Surgical treatment of postinfarction left ventricular aneurysm in 32 patients

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Thirty-two patients with large postinfarction left ventricular aneurysms shown at operation to consist of fibrous tissue are reported. All had angina and/or breathlessness, and none had a history of embolism. Thirty were correctly diagnosed by left ventricular cineangiography. Two of the 3 patients with inferior and 1 with an anterior aneurysm had associated ventricular septal defects, and 3 patients with an anterior aneurysm had mitral regurgitation. All had major coronary arterial lesions and 68 per cent had double or triple vessel disease. The aneurysm was excised in all patients; in 15 this was combined with saphenous vein bypass grafting of coronary arteries supplying surviving myocardium, in 3 with closure of a ventricular septal defect, and in 3 with mitral annuloplasty or replacement. Operative mortality was 6.2 per cent, and 79 per cent of the survivors are asymptomatic with average follow-up period of 18 months after operation.

Postinfarction ventricular aneurysm has been shown to have a poor prognosis (Schlichter, Hellerstein, and Katz, 1954). In addition patients often suffer from exertional dyspnoea associated with a high left ventricular end-diastolic pressure, and from angina due both to increased wall tension in the surviving myocardium (Austen et al., 1962) and to disease of coronary arteries supplying it. For these two reasons, it is appropriate to consider patients for surgical management.

We are reporting here our experience with 32 patients in whom a ventricular aneurysm was excised. In comparing reported series of patients, a major problem is one of definition. Our series includes only those patients who at operation were found to have transmural fibrous scars, clearly delineated from the surrounding muscle, and collapsing when suction was applied to the ventricular vent; the fibrotic nature of the wall of the aneurysm was confirmed by pathological examination of the excised specimen. In many but not all, aneurysm was suspected from the left ventricular angiogram. We have, however, found, like others (Gorlin, Klein, and Sullivan, 1967; Yacoub et al., 1973), that paradoxical outward bulging in systole (dyskinesis) of scarred or poorly perfused but viable myocardium may simulate aneurysm, and that some aneurysms may show akinetic segments but no dyskinesis on the left ventricular angiogram. Some (e.g. Dubnow, Burchell, and Titus, 1965) only classify as aneurysm those scars that are associated with localized protrusion of the external wall of the ventricle as well as of the ventricular cavity. On the other hand, Schlichter, et al. (1954) and Mourdis et al. (1968) include those cases in which there is no external bulge, described by the latter authors as ‘minor aneurysms’; our definition which is based on surgical pathological criteria includes such cases.

Patients

The 32 patients fulfilling these criteria were seen between April 1971 and April 1975. In many of these, ventricular aneurysm was suspected from the clinical features. In most of the others, all of whom were being investigated for coronary heart disease because of symptoms, aneurysm was recognized on the left ventricular angiogram. In 2 the presence of aneurysm was substantiated only at operation.

Clinical data (Table 1)

There were 27 men and 5 women ranging in age between 27 and 71 years (average 54). Twenty-nine of the patients complained of dyspnoea1 (average grade 3) and in 25 this was a dominant symptom; 1Angina and dyspnoea were graded 1 to 4 according to New York Heart Association criteria.
### TABLE 1  Clinical details

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<th>Case No.</th>
<th>Age (y)</th>
<th>Sex</th>
<th>Dyspnoea Grade</th>
<th>Dyspnoea Duration (mth)</th>
<th>Angina Grade</th>
<th>Angina Duration (mth)</th>
<th>Limiting symptom</th>
<th>Electrocardiogram</th>
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A, angina; D, dyspnoea; AMI, anterior myocardial infarction; IMI, inferior myocardial infarction; ST†, persistent ST segment elevation; LAHB, left anterior hemiblock; SVT, supraventricular tachycardia; VF, ventricular fibrillation; PVC, pulmonary venous congestion.
6 patients had dyspnoea at rest, including 2 who were in cardiogenic shock after recent myocardial infarction. Seventeen patients had angina but this was a dominant symptom in only 6. One patient was investigated because of recurrent tachyarrhythmias. All patients had had a previous myocardial infarct between 1 and 16 months before admission, with a typical history and electrocardiogram, and usually enzyme changes; 8 patients had had two such episodes. Two patients had a history of hypertension, one was diabetic, and 19 were smokers. No patient had a history suggestive of arterial embolism. Twenty-five patients were on treatment with digitalis and diuretics for congestive heart failure and 13 with beta-adrenergic blocking agents.

**Investigations**

The resting electrocardiogram was abnormal in all, showing evidence of transmural (Q wave) anterior infarction in 24, inferior in 1, and anterior and inferior in a further 6.¹ In 19 patients there was persistent ST segment elevation present for at least 6 months or since infarction if the history was shorter. Left anterior hemiblock (Rosenbaum, Elizari, and Lazzari, 1970) was present in 8. One patient had right bundle-branch block, but no pathological Q waves.

