

Ascending Aortic Aneurysms

Review of 100 Consecutive Cases

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SUMMARY

Aneurysms of the ascending aorta, if undiagnosed or untreated, may result in left ventricular failure from aortic valvular insufficiency. Aortic rupture, dissection, or compression of adjacent vital structures may also occur. The application of refined cardiopulmonary bypass devices, prosthetic heart valves, and synthetic grafts now allows successful surgical management of this disorder. This report presents our current diagnostic methods, surgical techniques, and the early and late results of 100 consecutive patients undergoing surgical treatment of aneurysms of the ascending aorta.

There were 72 males and 28 females, ranging in age from 25 to 72 (avg 51.2) years. All patients had angiographic studies to demonstrate precisely the location of the aneurysm and the presence or absence of aortic valvular insufficiency. Sixty-three patients required concomitant aortic valve replacement, and the remaining 37 patients had only aneurysm resection and replacement. Pathological studies revealed 69 aneurysms were atherosclerotic, 22 were secondary to cystic medial necrosis, with the remaining 9 considered to be possibly leucic in origin.

Despite the magnitude of the surgery and the advanced ages of some of these patients, the overall operative and hospital mortality rates were 4% and 9%. Survival rates by actuarial representation in 82 patients at 2, 4, 6, and 8 years were 82.9%, 78%, 70%, and 69.5%, respectively.

Additional Indexing Words:

Cardiopulmonary bypass
Aortocoronary bypass

Woven Dacron graft
Atherosclerosis

Aortic valve replacement
Marfan's disorder

SUCCESSFUL management of aortic aneurysms, despite their location, depends upon precise preoperative diagnostic studies and careful intraoperative and postoperative management. When the aneurysm involves the ascending aorta, progressive enlargement may dilate the aortic annulus, resulting in valvular incompetence. With long-standing insufficiency, the increased left ventricular work load results in progressive left-heart failure. Other sequelae of this disorder include dissection, rupture, or compression of adjacent vital structures. Because of this, an aggressive approach has been established employing resection of all aneurysms of the ascending aorta. The purpose of this report is to describe our surgical technique and present the results of our last 100 consecutive patients undergoing surgical repair of aneurysms of the ascending aorta.

Patients

Between February 1965 and February 1974, 100 patients on this service underwent resection of an aneurysm of the

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Supported in part by the U. S. Public Health Service (HL-05435).

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ascending aorta. There were 72 males and 28 females, ranging in age from 25 to 72 years, with an average age of 51.2 years. All patients had excision of the ascending aneurysm and replacement with a DeBakey woven Dacron graft.* Sixty-three patients had concomitant significant aortic valvular insufficiency requiring aortic valve replacement. For this, the Starr-Edwards prosthesis was used in the initial 23 patients, while the DeBakey aortic carbon ball valve† prosthesis was utilized for the subsequent 40 patients. Four patients underwent concomitant coronary artery bypass.

Symptoms

Ten patients were asymptomatic and were referred for evaluation of a mediastinal mass noted on routine chest X-ray (fig. 1). In the remaining 90 patients, the majority of the symptoms were related to the presence of valvular insufficiency producing chest pain and/or shortness of breath (table 1). Fifteen patients had symptoms of less than a month's duration, 23 had symptoms for 1 to 6 months, and 52 patients had had persistent or progressive symptoms for more than 6 months.

Associated Diseases

Twenty-three patients were found to have significant associated diseases (table 2). Eleven patients had hypertension, for which they had been on medication for varying

*United States Catheter and Instrument Corporation. A division of C. R. Bard, Inc., Box 566, Billerica, Massachusetts 01821.

†Surgitool. Artificial Organs Division, Travenol Laboratories, Inc., 3737 Library Road, Pittsburgh, Pennsylvania 15234.

