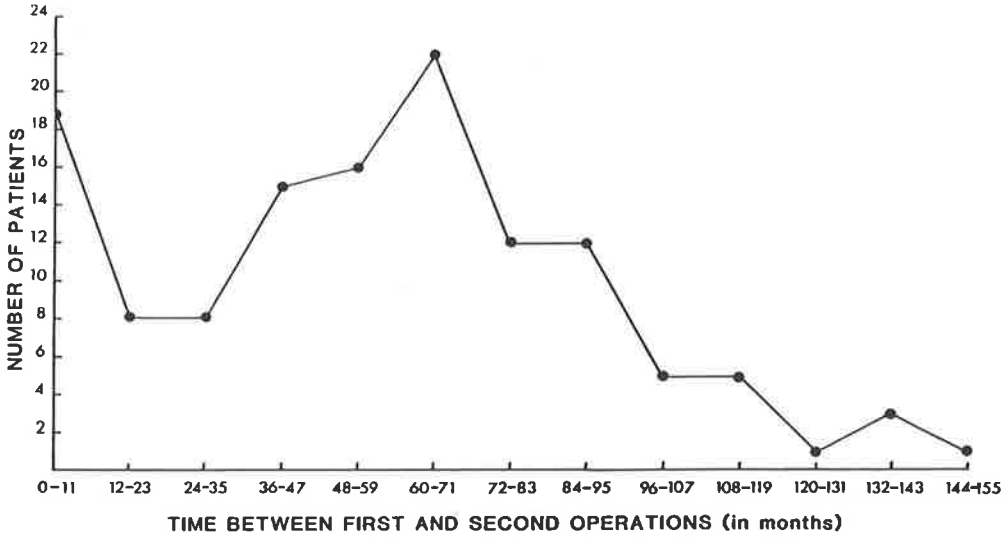

Figure 53: Interval between first and second operations in 136 redo patients.

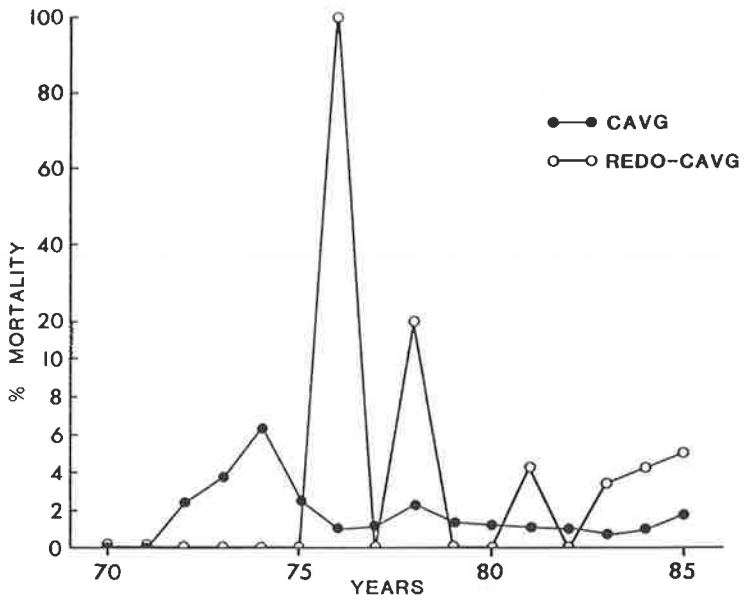

Figure 54: Annual mortality obtained for first and redo coronary artery bypass graft patients.

operation, nor was the sex ratio significantly different from the general operative group.

To try and assess some possible angiographic risk factors that may contribute to re-operation, the angiograms of the first 41 patients that underwent re-operation were analyzed in detail by a "blinded" cardiologist. This redo group represented a typical subset of the total patient pool, with the mean ages over the period of surgery of the first 41 redo patients, being the same at 54 years. The sex ratios were identical, occupation and activity were also similar. The redo group showed a higher percentage of reformed smokers at the time of second operation and a 70% drop in heavy smoking with the first operation. The incidence of diabetes and hypertension was not significantly different. The operative mortality for the first 41 patients was a high 7%, however, this represented only 3 deaths in all and it is difficult to make any useful inference in this small group. However, these deaths occurred early in the experience and it may represent the learning curve associated with redo surgery. The time course between the first and second operation has also been calculated and shows a bimodal distribution with an early peak in the first 12 months, followed by a characteristic normal distribution around 4 years post initial symptoms.

By review of the angiograms available on these patients prior to the first operation and prior to the second operation, the possibility of technical fault was sought. In 41 patients reviewed retrospectively, only 1 could be directly attributed to a poor technical procedure.

Another possible cause leading to redo is failure to treat significant lesions at initial operation. This is difficult to assess, particularly when one considers many redo patients had their first procedure when coronary artery bypass graft was in its infancy and

only severe disease was considered worthy of bypass. Lesions of 50% or more are now routinely bypassed, however, review of all available angiograms prior to the first operation revealed an additional 18 vessels would have been grafted by current criteria and this may have meant a reduction of 7 in the number of redo cases subsequently performed.

The more controversial factor alleged to influence coronary artery graft success is the quality of distal runoff vessels. Poor vessels are suggested to be more likely to cause graft failure than healthy ones associated with an isolated disease area. To consider this, all 41 patients had their distal disease graded at time of initial angiogram as good and free of distal disease, mild distal disease, moderate distal disease, severe distal disease. This was correlated with the ultimate graft outcome. Of the 72 grafts performed initially, 35 had blocked at time of re-operation and 4 were severely stenosed (90%+). Of these, 50% were present in hearts where the distal vessels were graded as having mild, moderate or severe distal disease. However, 50% of those with distal vessels graded as good, had blocked or stenosed grafts.

When the number of patients with blocked grafts was considered, 54% had been graded as good were found to have blocked grafts, with 53% graded as diseased were found to have blocks, this failed to illustrate distal vessel disease as a significant factor to distinguish the two groups. Even when allowance was made for possible technical causes for graft failure likely to be present in the first 12 months, the difference was still not significant.

Discussion

These results on a small number of patients are similar to those reported by larger reviews (Fitzgibbon et al, 1986; Bouragassa et al,

1984), which failed to identify angiographic risk factors predictive of subsequent re-operation other than technical or inadequate revascularization.

5.5 CORONARY ARTERY BYPASS SURGERY IN PATIENTS WITH DIABETES MELLITUS

The Framingham Study (Castelli, 1984) demonstrated in diabetic subjects that the relative risk of coronary artery disease was increased approximately two fold in males and four fold in females compared with matched non diabetic subjects. It has been reported that diabetics have more extensive atherosclerosis and increased prevelance of cardiac failure and a poorer prognosis following acute myocardial infarction. In longterm studies, up to ten years following myocardial infarction, diabetics have been shown to have a two fold increased in relative risk of death compared with non diabetics.

It is surprising that review of the relevant literature reveals little information on the outcome of coronary artery surgery in patients with diabetes mellitus who have coronary artery disease. The aim of this review was to assess whether the presence of diabetes mellitus imposed an additional operative risk in patients undergoing coronary artery surgery in South Australia and whether or not this risk was related to the sex of the patients or the nature of the diabetic therapy they were receiving. The earlier review of the first 4001 cases had failed to show it as an independent risk factor, so this study was conducted 7 years later, on a larger patient group with a longer period of follow-up.

Patient Group

Diabetes mellitus has been reported by others as a significant independent risk factor in the development of coronary artery disease and between 5 and 10% of patients undergoing coronary artery bypass graft surgery suffer from diabetes mellitus (Salomon et al, 1983; Devineni and McKenzie, 1985; Johnson et al, 1982; Lawrie et al, 1986). Several reports have demonstrated that such patients have an

increased hospital mortality as well as a reduced longterm survival. Within the Cardiothoracic Surgical Unit at the Royal Adelaide Hospital, the average age of diabetic patients and non diabetic patients at time of review was identical (57 years). However, the male/ female ratio showed twice the number of females in the diabetic group when compared to the non-diabetic group.

The diabetic patient presented with unstable angina in 15% of cases, compared with 10% for the non diabetic group ($p<.01$). Although prior myocardial infarction was the same in both groups, diabetics had more evidence of ischaemia and anterior chest lesions, 23% versus 17% ($p<.01$). Localized stenoses greater than 70% in major coronary arterial systems such as the left anterior descending marginal and the right main arteries, were higher in the diabetic subjects ($p<.05$) and the number of grafts in diabetics was greater than was non diabetics, 2.9 versus 2.6 ($p<.01$), with the hospital stay identical in both groups. What is not clear, is the role of therapy that the patient is receiving or differences between the sexes.

This study was designed to assess the early and late outcomes for 561 consecutive patients operated on in the Cardiothoracic Surgical Unit of the Royal Adelaide Hospital, with a diagnosis of diabetes mellitus, between 1971 and 1988, with respect to the type of diabetic therapy they were receiving at the time of surgery.

Results

The total patient group during this period was 10,506 patients, of which 5% were diagnosed as suffering from diabetes mellitus. The total follow-up was 97% and was achieved with only 17 patients being lost to complete follow-up (mean follow-up 5.6 years). The overall hospital mortality for the total coronary artery bypass graft group during this period was 1.3%, representing 137 deaths in a total patient

group of 10,506 patients. Within the diabetic group which comprised 5% (561 patients, 435 males, 126 females) of the total operative group, the 30 day mortality was 4.8%. Although not significant, the male 30 day mortality was 4.2%, with the female group being 6.3% (p=.058) (Table 16). The total number of deaths in the diabetic group was 124 (21%) over a mean period of follow-up of 5.6 years (range 0-17 years).

When the type of diabetic therapy being taken by the patient was considered, the group comprised 24% on diet alone, 46% on tablets and 30% on insulin. The age of the patients undergoing insulin treatment from within the male group was significantly younger (p<.004), but this was not a significant difference in the female group. Figure 55 shows previously documented actuarial survival curves for the 4,001 coronary artery bypass patients and the results from this study for the diabetic patients when divided into male and female patients. There was a significantly reduced overall survival for the female patients (p<.05) when compared with male patients.

When the treatment being received by each group was assessed, male patients showed no significant difference between diet, tablets and insulin (Figure 56). Diet controlled male patients tended to have a reduced late survival. Female patients however, had a reduced survival if they had diet controlled diabetes (p<.05) (Figure 56), despite no significant difference in age or other variables between the female subgroups. Furthermore, the 30 day hospital mortality for females showed a similar trend, with none of the insulin controlled patients dying, but 3 of 20 (15%) diet controlled and 5 of 60 (8.1%) tablet controlled diabetics dying. This was not significant (p=.058).

The female group showed no significant difference from the male group in age, heart size, previous infarction, contraction of the

TABLE 16

	MALE	FEMALE	p VALUE
AGE	57 years	57 years	p = n.s.
30 DAY MORTALITY	4.3%	6.8%	p < 0.058
INSULIN CONTROLLED	27%	35%	p = n.s.
DIET CONTROLLED	26%	16%	p = n.s.
TABLET CONTROLLED	47%	49%	p = n.s.
MODERATE or SEVERE LV CHAMBER ENLARGEMENT	20%	8%	p < 0.01
INDICATION FOR SURGERY:- CHRONIC ANGINA	80%	73%	p = n.s.
UNSTABLE ANGINA	11%	21%	p < 0.05
OTHER	9%	6%	p = n.s.

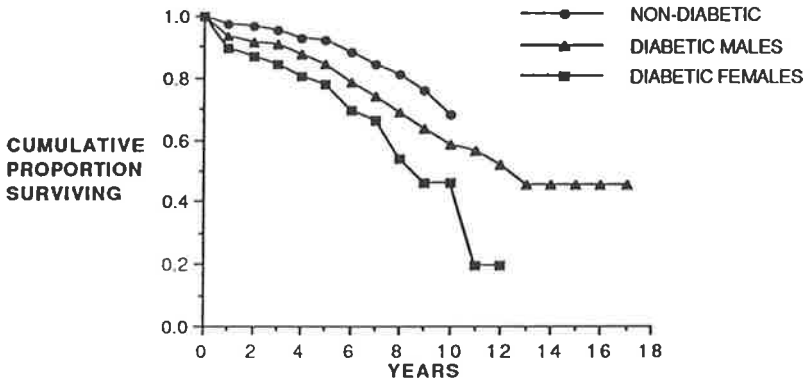

Figure 55: Survival curves for the first 4,001 coronary artery bypass graft patients and the male and female diabetic patients in this study.