Recurrent supraventricular tachyarrhythmia was recorded in 1 patient, and another had an atrioventricular junctional rhythm. The chest radiograph showed cardiomegaly and/or pulmonary venous congestion in 28 patients, in 4 of whom there was pulmonary oedema. Calcification in the wall of the aneurysm was seen in 1 patient, an abnormality of the left heart border was observed in 22 patients, and a posteroinferior bulge was seen in the lateral radiograph in 3. In 4 patients the cardiac contour was normal. The left ventricular end-diastolic pressure ranged from 6 to 40 mmHg with a mean of 22-3 mmHg (Table 2).

The left ventriculogram showed paradoxical movement in systole in 30 patients, of the anterior wall in 27, and of the inferoposterior wall in 3. In the other 2 cases akinetic segments were seen. Three of the patients with an anterior aneurysm had moderate to severe mitral regurgitation. Ventricular septal defects were present in 2 patients with posteroinferior aneurysms and in 1 patient with an anterior aneurysm. A filling defect compatible with a large thrombus was seen in 10 patients.

Selective coronary angiography was performed in 30 patients, using the Sones technique in all except 1; each major coronary vessel was graded from 0 to 4.¹ Electrocardiographic criteria for infarction were those of McConahay et al. (1970).

Operation

Three patients had an emergency operation. One of these was admitted in cardiogenic shock 4 weeks after a myocardial infarction; the second deteriorated abruptly after catheterization, and the third was investigated because of a persistent low output state following two episodes of ventricular fibrillation which had been rapidly terminated by cardioversion. The remaining 29 patients had elective procedures.

Operation was carried out using standard normothermic cardiopulmonary bypass. The heart was electrically fibrillated, to prevent embolization which might be caused when handling the heart.

The aneurysms as defined were easily identified thin-walled bulges of the left ventricle. Suction on the left ventricular vent produced collapse of the thin-walled area in all cases. This manoeuvre was useful in delineating the area to be resected. On incising this area the line of demarcation between the viable myocardium and the fibrous aneurysm was easily identified. There were pericardial adhesions overlaying the aneurysm in 25 patients. Organized mural thrombus was found in 19 patients. The aneurysm was excised and the left ventricular wound repaired using polypropylene sutures without buttressing with prosthetic material. The major vessel supplying the aneurysmal area was found to have a total or subtotal block in all cases and was not grafted.

Additional operative procedures were undertaken in 18 patients. Fifteen underwent concomitant saphenous vein bypass grafting of vessels not involved in the aneurysm: 7 patients had a single graft, 7 had two grafts, and 1 had three grafts. Aortocoronary bypass was performed by interposition of autologous saphenous vein between the aorta and distal coronary artery, using a single continuous suture for the anastomosis. Two patients with mitral regurgitation, resulting from chordal rupture in 1 and partial papillary muscle rupture in the other, had mitral valve replacement, and a third required annuloplasty. The septum was scarred in most cases, and in 3 patients there were postinfarction ventricular septal defects which were repaired through the open aneurysm. There were 2 surgical deaths (operative mortality 6-2%) resulting from myocardial failure. One of these patients was...
TABLE 2 Results of investigation and operation

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<th>Case No.</th>
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<th>Left anterior descending</th>
<th>Right</th>
<th>Other</th>
<th>Operation Left ventricular aneurysm</th>
<th>Additional procedure</th>
<th>Follow-up Duration (mth)</th>
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*No coronary arteriogram.

MR, mitral regurgitation (grade); VSD, ventricular septal defect; L, left main coronary artery stenosis; VG, vein graft; E, endarterectomy; LAD, left anterior descending coronary artery; CFX, left circumflex coronary artery; RCA, right coronary artery.
in cardiogenic shock after a massive recent infarction, the other patient had dyspnoea at rest. There were no deaths in the early postoperative period.

All patients were treated with anticoagulants for three months; digoxin and diuretics were used initially and discontinued when possible (Table 2).

Pathology
The resected portion of the left ventricle was examined histologically in 30 patients, and was composed of hyalinized fibrous tissue, with a few residual muscle bundles in most cases. The size of the aneurysm ranged from $3 \times 2$ to $15 \times 10$ cm (average 62 cm$^2$); one was heavily calcified over 6 cm$^2$.

Follow-up
This ranged from 6 to 56 months (average 17.8 months). One patient with severe triple vessel disease who did not undergo coronary revascularization had a further myocardial infarction 6 months after operation and died of congestive cardiac failure less than a year later. Cardiovascular symptoms and exercise tolerance improved considerably in all patients. Of the 29 survivors, 18 are now leading a normal active life without drug therapy, 5 are asymptomatic on standard anti-failure treatment, requiring less diuretic than in the preoperative period; 2 patients have grade 2 dyspnoea and 1 patient has grade 1 dyspnoea in spite of medical treatment. One patient has recurrent postoperative atrial tachyarrhythmias, partially controlled with beta-adrenergic blocking drugs. Two patients still have grade 2 angina pectoris. One of these did not have vein graft surgery in spite of major lesion in the circumflex artery. The other has been re-investigated: left ventriculography showed conspicuous improvement in left ventricular function with effective resection of the aneurysmal area; the right coronary artery graft was occluded.