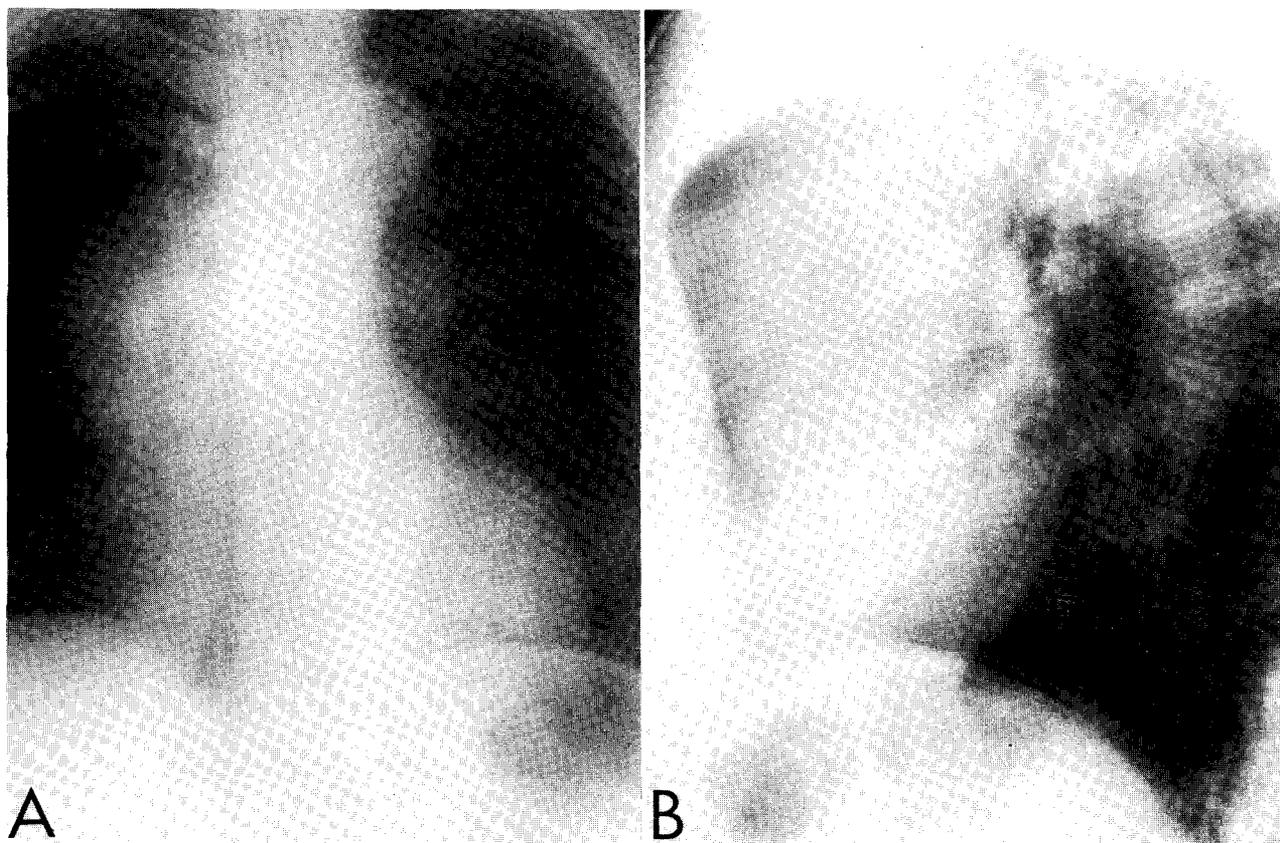


Figure 1

Roentgenogram of an asymptomatic patient demonstrates widened mediastinum and cardiomegaly in anteroposterior (A) and lateral (B) views.

lengths of time. Eleven patients had symptoms of coronary arterial disease, and five of these had had myocardial infarctions prior to their admission. Ten patients had been treated for syphilis, and six had skeletal stigmata of Marfan's syndrome. Three patients had a past history of rheumatic fever. Three patients had chronic lung disease, and three were known to have diabetes mellitus.

Diagnosis

Excluding the few patients with Marfan's skeletal abnormalities, the physical examination was not contributory to diagnosis except for the detection of cardiac murmurs and wide pulse pressure in 69 patients, suggesting aortic valvular incompetence. The resting electrocardiogram was normal in 26 patients, while 51 had evidence of left ventricular hypertrophy. Cardiac arrhythmias (atrial fibrillation and premature atrial or ventricular contractions) were noted in 13 patients. First-degree atrioventricular con-

duction defects were found in 7 patients, and changes indicative of old myocardial injury were noted in 3.

Roentgenographic examinations of the chest were interpreted as showing broadening of the mediastinal silhouette in 85 patients. In the remaining 15 patients the ascending aneurysm was not evident on the routine chest X-ray. Seventy-one patients were considered to have evidence of left ventricular enlargement.

All patients had aortography (fig. 2) and left ventriculography to demonstrate precisely the extent of the aneurysm and to evaluate the presence or absence of aortic valvular insufficiency. The catheterization procedures were performed through the brachial artery in 77 patients, and through the common femoral artery in the remaining 23. Serial exposures were made in the anteroposterior, oblique, and lateral projections. Aneurysmal disease of the ascending aorta was found in all patients. Fifty-five patients had

Table 1

Presenting Symptoms in Ninety Patients

Chest pain	61
Dyspnea	46
Cerebrovascular insufficiency	6
Fatigue	5
Palpitation	4

Table 2

Associated Diseases in Twenty-three Patients

Hypertension	11
Coronary arterial disease	11
Syphilis (treated)	10
Marfan's syndrome	6
Rheumatic heart disease	3
Chronic lung disease	3
Diabetes	3

