Surgical ablation of ventricular tachycardia: improved results with a map-directed regional approach

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ABSTRACT To determine whether a regional approach to surgery for ventricular tachycardia would improve on the results of previously reported methods of endocardial resection, an analysis was performed of our surgical experience over a 5 year period. Of 46 consecutive patients operated on for recurrent sustained ventricular tachycardia or ventricular fibrillation, 39 patients with ischemic heart disease underwent subendocardial resection and/or cryoablation. The mean age of the patients was 61 ± 8 (SD) years, the mean left ventricular ejection fraction was 32 ± 11%, and the mean number of ineffective antiarrhythmic drugs was 3.8 ± 1.2 per patient. In 35 of 39 patients in whom mapping data were obtainable, 56 (86%) tachycardias had earliest sites of activation in the left ventricle and nine (14%) had earliest sites in the right ventricle. Ten patients had 14 tachycardias (21%) mapped to areas outside visible dense scar. Of these 35 patients, 10 underwent localized subendocardial resection and 25 underwent a regional procedure in which all areas activated before the surface QRS during ventricular tachycardia were excised and/or cryoablated. In the operative survivors of electrophysiologically guided surgery, three of eight (38%) patients with the localized and one of 24 (4%) patients who underwent the regional procedure had recurrence of ventricular tachycardia during a follow-up period of 1 to 59 (mean 22 ± 17) months (p = .04). The favorable outcome of regional surgery was not influenced by the presence of multiple morphologies in 54%, disparate sites of origin in 29%, or inferior wall foci in 46% of patients. These data suggest that (1) some ventricular tachycardias have earliest sites of activation outside visible dense scar and/or within the right ventricle, (2) a regional approach to arrhythmia ablation can lead to operative success in over 90% of patients, and (3) multiple morphologies, disparate sites, and inferior wall origin are not adverse prognostic factors to success when this approach is used.

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IT IS NOW well accepted that subendocardial resection is an effective treatment for patients with ischemic heart disease and recurrent sustained ventricular tachycardia that is resistant to drug therapy. 1 Controversy, however, remains as to the extent of endocardium to be removed and the value of preoperative and intraoperative electrophysiologic guidance. Some groups advocate precise, map-directed, localized resection, while others perform mapping but remove almost all endocardial scar. 2-4 Postoperatively, spontaneous or induced ventricular tachycardia still occurs in 30% of patients undergoing both procedures 5, 6 and hence refinements are necessary to improve further the operative results. Since 1982, we have been performing an operation that combines features of both procedures, using supplemental cryothermy when indicated. The purpose of the present report is to document our favorable experience with this map-directed regional approach.

Material and methods

Patients (table 1). Between February 1981 and July 1985, a total of 46 patients with either documented sustained ventricular tachycardia or ventricular fibrillation underwent surgery for the elimination of their arrhythmias. Thirty-nine patients had ischemic heart disease and seven had ventricular tachycardia of other causes. The latter patients are alive and free of arrhythmia and will not be further discussed.

Among the patients with ischemic heart disease, there were 32 men and seven women from 44 to 75 (mean 61 ± 8) years old. Fifteen patients had a history of anterior myocardial infarction, 12 had inferior infarction, and 12 had both. The mean left ventricular ejection fraction was 32 ± 11%. Empiric drug ther-
KRAFCHÉK had additional patients three, left ventricular two to proven apy.

**TABLE 1**

<table>
<thead>
<tr>
<th>Surgical procedures (n = 39)</th>
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| Localized subendocardial resection | 10  
| Regional ablation | 25  
| Subendocardial resection | 3  
| Cryoablation | 3  
| Both subendocardial resection and cryoablation | 19  
| Nonmap-directed procedures | 4  
| Aneurectomy | 35  
| Coronary bypass grafting | 32  
| Mean No. vessels bypassed | 1.9 ± 0.8  
| Mean follow-up (months) | 22 ± 17 |

apy had failed in all and at least two further antiarrhythmic drugs had proven ineffective during serial electrophysiologic testing (range two to six, mean 3.8 ± 1.2) in each patient. Eight patients had additional indications for surgery: severe angina in three, left ventricular failure in two, and both in three others.