Discussion
Angiographic criteria for the diagnosis of left ventricular aneurysm are not generally agreed and are unreliable. Since many reported series depend upon the angiogram for diagnosis it is difficult to compare their surgical results. Our patients all had fibrous aneurysms seen at operation and confirmed in the majority by pathological examination of the specimen. The only other series where the same criteria were used was from the Cleveland Clinic (Loop et al., 1973a). The diagnosis had been made before operation in all except 2 of our patients by the observation of paradoxical movement of a segment of myocardium in systole seen on the left ventriculogram (Gorlin et al., 1967). In our experience, however, the left ventriculogram is not diagnostic in the sense that sometimes we have suspected aneurysm because of paradoxical wall movement, but at subsequent operation a fibromuscular hypokinetic area was found. This difficulty has been noted by others (Yacoub et al., 1973).

All of our patients presented with cardiac symptoms and were investigated for this reason. It is interesting to note, however, that there was no history of systemic emboli despite the fact that 59 per cent of the patients had mural thrombus at the time of operation. A similar incidence of mural thrombus has been previously reported by Dubnow et al. (1965) (65%) and by Schlichter et al. (1954) (54%), though these authors also reported a high incidence of arterial emboli (38% and 64%, respectively); however, both these studies were based on post-mortem material. The Cleveland Clinic group (Loop et al., 1973a) also found that arterial emboli were uncommon; the symptomatology of our patients was in fact similar in most respects to theirs. Other reported series are heavily weighted by patients with one or other dominant symptom, e.g. angina (Rao et al., 1974), congestive cardiac failure (Cooperman et al., 1975), ventricular tachycardia (Hazan et al., 1973). The majority of our patients had persistent dyspnoea after treatment with digitalis and diuretics, and some had frank pulmonary oedema, but more than half also had angina pectoris and this was the dominant symptom in 6 patients. This high incidence of angina was associated with severe coronary disease; only 8 of our patients had an isolated lesion of the left anterior descending coronary artery which was the finding in the majority of patients in the earlier reports (Cooley et al., 1958; Favoloro et al., 1968; Cooley and Hallman, 1968). The differences in patient selection may explain the widely varying operative mortality that has been reported, ranging from nil (Rao et al., 1974) to 32 per cent (Kay et al., 1970). The series reported by Rao et al. (1974) differed from others in that angina was the presenting symptom in 75 per cent of the patients. Our operative mortality figure of 6.2 per cent is very similar to that of Loop et al. (1973a) whose group of patients most closely resembled ours.

Additional aortocoronary bypass grafting was not routine at the beginning of the series but became so later when 15 patients had this done. This has been the common course of events (Merin et al., 1973;
Loop et al., 1973a; Cooperman et al., 1975). Most of
the aneurysms excised were large and only in 3 was
the area excised less than 20 cm². It is not possible
to compare this with other surgical series as the area
of aneurysm is usually not stated.

The patients who in addition had a ventricular
septal defect closed or mitral annuloplasty or valve
replacement all survived. A feature of interest in this
series is the presence of 2 patients with a large
postero-inferior aneurysm in association with a
ventricular septal defect. The rarity of postero-
inferior aneurysms has been previously observed
(Loop et al., 1973b) and in a very large series of 400
patients there were only 11 such cases, in 2 of whom
there was an associated ventricular septal defect;
both of these patients also survived operation, and
showed great symptomatic improvement.

The majority of our patients have improved
clinically and 18 are asymptomatic leading a normal
life without medical therapy. Only one patient is
worse, with increased severity of angina. There has
only been 1 late death, 16 months after operation.

Loop et al. (1973a) have attempted to compare
surgical with medical treatment and have suggested
that the expectation of life is substantially improved
by aneurysmectomy. The medical prognosis is,
however, judged from post-mortem data which may
well be unrepresentative (Schlichter et al., 1954;
Dubnow et al., 1965). Data available on the
expected mortality of patients with coronary disease
and left ventricular dysfunction also suggest a high
mortality in patients treated medically; for example,
Brusckhe, Proudrit, and Sones (1973) report a 46
per cent 5-year cardiac mortality in patients showing
dyskinesia (aneurysm) in the left ventricular
angiogram.

The low operative mortality, the excellent results
in terms of symptomatic relief, and the improved
expectation of life after excision of left ventricular
aneurysms suggest that operation should be advised
in these patients. Aneurysmectomy can be safely
combined with aortocoronary bypass grafting,
closure of ventricular septal defect, or correction of
mitral regurgitation when these additional pro-
cedures are indicated.

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