Surgery Using Cardiopulmonary Bypass in the Elderly

Larry W. Stephenson, M.D., Horace Mac Vaugh III, M.D., and L. Henry Edmunds, Jr., M.D.

SUMMARY This study included 89 patients, 70–82 years (mean 72.8 years), who had procedures using cardiopulmonary bypass since 1955. Twenty-six patients had elective aortic valve replacement (AVR), with two hospital deaths. One patient who underwent emergency AVR for bacterial endocarditis died of septic shock. Ten patients had AVR and coronary artery bypass surgery (CABG), with one hospital death (10%). Fourteen patients had mitral valve replacement (MVR), with eight hospital deaths (57%). Two died of left ventricular rupture after leaving the operating room, and the remainder died of low cardiac output. Twenty-five patients had CABG with no early deaths. Seven patients had aneurysms of the thoracic aorta, with two early deaths. Six patients had other procedures with one death, making a total of 16 operative deaths in the 89 patients.

Eighty-four of the patients (94%) were New York Heart Association (NYHA) Functional Class III or IV for congestive heart failure and/or angina, preoperatively. Of these, 12 were in extremis immediately before surgery, and six survived. There were 10 late deaths. The actuarial survival rates for one, two, and five years for all patients were 69% (40 patients), 47% (20 patients) and 21% (seven patients), respectively. At recent follow-up (mean 20 months) 84% of the hospital survivors were symptomatically improved at least one NYHA Functional Class.

We conclude that CABG and/or AVR can be performed in elderly patients with a low hospital mortality and with symptomatic improvement. However, MVR in the elderly carries an unusually high mortality (7.3 times greater than patients less than 70, in our experience), and this risk must be weighed when considering MVR in these patients.

OPEN HEART SURGERY has become common in the elderly. This is true not only in our experience but also in reports appearing in the literature.1,2,3 There are probably a number of reasons for this — a greater percentage of the population is over 70 years, many older adults are in good general health except for heart disease, coronary artery bypass surgery is now available, and advances in cardiac surgery and anesthesia have made open heart surgery increasingly safe.

This study is a review of our experience in elderly patients who have undergone surgical procedures using cardiopulmonary bypass. Early and late survival rates following surgery are compared for different disease categories. Hospital complications are reviewed, and a comparison is made between preoperative and late follow-up functional class. Particular emphasis is placed on those patients that have undergone mitral valve replacement, since the surgical mortality is higher in this group.

Material and Methods

Between 1955 and August 1977, 89 patients, 70 years of age or older, underwent procedures using cardiopulmonary bypass at the Hospital of the University of Pennsylvania. All but three of the patients were operated on since 1970. There were 51 males and 38 females, ranging in age from 70–82 years, with a mean age of 72.8 years.

Using the New York Heart Association (NYHA) Functional Classification, five patients were Class II (Prognostic Class III), and all of these patients had aortic valvular stenosis with syncope as the only symptom. Of the remaining patients, 46 were Functional Class III and 38 were Functional Class IV because of heart failure and/or angina. Follow-up of hospital survivors was 100%, with a mean duration of 20 months, ranging from 2–124 months. Follow-up was obtained by a review of hospital and clinic records. In some cases the patient and the patient’s physician were also contacted for additional information.

Results

Mortality and Morbidity

Types of cardiac procedure with corresponding hospital mortality rates (30-day mortality) are shown in table I. Twenty-seven patients had aortic valve replacement, 26 were done electively, with two hospital deaths. One patient died of respiratory failure and the other died of acute aortic dissection after leaving the operating room. One patient, who had an emergency aortic valve replacement for bacterial endocarditis, died of gram negative shock. Ten patients had aortic valve replacement and coronary artery bypass surgery with one hospital death from low cardiac output.

Fourteen patients had mitral valve replacement, with eight hospital deaths, a 57% mortality rate. The mitral valve was replaced using intermittent aortic cross-clamping for 10–20-minute periods at 28–32°C. The etiology of the mitral valvular disease was rheumatic in nine patients, ruptured chordae tendineae in three, mitral prolapse in one, and probably congenital in one patient with an associated atrial septal defect. Six of the eight patients who died had rheumatic valvular disease; the other two had ruptured chordae tendineae.