**Electrophysiologic mapping studies.** After failure of the tachycardia to respond to antiarrhythmic drugs was documented, preoperative hemodynamic and electrophysiologic mapping studies were undertaken. Three to five quadripolar catheters were inserted into the left and right ventricles of each patient and attempts were made by programmed stimulation to induce all previously documented forms of ventricular tachycardia. After initiation of each arrhythmia, catheter positions were verified by biplane fluoroscopy and bipolar electrogams were recorded from as many sites in both ventricles as possible. Recordings from 10 to 40 sites were usually obtained. A standardized grid (figure 1) with adjacent mapping sites 2 to 2.5 cm apart (measured by comparison with catheter interelectrode distances) was superimposed so that the location of each site could be determined. The electrogams used to determine local activation were those that contained high-amplitude, high-frequency components. The activation time at each site was measured from the onset of the surface QRS to the point on the electrogam at which the most rapid deflection crossed the baseline. The earliest site of endocardial activity was therefore defined as that with the earliest activation occurring before the surface QRS during the latter half of electrical diastole. 3, 7

**Operative procedures.** During normothermic bypass both epicardial and endocardial mapping of all morphologically distinct tachycardias was attempted with sequential positioning of hand-held bipolar electrodes. When the preoperative study suggested early right ventricular activation, the right ventricular endocardium was also mapped through the tricuspid valve. Sampling of multiple recording sites was facilitated by use of an intraoperative mapping grid, the distance between each site being 1 to 1.5 cm. The site of earliest identified endocardial activity was determined by intraoperative endocardial mapping when possible (figure 2). When ventricular tachycardia was noninducible or nonsustained, reliance was placed on the preoperative catheter map alone. Epicardial map data were used only when adequate endocardial data could not be obtained. 8

The aorta was then cross-clamped and cold cardioplegic solution was infused. Aneurectomy and subendocardial resection were both usually performed (table 1). In the first 10 patients subendocardial resection was localized to the earliest site of endocardial activation and included a small surrounding margin, as described by Harken et al. 9 Eight to twenty-five square centimeters of endocardium was removed. In the next 25 patients a regional procedure was performed in which areas containing the site of earliest activity and all other early sites, particularly those activated before the QRS onset, were excised and/or cryoablated. This usually involved the ablation of 20, and commonly up to 40 cm2 of endocardium (figures 3 and 4). Supplemental cryothermy was used when arrhythmic foci were found in papillary muscles, near valve anuli, or in areas outside

**FIGURE 1.** Endocardial catheter mapping technique. A and B, Superimposed grid on 45 to 60 degree left anterior oblique and anteroposterior projections of heart. C and D, Left and right ventricular endocardial surface showing locations of mapping sites and papillary muscles. E, Induced ventricular tachycardia with multiple endocardial electrogams. Vertical line indicates onset of QRS. Electrocardiographic leads and mapping sites are shown on the left. Activation times in milliseconds are on the right. A = anterior; F = free wall; FAP = femoral artery pressure; LV = left ventricle; M = mid region; P = posterior; S = septal surface; RV = right ventricle.
visible scar or when full thickness ablation of the septum was required. Cryoablation was achieved by use of a custom right-angle probe with a 1 cm tip (Valley Lab Nitrous Oxide Unit, Valley Lab Inc., Boulder, CO). The probe was applied to each site for 2 min at −75°C and the depth of cryolesions was determined by finger palpation. In four other patients no preoperative or intraoperative mapping data were available and a procedure that was not map directed was performed in which all visible endocardial scar or thickening was removed. Most patients underwent additional coronary bypass grafting (table 1). Mitral valve replacement was not performed in any patient.

**Follow-up.** Before hospital discharge, all patients underwent an electrophysiologic study with the use of epicardial pacing wires. The study protocol used was the same as that which induced the preoperative arrhythmia but included one additional extrastimulus. Epicardial stimulation was performed from the right ventricular apex at two drive cycle lengths (600 and 500 msec) and three or more extrastimuli plus burst pacing were used in 75% of patients. A radionuclide left ventricular ejection fraction was obtained at 10 to 14 days for comparison with the preoperative results.

After discharge from the hospital, the patients were followed by visits to their private physicians, frequent telephone interviews, and transtelephonic monitoring of any symptoms. Complete follow-up was obtained for all patients.

