The electrocardiogram after ventricular aneurysmectomy

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Surgical experience with ventricular aneurysmectomy alone or combined with coronary artery bypass surgery is accumulating.[1–6] However, the electrocardiographic changes after aneurysm resection have been documented in only a few studies.[7, 8] The purpose of this study was to define the spectrum of precordial electrocardiographic changes in a large population and to correlate such changes with clinical, angiographic, surgical, and pathological data.

Subjects and methods

At the Cleveland Clinic, between 1971 and 1976, 170 patients underwent resection of left ventricular aneurysm or scar without any other cardiac surgical procedure. Of these, the medical records of 104 patients contained both preoperative scalar electrocardiograms, as well as postoperative tracings done at least 3 weeks after the procedure. Fourteen patients were excluded from further study for the following reasons: five had complete right bundle branch block preoperatively; three had inferior or posterior ventricular aneurysms; four had "scars" or mixtures of "scar and muscle" rather than true aneurysms documented at surgery; and two had "false" or pseudoaneurysms. Thus, the 90 patients studied had true left ventricular aneurysms involving the septum, anterior, and/or apical myocardial walls.

The medical record of each patient was reviewed. The following data were extracted: age at operation, sex, symptoms and dates of myocardial infarction; coronary arterial lesions shown by angiography; left ventriculographic findings and preventriculographic left ventricular end-diastolic pressures. A coronary arterial lesion was considered important if at least 70% of the lumen was estimated to be obstructed. The operative reports were used to confirm the presence, location, and extent of the ventricular aneurysms. Postoperative serum glutamic oxaloacetic transaminase (SGOT) values were recorded on the first and second days after surgery. The area of resected aneurysm was estimated by multiplying its length and width as recorded in the pathology reports.

The preoperative electrocardiogram closest to the time of operation was reviewed. Most patients had tracings within 24 hours before surgery (range, several hours to 6 months). Postoperative electrocardiograms at least 3 weeks after surgery (range, 3 weeks to 26 months) were compared with preoperative tracings. As nearly as could be determined from clinical follow-up data, no patient had a postoperative myocardial infarction that could have altered the electrocardiogram.

All electrocardiograms were standardized in each lead. The height of the R wave and total height of the QRS complex were measured in each of the precordial leads V_{3R} through V_6. S-T segment elevation or depression was measured 0.08 seconds after the J point. Precordial S-T segment change was calculated by summing the S-T values in leads V_{3R} through V_6 both preoperatively and postoperatively and noting the difference. Precordial S-T segment lowering or elevation was defined as at least a 50% decrease or increase postoperatively.

Postoperatively, R waves were arbitrarily defined to be taller in the lateral precordial leads if the ratio of R wave height: QRS height (R:QRS ratio) increased by 25% in each of leads V_5 and V_6, or by 50% in V_6 alone. Patients with electrocardiograms meeting either of these criteria were categorized in group 1. In the anterior precordial leads, R waves were arbitrarily defined to be taller if the R:QRS ratio increased by 25% in each of leads V_{3R}, V_1 and V_2; or by 50% in any two consecutive leads, i.e., V_{3R} and V_1, or V_1 and V_2. Such changes met the criteria for group 2. R waves were considered taller across the precordium if the R:QRS ratio increased by 25% in at least six of the seven precordial leads; such changes were the criteria for group 3. R waves were considered new in any lead postoperatively if no R wave existed in that lead prior to operation. Patients were classified in group 4 if they met none of the criteria for groups 1 to 3.

Results

Table 1 demonstrates new or taller precordial R waves in at least one lead in 48 of 90 patients (53.3%) after left ventricular aneurysmectomy. Most of these R waves appear either in the anterior or lateral precordial leads alone. As shown in *Table 2*, 11 of 25 patients (44%) with new or taller postoperative lateral precordial R waves (group 1, *Fig. 1*) had precordial S-T segment lowering, and none had S-T elevation; three of three patients with new R waves or taller R waves across the precordium (group 3, *Fig. 2*) had precordial S-T lowering. In contrast, only 4 of 20 patients (20%) with new or taller anterior precordial R waves (group 2, *Fig. 3*) had

Table 1. New or taller precordial R waves after ventricular aneurysmectomy

Group	Location	No. of patients	Percent
1	Lateral precordial leads (V_5-V_6)	25	27.8
2	Anterior precordial leads (V_{3R}-V_2)	20	22.2
3	Across precordium	3	3.3
4	None of the above	42	46.7

Table 2. Correlation of precordial R wave and S-T changes after aneurysmectomy

	No. of patients		
Group	Precordial S-T lowering	Precordial S-T elevation	No precordial S-T change
1	11	0	14
2	4	3	13
3	3	0	0
4	7	3	32

S-T lowering and three (15%) actually had S-T elevation. These data suggest that groups 1 and 2 are not completely comparable. Thirty-two of 42 patients (76.2%) in group 4 (*Fig. 4*) had no S-T changes.