Two patients died of left ventricular rupture. One

From the Division of Cardiothoracic Surgery, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.

Address for reprints: Larry W. Stephenson, M.D., Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104.

Received November 25, 1977; revision accepted April 21, 1978.
patient had a size 3 Starr-Edwards caged ball mitral prosthesis and the other patient had a size 29 Bjork-Shiley mitral prosthesis. Both of these patients were NYHA Functional Class III for heart failure, and both had mixed mitral valvular stenosis and incompetence. In one the arterial blood pressure rose to 170/110 mm Hg three hours after reaching the intensive care unit, and massive bleeding followed shortly. The other patient was thought to convalascing satisfactorily when, on the evening of the sixth post-operative day, she became extremely anxious and had a cardiac arrest. In both patients left ventricular rupture was demonstrated at autopsy.

The other six patients who died after mitral valve replacement died of low cardiac output. Two were NYHA Functional Class III for failure pre-operatively; one had mitral valvular stenosis and the other valvular incompetence. Three were Functional Class IV for heart failure; one had mixed mitral valvular stenosis and incompetence, one incompetence, and one mitral valvular incompetence and coronary artery disease for which saphenous vein grafts were also placed. The sixth patient who died of low cardiac output was moribund at the time she was taken to the operating room, with severe mitral and tricuspid valvular incompetence. In addition to mitral valve replacement, a tricuspid valve annuloplasty was performed.

Twenty-five patients had coronary artery bypass surgery with no early deaths.

Two patients underwent ventricular septal defect closure after myocardial infarction; one died of low cardiac output. One patient each had repair of an atrial septal defect, double valve replacement, excision of a left atrial myxoma and removal of a Mobin-Uddin caval umbrella that had migrated to the heart.

Seven patients had operations on the thoracic aorta, three for Type I aortic dissection with two deaths. Four patients had procedures in which left heart bypass was used, three for rupture of the descending thoracic aorta and one for a Type III aortic dissection; all survived.

Hospital mortality appeared to be related to preoperative functional class for heart failure (table 2). There were no deaths among the five Functional Class II patients. Five of 24 patients who were Class III for heart failure and four of nine patients who were Functional Class IV for heart failure died in hospital. Of 39 patients that were Functional Class III or IV for angina or angina with some degree of failure, only one patient died.

Additionally, 12 patients were moribund at the time of operation. Included in this group were patients taken to the operating room with an endotracheal tube in place and/or catecholamine support; one-half of these patients survived.

Causes of hospital morbidity and mortality are shown in table 3. Low cardiac output requiring catecholamine and/or intraaortic balloon pump support was the most common major complication and was the cause of death in nine patients. Renal failure occurred in four patients, required dialysis in three patients, and was a contributing cause of death in one.

Low cardiac output and renal failure were not a direct result of operation in all of these patients, since many

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of Patients</th>
<th>Hospital Mortality No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic valve replacement</td>
<td>27</td>
<td>3</td>
<td>11%</td>
</tr>
<tr>
<td>Aortic valve replacement plus coronary bypass</td>
<td>10</td>
<td>1</td>
<td>10%</td>
</tr>
<tr>
<td>Mitral valve replacement</td>
<td>14</td>
<td>8</td>
<td>57%</td>
</tr>
<tr>
<td>Coronary bypass</td>
<td>25</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VSD closure</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(Post myocardial infarction)</td>
<td>2</td>
<td>1</td>
<td>50%</td>
</tr>
<tr>
<td>ASD closure</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Aortic-mitral valve replacement</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Left atrial myxoma</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Removal of foreign body</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Type I aortic dissection</td>
<td>3</td>
<td>2</td>
<td>67%</td>
</tr>
<tr>
<td>Rupture thoracic aorta</td>
<td>3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Type III dissection</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>16</td>
<td>18%</td>
</tr>
</tbody>
</table>

Abbreviations: VSD = ventricular septal defect; ASD = atrial septal defect.