**Definition of terms.** Sustained ventricular tachycardia was defined as that lasting more than 30 sec or causing hemodynamic collapse requiring cardioversion. Multiple morphologies and distinct tachycardias were considered present if they displayed QRS morphologies resembling both right and left bundle branch block or a divergence of the frontal plane axis of more than 90 degrees. A tachycardia was considered adequately mapped by preoperative or intraoperative means if recordings of activity from a minimum of four left ventricular catheter map sites or 20 intraoperative epicardial or endocardial sites were obtained. At least one endocardial electrogram occurring preferably before, or within 20 msec, of the surface QRS was also required. The site of origin of a tachycardia was the earliest site of activation for that morphology and was related to the preoperative or intraoperative grid map, as previously discussed. For purposes of analysis, these were grouped into regions of septal, anterior, or inferior sites. Disparate sites of origin were defined as sites of origin of morphologically distinct tachycardias that were at least 5 cm apart on the endocardial grid maps. Operative death was that occurring within 30 days of surgery. Postoperative recurrence of sustained ventricular tachycardia was that which was induced at the postoperative electrophysiologic study, occurred spontaneously, or may have resulted in sudden death. Surgery alone was considered successful if the patient was not taking antiarrhythmic drugs and did not have a postoperative recurrence of sustained ventricular tachycardia.

**Analysis of results.** The following parameters, including those previously reported to influence the outcome of surgery, were assessed in the operative survivors: age, degree of left ventricular dysfunction, extent of coronary disease, number of failed antiarrhythmic drugs, presence of multiple morphologies, disparate sites of origin, an inferior wall origin, aortic cross-clamp and cardiopulmonary bypass times, and the type of surgical procedure performed.

Kaplan-Meier methods were used to display the time-related

**FIGURE 2.** Left. Intraoperative mapping grid, showing endocardial surfaces of left and right ventricles. Right, Induced ventricular tachycardia with electrograms from selected sites, presented in a format similar to that of Figure 1. APM = anterolateral papillary muscle; LV = left ventricular; MV = mitral valve anulus; PPM = posteromedial papillary muscle; PV = pulmonic valve; Ref = reference electrode; RV = right ventricular; TV = tricuspid valve.
arrhythmia-free rates in patients who underwent the two operations. The probability of a true difference in outcome was determined by the generalized Wilcoxon test. Changes between preoperative and postoperative ejection fractions in the two groups were compared by Student’s t test. A p value <.05 was considered indicative of a statistically significant difference.

Results

Preoperative and intraoperative mapping studies. At electrophysiologic testing, there were 78 spontaneous or induced tachycardias in the 39 patients with ischemic heart disease (range one to six, mean 2 ± 1 tachycardias per patient). Fifteen patients had tachycardia of a single morphology, 12 patients had those of two morphologies, and 12 patients had three or more types of tachycardia. Among the 35 patients in whom mapping data were available, adequate preoperative catheter maps were obtained for 55 of 72 tachycardias (76%). For 41 of these tachycardias, electrograms were recorded from 10 or more sites in the left and right ventricles (mean 19 ± 10). Intraoperative epicardial maps were obtained of 37 tachycardias (51%) and intraoperative endocardial maps were recorded for 20 (28%). Specifically, intraoperative endocardial maps revealed 10 additional morphologies that had not been mapped preoperatively. Thus, among these 35 patients, preoperative or intraoperative endocardial mapping data were available for a total of 65 distinct ventricular tachycardias (90%), 55 with recorded presystolic activity, leaving only seven tachycardias unmapped.

Among patients in whom arrhythmias were mapped, 56 tachycardias had earliest sites of activation in the left ventricle and nine had earliest sites in the right ventricle. In these cases, nonfractionated right

FIGURE 3. Endocardial mapping data from a patient with three morphologically distinct ventricular tachycardias. A, Electrocardiogram and intraoperative map of tachycardia A. B and C, Electrocardiograms and catheter endocardial maps of tachycardias B and C, which could not be induced intraoperatively. Activation times in milliseconds before and after onset of QRS. Isochrones drawn at 10 msec intervals. In tachycardia B, the earliest site of activation was at the apex of the right ventricle.

FIGURE 4. Operative procedure performed in same patient shown in figure 3. Full-thickness excision of apexes of both ventricles and the distal septum was performed to include tachycardia B and the aneurysmal scar. Cryolesions were created as shown to include earliest sites of activation of tachycardias A and C, which were found in muscle outside dense scar. LV = left ventricular; RV = right ventricular; VT = ventricular tachycardia.
ventricular electrograms were recorded 20 to 100 msec before any left ventricular site. Twenty-three patients had tachycardia of multiple morphologies; nine were of disparate sites of origin and 15 were of an inferior wall origin. In 10 patients there were 14 tachycardias with earliest sites of activation found outside areas of dense scarring. Six of these were located on the left side of the interventricular septum, six on the right side, one on the right ventricular free wall, and one on the crista supraventricularis.