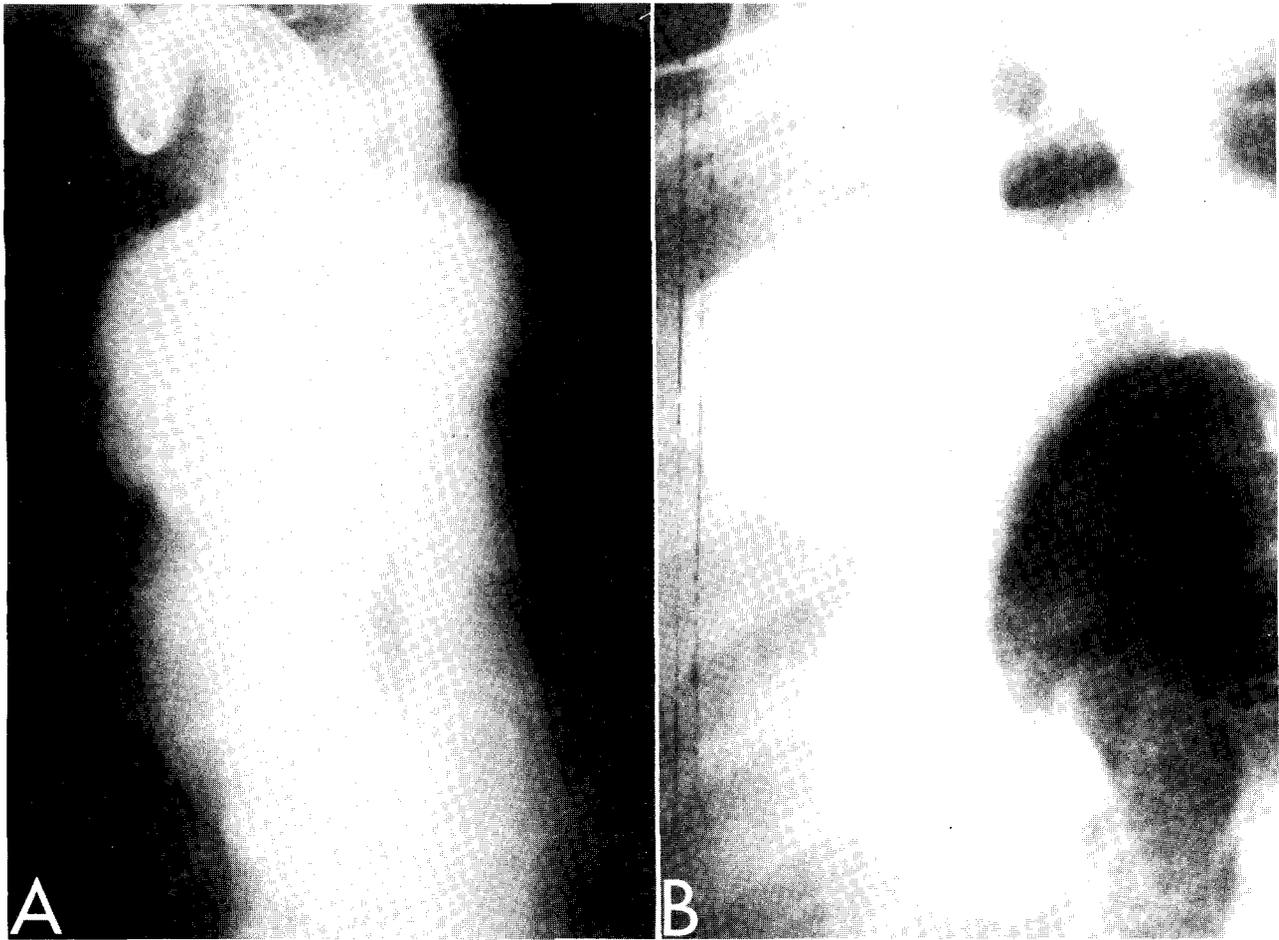


Figure 2

Aortogram demonstrates aneurysm of the ascending aorta and competent aortic valve in anteroposterior (A) and 60-degree left anterior oblique (B) projections.

fusiform aneurysms of the ascending aorta, with 10 patients having involvement of the sinuses of Valsalva. The remaining 45 patients had dissecting aneurysms: 31 with type I and 14 with type II.¹

Aortic root injection and left-heart catheterization confirmed the presence of significant aortic valvular insufficiency in 63 patients. During the past 6 years, selective coronary arteriography was also performed, when indicated, to evaluate the presence or absence of atherosclerotic occlusive disease of the coronary arteries. Four patients in this series were found to have significant occlusive disease of the coronary arteries.

Surgical Technique

With the patient in the supine position under general endotracheal anesthesia, the chest, abdomen, and femoral areas were prepped and draped. If the aneurysm was considered to extend up to the level of the proximal aortic arch, the arms were positioned to allow exposure of the axillary arteries for possible perfusion (fig. 3A).

