

## SURGERY

# Role of Coronary Artery Revascularization and Aneurysmectomy in Ventricular Arrhythmias in the Chronic Phase of Myocardial Infarction

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**Introduction and objectives.** The influence of coronary artery revascularization on the control of ventricular arrhythmias in patients with chronic myocardial infarction is uncertain. However, ablation of the arrhythmogenic circuit in these patients by aneurysm resection is useful for controlling ventricular arrhythmias. We made a prospective analysis of our clinical strategy in patients who were candidates for coronary artery revascularization and/or aneurysmectomy to determine its influence on the recurrence of ventricular arrhythmias.

**Patients and method.** Prospective study of 17 consecutive patients with chronic myocardial infarction and ventricular arrhythmias unrelated with an acute ischemic event, who had coronary artery disease and/or ventricular aneurysm susceptible to aggressive treatment. We evaluated our clinical strategy and the recurrence of ventricular arrhythmias during a mean follow-up period of 33.64 months.

**Results.** Two groups of patients were studied: patients with ventricular aneurysm (group I: 12 patients) and patients without ventricular aneurysm (group II: 5 patients). Seven patients of group I underwent endoaneurysmorrhaphy and endocardial resection (4 of these patients had associated revascularization procedures). Three patients were not candidates for aneurysmectomy or revascularization procedures. Two patients underwent only revascularization procedures. All the patients in group II were revascularized. The patients who underwent aneurysmectomy did not have recurrence of arrhythmias. In 5 of the 6 patients who underwent programmed electrophysiological stimulation after aneurysmectomy, no sustained arrhythmia could be induced. Patients who were only revascularized had a high rate of recurrence of ventricular arrhythmias (57%), which were inducible after revascularization.

**Conclusion.** Aneurysmectomy and endocardial resection constituted, in our experience, an effective tool for controlling ventricular arrhythmias associated with left ventricular aneurysm. Coronary artery revascularization in patients with ventricular arrhythmias and chronic myocardial

infarction probably does not prevent the recurrence of ventricular arrhythmias.

**Key words:** *Ventricular arrhythmia. Aneurysm. Coronary revascularization. Myocardial infarction.*

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## Papel de la revascularización coronaria y la aneurismectomía en las arritmias ventriculares asociadas a infarto de miocardio crónico

**Introducción y objetivos.** La influencia de la revascularización coronaria en el control de las arritmias ventriculares, en pacientes con infarto de miocardio crónico, es incierta y el control de éstas es más evidente cuando se consigue resear el circuito arritmogénico de un aneurisma. En este sentido, revisamos prospectivamente nuestra estrategia clínica en estos pacientes subsidiarios de revascularización coronaria y/o aneurismectomía con el objetivo de comprobar su influencia en la recurrencia de la arritmia.

**Pacientes y método.** Estudio prospectivo de 17 pacientes consecutivos con infarto de miocardio crónico y arritmias ventriculares no relacionadas con isquemia aguda, que presentaban enfermedad coronaria y/o aneurisma ventricular subsidiario de tratamiento intervencionista. Se analiza la estrategia desarrollada y la recurrencia de las arritmias ventriculares a lo largo de un seguimiento de 33,64 meses de media.

**Resultados.** Se consideraron 2 grupos de pacientes, según presentaran (grupo I) o no (grupo II) aneurisma de ventrículo izquierdo. De los 12 pacientes del grupo I, en siete se realizó endoaneurismorrafia y resección endocárdica (además, cuatro fueron revascularizados). Tres pacientes no fueron intervenidos por presentar un aneurisma no resecable y no ser subsidiario de revascularización. Dos pacientes sólo fueron revascularizados. Todos los pacientes del grupo II (5 pacientes sin aneurisma) fueron revascularizados. Los enfermos sometidos a aneurismectomía no tuvieron recurrencia de la arritmia, y ésta no se indujo en cinco de los 6 pacientes a los que se realizó estudio electrofisiológico postintervención. Los pacientes exclusivamente revascularizados presentaron una alta recurrencia arrítmica (57%) y su arritmia podía ser inducible tras la revascularización.