Reasons for not obtaining complete mapping data on all patients included deterioration of hemodynamic status during tachycardia or failure to initiate and sustain tachycardia, particularly once under general anesthesia. For those tachycardias that were mapped both preoperatively and intraoperatively, localization to similar areas was seen in all cases.

Surgical results. The surgical results for the 39 patients with ischemic heart disease are shown in figure 5. The follow-up period was 1 to 59 (mean 22 ± 17) months. There was an operative mortality of 10.2% (4/39) and a surgery-alone cure rate of 88.6% (31/35) in survivors.

The four operative deaths included two in patients who had localized procedures, one a regional and one a nonmap-directed procedure. These patients all had severe diffuse left ventricular dysfunction (ejection fractions of 14%, 16%, 18%, and 20%) and died of low cardiac output without recurrence of their arrhythmias.

Thus, of the remaining 35 operative survivors, 24 patients had regional resections, eight had localized resections, and three had nonmap-directed procedures. In 21 of 24 patients who underwent regional ablations, supplemental cryotherapy was used to treat ventricular tachycardia arising from scarred inferior papillary muscles in five patients, the basal inferior wall in two patients, the right ventricular free wall in one patient, and crista supraventricularis in one other. Five patients had left-sided cryoablation of either the septum or anterior left ventricular free wall to supplement endocardial excision. This was done to extend the area of ablation to include those outside areas of scarring that were also activated before the surface QRS. In seven patients with right and/or left septal foci, cryotherapy was applied to both sides of the septum by a new technique\textsuperscript{12,13} when earliest sites of activation were outside areas of dense scarring and intramural sites could not be excluded.

Among those undergoing map-directed procedures, postoperative recurrence of sustained ventricular tachycardia occurred in two of the eight patients who had localized procedures. These two recurrent tachycardias were identical to those seen preoperatively. A third patient died suddenly. These eight patients were followed for 1 to 59 (mean 37 ± 24) months. In contrast, of 24 patients who had regional surgery, who were followed for 6 to 41 (mean 17 ± 10) months, there was only one recurrence — a surgery-alone cure rate of 96% (p = .04). The postoperative tachycardia in the remaining patient had never been seen preoperatively. The three patients with recurrent ventricular tachycardia are receiving antiarrhythmic drugs. The two who had localized procedures still have occasional recurrences of ventricular tachycardia; the one patient who had a regional procedure now has suppression of his arrhythmia. A total of four late nonarrhythmic deaths also occurred: two due to heart failure, one as a result of myocardial infarction, and one from malignancy.

The distribution of possible adverse prognostic factors was evenly divided between the two groups of survivors (table 2). In those who underwent the region-
TABLE 2
Distribution of possible adverse factors (in survivors)

<table>
<thead>
<tr>
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<th>Localized (n = 8)</th>
<th>Regional (n = 24)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>62 ± 8</td>
<td>58 ± 13</td>
</tr>
<tr>
<td>Left ventricular ejection fraction (%)</td>
<td>37 ± 8</td>
<td>31 ± 11</td>
</tr>
<tr>
<td>Coronary disease(^a)</td>
<td>2.6 ± 0.5</td>
<td>2.0 ± 0.6</td>
</tr>
<tr>
<td>Ineffective drugs</td>
<td>4.1 ± 1.1</td>
<td>3.7 ± 1.1</td>
</tr>
<tr>
<td>Multiple QRS morphologies (% of patients)</td>
<td>50</td>
<td>54</td>
</tr>
<tr>
<td>Disparate sites of origin (% of patients)</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Inferior wall foci (% of patients)</td>
<td>25</td>
<td>46</td>
</tr>
<tr>
<td>Multiple morphologies, disparate sites, or inferior wall foci (% of patients)</td>
<td>62</td>
<td>75</td>
</tr>
<tr>
<td>Aortic cross-clamp time (min)</td>
<td>47 ± 17</td>
<td>55 ± 19</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time (min)</td>
<td>131 ± 41</td>
<td>131 ± 25</td>
</tr>
<tr>
<td>Postoperative recurrence of VT (% of patients)</td>
<td>38</td>
<td>4</td>
</tr>
</tbody>
</table>

\(^a\)Number of vessels with >50% stenosis.

al procedure, the high success rate of surgery was not adversely affected by the presence of multiple morphologies (54%), by disparate sites of origin (29%), or by inferior wall origin (46%). Preoperative and postoperative ejection fractions of patients undergoing the localized vs the regional procedure were also compared and no significant differences were noted (figure 6). Despite the more extensive procedure, there was no overall decrease in left ventricular function. Among patients who underwent regional surgery, the one recurrence of ventricular tachycardia occurred at 3 months. No recurrence of arrhythmia has occurred in the remaining 23 patients followed for 6 months or longer, or in the 16 patients followed for more than a year (figure 7).