The chest was opened through a median sternotomy incision. Cardiopulmonary bypass was instituted by cannulation of the superior and inferior venae cavae and the common

femoral artery. However, when the aneurysm was large or actively expanding close to the posterior wall of the sternum (as in 11 patients), heparin was administered and the femoral artery and vein were cannulated prior to median sternotomy (fig. 3B). For cannulation of the inferior vena cava, a no. 28 or no. 32 Argyle chest tube was advanced up to the level of the diaphragm. Once femoral vein-to-femoral artery bypass was established, the sternum was opened. The bypass circuit could then be completed by inserting a cannula into the superior vena cava through the right atrium. The venae cavae were then encircled with umbilical tapes, and total bypass was established by tightening these tapes.

The left ventricle was decompressed by a left atrial sump introduced through the right superior pulmonary vein. Once adequate cardiopulmonary perfusion pressure and flow rates were obtained, the aorta was cross-clamped distal to the aneurysm and proximal to the level of the innominate artery. With the sump decompressing the left heart, the aneurysm was opened. The coronary perfusion cannulas were inserted into the coronary ostia and secured into position (fig. 3C). When indicated, the valve leaflets were excised and a ball valve prosthesis was inserted with interrupted sutures of 2-0 Tycron (fig. 3D).

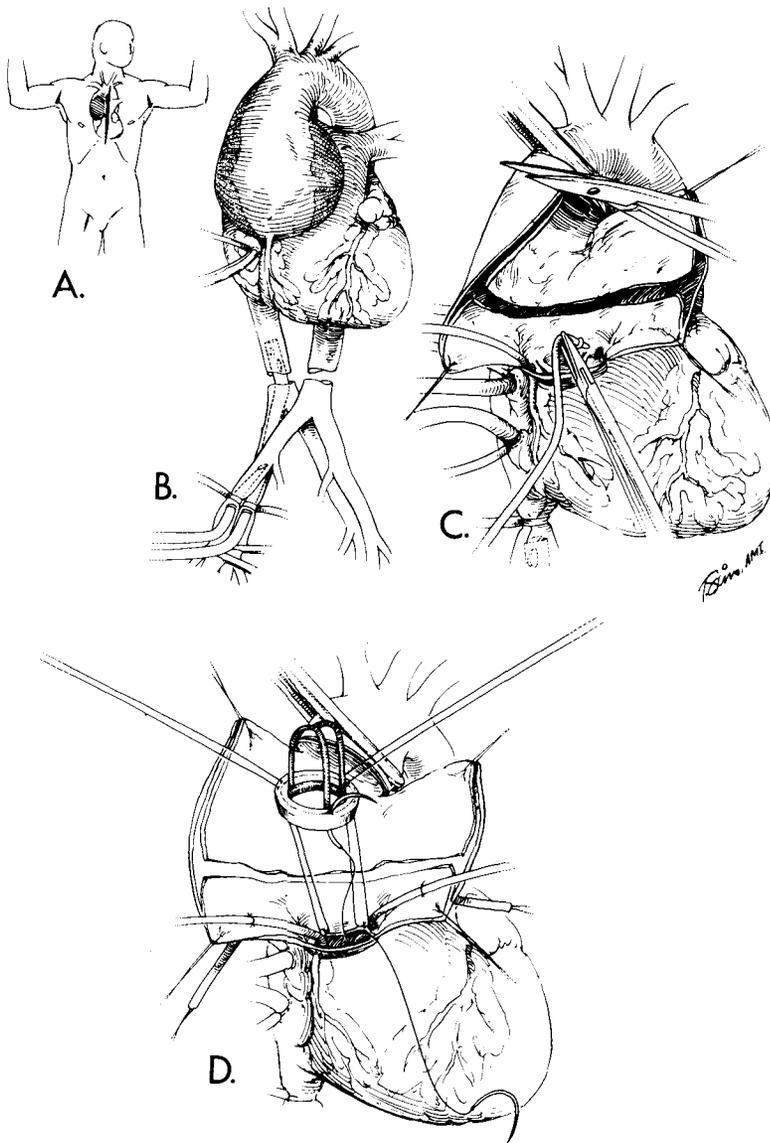


Figure 3

Drawing showing the surgical technique employed in this series. A: Positioning of patient on the operating table. B: Cannulation of the common femoral artery and femoral vein. C: Insertion of coronary artery perfusion cannulas. D: Insertion of a ball-valve prosthesis.

Upon completion of valve insertion, the aneurysmal wall was trimmed and an appropriately sized woven Dacron tube graft was selected and sewn end-to-end to the distal ascending aorta with continuous 2-0 Tycron sutures. For the dissecting aneurysms, care was taken to incorporate both the true and the false lumen to obliterate the false passage. When dealing with a thin aorta or with an acutely expanding process associated with an edematous aortic wall, the suture line was buttressed with Dacron velour strips (fig. 4A).