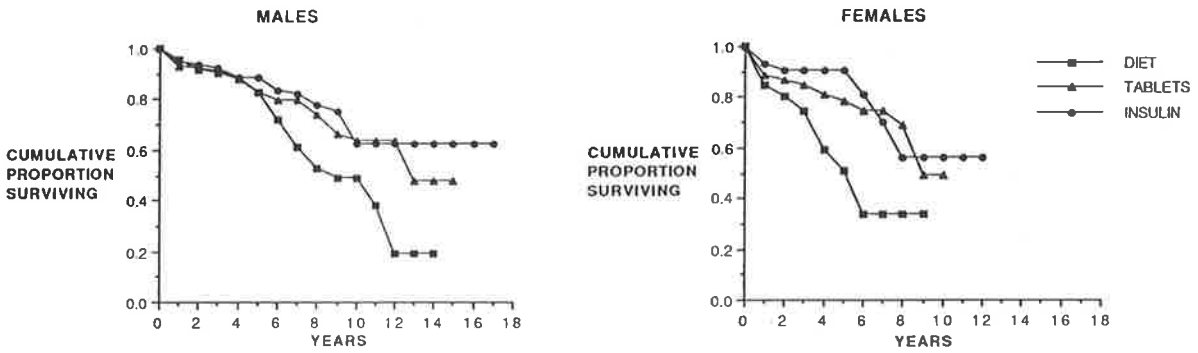

Figure 56: Outcome for male and female patients classified by type of diabetic therapy received.

ventricle, other cardiac pathology or smoking habit at time of surgery. In fact on angiogram, chamber size was generally smaller than males who had smoked more in the past (Table 16). Females did however, have a higher rate of hypertension and an increased incidence of cerebral vascular accident (Table 17) and at the time of surgery had an increased incidence of unstable angina (Table 16). Amongst the survivors, the insulin treated diabetics had a significantly higher rate of diabetic complications, including retinopathy ($p<.001$) peripheral vascular disease ($p<.001$) and stroke ($p<.05$).

Angina amongst the 430 survivors is listed in Table 17. In both males and females the pattern of return of angina was similar, with 44% of patients re-developing angina within 20 months following surgery. The angina when it returned, was described as: better in 58% of patients, the same in 21% and worse in 21%. Pre-operative levels of breathlessness were the same in both males and females, but improved post-operatively in both groups (Figure 57).

Work levels in surviving diabetic patients at time of review are shown in Figure 58 with no significant difference between the male and female patients.

TABLE 17

	MALE	FEMALE	p VALUE
PRE-EXISTING ANGINA	85%	91%	p = n.s.
PERIOD FREEOF ANGINA	98%	93%	$p < 0.05$
RETURN OF ANGINA	38%	52%	$p < 0.02$
CEREBRO-VASCULAR ACCIDENTS	10%	18%	$p < 0.05$
HYPERTENSION	35%	61%	$p < 0.0001$
CURRENTLY SMOKING	11%	6%	p = n.s.

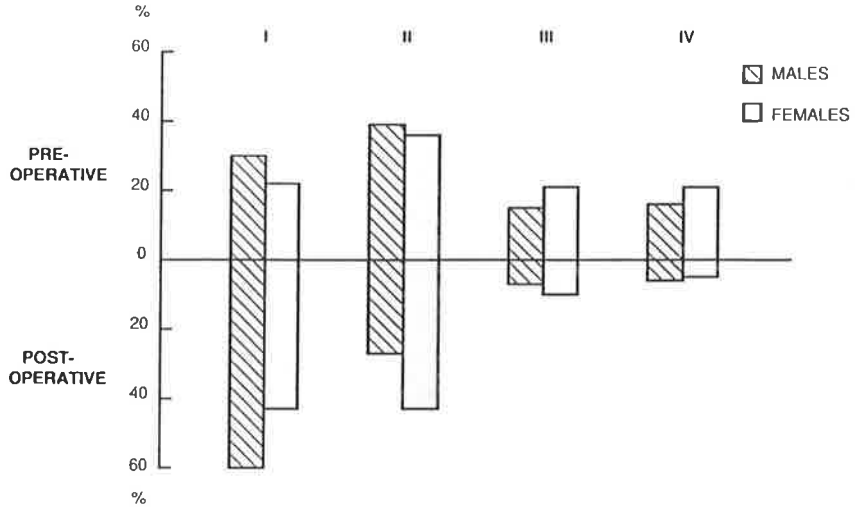

Figure 57: Dyspnoea pre-operatively and post-operatively in male and female diabetic patients undergoing coronary artery bypass grafts.

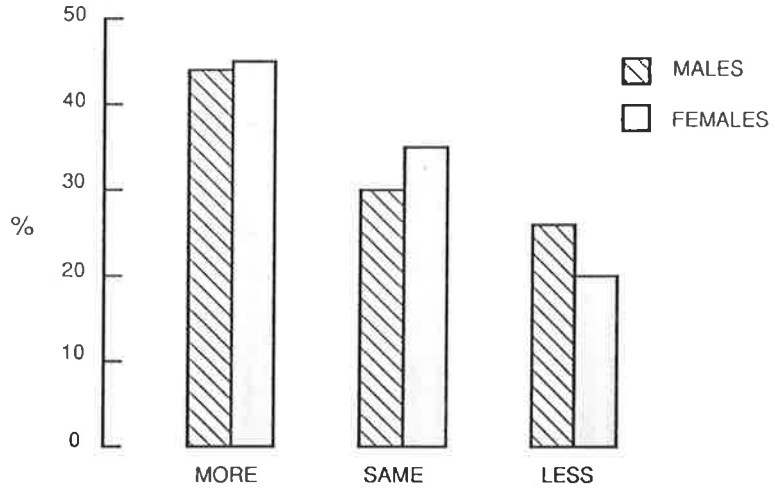

Figure 58: Work levels reported in surviving diabetic patients.

5.6 CORONARY ARTERY BYPASS GRAFT COMBINED WITH ANOTHER CARDIAC PROCEDURE

As experience with coronary artery vein bypass surgery increased, it was combined with other cardiac procedures. The effect of adding a coronary artery bypass graft to a valve replacement or an aneurysm repair both on hospital and long term survival as well as symptoms was assessed by this study.

Patient Group

Between 1971 and 1987, 658 patients (82% male, 18% female, mean age 60.4 years, range 31.6-83.1 years) underwent a coronary artery bypass graft with an additional cardiac procedure. The mean period of follow-up for the group was 4.5 years with 98.5% of patients successfully located. The total coronary artery experience of the unit at that time is shown on Table 18 with the associated cardiac procedure performed. The associated hospital mortality for each procedure is indicated in Table 19. The annual incidence of combined procedures is shown in Figure 59 and shows a marked increase towards the end of the review period.

Operative Details

The time on cardiopulmonary bypass was less than 80 minutes for 460 patients, with a further 100 between 80-100 minutes. Only 42 patients remained on bypass for greater than 120 minutes. Left ventricular function was unimpaired in 24% of patients, slightly impaired in 24%, moderately impaired in 38% and severe impairment was present in 14%. Similarly, pre-operative X-rays showed no cardiac enlargement in 43% of patients, mild enlargement in 24%, moderate enlargement in 26% and gross enlargement in 7%. Angiographically assessed ventricular function was normal in 30% of cases, moderately impaired in 15%, severe impairment in 13%, an area

TABLE 18

NUMBER OF CASES PERFORMED DURING REVIEW

Total No. CABG Alone	1971-1987	9462	93.5%
CABG and			
LVA Excision	1971-1987	135	
LVA Plication	1971-1987	166	
Valvuloplasty	1971-1987	6	658 patients
AVR	1971-1987	257	6.5%
MVR	1971-1987	86	
Other	1971-1987	8	
Total number of cases		10120	

TABLE 19

HOSPITAL MORTALITY FOR COMBINED PROCEDURES

OTHER PROCEDURE PERFORMED WITH CABG	NUMBER OF PATIENTS	HOSPITAL MORTALITY	%
Ventricular Aneurysm Excision	135	6	4%
Ventricular Aneurysm Plication	166	6	4%
Valvuloplasty	6	0	0%
AVR	257	4	2%
MVR	86	5	6%
Other	8	3	38%
Overall Group	658	24	3.6%

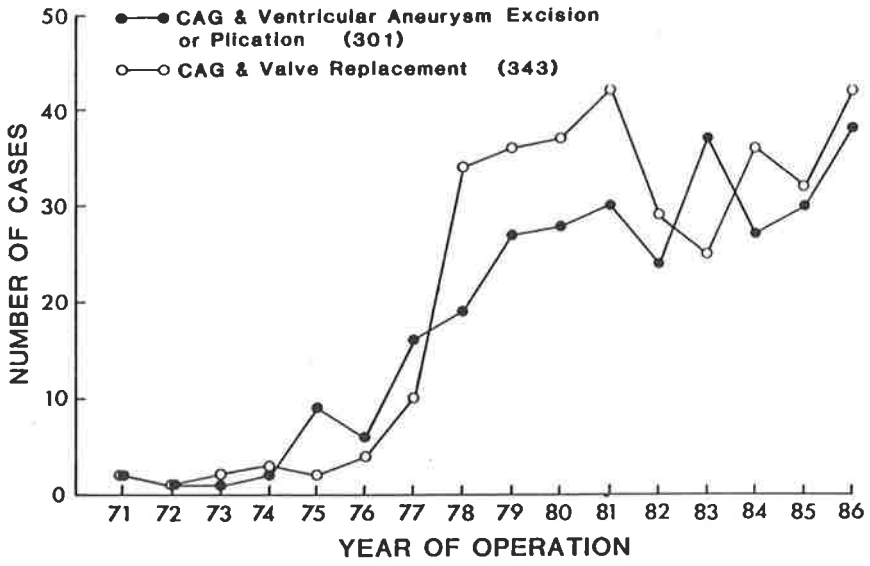

Figure 59: Number of cases performed per annum of coronary artery bypass graft with associated aneurysm excision or plication or valve replacement.

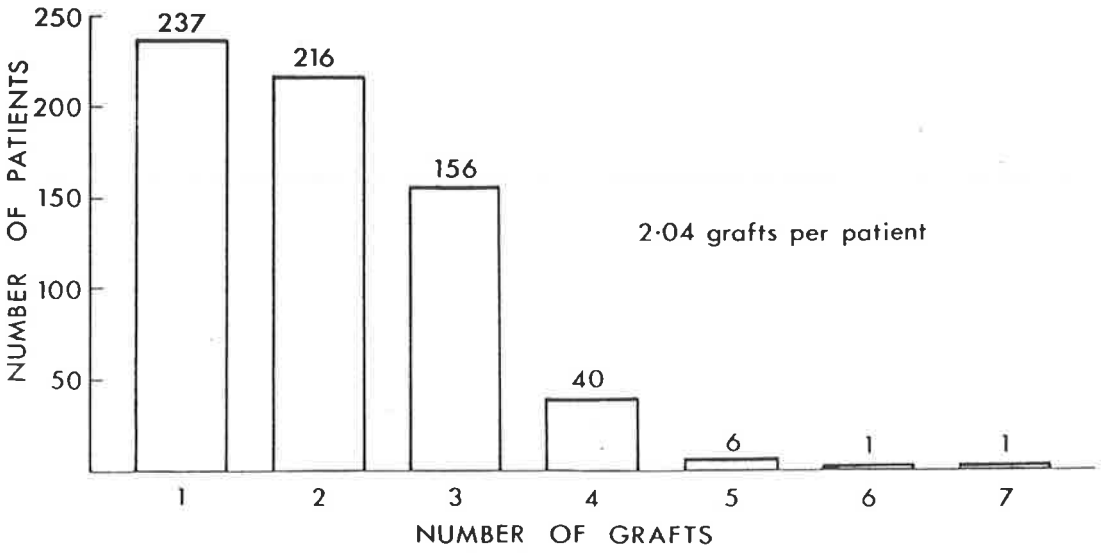

Figure 60: Number of grafts inserted at time of combined procedures in 658 patients.

of single impairment in 35%, and multiple areas of impairment in 7%. A mean of 2.04 grafts were inserted per patient (Figure 60).

Survival

The actuarial survival for the patient group is shown in Figure 61 with no significant difference between the male and female patients. The cause of death in 198 patients at time of follow-up is shown on Table 20, with the contributing proportion from the coronary artery bypass graft and valve patients and coronary artery bypass graft and ventricular aneurysm surgery. Figure 62 illustrates the individual survival of the various combined procedures, with no significant difference between the groups. When survival analysis for aortic or mitral valve replacements alone was compared with valve replacement and coronary artery bypass graft, no significant difference was found, suggesting that the addition of a coronary artery bypass graft does not increase the risk of the surgery, nor can it be demonstrated to improve the longterm survival (Figures 63, 64).