Discussion

Current surgical techniques. Of the currently available surgical procedures for recurrent ventricular tachycardia, map-directed localized subendocardial resection is now the most widely used and is of proven value. The surgical cure rate for the localized procedure has been 60% to 65%, and postoperative control with antiarrhythmic drugs has been achieved in another 25%.\(^1\)\(^-\)\(^5\) The success rate for mapped but primarily visually directed endocardial resection has been 74%.\(^6\) and that for encircling endocardial ventriculotomy, 80%.\(^14\)\(^,\)\(^15\)

Despite this success, these procedures all have limitations. Miller et al.\(^3\) who have had the largest experience with localized endocardial resection, recently reported that the success rate was lower in patients with tachycardias that exhibited spontaneous multiple QRS morphologies or that arose from disparate sites of origin or from the inferior left ventricular wall. They believe that failure of localized resection in the patients with multiple, widely distributed tachycardias reflects insufficient ablation of endocardial tissue and recommend wider resections in this group of patients. Tachycardias originating from the inferior wall have been a problem after both the localized and primarily visually directed resections, in that both procedures may adversely affect mitral valve function.\(^4\)\(^-\)\(^6\)\(^,\)\(^16\) Encircling endocardial ventriculotomy may cause deterioration of left ventricular function, making it suitable only for selected patients.\(^1\)\(^,\)\(^17\)\(^,\)\(^18\)

Two further theoretical limitations exist with respect to localized techniques based on mapping. Since these resections involve removal of only a relatively small amount of endocardium, very precise localization of the anatomic site of origin of all arrhythmias is essential. Such requirements may be beyond the capabilities of presently available diagnostic techniques, the spa-
tial resolution of which is limited. Furthermore, an assumption is usually made that the identified endocardial breakthrough lies close to the site of origin of the tachycardia, but in theory this may be at a more remote or intramural site. \textsuperscript{1, 19, 23}

**Regional surgery.** After failure of the localized procedure in two of our early patients, we modified our approach to ensure ablation of all areas in both ventricles activated before the onset of the surface QRS. We reasoned that treatment of a larger area would more likely include all arrhythmic sites. In the 25 patients subsequently undergoing surgery by the regional approach, only one patient died (4%). The occurrence of this death early in our experience, coupled with the deaths in the previous three patients, led to a subsequent policy of avoiding surgery in patients with diffuse global left ventricular dysfunction and ejection fractions of around 15%. Indeed, no further deaths have occurred in the last 21 patients and the overall surgical cure rate for all patients treated by this procedure has been 96%. Although the mean follow-up period was shorter for patients undergoing the regional procedure, all such patients remaining free of arrhythmia have now been followed for 6 months or longer and the difference in outcomes between the two groups has been statistically significant (figure 7).

Our criteria for determining success included failure to induce ventricular tachycardia at the postoperative electrophysiologic study and lack of spontaneous recurrence. In the electrophysiologic protocol epicardial wires were routinely used and included one additional extrastimulus beyond those that induced preoperative arrhythmias. Triple extrastimuli were usually applied. The predictive value of a normal study was 91%, a result similar to those of previous reports in which endocardial catheters alone were used.\textsuperscript{5, 6}

While it has been suggested by others\textsuperscript{5} that multiple morphologies, disparate sites of origin, and inferior wall foci may be adverse prognostic features for the success of localized resection, these did not appear to influence the results of regional surgery. Among the operative survivors of regional surgery, 18 (75%) patients had one or more of these features; none of these patients had recurrent arrhythmias. It is possible that the wider regional procedure both allows for inclusion of disparate sites and compensates for any potential inconsistency between the area of endocardial breakthrough and the anatomic site of arrhythmogenic tissue. Use of cryothermy has also obviated the problems associated with resections of inferior wall endocardium in the region of the posteromedial papillary muscle and mitral valve anulus.