Upon completion of the distal anastomosis, the graft was cut to length and the proximal anastomosis was begun posteriorly with 2-0 Tycron sutures utilizing the Dacron velour strip technique when indicated. Care was taken to incorporate the periannular fibrous tissue to strengthen the proximal anastomosis. With minimal manipulation, the coronary perfusion cannulas could be left in place and removed just prior to completion of the proximal anastomosis (fig. 4B). Before completing this anastomosis, the sump was discontinued; the left heart was allowed to fill with blood (evacuating any residual air); the head of the table was

lowered; coronary perfusion cannulas were removed; final sutures were inserted and tied; an air-evacuating needle was introduced between the sutures of the proximal anastomosis; and the aortic cross-clamp was removed. The head of the table was slowly raised to assure that any entrapped air would be vented through the needle.

Once a stable cardiac rhythm was present, the tapes around the venae cavae were individually released to prevent sudden cardiac overload. Cardiopulmonary bypass was gradually discontinued and the cannulas were removed when the cardiac output was satisfactory. The wall of the aneurysm was then closed over the graft. Temporary epicardial pacemaker wires were routinely applied to the anterior surface of the right ventricle, and left atrial pressure lines were inserted and brought out through the skin for more precise postoperative hemodynamic monitoring (fig. 4C). All wounds were closed in the routine manner, with the femoral artery and vein closed with running 5-0 Prolene suture.

Because of the location of the aneurysm, six patients re-

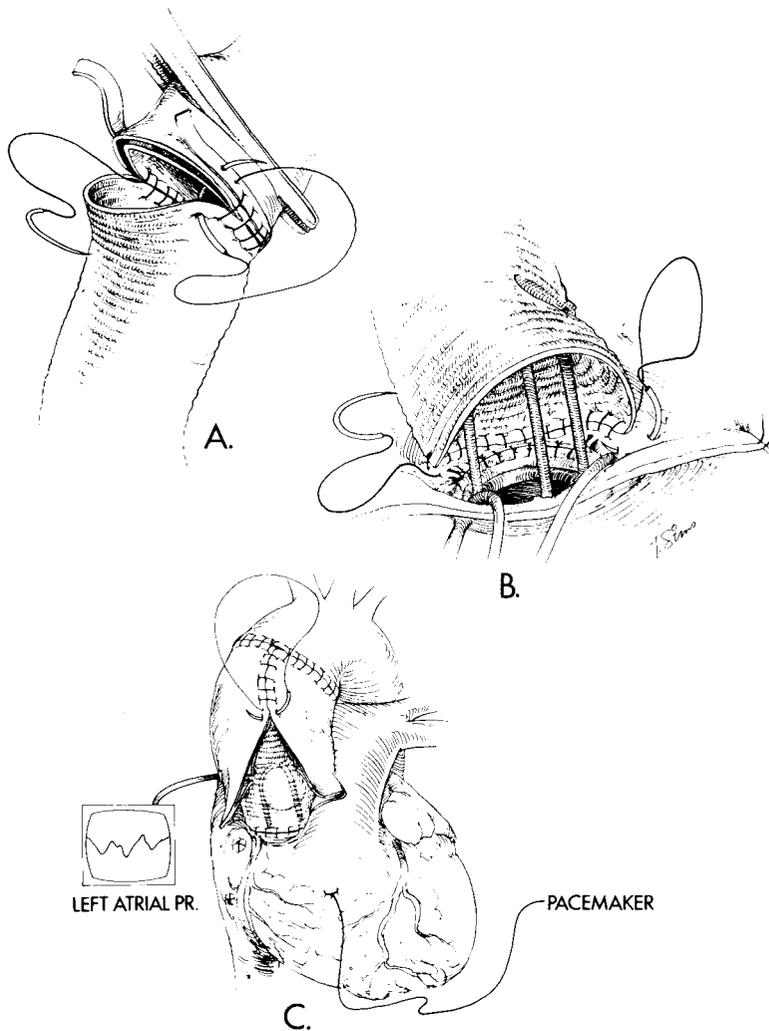


Figure 4

Drawing showing the surgical technique employed in this series. A: Obliteration of both the true and the false lumen of a dissecting aneurysm and reinforcement of the suture line by Dacron velour strips. B: Incorporation of the periannular fibrous tissue to strengthen the proximal anastomosis. The coronary artery perfusion cannulas are repositioned. C: The wall of the aneurysm being closed over the graft. Temporary epicardial pacemaker wire and left atrial pressure (PR) lines in place.

quired cross-clamping of the innominate artery. Total cerebral perfusion was accomplished in these cases by perfusing the right axillary artery in three and the right carotid artery in the other three. None of these patients required reimplantation of the innominate artery.