A comparison group for aneurysm excision and aneurysm plication with coronary artery bypass graft and coronary artery bypass graft surgery is not readily obtainable, but when compared with patients with moderate or diffuse ventricular contraction impairment undergoing coronary artery bypass graft alone, no significant difference was found (Figure 65).

Complications

Haemorrhagic complications (Figure 66) and embolic complications (Figure 67) requiring hospitalization in survivors, occurred, depending on the addition of a valve and anticoagulant therapy given, at a similar incidence to isolated aortic or mitral valve replacement patients. Of interest was that female patients had a significantly greater incidence of haemorrhagic complications

TABLE 20

CAUSE OF DEATH IN PATIENTS WITH CABG AND OTHER PROCEDURES

	Total Group	Valve Replacement	Ventricular Aneurysm
No. of Patients	198	94	100
Cardiac	62%	54%	71%
Hospital	12%	12%	12%
CVA	8%	10%	7%
Cancer	6%	6%	5%
Unknown	6%	9%	3%
Haemorrhage	3%	4%	2%
Endocarditis	3%	5%	-

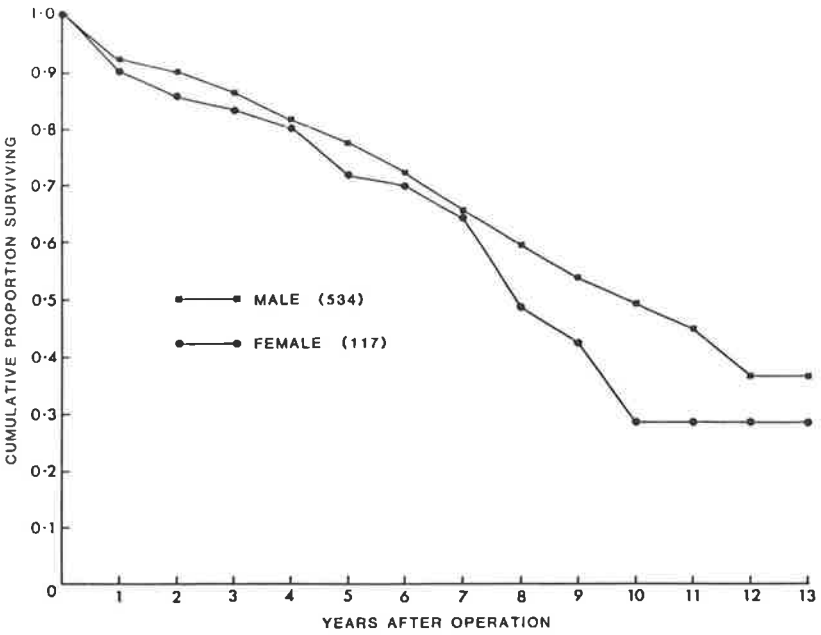

Figure 61: Overall survival for male and female patients following combined procedures.

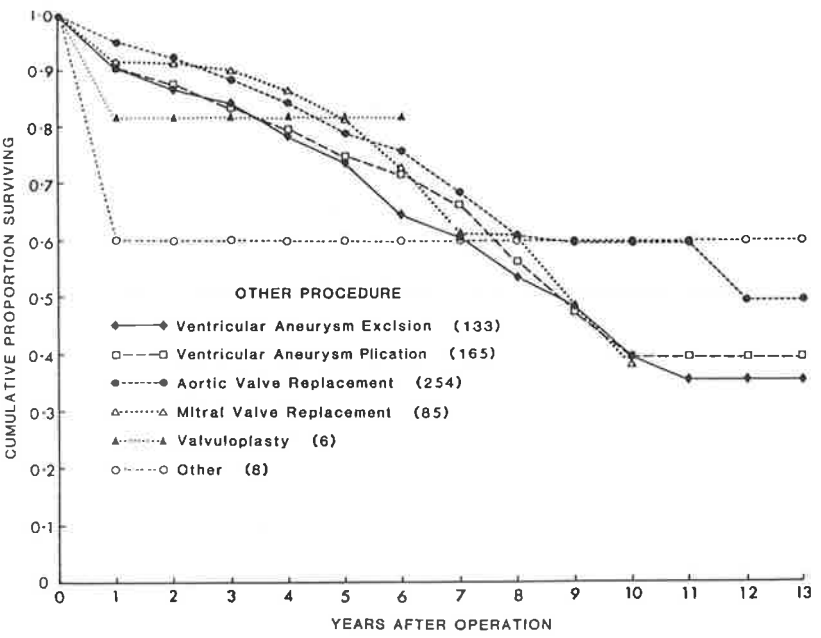

Figure 62: Overall survival for patients undergoing coronary artery bypass surgery and another cardiac procedure.

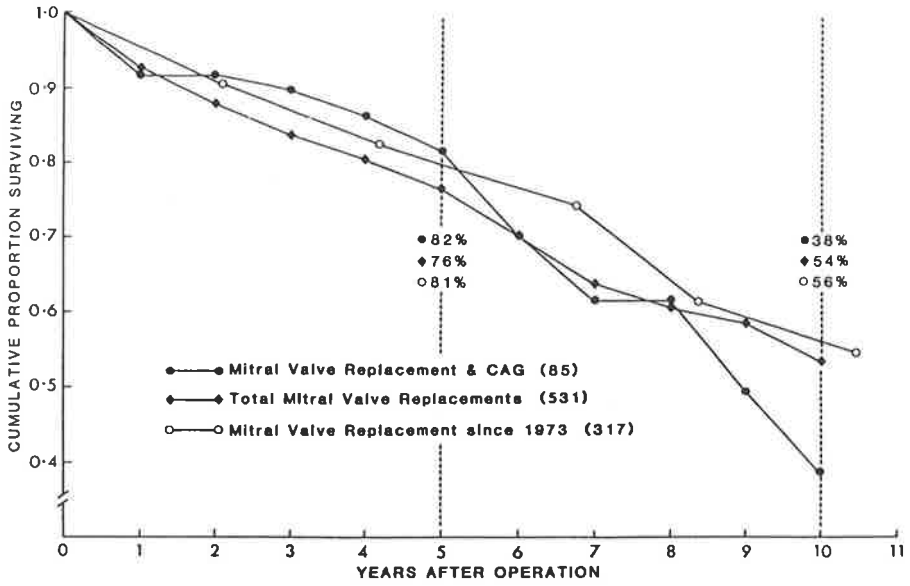

Figure 63: Survival in patients with a mitral valve replacement alone and with associated coronary artery bypass surgery.

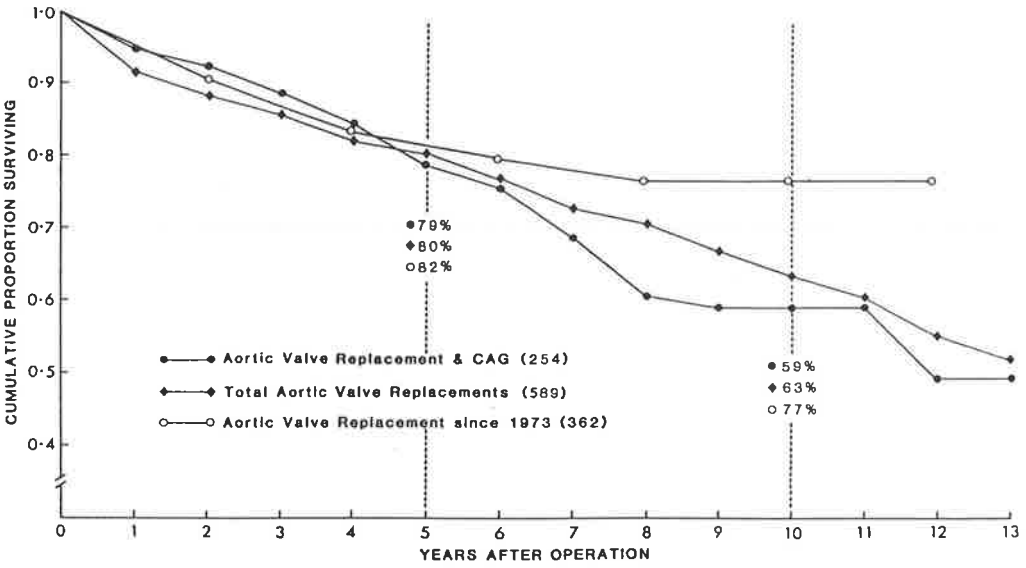

Figure 64: Survival in patients with an aortic valve replacement alone and with associated coronary artery bypass surgery.

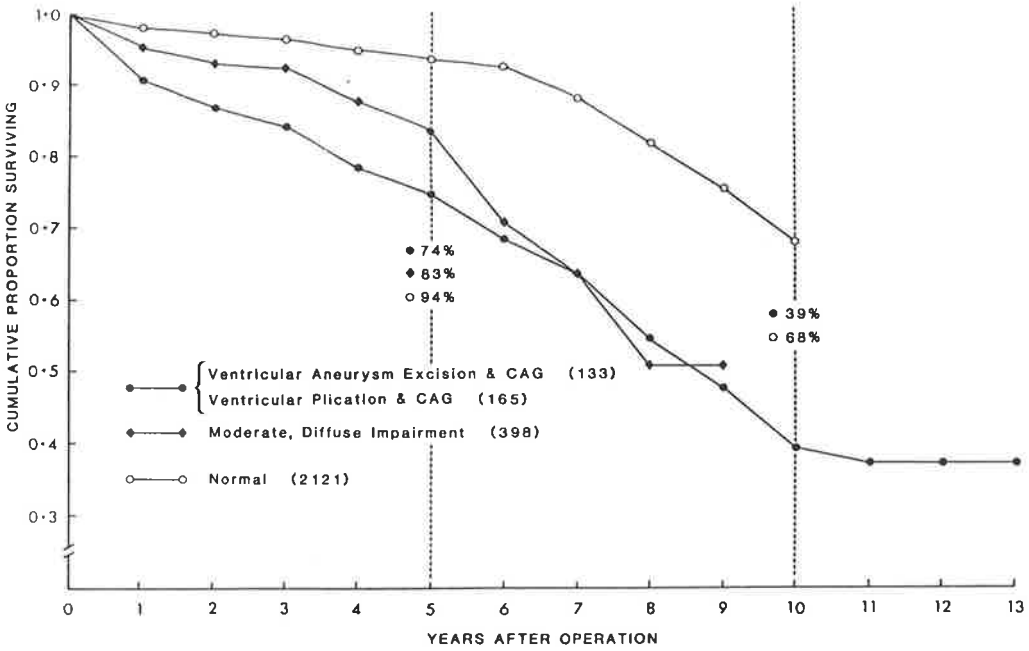

Figure 65: Survival for patients undergoing either ventricular aneurysm excision or ventricular plication and coronary artery bypass surgery, compared with patients undergoing coronary bypass surgery only having normal or impaired ventricular function.

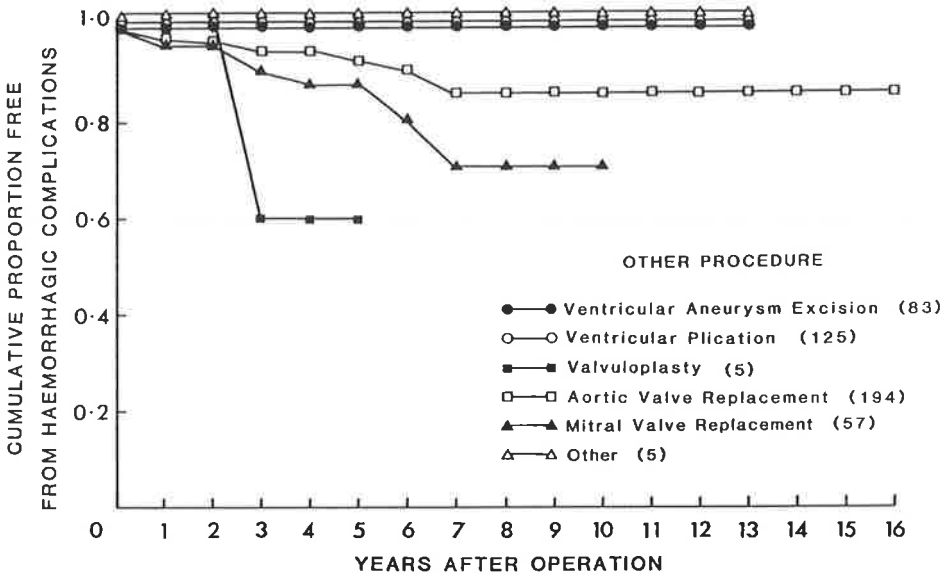

Figure 66: Overall time to haemorrhagic complications by types of additional procedure performed with coronary artery bypass surgery.

