Value of Programmed Ventricular Stimulation After Tetralogy of Fallot Repair
A Multicenter Study

Paul Khairy, MD, MSc; Michael J. Landzberg, MD; Michael A. Gatzoulis, MD, PhD; Hugues Lucron, MD; Jean Lambert, PhD; François Marçon, MD; Mark E. Alexander, MD; Edward P. Walsh, MD

Background—Studies have consistently shown that ventricular tachycardia (VT) and sudden cardiac death (SCD) complicate the long-term outcome after tetralogy of Fallot repair, yet the diagnostic and predictive value of electrophysiological testing in this population is uncertain.

Methods and Results—A multicenter cohort of 252 patients with repaired tetralogy of Fallot undergoing programmed ventricular stimulation was followed up for 18.5 ± 9.6 and 6.5 ± 4.5 years after corrective surgery and electrophysiological testing, respectively. Clinical VT and/or SCD occurred in 24.6%. Sustained monomorphic VT and polymorphic VT were induced in 30.2% and 4.4%. Including polymorphic VT in the definition of inducibility improved sensitivity (66.1 ± 6.0% versus 77.4 ± 5.3%, P = 0.0082) with a marginal reduction in specificity (81.6 ± 2.8% versus 79.5 ± 2.9%, P = 0.0455). Positive and negative predictive values were 55.2 ± 5.3% and 91.5 ± 2.2%. Independent risk factors for inducibility were age at study ≥ 18 years (OR, 3.3), palpitations (OR, 2.8), prior palliative surgery (OR, 3.1), modified Lown criteria ≥ 2 (OR, 5.6), and cardiothoracic ratio ≥ 0.6 (OR, 3.3). Event-free survival rates in noninducible and inducible patients at 1, 5, 10, and 15 years were 97.9%, 92.8%, 89.3%, and 89.3% versus 79.4%, 62.6%, 58.7%, and 50.3%, respectively (P < 0.0001). Both inducible monomorphic VT [relative risk (RR), 5.0; P = 0.0002] and polymorphic VT (RR, 12.9; P < 0.0001) predicted future clinical VT and SCD. In a multivariate analysis, inducible sustained VT was an independent risk factor for subsequent events (RR, 4.7; 95% CI, 1.2 to 18.5; P = 0.0268).

Conclusions—Programmed ventricular stimulation is of diagnostic and prognostic value in risk stratifying patients with repaired tetralogy of Fallot. In this patient population, inducible sustained polymorphic VT should not be disregarded as nonspecific. (Circulation. 2004;109:1994-2000.)

Key Words: arrhythmia ■ death, sudden ■ electrical stimulation ■ tetralogy of Fallot

Tetralogy of Fallot is the most common cyanotic heart disease beyond infancy, accounting for 10% of all congenital heart malformations. "Corrective" intracardiac repair has been performed for > 40 years with excellent results. Nevertheless, ventricular arrhythmias have consistently been reported, and sudden cardiac death (SCD) is the most common cause of mortality late after repair. Considerable efforts have been directed toward identifying predictors to stratify patients into high- and low-risk categories for these events. Programmed ventricular stimulation has been used in selected patients at many centers; however, attempts to clarify its predictive value have been limited by small patient numbers and relatively low event rates. We sought to assess the diagnostic value and prognostic significance of programmed ventricular stimulation in a multicenter cohort with repaired tetralogy of Fallot.

Methods

Study Population
The cohort consisted of patients with repaired tetralogy of Fallot and programmed ventricular stimulation performed between 1985 and 2002 from Children’s Hospital Boston, Centre Hospitalier et Universitaire de Nancy, and 6 centers that recently identified noninvasive risk factors for tetralogy of Fallot (Royal Brompton Hospital, Children’s Hospital of Pittsburgh, University of Minnesota Hospital and Clinic/Variety Club Children’s Hospital, South Carolina Children’s Heart Center, Tokyo Women’s Medical College, and Toronto Hospital). Patients with unrepaird tetralogy, pulmonary atresia, AV canal, and double-outlet right ventricle were excluded. Aspects of subsets of these populations have previously been reported.

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Data Collection and Follow-Up

Data were collected in accordance with individual hospital institutional review board policies. Details about baseline characteristics, surgical history, symptoms before electrophysiological testing, hemodynamic parameters, Holter recordings, cardiothoracic ratios, and valvular regurgitation severity were measured. Sources included electronic and paper cardiological, surgical, electrophysiological, echocardiographic, hemodynamic, chest radiographs, and cardiac MRI. Data were manually recorded and analyzed.