<table>
<thead>
<tr>
<th>Functional Class (NYHA)</th>
<th>No. of Patients</th>
<th>Hospital Mortality No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>II</td>
<td>24</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>II</td>
<td>11</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>II + CHF</td>
<td>11</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>III</td>
<td>9</td>
<td>4</td>
<td>44%</td>
</tr>
<tr>
<td>Angina</td>
<td>15</td>
<td>1</td>
<td>7%</td>
</tr>
<tr>
<td>Angina + CHF</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>In extremis</td>
<td>12</td>
<td>6</td>
<td>50%</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>16</td>
<td>18%</td>
</tr>
</tbody>
</table>

Abbreviations: NYHA = New York Heart Association; CHF = congestive heart failure.

<table>
<thead>
<tr>
<th>Major Complications</th>
<th>No. of Patients*</th>
<th>Contributing Cause of Death*</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cardiac output</td>
<td>13</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Renal failure</td>
<td>4</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Neurologic</td>
<td>6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>5</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Reoperation for bleeding or tamponade</td>
<td>4</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pacemaker for heart block or arrhythmia</td>
<td>3</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Left ventricular rupture</td>
<td>2</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Acute aortic dissection</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Septic shock</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Sternal wound infection</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bleeding diathesis</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Fell out of bed and fractured hip</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>16 (18%)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*Some of the patients are counted more than once if they had more than one complication.
were NYHA Functional Class IV or in extremis immediately before operation. Six of these patients required catecholamine support and/or the intraaortic balloon pump immediately before operation, and two had preoperative renal failure.

Neurologic complications after operation included one patient who did not awaken and died one week later. Three patients developed hemiparesis (in two it was transient), and two patients were moderately mentally obtundent; this eventually cleared.

Of 73 survivors, 54 (74%) had an uneventful hospital convalescence.

Late Follow-Up

There were 10 late deaths, from 32 days to 45 months after operation. Causes of late death are shown in table 4. Four patients died of pneumonia and three patients died of congestive heart failure. One patient died of cancer. Another ruptured an abdominal aortic aneurysm. The cause of death is unknown in the tenth patient.

Late complications included nonfatal bleeding episodes in six patients who were taking coumadin for a valvular prosthesis. One patient had multiple episodes of thromboembolism related to a prosthetic valve, and another required a pacemaker for heart block.

The actuarial survival curve for all 89 patients is shown in figure 1. Survival rates for these patients are 69% at the end of one year, 47% at two years and 21% at five years. For 73 hospital survivors, survival rate is 89% at the end of one year, 75% at two years and 41% at five years. The one year actuarial survival rate for aortic valve replacement is 81% (19 patients), and is 93% (13 patients) for coronary artery bypass grafts. Actuarial survival for the general population going from age 73 to 74 is 95%. The two-year survival rates are 65% for aortic valve replacement (11 patients) and 93% for coronary artery bypass grafts (three patients). For the general population the survival rate is 91%.

For hospital survivors who had aortic valve replacements, the one- and two-year survival rates are 95% and 85%, respectively. The six patients surviving mitral valve replacement have been followed from two to 77 months. One patient died 25 months after operation. The other five patients remain improved by at least one functional class over their preoperative condition.

From two months to one year after operation, 64 of the 73 hospital survivors (88%) improved at least one functional class, two patients were symptomatically the same, one was worse, and six died. At last follow-up of the 63 remaining survivors (mean 20 months), 26 were Functional Class I, 34 were Functional Class II, and three were Functional Class III.

Discussion

“Elderly” is defined by Webster’s New Collegiate Dictionary as being “rather old, past middle age.” In this report we chose to include all patients over the age of 70 years. Reports in the literature have varied as to

![Figure 1. Actuarial survival in 89 elderly patients following cardiopulmonary bypass procedures.](http://circ.ahajournals.org/doi/abs/10.1161/01.CIR.58.2.252?journalCode=circ)
the cutoff age for elderly. One report included all patients over the age of 45, although many authors have used ages 60 or 65. A few authors have used age 70, which seems more appropriate in view of the increasing mean life span and general good health of many older citizens.