Clinical-electrocardiographic correlates

Table 3 reveals that two thirds of the patients studied were 55 years old or younger and that 88.9% were men. Interestingly, 56% of group 1 patients and 50% of group 2 patients had symptoms of congestive heart failure on initial presentation, compared with 31% of group 4. Most group 4 patients (52.4% had presenting symptoms of angina pectoris; 40% of group 2 patients had preoperative angina. Asymptomatic patients underwent aneurysmectomy mainly to improve impaired left ventricular function demonstrated on ventriculography.

Angiographic-electrocardiographic correlates

Left anterior descending artery obstructive lesions were present in all patients studied (*Table 4*). However, only 8% of group 1 patients had lesions involving other coronary arteries, whereas 33.3% of group 4 patients had additional significant lesions; 20% of group 2 patients had additional lesions.

Only 8% of group 1 patients had preoperative left ventricular end-diastolic pressures (LVEDP) less than or equal to 15 mm Hg, compared with 35% and 21.4% for groups 2 and 4, respectively.

Surgical/pathologic-electrocardiographic correlates

A higher percentage of group 4 patients (43.9%) underwent operation

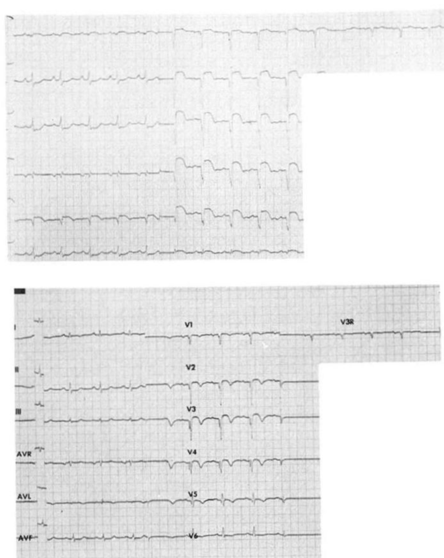

Fig. 1. Example of taller R waves in lateral precordial leads (V_5-V_6) after ventricular aneurysmectomy. **A,** (*top*) preoperative electrocardiogram and **B,** (*bottom*) postoperative tracing. Postoperatively, there is a new R wave in V_5, and the R: QRS ratio is increased in V_6. S-T segments are lower in most of the precordial leads postoperatively (see text).

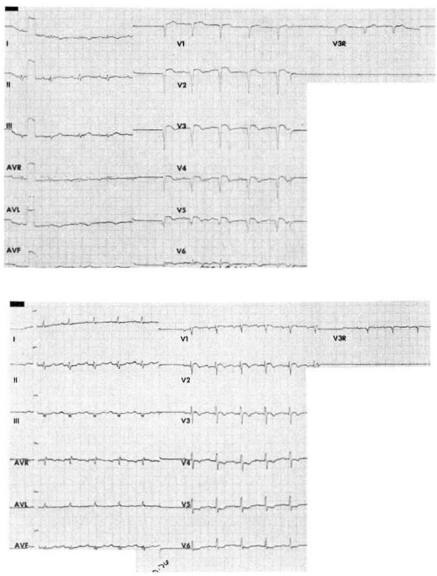

Fig. 2. Example of taller R waves in anterior precordial leads (V_{3R}-V_2) after ventricular aneurysmectomy. In this case, the R:QRS ratio increases postoperatively in V_{3R}, and there is a new R wave in V_1. **A,** (*top*) and **B,** (*bottom*) as in *Figure 1*.