Programmed Ventricular Stimulation

Electrophysiological studies were performed in patients under conscious sedation in a drug-free state. Programmed ventricular stimulation was achieved at twice the diastolic threshold at ≥2 right ventricular sites (typically apex and outflow tract) with ≥2 eight-beat drive trains (cycle lengths between 400 and 600 ms) and up to 3 extrastimuli with coupling intervals ≥180 ms. In the absence of inducible VT, the protocol was repeated in all but 5 patients with an isoproterenol infusion titrated to increase heart rate by 20% to 50%. Ventricular burst pacing and S5 protocols were not routinely used.

Results were classified into 3 categories: negative, sustained monomorphic VT, or sustained polymorphic VT. Sustained VT was defined as persisting ≥30 seconds or requiring electrical conversion. SCD was defined as death attributed to a cardiac cause occurring within 1 hour of acute symptoms. To assess the prognostic significance of programmed ventricular stimulation, time 0 was defined as time of electrophysiological testing, and patient-years were accrued until occurrence of the primary outcome, study termination, or death resulting from other causes.

Diagnostic Value of Programmed Ventricular Stimulation

During follow-up, the primary outcome was tachycardia (VT) or SCD, whether or not resuscitation was successful. VT was considered sustained if it persisted ≥30 seconds or required electrical conversion. SCD was defined as death attributed to a cardiac cause occurring within 1 hour of acute symptoms. To assess the prognostic significance of programmed ventricular stimulation, time 0 was defined as time of electrophysiological testing, and patient-years were accrued until occurrence of the primary outcome, study termination, or death resulting from other causes.

Results were classified into 3 categories: negative, sustained monomorphic VT, or sustained polymorphic VT. Sustained VT was defined as persisting ≥30 seconds or requiring cardioversion. Induction of nonsustained VT was not coded consistently by all contributing centers and could not be analyzed in this study. If >1 study was performed, results from the earliest were retained for analysis. Standard definitions were used for sensitivity, specificity, diagnostic accuracy, and predictive values of programmed ventricular stimulation in identifying patients with clinical sustained VT or SCD. Positive LR(+) and negative LR(−) likelihood ratios were defined as sensitivity/(1 − specificity) and (1 − sensitivity)/specificity, respectively.

Statistical Analysis

Continuous variables are presented as mean ± SD and dichotomous variables as percentages. Baseline characteristics and clinical outcomes according to results of programmed ventricular stimulation were compared by use of χ², Fisher’s exact, 1-way ANOVA, or McNemar’s test when appropriate. Logistic regression models were used to identify predictors of inducible VT. Event-free survival curves were plotted and compared by use of the Kaplan-Meier method and log-rank statistic.

To assess the predictive value of inducible VT, multivariate Cox proportional-hazard models were used to account for duration of follow-up and adjusted for clinical, surgical, hemodynamic, ECG, and radiographic variables. The proportional-hazards assumption was verified by time-dependent interactions and goodness-of-fit statistics (weighted Schoenfeld residuals). Two-tailed values of P < 0.05 were considered statistically significant. Testing was performed with SAS software version 8 (SAS Institute).

Results

Baseline Characteristics

A total of 252 patients, 59.4% male, with repaired tetralogy of Fallot underwent programmed ventricular stimulation at 16.0 ± 12.3 years (range, 3.3 to 55.6 years) of age. Follow-up duration after corrective surgery and programmed ventricular stimulation was 18.5 ± 9.6 and 6.5 ± 4.5 years. ECGs were available in 100%; chest x-rays, 97%; echocardiograms, 97%; Holters, 95%; cardiac catheterization, 94%; and cardiac MRI, 6%. Valvular regurgitation severity by MRI and echocardiography was concordant in all but 1 patient in whom “probably mild” pulmonary regurgitation by echocardiography was graded moderate by MRI; the latter grade was retained.

Median age at corrective surgery was 4.5 years, and 57.2% had transannular right ventricular outflow tract patches. Surgical palliation with systemic to pulmonary shunting was performed before repair in 46.3%. Age at repair and prior palliative shunt did not differ significantly by enrollment site. At the time of programmed ventricular stimulation, QRS duration was 146 ± 36 ms, with QRS ≥180 ms in 19.4% and left anterior hemiblock in 22.6%. Right ventricular systolic and end-diastolic pressures were 44 ± 16 and 8 ± 4 mm Hg, with 74.2% and 14.3% having at least moderate pulmonary and tricuspid regurgitation, respectively. The average cardiothoracic ratio was 56.3 ± 6.1%. Before electrophysiological testing, 27.7% reported palpitations, 23.6% reported syncope, 16.7% had documented sustained VT, and 1.2% were resuscitated from cardiac arrest. Characteristics stratified according to results of programmed ventricular stimulation are summarized in Table 1.