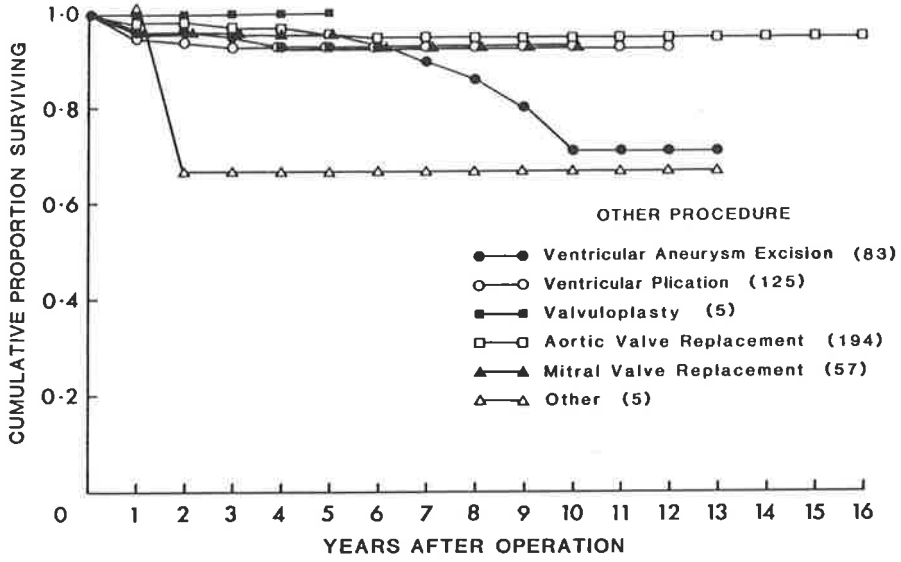

Figure 67: Overall time to embolic complications by types of additional procedure performed with coronary artery bypass surgery.

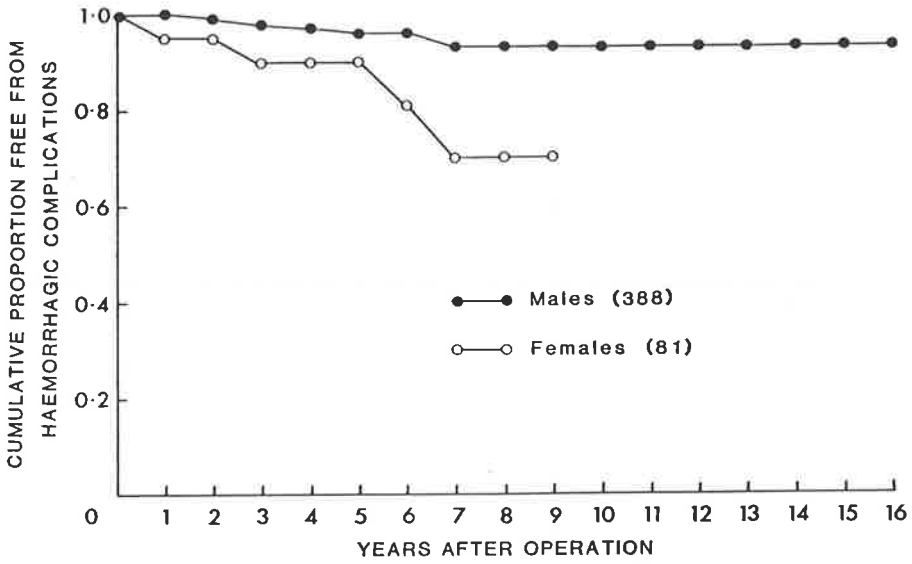

Figure 68: Haemorrhagic complications requiring hospitalization in males and females following coronary artery bypass surgery with another procedure.

($p<.0001$), and for which no apparent explanation exists at present (Figure 68).

Symptomatic Outcome

In the 451 survivors, breathlessness was significantly improved (Figure 69). Activity was "better" in 330 patients (73%), the "same" in 75 patients (17%) and "worse" in 46 patients (10%). Angina was present in 66% of patients prior to surgery, but in only 27% at time of follow-up. Individual differences were not detected between operative sub-groups.

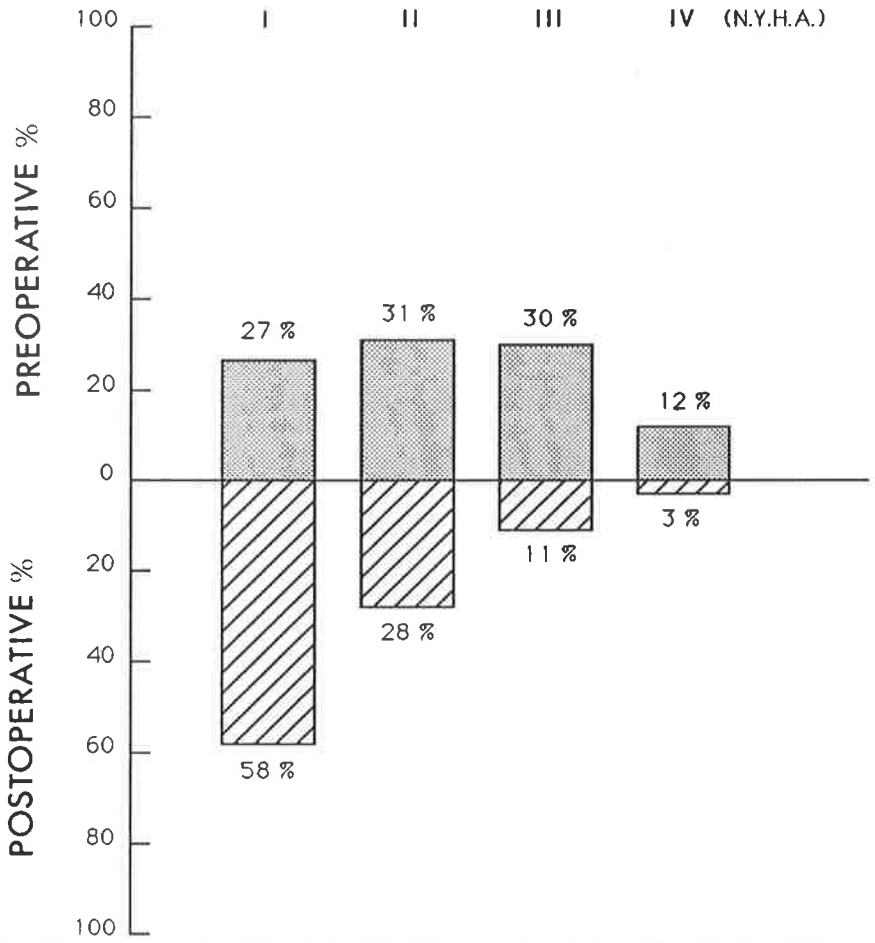

Figure 69: Breathlessness before and after coronary artery bypass surgery with another procedure.

5.7 RESULTS FOLLOWING CORONARY ARTERY ANGIOPLASTY

In order to determine the outcome, complications and need for subsequent surgery following coronary artery angioplasty, the results following the first 1155 angioplasties performed in the Royal Adelaide Hospital Cardiovascular Investigation Unit were determined. It is not the purpose of this study to draw comparisons between andgioplasty techniques or results, but rather to see how the practice of angioplasty relates to CABG. A questionnaire was sent to all patients who had undergone angioplasty (Appendix VII). This questionnaire sought information similar to that already acquired for the coronary artery patients in the initial follow-up of the first 4,001 patients (Appendix III). However, the questionnaire was somewhat refined and shortened in order to gain improved patient compliance. A 97% complete follow-up was obtained for the patient group. Fourteen patients had incomplete data and 21 although known to be alive refused or were unable to reply. No patient had a follow-up of less than 6 months.

Clinical Results

The immediate clinical angiographic success for the 1155 procedures was 91%. The left anterior descending 94% success in 578 patients, right coronary artery 85% success in 267 patients, left circumflex 90% in 139 patients, 91% in 155 multiple artery procedures, 100% in two left main coronary arteries and 91% in 18 coronary artery bypass graft dilatations. In these procedures the complication rate was low, there were 3 deaths (0.3%), there were 17 myocardial infarctions (1.5%), 18 patients had a CK rise without new Q wave (1.5%), 16 patients had to have an emergency coronary artery bypass grafting (1.5%), 17 patients had ventricular fibrillation without sequelae (1.5%), and 12 had vascular complications (1.0%). Of the

original 1155 procedures, 127 were repeat percutaneous transcardiac angioplasties. Of the 1155, the average age was 55.9 years and 73% were male. The age ranged from 24 to 79 years.

Mortality

Twenty-seven patients have died, 17 had a cardiac cause and 10 had a non cardiac cause. Three died (0.3%) within 24 hours of angioplasty. The total mortality was 2.6%. This was 2.2% in those patients who had only one angioplasty and 3.9% in those patients who had two or more angioplasties. Of the 1028 primary procedures, 152 (15%) had a second procedure. One hundred and twenty seven of these patients were included in the 1155 procedures. Twenty five patients had a second angioplasty since the cut off date of the follow-up, (June 30th, 1988). The study was commenced on the 1st January, 1989 giving all patients at least 6 months follow-up. One hundred and forty (14%) had a coronary artery bypass grafting, at sometime following angioplasty. Eleven percent of patients who had only 1 angioplasty proceeded to coronary artery bypass grafting, whereas 23% of 93 patients who had a second angioplasty proceeded to coronary artery bypass grafting. Sixteen patients had a coronary artery bypass grafting as an emergency procedure (performed within 24 hours of angioplasty). For ease of analysis the patients are divided into three groups:

Group A - those who had 1 angioplasty, no coronary artery bypass grafting and were alive (899 patients).

Group B - those patients who had 2 or more angioplasties, no coronary artery bypass grafting and were alive (93 patients).

Group C - those who had coronary artery bypass grafting or had died (163 patients), were thus excluded from further analysis.

On analysis of the arteries (left anterior descending system, left circumflex system, right coronary system and multiple vessel dilatations) there were no significant difference between arteries or multiple vessels as to whether the patient needed a subsequent angioplasty or coronary bypass grafting.

Myocardial Infarction

Ten percent of patients were re-admitted to hospital at some time after the angioplasty because of chest pain. This admission was unrelated to another procedure. If admission was for more than a few days and myocardial infarction was suspected, details of the admission confirming myocardial infarction was sought from the treating doctor. In group A patients this was 3.7%, in group B patients 4.6% and in group C those who had surgery or death it was 18%. Most of the post-angioplasty myocardial infarction occurred within the first year. It is not apparent why the high patient percentage which reported myocardial infarction occurred in those who had surgery. However, 50% of those progressing to emergency surgery did have a limited myocardial infarction.

Angina

For group A patients, 86% reported having angina before the first angioplasty, 92% had a period free of angina after angioplasty, but 51% said they had recurrence of chest pain at time of follow-up. They had not sought further intervention for this chest pain. Of those who had had two angioplasties (group B), 91% had angina before the first angioplasty, 97% had a period free of angina after the first and second angioplasty, but 37% had some late recurrent angina. In those who had surgery (group C), 95% had angina before angioplasty, 72% had a period free of angina after angioplasty, but 93% had recurrence of reported angina before surgery. The severity of the angina was not

sought in this study. Most of the angina occurred within the first 10 months following angioplasty (80%).

Breathlessness

There was an overall increased ability to exercise without breathlessness following angioplasty. With those who described breathlessness at rest, it was 13% before angioplasty but only 3% afterwards. There was also improvement in those who had breathlessness with light exercise from 23% to 9%, similarly with moderate exercise, with 62% of the patients after angioplasty becoming breathless with strenuous exercise compared with 36% before

Activity

The activity experienced by the patients in general was improved following angioplasty, 42% in group A and group B said they could do the same amount of activity, 37% in group A and 40% in group B said they could do more activity, whereas 21% in group A and 20% in group B said that they could do less.

Work Participation

As far as could be determined there was no reduction in the participation in the workforce.

Medication

Fifteen percent of the total group were taking no medications at time of review, 15% were taking some form of cardiac medication which could well have been for hypertension, but it was not possible to determine the precise reason for the medication prescribed. Twenty-seven percent were taking aspirin only, and 34% aspirin plus some other form of cardiac medication. 1.6% describe some form of complication from the medication (2 had upper gastrointestinal haemorrhage, 9 had developed an ulcer due to aspirin and 5 had a

cerebrovascular accident).

Discussion

The precise indications for coronary artery angioplasty or CABG remain controversial, however it appears to offer a safe option in many patients with cardiac chest pain (Willman, 1984). The procedure is also apparently cost effective when compared to CABG (Jang et al, 1984) and when chest pain is relieved, demonstrates a high level of return to work with 90% still working 1.4 years after angioplasty in a group of patients 60 years or younger (Holmes et al, 1984). When either subsequent or emergency CABG is required in patients following angioplasty, this appears to be possible without significant added mortality or morbidity (Akins and Block, 1984; Foster et al, 1984b; Talley et al, 1989).