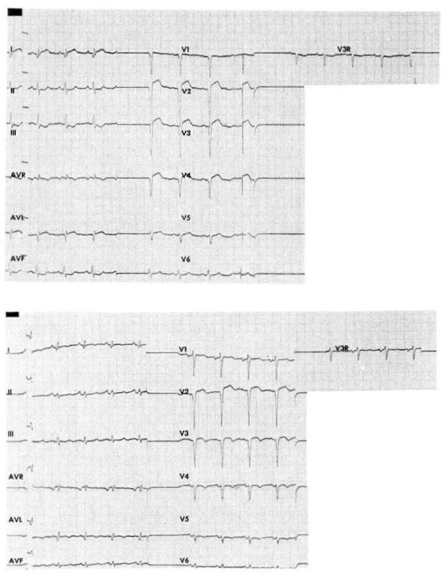

Fig. 3. Example of taller R waves across the precordium after ventricular aneurysmectomy. Note the new R waves in V_1-V_5 and the increased R:QRS ratio in V_6. **A,** (*top*) and **B,** (*bottom*) as in previous figures.

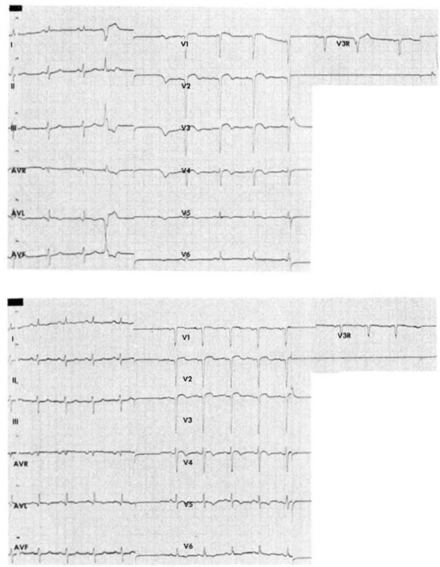

Fig. 4. Example of no increase in the R:QRS ratio in any precordial lead after ventricular aneurysmectomy. **A,** (*top*) and **B,** (*bottom*) as in previous figures.

Table 3. Clinical correlates of precordial R wave changes after aneurysmectomy

	No. of patients			
	Group			
	1	2	3	4
Age (yr)				
<56	12	13	2	33
≥56	13	7	1	9
Sex				
Male	25	16	3	36
Female	0	4	0	6
Preoperative symptoms				
Recurrent ventricular tachycardia	0	0	0	3
Congestive heart failure	14	10	0	13
Angina pectoris	5	8	1	22
Peripheral emboli	1	0	0	0
No symptoms	8	4	2	10

more than 2 years after initial myocardial infarction than either group 1 (16%) or group 2 (16.7%) patients (*Table 5*). Proportionately more group 2 patients (50%) had SGOT values higher than

Table 4. Angiographic correlates of precordial R wave changes after aneurysmectomy

	No. of patients			
	Group			
	1	2	3*	4
Significant coronary arterial lesions				
Left anterior descending coronary artery only	23	16	2	28
Left anterior descending artery + other†	2	4	1	14
Left ventricular end-diastolic pressure (mm Hg)				
≤15	2	7	0	9
15–30	17	9	2	26
>30	6	4	0	7

* One left ventricular end-diastolic pressure not recorded in chart.

† Other lesions include those involving major branches of right or circumflex coronary arteries, or major diagonal branches of left anterior descending artery proximal to lesions of the main trunk of left anterior descending artery.

Table 5. Surgical and pathological correlates of precordial R wave changes after aneurysmectomy

	No. of patients			
	Group			
	1	2	3	4
Time between first myocardial infarction and surgery*				
≤2 yr	21	15	2	23
>2 yr	4	3	1	18
SGOT† after surgery (units/liter)				
<100 on first two postoperative days	19	10	3	33
≥100 either day	6	10	0	9
Estimated area of resection				
≤20 sq cm	2	3	0	10
20–50 sq cm	6	9	1	23
>50 sq cm	16	6	2	5
Not reported or inadequate pathological description	1	2	0	4

* Date of myocardial infarction could not be determined in three cases.

† Normal values = 8–33 IU/liter.

100 units on either of the first two postoperative days than any other group.

Group 1 and group 3 patients had the largest areas resected: 66.7% of each group had more than an estimated 50 sq cm removed, whereas only 13.2% of group 4 patients had such large areas resected; in fact, 26.3% of group 4 patients had less than 20 sq cm resected.