Diagnostic Value of Programmed Ventricular Stimulation

Sustained monomorphic VT was induced in 30.2% (n = 76), sustained polymorphic VT was induced in 4.4% (n = 11), and 65.5% (n = 165) were noninducible. An average of 2.7 ± 0.6 extrastimuli were required for induction, with isuprel infusion in 23.5%. Of initially negative studies, 11% became positive with isuprel. Of 87 patients with inducible sustained VT, 26 received antiarrhythmic therapy alone, 15 had ICDs alone, and 8 had both antiarrhythmics and ICDs. VT ablation was performed in 3 patients at the initial study (and 4 others after recurrent events). The primary outcome occurred in 62 patients (24.6%): VT alone in 45, VT and SCD in 14, and SCD without documented VT in 3 patients. Three died of other causes: end-stage congestive heart failure, recreational drug overdose, and cerebral edema after right ventricular outflow tract revision. The last patient had experienced clinical sustained VT before his death.

Table 2 classifies patients according to 2 definitions of inducibility, depending on whether sustained polymorphic VT is considered positive. Diagnostic characteristics of programmed ventricular stimulation are summarized accordingly in Table 3. Including polymorphic VT resulted in greater sensitivity (77.4% ± 5.3% versus 66.1% ± 6.0%, P = 0.0082) with...
a marginal decrease in specificity \((P=0.0455)\). Overall diagnostic accuracy approached 80%. More than 3-fold increase in odds of clinical VT or SCD followed a positive study \([LR(+)\), 3.77\]. Compared with inducible monomorphic VT alone, a negative study was associated with a greater reduction in odds of the combined outcome \([LR(-)\), 0.28 versus 0.42\]. Predictors of inducible sustained monomorphic or polymorphic VT, ORs, and 95% CIs are summarized in Table 4. Of note, presence of a left anterior hemiblock did not predict inducibility \((P=0.6757)\).

**Prognostic Significance of Programmed Ventricular Stimulation**

After programmed ventricular stimulation, 16.8% experienced sustained VT or SCD: VT alone, 8.1%; SCD alone, 3.7%; and VT and SCD, 5.0%. Actuarial event-free survival rates of the entire cohort at 1, 5, 10, and 15 years were 91.5%, 82.7%, 79.2%, and 74.3%, respectively (Figure 1A). Induction of sustained monomorphic \([relative risk (RR), 5.0]\) and polymorphic \((RR, 12.9)\) VT was a powerful predictor of subsequent events (Table 5 and Figure 1B). Event-free survival rates in noninducible and inducible patients at 1, 5, 10, and 15 years were 97.9%, 92.8%, 89.3%, and 89.3% versus 79.4%, 62.6%, 58.7%, and 50.3%, respectively.
Kaplan-Meier event-free survival curves are illustrated in Figure 2. Mode of VT induction, including number of required extrastimuli, was not predictive of subsequent events (P=0.9162).

Inducible sustained monomorphic or polymorphic VT remained an independent predictor of outcome (RR, 4.7; 95% CI, 1.2 to 18.5; P=0.0268) in multivariate regression analyses controlling for age at corrective surgery and electrophysiological testing, gender, presence of a transannular patch, prior palliative surgery, clinical symptoms, QRS duration, right ventricular pressures, at least moderate tricuspid or pulmonary regurgitation, atrial arrhythmias, cardiothoracic ratio, class I or III antiarrhythmic agents, and presence of an ICD. When the 29 patients with ICDs and 3 with primary VT ablation (2 also had ICDs) were excluded, positive programmed ventricular stimulation remained a powerful predictor of clinical VT and SCD (RR, 4.9; 95% CI, 1.9 to 12.6; P=0.0012).

### Routine Screening Versus Clinical Indication for Programmed Ventricular Stimulation

Overall, 93 patients (36.9%) had programmed ventricular stimulation as “routine” screening, whereas 159 (63.1%) had clinical symptoms and/or recorded ventricular arrhythmias that prompted further testing. Test characteristics in these patient subgroups are summarized in Table 6. Inducible sustained monomorphic or polymorphic VT independently predicted subsequent clinical VT or SCD in patients routinely