Pathology

The resected aneurysm and valvular tissue were submitted to gross and microscopic evaluation. Sixty-nine aneurysms were considered to be secondary to atherosclerotic degeneration of the aorta. Twenty-two had changes of cystic medial necrosis, while nine were attributed to syphilitic aortitis.

Early Results

Since the operative risk and postoperative results are influenced by the requirement of concomitant aortic valve replacement, the patients were divided into two groups. Group 1 consisted of the 63 patients who required aneurysm resection and aortic valve replacement. The remaining 37 patients who underwent only

resection of the aneurysm of the ascending aorta comprised group 2.

Group 1

Hospital Complications

Three patients had pulmonary problems, including two with pneumonitis and one with respiratory insufficiency requiring tracheostomy. One patient developed permanent atrioventricular block requiring implantation of an epicardial pacemaker, and another had pulmonary edema secondary to left ventricular failure. Because of persistent postoperative bleeding, two patients underwent mediastinal re-exploration. One patient developed mild renal failure not requiring dialysis. A transient right hemiparesis was noted in one patient. All these complications were managed successfully.

Hospital Mortality

Two patients expired of intractable ventricular fibrillation at the time of surgery. Three early deaths

were attributed to myocardial infarction. Another death was caused by anoxic encephalopathy due to intraoperative air embolism, and one patient died of massive gastrointestinal bleeding.

Group 2

Hospital Complications

Two patients had pneumonitis, and one had unilateral pleural effusion requiring thoracentesis. Two patients had hemiplegia following surgery; one had complete and the other had partial recovery at the time of discharge. One patient developed congestive heart failure, and another was explored for postoperative bleeding.

Hospital Mortality

Two deaths occurred at the time of surgery; one was due to myocardial infarction and the other was attributed to aortic dissection secondary to femoral artery perfusion. The remaining four deaths were secondary to myocardial infarction and left ventricular failure.

Late Results

Eighty-seven patients were discharged from the hospital. Five patients were lost to follow-up and were doing well when last evaluated 1 to 4 (avg 2.4) years after surgery. Therefore, complete follow-up evaluation of 82 patients 4 months to 9 (avg 4.7) years after surgery provides the basis for analysis of the late results.

Late Morbidity

In group 1, one patient 72 years of age returned with symptoms of coronary arterial disease seven years after surgery. One of the patients in group 2 developed aortic valve insufficiency six years after aneurysm resection and underwent successful aortic valve replacement; two years later, this patient had a cerebral embolus resulting in mild residual hemiparesis. One patient developed coronary arterial disease and was found to be diabetic (three years later), while another developed hypertension seven years after surgery.

Late Mortality

In group 1, 6 patients died of myocardial infarction, with an average postoperative interval of 39 months. Three patients expired from carcinoma, with an average time lapse of 24 months following surgery. Two patients died of cerebral emboli 6 and 73 months after operation, and another patient was lost secondary to an escaped ball from a Starr-Edwards prosthesis 3 years after surgery. In 2 patients who expired 29 and 37 months postoperatively, the cause of death was not established. Hepatitis at 4 months and a ruptured descending thoracic aneurysm 5 years after

surgery accounted for the remaining 2 deaths. Actuarial representations of the survival rates of the 53 patients at 2, 4, 6, and 8 years are 83%, 75.4%, 69.8%, and 68%, respectively (fig. 5A).

In group 2, 4 patients died of myocardial infarction, with an average postoperative interval of 21 months. One patient expired from carcinoma of the thyroid gland 38 months after surgery. The remaining 3 deaths occurred suddenly, with an average time lapse of 46 months, and were attributed to cardiac arrhythmias or myocardial infarction (no autopsies were performed). Actuarial representations of the survival rates of these 29 patients at 2, 4, 6, and 8 years are 82.7%, 79.3%, 72.4%, and 72.4%, respectively (fig. 5B).

Combined analysis of these 82 patients (groups 1 and 2) revealed actuarial representation of the survival rates at 2, 4, 6, and 8 years as 82.9%, 78%, 70%, and 69.5%, respectively (fig. 5C).

Discussion

Despite the etiology of aneurysms of the ascending aorta, successful surgical excision is possible, and when indicated the aortic valve should be replaced.