This study would support these earlier findings and also includes the expected early poor results associated with not only the learning curve of any new procedure, but also the difficulties in defining patient selection criteria (Kelsey et al, 1984; Meier and Grentzig, 1984; Talley et al, 1989).

The occurrence of CABG after the introduction of coronary artery angioplasty had an initial decrease after the inception of the technique. In 1978, Gruentzig (Gruentzig et al, 1979) reported that of their first 50 patients, CABG was performed in 17 (34%) within 6 months of the angioplasty. Seven (14%) of these patients requiring emergency revascularization. Similar results were reported in the National Heart, Lung and Blood Institute's (NHLBI) registry, which compiled data from 1977 to 1982 (Detre et al, 1988). In this cohort the rate of referral for CABG was reduced to a total of 5.6% with only 3.4% requiring an emergency operation. This would indicate better patient selection and more experienced operators. The rate of

emergency operation compares well with our 1.5% emergency rate, but subsequent CABG was 11%. Our overall mortality at about 1 year of 2.6%, compares with the cumulative reported experience of others of 3.2% (Detre et al, 1989).

Symptomatic outcome following angioplasty in our group of patients for angina, breathlessness and general activity is comparable to that reported by others in the NHLBI (Detre et al, 1988; 1989), which also showed similar reliance on medications. Overall activity, angina and breathlessness at one to two years after treatment was not as favorable as found in CABG patients in either our study (Section 5.1) or by others (CASS, 1983a).

As techniques and experience improve coronary artery angioplasty will continue to play an increasing role in management of coronary artery vascular stenosis.

SECTION VI

SUMMARY AND CONCLUSIONS

PROSTHETIC VALVE REPLACEMENT SURGERY

Despite the ever changing options available in prosthetic valves, the Cardiothoracic Surgical Unit of the Royal Adelaide Hospital has tended to follow a conservative approach preferring to use mechanical valves of the Starr-Edwards or Bjork-Shiley type. While changes in the details of the valve construction have occurred over the 25 year review period the basic design of both valves remains fundamentally unaltered. This study was unable to demonstrate any significant survival or complication advantage between the various types of Starr-Edwards or Bjork-Shiley valves used. There was a statistically significant difference between the incidence of thromboembolic complications with the aortic Bjork-Shiley valve when compared with the aortic Starr-Edwards valve over a similar time period however, the clinical significance of this remains unclear. It is important to note the difficulties in comparing such complications. In addition, when performing a large number of statistical tests, occassionally by chance alone a result will be found to be statistically significant.

Over the period of review both the mitral and aortic surgery has been associated with a decrease in hospital mortality, which has been in part due to improved techniques of cardiac surgery and also improved post-operative care. The actuarial survival observed with both aortic and mitral surgery highlights the seriousness of the underlying pathology associated with these conditions. Although

death certificates are a poor substitute for autopsy data, the 6% of all deaths attributed to endocarditis in the mitral valve replacement group emphasizes the seriousness of this complication. Re-operation occurring in the mitral Starr-Edwards group was in 4 of the 6 cases due to endocarditis. The poor outcome associated with patients suffering from increasing grades of dyspnoea is known, however, it illustrates the necessity for an early decision to operate before the condition progresses, with the associated decrease in longterm survival. The poor outcome in the presence of atrial fibrillation reflects the increasing liklihood for embolic events in such patients.

Only severe complications in survivors have been assessed. This avoids collecting retrospective data on deceased patients, however, it ignores a significant percentage of patients who undergo surgery. By looking at complications requiring hospitalization the bias of patients reliably reporting minor complications is removed. Hospitalization generates the necessary documents to provide evidence of these complications and also provides an accurate date at which complications occur, so that actuarial analysis can be performed.

Reports alleging wide superiority of one prosthetic valve type over another should compare valves inserted contemporaneously, preferably within the same institution. These studies support the satisfactory outcome reported with the Starr-Edwards prosthesis in the mitral position by others (Section II).

Multiple valve replacements carried an hospital mortality of 9%. However, once discharged from hospital, the longterm survival was equivalent to the mitral valve replacement group alone.

Until clear changes in valve superiority can be demonstrated, the Cardiothoracic Surgical Unit, at the Royal Adelaide Hospital is likely to continue with its use of Starr-Edwards ball caged valves in

the mitral position and increasingly use the Bjork-Shiley Monostrut valve for aortic replacements.

PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFT SURGERY

The study of the first 4,001 patients undergoing coronary artery bypass graft surgery within the Royal Adelaide Hospital, from 1971 to 1982, provides a commentary on an evolving operation. The operation is associated with a low mortality rate, excellent symptomatic relief, survival for the first 5 years after surgery also appears to be excellent. Survival data shown in this study beyond that time cannot be accurately calculated until more patients with longer follow-up are available. In the period of review the age of patients, the number of grafts inserted and the proportion of women undergoing operation has risen. In the same period, hospital mortality and the duration of cardiopulmonary bypass has fallen. Symptomatic relief has persisted over a prolonged period of time. A poor symptomatic outcome was usually obvious in the first 12 months after operation. The rate of second operations is similar to that reported elsewhere, as is the peri-operative infarction rate.

Although the cost effectiveness of such surgery should be studied, the operation must first be considered on the basis of symptomatic relief. This has been established from the results presented. Others have attempted to demonstrate its effect on longivity against possible control groups (CASS, 1983a). It can be reasonably deduced that the initial expense of the procedure in the Australian community is worthwhile in the longterm and may result in cost savings, although it must be acknowledged that the diagnosis of heart disease and the subsequent major surgery can precipitate early retirement from the workforce which appears to occur in about

4% of the patient group studied.

This study has not been able to clearly identify pre-operative risk factors that predispose to redo surgery, other than inadequate bypass grafting at the time of primary operation, or technical errors. Patients who undergo redo surgery have similar long term survival, when compared with first-time patients after the hospital mortality is excluded. The challenge remains to reduce the hospital mortality for such patients by improved selection and operative techniques. This is particularly important as about 16% of patients 10 years after their first CABG, will have undergone redo surgery.

The management of diabetic patients requiring coronary artery bypass graft surgery remains however a difficult problem. These patients suffer from an increased hospital mortality, which is three times that of the general patient group. Further, their longterm survival is significantly shorter than that of the general patient group. Whether coronary artery bypass graft surgery has any role to play in the shortening of the survival of these patients in the longterm is not clear, nor is it likely to be resolved, as an appropriate control group of non surgically treated diabetics or medically treated diabetics is not possible to obtain.

Within the diabetic group the nature of the therapy the patient receives, be it diet, tablet or insulin may have significant effect on the longterm outcome for these patients. Female patients controlled by diet tend to have a higher hospital and longterm mortality when compared with the tablet and insulin group and this trend is present also in males. This is despite no major difference between the groups at time of surgery. It may be that peri-operative surveillance of diet control diabetes is not as complete as their insulin controlled counterparts. After discharge, attending physicians and local doctors

may not monitor their conditions as closely, when they are not placed on regular insulin or tablets. If this hypothesis is correct, then it is a correctable factor.

Further, female diabetics also have a poorer outcome than males following surgery, with an increased rate of return of angina, higher stroke rate and higher longterm mortality. The only significantly different post-operative risk factor between males and females found in this study, was a higher incidence of women known to be hypertensive and receiving anti-hypertensive medication. Whether this finding explains the differences is not certain.

Despite the finding that the insulin dependent group had a higher rate of complications, such as vascular disease of the eye, peripheral vessels and cerebral circulation, they did not have an decreased short or longterm survival. This would suggest that despite the more aggressive peripheral vascular disease suffered by insulin dependent diabetic patients, this does not lead to an increased mortality for these patients following coronary artery surgery.

This study suggests that patients who are diabetic are at increased risk at time of surgery from coronary artery disease and that females are at greater risk than males. Diet controlled diabetics need to be given greater attention in the peri-operative period following discharge, as they seem to be a group at increased risk. Further work is required to define the particular risk factors within this group.

When patients have a coronary artery bypass graft performed simultaneously with valve replacement or aneurysm plication, the addition of the bypass graft does not appear to adversely influence the long term survival. It is difficult to have adequate control groups to make useful comparisons in such situations, but the data in this

study would support adding a coronary artery bypass graft, if the surgeon felt it was clinically indicated on symptomatic grounds.

Coronary artery angioplasty has experienced increasing popularity, in part because of the ease with which it can be performed and also the fact that major surgery is not required. The results presented would indicate that angioplasty can be performed safely in an experienced centre however, in a situation of repeat angioplasty patients, there is often a rapid progression to surgical treatment. Only 16 patients required emergency coronary artery bypass grafting as a result of 1155 angioplasties. Eleven percent of patients having only an initial angioplasty proceeded to surgery during the period of review, whereas 23% of 93 patients requiring a subsequent angioplasty proceeded to coronary artery bypass grafting. It may not be appropriate for all patients to be subjected to repeat angioplasties, when it is clear that the disease is unlikely to be controlled for a prolonged period following angioplastic dilatation.

While the debate still continues as to the need of a cardiac surgical facility in the institutions performing angioplasty, it is important to note the low mortality (0.3%) and successful emergency surgery performed in this group of patients. Whether or not similar results can be obtained where the patient is required to be transferred to a centre with cardiothoracic surgical facilities is unknown.

The symptomatic outcome following angioplasty with respect to activity level, breathlessness and angina, is not as satisfactory as following coronary artery bypass surgery. However, this must be offset by not only the lower cost, but also the apparently lesser impact on employment, not only in time off work, but also premature retirement.

APPENDIX I

CARDIAC FILE

UR: NAME: OP. DATE: B/P NO: SEQ. NO:

1.	SEX	1 Male	2 Female							6
2.	DIAGNOSIS	1 Cong.	2 Acq	3 Con/ Acq	4 NAD					7
3.	CONGEN. Major	1 PDA	2 Coarc	3 VSD	4 ASD	5 Fallot	6 PS	7 VascR	8 Other	8
4.	CONGEN. Secon.	1 PDA	2 Corac	3 VSD	4 ASD	5 Fallot	6 PS	7 VascR	8 Other	9
5.	CONGEN. Tert.	1 PDA	2 Coarc	3 VSD	4 ASD	5 Fallot	6 PS	7 VascR	8 Other	10
6.	ACQUIRED Major	1 Mitral	2 Aortic	3 Tricus	4 AorAn	5 CAD	6 ConPer	7 CHB	8 Other	11
7.	ACQUIRED Secon.	1 Mitral	2 Aortic	3 Tricus	4 AorAn	5 CAD	6 ConP	7 CHB	8 Other	12
8.	ACQUIRED Tert.	1 Mitral	2 Aortic	3 Tricus	4 AorAn	5 CAD	6 ConP	7 CHB	8 Other	13
9.	MITRAL	1 MS	2 MI	3 MS/MI						14
10.	AORTIC	1 AS	2 AI	3 AS/AI						15
11.	DATE OF BIRTH:									16–21
12.	WEIGHT IN KILOGRAMS:									22–24
13.	HOSPITAL	1 RAH	2 ACH	3 QEH	4 RGH	5 FMC	6 Modb.	7 Other		25
14.	NO. OF PREVIOUS CARDIAC OPERATIONS:	1	2	3	4	5				26
15.	DYSPNOEA	0 Unk.	1 Gr.I	2 Gr.II	3 Gr.III	4 Gr.IV				27
16.	SIG. OTH. DISEASE	1 Lung	2 Kidney	3 GasInt	4 Cerbr	5 Multi	6 Malig		8 Other	28
17.	SYNCOPE	1 Yes	2 No							29
18.	PREVIOUS MYOCARD. INFARCT	1 Yes	2 No							30
19.	ANGINA	0 Unk.	1 Gr.I	2 Gr.II	3 Gr.III	4 Gr.IV				31