### Table 3. Diagnostic Value of Programmed Ventricular Stimulation

<table>
<thead>
<tr>
<th></th>
<th>Sustained Monomorphic VT</th>
<th>Sustained Monomorphic or Polymorphic VT</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity, %</td>
<td>66.1 ± 6.0</td>
<td>77.4 ± 5.3</td>
<td>0.0082</td>
</tr>
<tr>
<td>Specificity, %</td>
<td>81.6 ± 2.8</td>
<td>79.5 ± 2.9</td>
<td>0.0455</td>
</tr>
<tr>
<td>Diagnostic accuracy, %</td>
<td>77.8 ± 2.6</td>
<td>79.0 ± 2.6</td>
<td>0.3657</td>
</tr>
<tr>
<td>Positive predictive value, %</td>
<td>53.9 ± 5.7</td>
<td>55.2 ± 5.3</td>
<td>NA</td>
</tr>
<tr>
<td>Negative predictive value, %</td>
<td>88.1 ± 2.4</td>
<td>91.5 ± 2.2</td>
<td>NA</td>
</tr>
<tr>
<td>Positive likelihood ratio</td>
<td>3.59</td>
<td>3.77</td>
<td>NA</td>
</tr>
<tr>
<td>Negative likelihood ratio</td>
<td>0.42</td>
<td>0.28</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Table 4. Predictors of Inducible Sustained VT

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Univariate analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at EP study</td>
<td>1.07</td>
<td>1.04–1.11</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age ≥18 y</td>
<td>6.0</td>
<td>3.0–12.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age at corrective surgery</td>
<td>1.07</td>
<td>1.02–1.12</td>
<td>0.0060</td>
</tr>
<tr>
<td>Age ≥7 y</td>
<td>3.3</td>
<td>1.9–5.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Palpitations</td>
<td>2.8</td>
<td>1.6–5.0</td>
<td>0.0004</td>
</tr>
<tr>
<td>Syncope</td>
<td>4.9</td>
<td>2.6–9.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Prior palliative surgery</td>
<td>2.9</td>
<td>1.7–5.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Documented AF/flutter</td>
<td>2.1</td>
<td>1.0–4.4</td>
<td>0.0522</td>
</tr>
<tr>
<td>QRS, ms</td>
<td>1.03</td>
<td>1.02–1.04</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>QRS ≥180 ms</td>
<td>7.3</td>
<td>3.6–14.6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Modified Lown ≥2</td>
<td>3.8</td>
<td>1.9–7.6</td>
<td>0.0002</td>
</tr>
<tr>
<td>RV systolic pressure, mm Hg</td>
<td>1.02</td>
<td>1.00–1.04</td>
<td>0.0574</td>
</tr>
<tr>
<td>At least moderate PR</td>
<td>2.5</td>
<td>1.3–5.0</td>
<td>0.0074</td>
</tr>
<tr>
<td>At least moderate TR</td>
<td>2.4</td>
<td>1.1–4.9</td>
<td>0.0201</td>
</tr>
<tr>
<td>Cardiothoracic ratio ≥0.60</td>
<td>3.3</td>
<td>1.8–6.1</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Multivariate analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at EP study ≥18 y</td>
<td>3.3</td>
<td>1.1–10.5</td>
<td>0.0416</td>
</tr>
<tr>
<td>Palpitations</td>
<td>2.8</td>
<td>1.2–6.8</td>
<td>0.0234</td>
</tr>
<tr>
<td>Prior palliative surgery</td>
<td>3.1</td>
<td>1.2–7.6</td>
<td>0.0163</td>
</tr>
<tr>
<td>Modified Lown ≥2</td>
<td>5.6</td>
<td>1.0–30.9</td>
<td>0.0493</td>
</tr>
<tr>
<td>Cardiothoracic ratio ≥0.60</td>
<td>3.3</td>
<td>1.2–8.8</td>
<td>0.0200</td>
</tr>
</tbody>
</table>

AF indicates atrial flutter. Other abbreviations as in Table 1.
screened (RR, 10.4; 95% CI, 1.1 to 100.2; \( P = 0.0425 \)) and with clinical indications (RR, 4.2; 95% CI, 1.6 to 11.2; \( P = 0.0036 \)) for programmed ventricular stimulation.

**Discussion**

Despite encouraging results with surgical repair of tetralogy of Fallot,\(^2,3\) late cardiac mortality resulting from ventricular arrhythmias and sudden death is observed in a substantial proportion of patients.\(^4\)–\(^6,18,19\) Beyond the first 5 to 10 years after repair, a small but steady decline in freedom from VT and SCD has been observed, with 11.9% experiencing VT and 8.3% dying suddenly by 35 years.\(^5\) Given that \(>60\%\) of patients in the present study had clinical indications prompting electrophysiological testing, this cohort represents a higher-risk population, consistent with the 23.4% incidence of VT and 6.7% incidence of SCD over 18.5± 9.6 years.