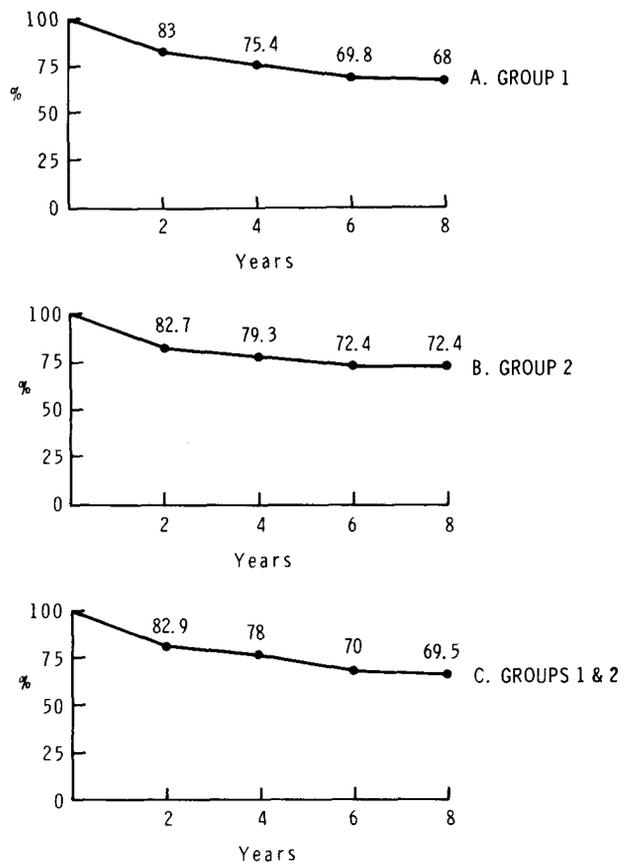


Figure 5

Actuarial representation of the survival rates at two, four, six, and eight years.

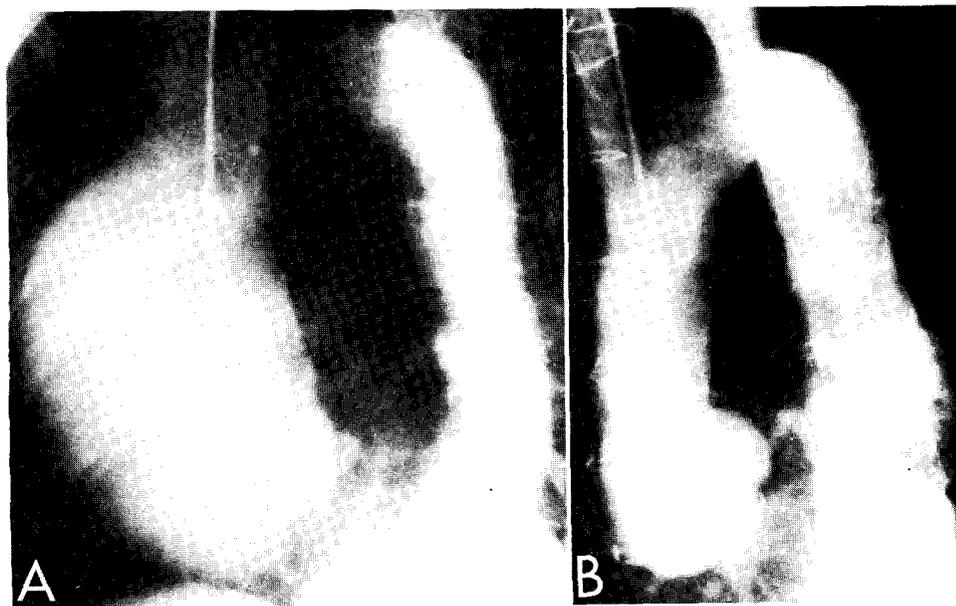


Figure 6

Preoperative aortogram in 60-degree left anterior oblique projection (A) demonstrates aneurysm of the ascending aorta. Postoperative aortogram in 45-degree left anterior oblique projection (B) 39 months after aneurysmal resection and graft replacement demonstrates mild dilatation of the sinuses of Valsalva and the ascending aorta proximal to the graft.