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## ABBREVIATIONS

SMVT: sustained monomorphic ventricular tachycardia  
VF: ventricular fibrillation  
MADIT: Multicenter Automatic Defibrillator Implantation Trial  
TD: typical deviation  
EPS: electrophysiological study  
AID: automatic implantable defibrillator  
AMI: acute myocardial infarction

**Conclusiones.** La aneurismectomía complementada con resección endocárdica constituyó, según nuestra experiencia, una eficaz herramienta para el control de las arritmias ventriculares asociadas a aneurisma de ventrículo izquierdo. La revascularización coronaria en pacientes con arritmias ventriculares e infarto de miocardio crónico no parece influir en la prevención de recurrencia arrítmica.

**Palabras clave:** *Arritmia ventricular. Aneurisma. Revascularización coronaria. Infarto de miocardio.*

## INTRODUCTION

The diagnostic-therapeutic strategy for patients with persistent ventricular arrhythmias associated with chronic myocardial infarction include the study of coronary artery anatomy, ventricular function, and programmed electrical stimulation to test the reproducibility of the arrhythmia and its possible source. Cardiac revascularization is the treatment of choice in the presence of residual ischemia. Nevertheless, the efficacy of cardiac revascularization in controlling ventricular arrhythmias is unclear.<sup>1-4</sup> In the presence of ventricular arrhythmia, aneurysmectomy in conjunction with endocardial resection has resulted in greater success rates for controlling ventricular arrhythmias.<sup>5,6</sup>

In this study, we performed a prospective follow-up study of our clinical interventions that included coronary revascularization, resection of the aneurysm or the implantation of an automatic defibrillator (AID), or both, in patients with ventricular arrhythmias and chronic myocardial infarction.

## PATIENTS AND METHOD

Between June, 1995, and September, 2001, we studied 53 patients with ventricular arrhythmias in our cardiac electrophysiological laboratory at the Hospital Universitario Virgen Macarena de Sevilla. Of these 53 patients, 17 had heart disease with ventricular

aneurysm secondary to interventionist treatment. A total of 15 patients had a history of myocardial infarction, but all patients presented with symptoms of hypokinesia, akinesia, or dyskinesia, or all three. We excluded from the study those patients with evidence of acute ischemia associated with the arrhythmic event and divided the patients into 2 groups: those who had a left ventricular aneurysm (group 1) and those who did not (group 2).

## Coronary angiography

Coronary angiography was performed in accordance with standard procedures between 5 and 30 days after the episode of arrhythmia.

## Coronary revascularization

The indication for performing coronary revascularization was established according to the severity of the lesions on coronary angiogram and after evaluating the existence of residual ischemia.

## Surgical procedure for ventricular aneurysms

Surgical procedures were performed using the Jatene and Cooley endoaneurysmorrhaphy technique,<sup>7</sup> with surgical endocardial resection of the edges of the fibrous scar. The criteria for resection were exclusively technical, and the surgical team evaluated whether the resection was physically possible, taking into account anatomical features as seen on contrast ventriculography.

## Electrophysiological study

Electrophysiological study was performed using two quadripolar 6 Fr electrocatheters for recording and stimulation. The stimulation protocol at the apex of the right ventricle used 1 to 3 premature extra stimuli during the sinus rhythm and during 3 cycle longitudes (600, 500, and 400 ms) of stimulation with a ventricular pacemaker. The arrhythmia induction test was considered positive if it induced ventricular tachycardia that was sustained for more than 30 seconds or if it was poorly tolerated hemodynamically, requiring electrical cardioversion to stop it.

## Follow-up

During follow-up, recurrent arrhythmia was considered to be present after documentation of the existence of sustained ventricular arrhythmia on electrocardiograph or recording results from the defibrillator electrogram, and in the presence of sudden cardiac death. Follow-up was performed by direct contact in the outpatient clinic or by telephone interview.