20.	CYANOSIS	1 Cent.	2 Peripheral							
21.	HIS.RH. FEVER	1 Yes	2 No							
22.	EMBOLISM	1 Yes	2 No							
23.	E.C.G.	1 Norm	2 LV+	3 RV+	4 LV/RV+					
24.	E.C.G. Rhythm	1 Sinus	2 AtFib	3 CHB	4 Flutter				8 Other	
25.	E.C.G. Partial Block	1 Right	2 Left	3 PR Interval						
26.	X-RAY Left	1 Norm	2 LA+	3 LV+	4 LA/LV+					
27.	X-RAY Right	1 Norm	2 RA+	3 RV+	4 RA/RV+					
28.	X-RAY Lung	1 Norm	2 Pleth Grl	3 Pleth GrII	4 Reduc	5 Periph Shtdn	6 Basal Shtdn	7 Pulm Cong	8 Venous	
29.	PRESSURE LA mmHg									
30.	PRESSURE RV mmHg									
31.	a). Shunt R-L			1 Yes	2 No					
	b). Shunt L-R									
	c). Bi-directional Shunt			1 Yes	2 No					
32.	PRIMARY LESION GRADIENT: (P+A)									
33.	PULM/ART RESIST	0 Unk	1 0-8	2 8 upwards						
34.	INVESTI- GATION	0 Unk	1 Cath	2 Angio	3 Cath/Angio					
35.	SURGEON	0 Unk	1 HDS	2 JHB	3 JPR	4 DRC	5 JLW	6 IKR	7 JS	8 Other
36.	OPERATION	1 Clos	2 Left Heart	3 HL/BP (Melr)	4 Atrial Well	5 Surf Hypo	6 Bubbl	7 Membrane		

37.	OPERATION	1 Explor	2 Palliat	3 Corrct	4 Multiple						
38.	PALLIAT OP	1 Blalck	2 Pott's	3 Glenn	4 Bl-Han	5 Pacemaker			8 Other		
39.	CORREC. Primary (I)	1 Valvot	2 Valv Plasty	3 Valve Repl	4 Intra card Sh/Clos	5 Fallot Repair	6 Coarc Repair	7 Aortic Resect	8 Divisn PDA	9 Lig PDA	
40.	CORREC. Primary (II)	1 Single VGraft		3 LV Resec	4 Double VGraft	5 Triple VGraft	6 Quad VGraft	7 Quin or +	8 Other		63
41.	CORREC. Secon. (I)	1 Valvot	2 Valv Plasty	3 Valve Repl	4 Intra Card Sh/Clos	5 Fallot Repair	6 Coarc Repair	7 Aortic Resect	8 Divisn PDA	9 Lig PDA	64
42.	CORREC. Secon. (II)	1 Single VGraft		3 LV Resec	4 Double VGraft	5 Triple VGraft	6 Quad VGraft	7 Quin or +	8 Other		65
43.	CORREC. Tert. (I)	1 Valvot	2 Valv Plasty	3 Valve Repl	4 Intra Card	5 Fallot Repair	6 Coarc Repair	7 Aortic Resect	8 Divisn PDA	9 Lig PDA	66
44.	CORREC. Tert. (II)	1 Single VGraft		3 LV Resec	4 Double VGraft	5 Triple VGraft	6 Quad VGraft	7 Quin or +	8 Other		67
45.	GRAFT MATERIALS	1 Autogt	2 Homogt	3 Hetgt	4 Synth	5 Combin					68
46.	SYNTHETICS	1 Dacron	2 Teflon	3 Nylon	4 Ivalon	5 Bahn. Cusp	6 Starr-EdwVv	7 P/Mkr	8 Other Vv		69
47.	HYPO-THERM	1 Norm 35-37°	2 Mod 28-35°	3 Severe < 28°							70
48.	PERFUSION TIME (minutes)										71-73
49.	GRADE OF MAJOR LESION	1 Gr.I	2 Gr.II	3 Gr.III							74
50.	CALCIUM	0 Unk	1 Yes	2 No							75
51.	POST-OP HAEM.	0 Unk	1 Norm	2 Mod	3 Thorac				8 Cause Dth.		76

52.	RESPTRY COMPLIC	0 Unk	1 No	2 Mod	3 Brcsp	4 Trac +/Res	5 Prolong Resp.Supp	8 Cause Death	
53.	CARDIO-PLEGIA	1 Yes	2 No						
54.	RENAL	1 Mod	2 Dialys	3 Cause Death					
55.	CEREBRAL	1 Trans	2 Perm	3 Cause Death					
56.	INFECTION	1 Minor	2 Mod	3 Severe	4 Cause Death				
57.	HEART BLOCK	1 Trans	2 Perm	3 Pres Pre-op	4 Cause Death				
58.	OTHER CARD COMPLIC	1 Minor	2 Mod	3 Severe	4 Cause Death				
59.	OTHER COMPLIC	1 Minor	2 Mod	3 Severe	4 Cause Death				
60.	RESULTS	1 Alive	2 OpDth	3 HospDth					

TYPE OF VALVE INSERTED IN EACH POSITION:

61. AORTIC
62. MITRAL
63. PULMONARY
64. TRICUSPID

1. Starr-Edwards.
2. Carpentier.
3. Hancock.
4. St. Jude.
5. Fascia Lata.
6. Bjork-Shiley.
7. Track.
8. Shumway Ring.
9. Other.
10.

APPENDIX II

CORONARY FILE

UR: NAME: OPN. DATE: B/P NO: SEQ. NO:

1. DATE OF BIRTH [ ][ ][ ][ ][ ][ ] 6-11

2. SEX: Male = 1, Female = 2. [ ] 12

3. DATE OF OPERATION [ ][ ][ ][ ][ ][ ] 13-18

4. INDICATION FOR SURGERY: (Where several indications exist show the two most immediate)
   1. Angiographic abnormality rather than symptoms.
   2. Angina pectoris, chronic.
   3. Unstable angina.
   4. Recurring arrhythmia.
   5. Acute myocardial infarction.
   6. Re-operation for failed revascularisation procedure.
   7. Shortness of Breath.
   8. Other.

   (Primary Indication) [ ] 19

   (Secondary - if applicable) [ ] 20

OTHER ASSOCIATED DISEASES

5. DIABETES Yes = 1, No = 2. [ ] 21

6. CHOLESTEROL Admission value mgm%. [ ][ ][ ] 22-24

7. HYPERTENSION Yes = 1, No = 2. [ ] 25

8. OTHER Yes = 1, No = 2. [ ] 26

9. SMOKING How many cigarettes/day. (During the last 12 months). [ ][ ] 27-28

10. PREVIOUS OR PRE-OPERATIVE INFARCT OR INFARCTS:
    1. No M.I.
    2. Single infarct.
    3. Multiple infarcts.

    [ ] 29

11. INTERVAL TO LAST PREVIOUS INFARCT:
    1. No infarct.
    2. Up to 24 hours.
    3. 2 to 7 days.
    4. 8 to 14 days.
    5. 15 days to 3 months.
    6. More than 3 months.

    [ ] 30

ECG - ISCHAEMIC CHANGES

12. ANTERIOR
13. LATERAL
14. INFERIOR

1. No ischaemic changes.
2. Acute transmural infarct.
3. Chronic transmural infarct.
4. Acute subendocardial infarct.
5. Chronic subendocardial infarct.
6. Other myocardial ischaemia (ST - T wave changes only)
7. Ischaemic changes after exercise.

[ ] 31

[ ] 32

[ ] 33

15. X-RAY - HEART SIZE (PA)
    1. No enlargement.
    2. Mild enlargement.
    3. Moderate enlargement.
    4. Gross enlargement.

    [ ] 34

16. L.V. END. DIASTOLIC PRESSURE mmHg - Give peak pressure including a wave if present. [ ][ ][ ] 35-37

17. L.V. ANGIOGRAM - Chamber Size.
    1. Normal.
    2. Slight enlargement.
    3. Moderate enlargement.
    4. Severe enlargement.
    [ ] 38

18. L.V. ANGIOGRAM - Contraction.
    1. Normal.
    2. Contraction impaired - diffuse - moderate.
    3. Contraction impaired - diffuse - severe.
    4. Contraction impaired - local - single.
    5. Contraction impaired - local - multiple.
    [ ] 39

19. L.V. ANGIOGRAM - Aneurysm.
    1. Anterior.
    2. Inferior.
    [ ] 40

CORONARY ANGIOGRAM

20. Right main ------- 1. Normal. ---------- [ ] 41
21. Posterior descend. 2. Narrowed by less than 50%. [ ] 42
22. Left main --------- 3. 50 to 70%. ---------- [ ] 43
23. L.A.D. 4. > 70% or more but less than total. [ ] 44
24. Diagonal --------- 5. Total obstruction without distal filling. ---------- [ ] 45
25. Circumflex 6. Total obstruction with distal filling. [ ] 46
26. L. Marginal ------- 7. Diffuse narrowing or multiple obstruction ---------- unsuitable for grafting. [ ] 47

OPERATION

27. Right Main ------- 1. Saphenous vein graft end to side. ---------- [ ] 48
28. Posterior desdend. 2. Saphenous vein graft side to side. [ ] 49
29. Inferior surf. br.---3. Internal mammary graft (in situ). ---------- right main [ ] 50
30. L.A.D. 4. Internal mammary graft (free). [ ] 51
31. Diag. (1) --------- 5. Saphenous vein graft and endarterectomy. ---------- [ ] 52
32. Diag. (2) 6. Other vein graft. [ ] 53
33. Intermediate ----- 7. Other artery graft. ---------- [ ] 54
34. Circ. (main) 8. Other procedure. [ ] 55
35. Lat Cx (1) ---------- [ ] 56
36. Lat Cx (2) [ ] 57
37. Terminal Cx ---------- [ ] 58
38. [ ] 59
39. Other vessel ---------- [ ] 60

40. OTHER CONCOMITANT PROCEDURES.
1. Aneurysm excision.
2. Excision of recent infarct.
3. Excision of akinetic area.
4. Ventricular plication.
5. Valvuloplasty.
6. Valve replacement.
7. VSD closure.

☐ 61

41. DURATION OF BYPASS (minutes). ☐☐☐ 62-64

42. HOSPITAL DISCHARGE - RESULT.
1. Alive.
2. Operation table death.
3. 24 hour death.
4. Subsequent death during this hospital admission.

☐ 65

43. EVIDENCE OF PERI-OPERATIVE INFARCT AT DISCHARGE (determined by new Q waves)
1. Yes.
2. No.

☐ 66

44. CAUSE OF DEATH DURING THIS HOSPITAL ADMISSION
1. Low cardiac output due to infarct.
2. Arrhythmia due to infarct.
3. Low cardiac output - other causes.
4. Arrhythmia - other causes.
5. Respiratory failure.
6. Renal failure.
7. Haemorrhage.
8. Pulmonary embolus.
9. Other causes.

☐ 67

45. HOSPITAL COMPLICATIONS (Code up to two)
1. Post-op haemorrhage. (requiring re-operation)
2. Respiratory.
3. Renal.
4. Cerebral.
5. Infection.
6. Pacing required.
7. Re-operation. (Other)

☐ 68

☐ 69

46. ARRHYTHMIAS.
1. Heartblock.
2. Atrial fibrillation/Flutter.
3. Ventricular Tachycardia.
4. Ventricular Fibrillation within 24 hours post-op
5. Ventricular Fibrillation after first 24 hours.
6. Other.

☐ 70

47. DATE OF DISCHARGE FROM HOSPITAL OR DEATH. ☐☐☐☐☐☐ 71-76

48. IN THE CASE OF RE-OPERATION WAS THIS FOR:
1. Not Applicable.
2. New Disease.
3. Disease In Previous Graft.
4. Both (2 & 3).

☐ 77

49. Date of Previous Operation. ☐☐☐☐☐☐ 78-83

50. NUMBER OF PRIOR ANGIOPLASTIES. 84

1. Date of Angioplasty. 85 90

2. Date of Subsequent Angioplasty. 91 96

APPENDIX III

CASE NO : 1-4

CARDIO-THORACIC SURGICAL UNIT

ROYAL ADELAIDE HOSPITAL

CORONARY ARTERY GRAFT FOLLOW UP.

NAME: .....

ADDRESS: .....

PHONE NO.: .....

CURRENT GENERAL PRACTITIONER : .....

CURRENT CARDIOLOGIST : .....

1. In which year did you have your bypass operation? 19 ☐☐ 5-6

If patient deceased in which year? 19 ☐☐ 7-8

In the questions that follow please tick the appropriate boxes to show which answer is correct for you.

2. SYMPTOMS : 9

(1) Did you have angina before your operation?

YES ☐ 1.

NO ☐ 2.

(2) Have you had any angina since your operation? 10

YES ☐ 1.

NO ☐ 2.

IF YES :

(a) Compared with the angina before your operation, is it : 11

LESS ☐ 1.

THE SAME ☐ 2.

WORSE ☐ 3.

(b) How long after your operation did the angina first reappear? (in months, e.g. 0 2 3 for 23 months) 12-14

☐☐☐

(3) Did you have shortness of breath before your operation? 15

YES ☐ 1.

NO ☐ 2.

(4) Have you had any shortness of breath since your operation? 16

YES ☐ 1.

NO ☐ 2.

IF YES:

(a) Compared with the shortness of breath before your operation is it : 17

LESS ☐ 1.

THE SAME ☐ 2.

WORSE ☐ 3.