Discussion

Although experience with ventricular aneurysm resection is accumulating, we are aware of only two publications in the English literature documenting electrocardiographic changes postoperatively: one case report[7] and one series of 26 cases.[8] Soloff and Rutenberg[7] described one patient with "the disappearance of the previously noted large Q waves in I, AVL and V_6" and the appearance of new tall R waves in these leads. Cokkinos et al[8] studied 26 patients "a few days after surgery" noting changes in QRS duration and axis, S-T elevation in a single lead, R wave net positivity in leads 1 or AVF and Q waves incidence in all leads. No angiographic correlates were made.

The results of our study show over 50% of patients who have undergone left ventricular aneurysmectomy as the only surgical procedure had new or taller R waves in at least one precordial lead postoperatively, if the aneurysm was in the distribution of an occluded left anterior descending coronary artery. The QRS and S-T changes probably were not transient, since tracings were obtained at least 3 weeks after surgery. Surgical technics have been described.[9]

New or taller R waves in the lateral precordium (group 1) were commonly accompanied by precordial S-T segment lowering. Additionally, patients with such changes were likely to undergo operation within 2 years of initial myocardial infarction with symptomatic congestive heart failure, single-vessel coronary disease and elevated left ventricular end-diastolic pressure. Finally, large areas of aneurysm tended to be resected. New or taller R waves in this group most commonly represented viable myocardium replacing aneurysm scar in the distribution of the lateral precordial leads.

In contrast, patients with no new or taller R waves in either the anterior or lateral precordial leads (group 4) were more likely to be seen later after their initial myocardial infarction with angina pectoris and multivessel coronary artery lesions. They tended to have less area resected. Thus, more extensive myocardial fibrosis and less extensive resection probably explain the absence of electrocardiographic change in this group.

That precordial S-T depression accompanied new or taller anterior R waves less than half as frequently as new or taller lateral R waves (4 of 20 patients versus 11 of 25 patients, respectively) implies that these groups may not be comparable. It is interesting that 20% of group 2 patients had multivessel lesions compared with 8% of group 1 patients, and that proportionately twice as many group 2 patients had SGOT values higher than 100 units (10 of 20 patients versus 6 of 25 patients). Thus, more group 2 patients were susceptible to perioperative myocardial infarction possibly manifest by some of the higher SGOTs postoperatively; three group 2 patients had new Q waves in V_5-V_6 postoperatively (one patient had triple-vessel disease with peak SGOT 128 units, and the other two had reported single-vessel disease with peak SGOTs of 198 and 99 units). In these three cases, the new anterior R waves were possibly reciprocal changes. Undoubtedly, some group 2 patients also had aneurysm scar replaced by viable myocardium in the distribution of the anterior precordial leads.

Two of the three patients with new or taller R waves across the precordium had more than 50 sq cm resected (approximately 130 and 135 sq cm, respectively), and both had lesions involving only the left anterior descending coronary artery. The third patient had an estimated 40- to 50-sq cm aneurysm resected and a 90% lesion occluding a diagonal branch of his left anterior descending artery, in addition to the lesion of the main trunk of his left anterior descending coronary artery.

No inferences regarding clinical response to aneurysmectomy should be made from our data since this was not studied.

Further study of the changes in the scalar electrocardiogram after aneurysm resection seems necessary to determine its clinical usefulness.

Summary

The medical records of 90 patients who underwent left ventricular aneurysm resection without any other cardiac surgical procedure were reviewed. Postoperative electrocardiograms were compared to preoperative tracings; 53.3% of patients had new or taller R waves postoperatively in the lateral precordial leads, V_5-V_6 (group 1), anterior precordial leads, V_{3R}-V_2 (group 2), or across the precordium in at least six of the seven precordial leads (group 3).

The remaining 46.7% of patients had none of these changes (group 4). Postoperative precordial S-T segment lowering was most commonly observed in groups 1 and 3. Electrocardiographic changes were correlated with clinical, angiographic, surgical, and pathological data. Group 1 patients usually underwent operation within 2 years of initial myocardial infarction with symptomatic congestive heart failure; single-vessel coronary artery disease involving the left anterior descending artery; and elevated left ventricular end-diastolic pressure. They also had larger areas of aneurysm resected. In contrast, proportionately more patients in group 4 were seen more than 2 years after their initial myocardial infarction with angina pectoris and multivessel coronary lesions; they also had less area resected. Group 2 patients differed from group 1 patients in several parameters; three group 2 patients had new Q waves in V_5-V_6 postoperatively, with taller anterior precordial R waves possibly representing reciprocal changes. Only three patients were represented in group 3.

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