### Statistical analysis

The qualitative variables were compared by means of the exact Fisher test. The quantitative variables were expressed as mean and standard deviation (SD) and analyzed by the Student *t* test.

### RESULTS

Baseline clinical characteristics of the patient sample are shown in Table 1. All but 1 patient presented with significant cardiac lesions (stenosis  $\geq 50\%$ ). That patient had a history of traumatic myocardial infarct at the age of 4 years, and at the age of 24 years presented with sustained monomorphic ventricular tachycardia (SMVT), evident by the presence of an apical aneurysm on ventriculography. One patient with a ventricular aneurysm did not agree to repeat coronary angiography and provided the record from a coronary angiography exam performed 5 years previously, which revealed occlusion of the anterior descending artery. A total of 12 patients had an aneurysm in the left ventricle, 11 in the anterior location and one in the posterobasal location. The mean ejection fraction was 32% (SD, 9.93). The spontaneous ventricular arrhythmia was an SMVT in 12 patients, ventricular fibrillation (VF) in 4 patients, and 1 patient presented with characteristics of the MADIT type (non-sustained ventricular tachycardia, EF<35%, and inducible

TABLE 1. Baseline clinical characteristics of the 17 patients

	Group I With aneurysm (n=12)	Group II Without aneurysm (n=5)	
Men	11 (92%)	4 (80%)	NS
Age, years	58 (24-76); SD, 13.67	60 (45-65); SD, 8.43	NS
Previous AMI	12	3	
Anterior AMI	7	2	
Inferior AMI	1	1	
Anterior +inferior AMI	4	0	
Segment motility changes	12	5	
Ejection fraction	30% (17-42); TD, 8.7238%	(20-48); TD, 11.15	NS
VII aneurysms			
Anterior	11		
Posterobasal	1		
Heart disease*			
Normal	1	0	
One vessel	4	3	
$\geq 2$ vessels	6	2	

\*One patient with a ventricular aneurysm refused repeat coronary angiography and provided a report from an angiographic exam performed 5 years previously which showed the occlusion of the anterior descending artery. AMI indicates acute myocardial infarction; SD, standard deviation; NS, not significant.

TABLE 2. Intervention performed

	Group I With aneurysm (n=12)	Group II Without aneurysm (n=5)
Revascularization alone	2	5
Aneurysmectomy alone	3	
Aneurysmectomy+revascularization	4	
No intervention	3	

Type of revascularization: percutaneous angioplasty in 8 patients and aortocoronary bypass in 3 patients.

SMVT). The episode of arrhythmia occurred between 7 days and 20 years after the myocardial infarct (mean, 39 months; SD, 62.77).

### Coronary revascularization and aneurysmectomy (Table 2)

Of the 12 patients with a left ventricular aneurysm (group 1), 7 underwent an endoaneurysmorrhaphy with the Jatene technique accompanied by endocardial resection; 4 of these patients also underwent revascularization. In 2 patients with aneurysm it was only possible to perform coronary revascularization. There were 3 patients whose aneurysms could not be resected and who could not undergo coronary revascularization. All the patients in group 2 (5 cases without aneurysm) underwent revascularization. Therefore, among both groups there were 7 patients who only underwent revascularization and 14 who underwent some type of intervention.

### Electrophysiological study (Table 3)

A pre-intervention electrophysiological study (EPS) was performed in only 5 patients? in 3 patients because they had not undergone an intervention of any type, in another patient because the study was negative and was obviously not going to change after the intervention, and in the fifth patient who was diagnosed post-operatively with an advanced gastric neoplasm after the aneurysmectomy who rejected the post-intervention EPS. In 6 patients the post-intervention EPS was not performed because of logistical problems and in opposition to our wishes. In any case, the fact that arrhythmias could be induced in 4 patients following revascularization and not induced in 2 patients following aneurysmectomy allowed us to adjust the AID appropriately. The remaining 6 patients underwent pre- and post-intervention EPS.