(b) How long after your operation did the shortness of breath first reappear? (in months, eg 0 2 3 23 months) 18-20

☐☐☐

(5) Since your operation have you been readmitted to hospital because of your heart? 21

YES ☐ 1.

NO ☐ 2.

IF YES :

Which Hospital : 22

Under which Doctor : 23

What was the date : 24-26

For what reason : 27-29

.....

Was a further bypass operation necessary? 30

YES ☐ 1.

NO ☐ 2.

3. ACTIVITY:

Please compare your level of activity and exercise before and after the operation. 31

After the operation was it :

BETTER ☐ 1.

THE SAME ☐ 2.

WORSE ☐ 3.

4. EMPLOYMENT:

Please tick one box in each column :

(1)	Before Operation	After Operation	32-33
Working full time	☐ 1.	☐ 1.	
Working part time	☐ 2.	☐ 2.	
Retired	☐ 3.	☐ 3.	
Pensioner	☐ 4.	☐ 4.	
Unemployed	☐ 5.	☐ 5.	
Independent	☐ 6.	☐ 6.	

OFFICE USE ONLY

If a housewife and not otherwise employed were you able to do :

34-35

	Before Operation	After Operation
Full home duties	☐ 1.	☐ 1.
Part home duties	☐ 2.	☐ 2.
No home duties	☐ 3.	☐ 3.

(2) (a) If you were not employed before your operation was it because of :

Your Age	☐	1.
Your Heart	☐	2.
Other Medical Reasons	☐	3.
Redundancy	☐	4.
Voluntary Retirement	☐	5.
Community attitudes to your heart disease	☐	6.
Poor job opportunities	☐	7.

(b) If you were not employed after your operation was it because of :

37

Your Age	☐	1.
Your Heart	☐	2.
Other Medical Reasons	☐	3.
Redundancy	☐	4.
Voluntary Retirement	☐	5.
Community attitudes to your heart disease	☐	6.
Poor Job Opportunities	☐	7.

5. TREATMENT:

(1) Please list all drugs you are currently taking :

38

.....

.....

.....

Would you specify any of the above drugs that you are taking for high blood pressure :

39

.....

.....

.....

OFFICE USE ONLY

(2) Since your operation how often do you visit the doctor? : 40

	NEVER ☐	1.	
	(LESS OFTEN ☐	2.	
Than before operation	= (SAME AMOUNT ☐	3.	
	(MORE OFTEN ☐	4.	

(3) Did you smoke before your operation? : YES ☐ 1. 41

NO ☐ 2.

(a) Do you smoke now? : NO ☐ 1. 42

YES BUT LESS THAN BEFORE ☐ 2.

YES THE SAME AS BEFORE ☐ 3.

YES MORE THAN BEFORE ☐ 4.

Thank you for your help.

Please check that you have answered all the questions then return this form in the reply-paid envelope provided, to:

Coronary Artery Survey Secretary,
C/- Cardio-Thoracic Surgical Unit,
Royal Adelaide Hospital,
North Terrace,
ADELAIDE. S.A. 5000.

APPENDIX IV

Dear Patient,

The Cardio-Thoracic Surgical Unit of the Royal Adelaide Hospital is embarking on a major follow-up study of all patients who have undergone coronary artery grafting in this unit. The survey up to the end of 1981 embraces over 4,000 patients and is the largest in Australasia. It is obviously of vital interest to know the long term results of the operation and we therefore seek your co-operation in filling out the attached questionnnaire, and returning it in the reply paid envelope enclosed.

The co-ordinator of this survey is Dr. Guy Maddern and any enquiries can be directed to him by ringing the Royal Adelaide Hospital during office hours.

Thank you for your help.

Yours sincerely,

David Craddock
Head,
Cardio-Thoracic Surgical Unit

NOTE: If, for some reason, the patient is unable to complete the questionnaire or is deceased, could the nearest relative please do so to the best of their ability, and write on the form the reason why the patient could not complete it.

APPENDIX V

VALVE FOLLOW-UP QUESTIONNAIRE

No. ____

OFFICE USE 1-5

NAME _____

ADDRESS _____

TELEPHONE NO. _____

CURRENT CARDIOLOGIST _____

CURRENT GENERAL PRACTITIONER _____

PLEASE FILL THE APPROPRIATE BOX:

1. In which year did you have your valve replacement operation? 1 9 ☐☐ 6-7

2. If patient is deceased: 1

   1) What was the date of death - e.g. 1st June 1973 (If date unknown, give year) ☐1☐0☐6☐7☐3 2 8

   ☐☐☐☐☐☐ 9-14

   2) In which State of Australia? _____

   3) Did the patient die from heart trouble?

   NO ☐ 1 15

   YES ☐ 2

   UNSURE ☐ 3

3. We are interested in assessing your level of breathlessness before and after operation. Please mark ONE box in each column appropriate to your condition immediately prior to operation and for your present condition.

	Before operation	After operation	
1) Breathless only on very strenuous exercise	☐	☐	1
2) Breathless with moderately strenuous activity only e.g., housework, walking sport etc.	☐	☐	2
3) Breathless with light activity, e.g. showering, dressing, walking on the flat.	☐	☐	3
4) Breathless even at rest	☐	☐	4

16-18

4. Did you have a previous valve operation before your valve replacement? 0

   NO ☐ 1 19

   YES ☐ 2

   Date of Valvotomy ..... ☐☐☐☐☐☐ 20-25

5. Have you in the past, or are you currently taking anticoagulant tablets (blood thinning tablets), because of your valve?

NO ☐ 1 26

YES ☐ 2

If YES (that is, if you are on anticoagulants) have you had any bleeding as a result?

NO ..... ☐ 1 27

YES but not requiring hospitalization ..... ☐ 2

YES requiring hospitalization ..... ☐ 3

Which hospital? _____ Doctor _____ Year _____

Type of bleeding problem _____

_____ 1-9 28

_____

6. Have you been troubled by blood clots ('emboli') from the replaced valve?

NO ..... ☐ 1 29

YES but not requiring hospitalization ..... ☐ 2

YES requiring hospitalization ..... ☐ 3

Which hospital? _____ Doctor _____ Year _____

Type of clot problem _____

_____ 1-9 30

_____

7. Have you required hospitalization for any other reasons due to your valve e.g., infection, faulty function, re-operation, low blood count etc.?

NO ☐ 1 31

YES ☐ 2

If YES, Please state cause:

_____ 1-9 32

_____

_____

Hospital _____ Doctor _____ 1-9 33

APPENDIX VI

DIABETIC CORONARY BYPASS QUESTIONNAIRE

Name:_____ Seq. No.☐☐☐☐☐

Address:_____ UR No.☐☐☐☐☐☐

_____

Telephone:_____ Date of Birth:_____

PLEASE ANSWER THE FOLLOWING QUESTIONS:

1. Date of First Coronary Bypass? (if you remember) day ☐☐ month ☐☐ year ☐☐

   (a) If patient deceased could you please state date and cause of death._____

   _____

   (b) Have you had another coronary bypass? YES/NO

   If so, when?_____

   If so, where?_____

   (c) Have you had any other operations or complications since your bypass? YES/NO

   If so, when?_____

   If so, where?_____

   What operation?_____

   _____

2. We are also interested in your chest pain on exertion (angina) before and after coronary bypass.

   (a) Did you have angina before your first bypass? YES/NO
   (b) After bypass, did you have a period free of angina? YES/NO
   (c) Has the angina come back since your bypass? YES/NO
   (d) If so, how long after the first bypass did the angina come back?_____

   (e) If the angina has returned, compared with angina prior to bypass surgery, is it:

   Better ☐

   Same ☐

   Worse ☐

3. Have you had a "heart attack" since coronary bypass? YES/NO

   If so, when?_____

   Which hospital did you attend?_____

PLEASE TURN OVER . . . . .

4. We are interested in assessing what it takes to make you breathless before your bypass and now.

	Before first bypass	Now
(a) Breathless on very strenuous exercise e.g. running or climbing more than 3 flights of stairs.	YES/NO	YES/NO
(b) Breathless with moderately strenuous activity e.g. housework, walking, sport.	YES/NO	YES/NO
(c) Breathless with light activity e.g. showering, dressing,	YES/NO	YES/NO
(d) Breathless even at rest.	YES/NO	YES/NO

5. Since bypass would you regard your ability to do physical work e.g. gardening, manual labour, sport, housework, etc., as

more ☐

less ☐

same ☐

6. How long have you had diabetes?_____

(a) Do any other members of your family have diabetes? YES/NO
If YES, how many?_____

(b) What is your current Diabetic therapy?
DIET only YES/NO

or DIET & TABLETS YES/NO
Please give name of tablet(s)_____
No. taken daily?_____
How long have you taken tablets?_____

or DIET & INSULIN YES/NO
Please give name of insulin(s)_____
No. of injections per day?_____
How long have you taken insulin?_____

7. Do you have high blood pressure(hypertension)? YES/NO
If YES, what tablets do you take?_____

8. Have you had any complications as a result of your diabetes?
Eye problems needing laser therapy? YES/NO
Kidney problems? YES/NO
Blood vessel disease in the legs? YES/NO
A stroke (cerebrovascular disease)? YES/NO

9. Do you smoke? YES/NO
If YES how many a day?_____
If NO when did you stop?_____

10. Do you perform any blood tests at home? YES/NO
If YES, what is your average blood sugar?_____

APPENDIX VII

CORONARY ANGIOPLASTY FOLLOW-UP QUESTIONNAIRE

Name: _____ Seq. No. ☐☐☐☐

Address: _____ UR No. ☐☐☐☐☐☐

_____

Telephone: _____ Date of Birth: _____

PLEASE ANSWER THE FOLLOWING QUESTIONS:

1. Date of First Coronary Angioplasty? (if you remember) day ☐☐ month ☐☐ year ☐☐

   a) Have you had another Coronary Angioplasty? Yes / No
   If so, when? _____
   If so, where? _____

   b) Have you had a heart operation since angioplasty? Yes / No
   If so, when? _____
   If so, where? _____

2. We are also interested in your chest pain on exertion (angina) before and after coronary angioplasty.

   a) Did you have angina before your first angioplasty? Yes / No
   b) After angioplasty, did you have a period free of angina? Yes / No
   c) Has the angina come back since your angioplasty? Yes / No
   d) If so, how long after the first angioplasty did the angina come back? _____

3. Have you had a "heart attack" since angioplasty? Yes / No
   If so, when? _____
   Which hospital did you attend? _____

4. We are interested in assessing what it takes to make you breathlessness before and after angioplasty. Please place ONE tick in the appropriate column to describe your condition immediately before your first angioplasty and to describe your present condition.

	Before first angioplasty	Now
a) Breathless on very strenuous exercise, e.g. running, or climbing more than 3 flights of stairs.	☐	☐
b) Breathless with moderately strenuous activity only, e.g. housework, walking, sport, etc.	☐	☐
c) Breathless with light activity, e.g. showering, dressing, walking on the flat.	☐	☐
d) Breathless even at rest.	☐	☐

PLEASE TURN OVER. . . . . .

5. What medication and tablets are you currently taking?

_____

_____

Have you had any complications from your medication? Yes / No

If so, what are the complications?

_____

_____

6. Have you needed to be admitted to hospital for any reason since your angioplasty, e.g. infection, chest pain, operation, low blood count, etc.? Yes / No

If yes, please state reason:

_____

Which hospital? _____

When? _____

7. We are interested in your ability to work before and after coronary angioplasty. (Please tick the appropriate box.)

a) Were you working in full-time or part-time paid employment before your first angioplasty

- Full-time ☐
- Part-time ☐
- Not working ☐

b) Following your first angioplasty were you in paid employment? Yes / No

If so, were you

- working more hours ☐
- same hours ☐
- less hours ☐
- not working? ☐

If no, were you

- retired ☐
- sickness benefits ☐
- unemployed ☐
- other? ☐

c) Since angioplasty would you regard your ability to do physical work, e.g. gardening, manual labour, sport, housework, etc., as

- more ☐
- less ☐
- same ☐

8. Do you have any comments about

- the survey
- coronary angioplasty
- your experience at Royal Adelaide Hospital
- any other comments?

_____

_____

_____

APPENDIX VIII

MEMORANDUM

TO

DR. GUY MADDERN
CARDIO-THORACIC SURGICAL UNIT

FROM

FINANCE DIVISION

CARDIO-THORACIC SURGICAL UNIT
BY-PASS STUDY

Part of this study is to ascertain the cost of performing a 'Heart By-pass Operation'. Certain costs associated with the operation are directly related to this type of operation, e.g. the level of Nursing and Medical Care, Medical and Surgical Supplies and several other costs for the operation. Several direct costs are available from the Cost Centre Reports for CTSU, the two Wards and the Cardio-Thoracic Theatre.