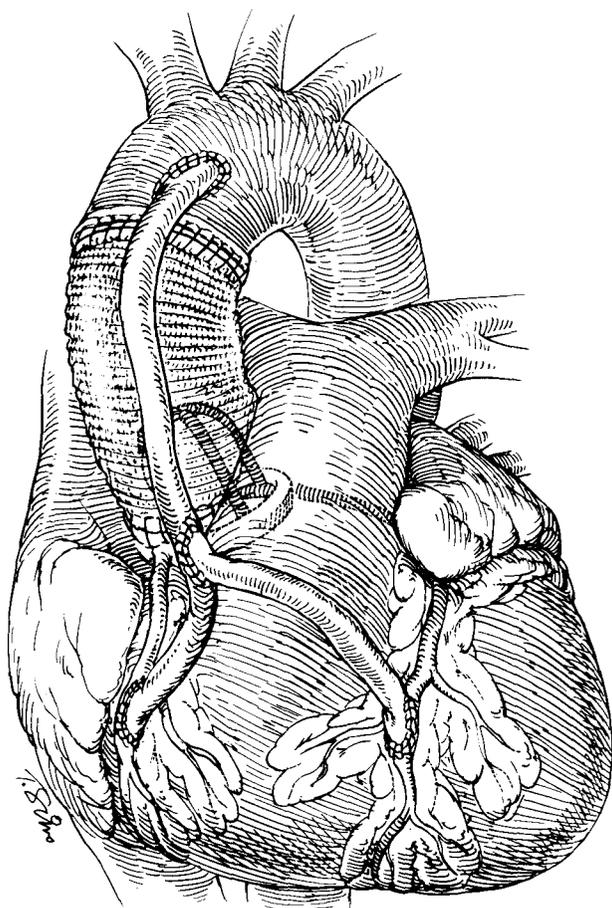


Figure 7

Drawing showing autogenous saphenous vein bypass graft from the distal ascending aorta to the right and left anterior descending coronary arteries in a patient with aortic valve prosthesis and tubegraft replacement of the ascending aorta.

Recent reports suggest that coronary reanastomoses reduce the incidence of postoperative bleeding and recurrent aneurysm formation at the proximal anastomosis.²⁻⁴ The technique employed at this institution, as described, does not necessitate reanastomosis of the coronary ostia.⁵ We feel it is important to incorporate the periannular fibrous material into the proximal anastomosis, thereby providing the maximal strength without altering the coronary ostia. On the basis of our yearly follow-up examinations, only three patients in this series developed mild dilatation of the aorta proximal to the graft (fig. 6). Furthermore, no reoperations have been required for, or late deaths attributed to, recurrent aneurysms.

Recent reports also demonstrate high operative and hospital mortality rates, ranging from 20% to 64%.^{3, 4, 6-10} Many of these deaths were reportedly due to uncontrollable hemorrhage or aortic dissection. The use of buttressing strips has eliminated the frustrating problem of suture-line bleeding. Because of intraoperative aortic dissection, there has been recent concern regarding the safety of femoral artery can-

nulation and retrograde perfusion.⁶ In our series, where femoral artery perfusion was uniformly employed, only one patient had retrograde aortic dissection originating from an intimal tear in the common iliac artery. We are convinced that careful cannulation of the common femoral artery can, in most instances, be successful. We also employ simultaneous monitoring of the contralateral femoral and radial arterial pressures to enable early detection of aortic dissection.

To avoid ischemic injury of the myocardium, we routinely employed bilateral normothermic coronary artery perfusion, monitoring the coronary perfusion pressure and flow rates. With coronary perfusion, the heart, in most instances, continues to beat, indicating no major physiological or metabolic alterations. Because of the possibility of intramural dissection of the coronary arteries, we do not use an ostial purse-string suture to secure the coronary perfusion cannulas in place. Instead, we employ a U-stitch through the aortic wall, 2 to 4 cm away from the ostium.

The high incidence of death attributed to coronary arterial disease emphasizes the importance of knowing the status of the coronary arteries prior to surgical intervention. In patients with significant concomitant occlusive disease of the coronary arteries, coronary artery bypass should be performed. This can be accomplished utilizing the internal mammary artery or autogenous saphenous vein grafts. When vein grafts are used, as in four patients in this study, the distal anastomoses are performed prior to aneurysm resection, allowing coronary perfusion through the grafts. Following resection and replacement of the

aneurysm, the vein grafts are anastomosed to the aorta at the level of the innominate artery (fig. 7).

The life-threatening sequelae of aneurysms of the ascending aorta are well known, and despite the magnitude of the surgery required for treatment of this disorder, a significant number of patients can benefit from surgical intervention.

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Discussion

Dr. Frederick B. Parker, Jr., Syracuse, New York: Sir, this was a very impressive series, and I enjoyed it very much. I am interested in how many of those cases were truly an acute dissection — in other words, dissecting aneurysms of type I or type II — that you operated on within the first week of dissection.

Dr. Liddicoat: That is a good question. I hasten to add that we routinely try to get the patients over the initial dissection crisis prior to operation. For this we confine all people to the Intensive Care Unit, control the hypertension if present, and closely monitor them in the hope that we can get them over this episode; so we are not dealing with acutely edematous material.

Dr. Hassan Najafi, Chicago, Illinois: What was the

distribution of cystic medial necrosis other than Marfan's in your 22 patients with cystic medial necrosis? Was it all among hypertensive patients, or was it spread throughout your group other than lues?

Dr. Liddicoat: All the patients with Marfan's syndrome had evidence of cystic medial necrosis, and cystic medial necrosis was also the most common pathological finding in the patients with hypertension.

Dr. Najafi: Patients with ascending aortic aneurysm, and particularly those with aortic insufficiency, should not be followed medically. Without question, these patients are surgical candidates. The natural history of the disease is very serious without surgical therapy.