### Clinical recurrence of ventricular arrhythmias (Table 4)

A total of 15 patients were followed for more than 1 year, and 1 patient was followed for 6 months; in ad

**TABLE 3. Results from the electrophysiological study**

	Group I: patients with aneurysm (n=12)		
	Aneurysm +resection	Revascularization alone	No intervention
Only 1st EPS:4 patients + result:4	1*		3 (AID)
Only 2nd EPS:4 patients + result:2 - result:2	2	2 (AID)	
1st and 2nd EPS:4 patients + /+ result:1 + /- result:3	1 (AID) 3		

\*This patient was diagnosed postoperatively with an advanced gastric neoplasm, and for this reason it was not appropriate to subject the patient to a second EPS.

	Group II: patients without aneurysm (n=5), all underwent revascularization	
	Results	
Only 1st EPS:1 patient	- (AID)	
Only 2nd EPS:2 patients	+ (AID)	
1st and 2nd EPS:2 patients	+ /+ (AID)	

1st and 2nd EPS indicates electrophysiological study pre- and post-intervention; AID, automatic implantable defibrillator.

**TABLE 4. Recurrence of ventricular arrhythmias\***

	Number of patients	Recurrence
Group I. With aneurysm	12	3 (25%)
With resection	7	0 (0%)
Without resection	5	3 (60%)
No intervention	3	2
Revascularization alone	2	1
Group II. Without aneurysm	5	3 (60%)

\*Follow-up was for 33.64 months (range, 2 to 72 months) and there were recurrences in 6 patients (35%).

dition, one of the patients who underwent intervention for an aneurysm died 2 months after the procedure of noncardiac-related causes (hemorrhagic shock due to gastric neoplasm). Mean follow-up was 33.64 months (2 to 72 months). During this entire period, 6 patients

**TABLE 5. Comparison of the strategy developed**

	Pacientes	Aneurysm surgery	Revascularization alone	Spontaneous Initial VF	AID	Recurrence
Negative 2nd EPS	5	5		0		0
Negative 1st EPS	1		1	1	1	0
Positive 2nd EPS	7	1	6	3	7	4
Patients who did not undergo intervention**	3		0	3	2	
Total	16*	6*	7	4	11	6

\*There was patient with a positive pre-surgery EPS in whom it was deemed inappropriate to perform a second EPS because the patient was diagnosed postoperatively with an advanced gastric neoplasm. This patient did not present with a recurrence of arrhythmia during the 2-month interval between surgery and the patient's death due to digestive hemorrhage. \*\*These 3 patients had aneurysms that were not resectable and were did not undergo revascularization, having a positive baseline EPS. VF indicates ventricular fibrillation; EPS, electrophysiological study.

had a recurrence of sustained ventricular arrhythmia (3 of the SMVT type and 3 of the VF type; 3 patients belonged to group 2 and 3 to group 2). The 3 recurrences in group 1 corresponded to patients whose aneurysms had not been resected ( $P<.05$ ). With regard to the patients who only underwent revascularization (2 in group 1 and 5 in group 2), the recurrence rate was 57%. The time interval between the initial episode of arrhythmia and the recurrent episode varied from 1 to 5 months.

### Implantation of an automatic implantable defibrillator (AID) (Tables 3 and 5)

The decision as to whether or not an AID should be implanted was influenced by: whether the spontaneous ventricular arrhythmia was of the VF type, whether the patient could undergo an intervention or not, and the result of the post-intervention EPS. There was no indication for an AID in 6 patients, all of whom had undergone aneurysmectomy. In 5 of these patients, post-intervention EPS was negative. The 6th patient, diagnosed with advanced gastric neoplasm postoperatively, was not subjected to a second EPS as the patient's spontaneous arrhythmia was not of the VF type. None of these 6 patients had a recurrence of arrhythmia. In the remaining 11 patients, the implantation of an AID was indicated: in 3 because they did not undergo intervention and presented with a positive baseline EPS; in 7 patients because the post-intervention EPS was positive, and in 1 patient because the pre-intervention EPS was negative (revascularization) and the spontaneous arrhythmia was of the VF type.