The additional cost to be determined is a bed cost for general overheads, e.g. Fuel, Cleaning, Administration, Maintenance etc. The derived 'Cost per Occupied Bed Day' for 1981/82 is $215.43. This however, is not the cost required for this exercise as it is an average cost for a 'Hospital Bed'; not an A4 or A5 bed. The basis of calculation is similar and is used to determine an 'add-on notional value' for a Hospital Bed, additional to certain treatment costs for a By-Pass Patient, (i.e. Medical, Nursing and Scientific & Technical Salaries, Pathology, Radiology, Durgs, Medical & Surgical Supplies etc.).

A cost of $85.45 per occupied bed day has been calculated and should be regarded as a proportion of INPATIENT COSTS for 1981/82. Additional direct costs, including those on the Cost Centre Reports should be taken into account.

Phil Southam
PROJECT OFFICER, FINANCE BRANCH.

7/9/82

SALARIES & WAGES

- Non-Medical	$ 42,379,250-28
- Medical	10,357,163-16
- Superannuation	847,337-16
- Terminal Payments	312,898-04
	$ 53,896,648-64

Of Salaries; Medical, Nursing, Scientific & Technical and some Administration are directly debited to the Cardio-Thoracic Cost Centres. Therefore, total Medical, Nursing and direct Scientific & Technical and Administration salaries should be deducted from "overhead" salaries.

Less - Nursing	$ 21,456,354-32	
- Medical	10,357,163-16	
- Scientific & Tech.	73,674-80	(Cost Centre 6050)
- Administrative	46,039-35	(Cost Centres 6342, 6352 & 7352)
	$ 31,933,231-63	

TOTAL "OVERHEAD" SALARIES	$ 21,963,417-01

GOODS & SERVICES

- Food Supplies	$ 1,640,091-39
- Medical & Surgical	8,090,343-02
- Fuel, Light & Power	1,066,451-57
- Domestic Supplies	1,766,339-71
- Additional Works & Serv.	52,974-52
- Equipment	697,167-90
- Maintenance Contracts	93,564-00
- Repairs & Maintenance	1,490,308-83
- Admin. Expenses	4,055,311-32
- Pathology Charges	8,066,751-46
	$ 27,019,276-72

Deduct from "overheads"; Medical & Surgical Supplies, Equipment (Direct Debit), Maintenance Contracts and Pathology Charges.

TOTAL "OVERHEAD" GOODS & SERV.	10,071,450-34
TOTAL "OVERHEAD" PAYMENTS	$ 32,034,867-35
Less Dental	364,019-66)see
Communicable Diseases	411,718-03)page 2.
TOTAL NORTH TCE "OVERHEADS"	$ 31,259,129-66

DEDUCTION FOR DENTAL

- Superannuation	$ 28,265-00
- Maintenance	177,373-79
- Admin. Expenses	105,058-31
- Fuel, Light & Power	53,322-56
	$ 364,019-66

DEDUCTION FOR COMMUNICABLE DISEASE

	6390	7391	7392
- Admin. Salaries	-	236,588-95	29,363-47
- Paramedical Salaries	-	64,704-98	-
- Catering/Housekeeping Sals.	-	1,651-08	-
	-	302,945-01	29,363-47
- Fuel, Light & Power	-	19,213-38	504-00
- Domestic Supplies	-	7,409-25	-
- Group Laundry & C.L.S.	-	1,686-22	579-40
- Repairs & Maintenance	-	8,088-97	-
- Admin. Expenses	1.107-31	29,947-90	1,654-94
	1,107-31	66,345-72	2,738-34

Total	$ 402,499-85
Plus Superannuation	9,218-18
	$ 411,718-03

DERIVATION OF NON-INPATIENT COSTS

- Salaries & Wages	$ 21,963,417-01
less Communicable Dis.	332,308-48
Catering Salaries	2,877,912-27
	$ 18,753,196-26

Non-Inpatient (Based on occasions of service)
= .222624 x $18,753,196-26

NON-INPATIENT SALARIES	$ 4,174,911-56
COMM. DISEASES SALARIES	332,308-48
"OVERHEAD" INPATIENT SALARIES	17,456,196-97

- Total Goods & Services	$ 10,071,450-34
less Dental	335,754-66
Communicable Dis.	70,191-37
	$ 9,665,504-31
less costs not applicable	
Food	1,640,091-39
50% Group Laundry	583,957-52
	$ 7,441,455-40

Non-Inpatient (Based on occasions of service)
= .222624 x $7,441,455-40

NON-INPATIENT GOODS & SERV.	$ 1,656,646-56
DENTAL	335,754-66
COMMUNICABLE DISEASES	70,191-37
"OVERHEAD" INPATIENT G & S	8,008,857-75

CALCULATION OF "NOTIONAL ADD-ON VALUE"

Inpatient "overhead" Salaries		$ 17,456,196-97
Inpatient "overhead" Goods & Services		8,008,857-75
		$ 25,465,054-72
Less Meals & Accomodation (Staff)		536,165-05
		$ 24,928,889-67
Occupied Bed Days = 291,722		
Notional Add-On Value per Occupied Bed Day		$85-45 *

* To be added to costs of Nursing Salaries, Medical Salaries, Scientific & Technical Salaries (CTSU Theatre), Direct Administrative Salaries, Radiology & Pathology Charges, Equipment Purchases, Medical & Surgical Supplies and Maintenance Contract Charges.

1/7/81 - 30/6/82 DR. G. MADDERN
HOSLCCR Cardio Thoracic THEATRE 12/07/82 Royal Adelaide PAGE 224

Classification		Description		Actual	Balance Subj. Total
01100	6050	Sals-Nursing(REG)	Cardio TH	177385.63	
01200		Sals-Nursing(ENR)	Cardio TH	119685.71	
01300		Sals-Nursing(STU)	Cardio TH	751.67	
					$297823.01 OD
02500	6050	Sals-Scient & Tec	Cardio TH	73674.80	
					$ 73674.80 OD
16201	6050	Pat Mon Equip Card	Thoracic	7657.86	
16202		Pacemakers Cardio TH	OP TH	2470.00	
16203		Catheters Card	Thoracic	25988.86	
16204		Trans & Infusion C	Thoracic	4030.89	
16207		Needles	Card.Thoracic	861.90	
16210		Appl & Inst	Card Thoracic	5487.35	
16215		Spec Inst	Card Thoracic	1254.62	
16216		Spec Surg Inst Card	Thorac	9295.62	
16220		Dres Band Plaster C	Thorac	495.36	
16223		Surg Dres & Band	C Thorac	776.00	
16226		Sutures	C Thorac	29204.11	
16230		Items-Home Dial	C Thorac	222.50	
16240		Prostheses	C Thorac	1590.00	
16242		Spec Impl Pros	C Thorac	750.00	
16244		Impl Heart Valves	C Thorac	152073.00	
16245		Arterial Grafts	C Thorac	3069.50	
16250		Med & Surg Sup -	C Thorac	14768.44	
16251		Med & Surg Impr	C Thorac	89.13	
16254		Face Masks Paper	C Thorac	63.00	
16255		Protect Gar Disp	C Thorac	1499.62	
16256		Tubes & Access	C Thorac	12787.10	
16258		Gloves Surgeon	C Thorac	205.92	
16259		Disp Gloves	C Thorac	97.11	
16260		Drainage Bags	C Thorac	1672.00	
16264		Sterilizing Indi	C Thorac	159.50	
16266		By-Pass Equip	C Thorac	72594.00	
16267		Disp Oxygenators	C Thorac	164046.00	
16271		Film Tubing	C Thorac	36.72	
16274		Autoclave Bags	C Thorac	918.70	
16275		Autoclave Paper	C Thorac	308.98	
16277		Drainage Equip	C Thorac	1005.00	
16340		Other	C Thorac	6641.00	
16423		CAT Scanner Fees	C Thorac	230.00	
16603		Special Supplies	C Thorac	206.03	
					$522555.82 OD
22802	6050	Footwear	C Thorac	65.50	
					65.50 OD
28210	6050	Repl Equip Med	C Thorac	6690.00	
28260		Rep Other	C Thorac	766.00	
					7456.00 OD
29260	6050	Add Equip Other	C Thorac	9.75	
					9.75 OD
31210	6050	Rep - Equip Med	C Thorac	485.00	
31220		Rep - Equip Oth...	C Thorac	198.80	
					683.80 OD
34016	6050	Interpreter Serv	C Thorac	0.00	
34360		Print & Station	C Thorac	161.31	
34561	6050	Taxi Staff	C Thorac	14.19	
					180.50 OD
TOTAL FOR COST CENTRE				9902449.18	$902449.18 OD

HOSLCCR A4 CARDIOTHORACIC SURGICAL UNIT 12/7/82 Royal Adelaide

CLASSIFICATION		DESCRIPTION			ACTUAL	BALANCE SUBJ. TOTAL
01100	6342	Sals-Nursing(REG)	A4		275416.85	
01200		Sals-Nursing(ENR)	A4		38147.79	
01300		Sals-Nursing(STU)	A4		107997.77	
01400		Sals-Nursing(TRN)	A4		80.73	
						$421643.14 OD
02100	6342	Sals-Admin	A4		11268.38	
						$ 11268.38 OD
16203	6342	Catheters	A4	CTSU	194.00	
16215		Spec Inst	C6		5.00	
16220		Dres Band Plaster	A4		14.16	
16250		Med & Surg Sup-Ot	A4		444.00	
16251		Med & Surg Impr	A4		465883.52	
16256		Tubes & Access	A4		2.60	
16411		IMVS Path - Inpat	A4		45015.94	
16603		Special Supplies	A4		27.34	
						$511586.56 OD
28210	6342	Repl Equip Med	A4		312.48	
						$ 312.48 OD
29210	6342	Add Equip Med	A4		1500.00	
						$ 1500.00 OD
34120	6342	Computer Services	A4		343.45	
34261		Repl L Prop	A4		25.80	
34561		Staff Staff	A4		9.02	
						$ 378.27 OD
TOTAL FOR COST CENTRE					946688.83	$946688.83 OD

HOSLCCR A5 CARDIO THORACIC SURGICAL UNIT 12/7/82 Royal Adelaide

CLASSIFICATION		DESCRIPTION		ACTUAL	BALANCE SUBJ. TOTAL
01100	6352	Sals-Nursing(REG)	A5	139908.12	
01200		Sals-Nursing(ENR)	A5	25980.07	
01300		Sals-Nursing(STU)	A5	87722.58	
01400		Sals-Nursing(TRN)	A5	80.73	
					$254215.45 OD
02100	6352	Sals-Admin	A5	11518.95	
					$ 11518.95 OD
16202	6352	Pacemakers A5	CTSU	220.00	
16219		Sphyc & Parts	A5	250.00	
16251		Med & Surg Impr	A5	1466.04	
16411		IMVS Path - Inpat	A5	8247.67	
					$ 10183.71 OD
25230	6352	Other Works	A5	2097.04	
					$ 2097.04 OD
29260	6352	Add Equip Oth	A5	35.66	
					$ 35.66 OD
34561	6352	Taxi Staff -A5 Card Vasc		10.67	
					$ 10.67 OD
TOTAL FOR COST CENTRE				277537.53	$277537.53 OD

HOSLCCR CARDIO THORACIC SURGICAL UNIT 12/7/82 Royal Adelaide

CLASSIFICATION		DESCRIPTION		ACTUAL	BALANCE SUBJ. TOTAL
01100	7352	Sals-Nursing(REG)	Cardio Th	1745.82	
01200		Sals-Nursing(ENR)	Cardio Th	904.57	
01500		Sals-Nursing(UNQ)	Cardio Th	25.21	
					$ 2675.60 OD
02100	7352	Sals-Admin	Cardio Th	23252.02	
					$ 23252.02 OD
04300	7352	Sals-RMO	Cardio Th	217078.40	
04500		Sals-VMS	Cardio Th	81867.13	
					$298945.53 OD
16206	7352	Needle Disp	Cardio Th	21.60	
16216		Spec Surg Inst	Cardio Th	158.00	
16411		IMVS Path - Inpat	Cardio Th	74136.92	
					$ 74316.52 OD
29210	7352	Add Equip Med	Cardio Th	4404.00	
					$ 4404.00 OD
31220	7352	Rep - Equip Oth	Cardio Th	73.46	
					$ 73.46 OD
34120	7352	Computer Services	Cardio Th	10.00	
34122		Data Processing	Cardio Th	1577.56	
34561		Taxi Staff	Cardio Th	2.26	
					$ 1589.82 OD
TOTAL FOR COST CENTRE				405256.95	$405256.95 OD

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