Review of this experience, as well as other reports, indicates that hospital mortality in elderly patients is influenced by preoperative functional class for heart failure. Although hospital mortality is low for aortic valve replacement and/or coronary artery bypass surgery, 2, 5, 6, 9, 11, 14, 17, 20, 21, 24, 29, 32, 37 mortality is high in elderly patients who undergo mitral valve replacement. 5, 8, 14, 15, 19, 22, 33, 36 The reasons for increased mortality after mitral valve replacement are not clear.

In our experience mortality from mitral valve replacement increases with advancing age. The 30-day hospital mortality for all patients who had mitral valve replacement, including those with endocarditis, myocardial infarction, and prosthetic dysfunction since June 1973, is 5.5% (8/145) in patients less than 60 years old. Mortality is 14% (6/44) in patients 60–69 years of age, and 54% (6/11) in patients over 70 years of age.

Two patients over the age of 70 who had mitral valve replacement died of left ventricular rupture. Both patients had mixed mitral valvular stenosis and incompetence, both were NYHA Functional Class III for failure, and ventricular rupture occurred after both the patients left the operating room. Papillary muscles were not cut in either patient, and at autopsy there was no evidence of a fresh myocardial infarct. In both patients the site of rupture was distant from the valve annulus in an area unlikely to have been injured at operation. In one patient severe hypertension immediately preceded ventricular rupture, which might have been prevented by therapy to reduce afterload. In a recent review of the surgical literature, Bjork reported 26 cases of left ventricular rupture. 44 This complication was more common in older patients, but occurred after the chest was closed in only nine patients.

The fact that six patients died of low cardiac output after mitral valve replacement indicates reduced left ventricular contractile reserve in older patients. Thirteen of the 14 patients who underwent mitral valve replacement had mitral valvular incompetence or mixed valvular incompetence and stenosis. Kirklin, Kouchoukos and associates have shown valve replacement for mitral insufficiency is associated with decreased cardiac output because of an acute increase in left ventricular afterload. 45, 46 Since all but one of these patients had mitral incompetence and since mortality is directly proportional to age in patients undergoing mitral valve replacement, we conclude that reduction of afterload may be particularly important in elderly patients to reduce the incidence of left ventricular rupture and low cardiac output.

Although 54 of the 73 hospital survivors (74%) had an uneventful hospital convalescence, the incidence of renal and neurologic complications was higher than in younger patients. 41, 42 The fact that the incidence of pulmonary complications was not higher is surprising with advanced age, ability to recover from complications and reserves of other organ systems are more limited, and sometimes the patient's motivation to get well is less; these factors may contribute to increased mortality. 49, 50

Survival rates of patients who left the hospital after aortic or mitral valve replacement or coronary bypass surgery approximate those of the general population of similar age. Late complications related to operations are few. The majority of hospital survivors, including those that underwent mitral valve replacement, are symptomatically improved.

This experience documents the relative safety of aortic valve replacement and coronary artery bypass surgery in patients over age 70. Although mortality and the incidence of complications are higher than in younger patients, most recover without difficulty. This experience also supports lifesaving attempts in selected, critically ill, elderly patients. In half of these patients the attempts were successful. Lastly, the increased risk of mitral valve replacement in elderly patients is clearly documented. In these patients current methods to reduce afterload, including the intraaortic balloon, may reduce operative mortality.

References


24. McCallister BD, Schmidt M, Reed WA, Killen DA, Crockett JE, McConahan DR, Bell HH: Coronary artery bypass in patients over the age of 70: initial and late results. Circulation 52 (suppl II): 119-191, 1975

25. Mahaim CH: Heart surgery after the age of 60 years. Revue Med Suisse Romande 87: 603, 1967 (Fr)


33. Smith JM, Lindsay WG, Lilienhein RC, Nicollot DM: Cardiac surgery in geriatric patients. Surgery 80: 443, 1976

34. Spencer FC, Trinkle JK, Eiseman B, Reeves JT, Surawicz B: Aortic valve replacement in elderly patients with cardiac failure. JAMA 189: 103, 1964


Surgery using cardiopulmonary bypass in the elderly.
L W Stephenson, H MacVaugh, 3rd and L H Edmunds, Jr

Circulation. 1978;58:250-254
doi: 10.1161/01.CIR.58.2.250

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/58/2/250

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/