### Anti-arrhythmia treatment in follow-up

An anti-arrhythmia medication was prescribed (sotalol, amiodarone, carvedilol, or atenolol) for 14 patients: for 9 patients in group 1 and 5 in group 2. In group 1, 4 of the 7 patients whose aneurysm was resected received anti-arrhythmia medication and the 5 patients who did not undergo intervention for the aneurysm received anti-arrhythmia medication.

## DISCUSSION

We attempted to study a group of patients with sustained ventricular arrhythmia associated with a chronic myocardial infarct who presented with heart disease or ventricular aneurysm, or both, after revascularization or aneurysmectomy. Our aim was to determine if these interventions influenced the recurrence of arrhythmias.

In actuality, the number of interventions for ventricular aneurysms due to arrhythmias has decreased due to the implantation of automatic defibrillators. Nevertheless, the complete management of these patients with resection of the aneurysm, ablation of the arrhythmogenic focus, and coronary revascularization, would appear to be the best intervention. It has actually been possible to simplify these procedures, particularly with use of intraoperative mapping. Some authors<sup>6,8,9</sup> have shown that aneurysmectomy with endocardial resection of the edges of the fibrous scar without intraoperative mapping achieves results similar to those obtained by using mapping. In our study, the success rate for avoiding the recurrence of arrhythmias was complete, and the arrhythmia stopped being reproducible in 5 of the 6 patients in whom post-surgical EPS was performed. This was not the case in those patients whose aneurysms were not resected, and a recurrence of arrhythmias occurred in 3 of these 5 patients ( $P < .05$ ). Frapier et al,<sup>6</sup> after performing endocardial resection with cryoablation without using intraoperative mapping, achieved an 89% lack of recurrence of arrhythmias and they could no longer induce arrhythmias in 94.5% of their patients.

The influence of coronary revascularization for controlling ventricular arrhythmia in patients with chronic myocardial infarcts is uncertain. When it can be determined that acute ischemia is the trigger for the arrhythmia (principally polymorphic or VF ventricular tachycardia), revascularization has proven to be useful.<sup>3,4</sup> Nevertheless, in the majority of cases, it is difficult to prove the source of the ischemic trigger. We were able to prove in our study that there is a high recurrence rate of arrhythmias (57%) in those patients who only undergo revascularization, and that their arrhythmias are inducible after the revascularization. Therefore, the substrate of the arrhythmia is scarcely modified by this intervention. A similar conclusion was reached by Brugada et al<sup>10</sup> and others.<sup>1</sup>

It is of note that the majority of our patients received anti-arrhythmia agents during follow-up, which may have skewed our results.

Of the 2 factors that can originate ventricular arrhythmias associated with chronic myocardial infarction, with scarring and ischemia as contributing factors, scarring is probably the most important. Resection of the scar, therefore, should be performed whenever possible, particularly when an aneurysm is present. In cases of infarct without aneurysm, endocar-

dial ablation of the arrhythmia substrate is limited by the necessity of maintaining the patient on TV during the study, although there have been reports of attempts to perform this during sinus rhythm.<sup>11</sup> This method, combined with coronary revascularization and the appropriate anti-arrhythmia therapy, may allow us to save some of our patients from the disagreeable experience of AID electric shocks.

## CONCLUSIONS

Aneurysmectomy with endocardial resection constitutes, in our experience, an efficient tool for controlling ventricular arrhythmias associated with aneurysms of the left ventricle.

Coronary revascularization in patients with ventricular arrhythmias and chronic myocardial infarction do not appear to influence the prevention of the recurrence of arrhythmias.

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