**Importance of endocardial mapping.** We believe that an additional reason for the high rate of surgical success was the contribution of endocardial mapping. Among patients who underwent map-directed procedures, endocardial mapping data was available for 90% of all spontaneous or induced arrhythmias. With identification of early sites of activation, relevant areas could be selectively treated. When scarred papillary muscles were not implicated, these areas could be spared and mitral valve replacement avoided.\textsuperscript{4, 6}

The importance of detailed endocardial mapping was further emphasized by the 10 patients in this series who had tachycardias with earliest sites of activation found outside areas of dense scarring. In each case, intraoperative inspection showed these sites to be macroscopically indistinguishable from other areas of the ventricle. These areas probably represented border zones of heterogeneous infarction, which are known to be highly susceptible to the formation of arrhythmias.\textsuperscript{24, 25} Previous pathologic studies have shown that in patients with multivessel disease, infarction may frequently be heterogeneous, with affected areas found in diverse locations.\textsuperscript{26} Moreover, small areas of necrosis may be difficult to see on gross inspection and overlying endocardium sometimes appears macroscopically normal.\textsuperscript{26} Alternatively, it is possible that such sites of endocardial breakthrough represent preferential conduction from neighboring foci. These sites were therefore cryoablated together with surrounding areas of early activation. In all 10 patients, ventricular tachycardia was effectively abolished, a result that suggests that mapping was an important determinant in the success of surgery.

Josephson et al.\textsuperscript{11} have also discussed the importance of endocardial mapping, and have emphasized the need for both preoperative and intraoperative electrophysiologic mapping. Consistent with the experience of others,\textsuperscript{19, 21, 27} we frequently were not able to obtain intraoperative endocardial maps due to failure to initiate or sustain ventricular tachycardia. Our current policy, therefore, is to attempt to map all tachycardias preoperatively and select for surgery patients in whom the majority of tachycardias can be mapped.

**Utility of cryothermy.** The differences between results from the present study using endocardial resection and cryothermy and those using endocardial resection alone may also be, in part, a result of the use of cryothermy. Although still a relatively new form of treatment, cryothermy was used in 21 of 24 patients undergoing regional ablations. The availability of cryothermy provided a means of dealing with arrhythmias arising from papillary muscles or near valve anuli.
without the need for mitral valve replacement. Since cryothermy destroys electrically active tissue while leaving major structural elements intact,28 wider ablations could safely be performed, thereby avoiding the need for complex reconstruction. When ventricular tachycardia was mapped to areas outside scarring on the interventricular septum, the exact size and depth of the focus was unknown. Therefore, in the absence of dense scarring to suggest a more superficial location,29 biventricular cryothermy was applied to both sides of the septum to ensure full-thickness ablation (figure 4).12,13 In previous series early sites of activation on the right side of the septum have been left untreated30 and this may be an additional reason for spontaneous recurrences.

Study limitations. We recognize that this study was not a randomized, prospective comparison of two surgical techniques. Unknown influences other than the surgical procedures per se may have accounted for the differences in the results in the two groups. In the assessment of previously cited adverse factors, our definition of multiple morphologies emphasized both spontaneous and induced arrhythmias rather than spontaneous morphologies alone. Nevertheless, the patient groups were similar with respect to age, degree of left ventricular dysfunction, coronary disease, and distribution of other characteristics with possible adverse effects. The results in patients who underwent localized resection are similar to those stated in the literature,7 while the outcome in those who had the regional procedure represents an improvement over those previous reports.

Clinical implications. Our experience demonstrates that a map-directed regional approach combining aneurysmectomy, subendocardial resection, and cryothermy can provide a high rate of cure in selected patients with drug-resistant ventricular tachycardia. When these methods are used to achieve a wider ablation of areas with early activation, a surgical success rate of over 90% can be achieved with low mortality. The previously suggested adverse features relevant to localized subendocardial resection do not seem to affect the outcome when a regional approach is used. Provided that tachycardias can be mapped and that some segmental left ventricular function remains preserved, we currently are prepared to perform this procedure in patients with drug-resistant arrhythmias. However, patients with diffusely poor left ventricular function and/or tachycardias that cannot be mapped remain unsuitable. These patients may be candidates for therapy with a drug such as amiodarone or the automatic implantable defibrillator.30,31 Our results further emphasize the need for preoperative and intraoperative endocardial mapping in that some tachycardias have early sites of activation in sites outside visible dense scarring or within the right ventricle. We believe that all such sites should be treated.

In most centers, surgery is considered only when exhaustive pharmacologic trials with standard and investigational drugs have failed. However, the results of this preliminary study suggest that for suitable patients, map-directed regional surgery could be considered at an earlier stage. Our current high rate of success encourages us to continue using this approach.

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