Considerable progress has been made toward identifying noninvasive risk factors for VT and SCD in corrected tetralogy of Fallot. In the largest cohort study to date,\(^5\) independent predictors of clinical VT were QRS > 180 ms and annual increase in QRS duration. Additional risk factors for SCD have included older age at repair, presence of a transannular right ventricular outflow tract patch, frequent ectopic beats,\(^20,21\) increased right ventricular systolic pressures,\(^19,22,23\) complete heart block,\(^19,24\) and increased JT dispersion.\(^25,26\) Despite advances in noninvasive risk stratification, identification of high-risk subgroups has not been sufficiently accurate to guide management decisions reliably.

Attempts to clarify the utility of electrophysiological testing had previously been limited by small numbers of adequately studied patients and relatively infrequent occurrence of subsequent events, precluding meaningful estimates of diagnostic and predictive values.\(^7\)–\(^9\)

In this patient population, the 34.5% rate of inducible sustained VT was similar to the rate of 34.8% reported in postinfarction patients with ejection fractions ≤40% and nonsustained VT.\(^27\) Moreover, the diagnostic value [sensitivity, 77.4%; specificity, 79.5%; diagnostic accuracy, 79.0%; LR(+) , 3.77; and LR(−), 0.28] and prognostic significance (RR, 4.7 for subsequent clinical VT or SCD) compared favorably to programmed ventricular stimulation after myocardial infarction.\(^28\)–\(^30\) Although several risk factors for inducible VT were identified, electrophysiological testing independently predicted future events after controlling for these and other clinical, ECG, and hemodynamic variables. Although the study was not designed to appraise therapeutic strategies, inducible sustained VT was a significant predictor of events in patients with and without antiarrhythmic agents, VT ablation, and ICDs.

The arrhythmic substrate in tetralogy has been likened to postinfarction scar-related VT. Induced VT is most commonly monomorphic and macareentrant, rotating clockwise or counterclockwise around myotomy scars or surgical patches.\(^20,31,32\) In patients with coronary artery disease, inducible sustained polymorphic VT is considered either nonspecific or evidence of ventricular instability.\(^33,34\) Antiarrhythmic therapy may convert inducible polymorphic VT into a more stable substrate.\(^35\) Recent clinical trials have included sus-

<p>| Table 5. Prognostic Significance of Inducible VT |</p>
<table>
<thead>
<tr>
<th>EP Testing</th>
<th>RR (95% CI)</th>
<th>( P )</th>
<th>1 y</th>
<th>5 y</th>
<th>10 y</th>
<th>15 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>1.00</td>
<td>...</td>
<td>97.9</td>
<td>92.8</td>
<td>89.3</td>
<td>89.3</td>
</tr>
<tr>
<td>SMVT</td>
<td>5.0 (2.1–11.9)</td>
<td>0.0002</td>
<td>79.4</td>
<td>67.1</td>
<td>63.6</td>
<td>63.6</td>
</tr>
<tr>
<td>SPVT</td>
<td>12.9 (3.9–43.2)</td>
<td>&lt;0.0001</td>
<td>80.0</td>
<td>53.3</td>
<td>26.7</td>
<td>0.0</td>
</tr>
<tr>
<td>SMVT or SPVT</td>
<td>5.8 (2.5–13.2)</td>
<td>&lt;0.0001</td>
<td>79.4</td>
<td>62.6</td>
<td>58.7</td>
<td>50.3</td>
</tr>
</tbody>
</table>

EP indicates electrophysiological; SMVT, sustained monomorphic VT; and SPVT, sustained polymorphic VT.

**Figure 2.** Kaplan–Meier event-free survival curves plotted and compared according to whether inducibility is limited to sustained monomorphic VT (A) or includes sustained polymorphic VT (B). Note wider separation of curves when polymorphic VT is considered positive.
Positive likelihood ratio 4.10 3.78 NA
/H11006
3.5 0.0084
/H11006
5.9 0.0007
/H11006
8.8 66.7
/H11006
4.2 78.9
/H11006
3.2 1.0000
/H11006
Diagnostic accuracy, % 79.6
/H11006
Specificity, % 79.1
/H11006
3.9 1.0000
/H11006
4.4 79.8
/H11006
5.7 1.0000
/H11006
Sensitivity, % 85.7
Underlying substrate may occur over time, careful follow-up
/further testing with programmed ventricular stimulation.
/Invasive parameters may be helpful in preselecting patients for
Currently assessing whether risk assessment based on noninvasive
Values are influenced by pretest probability. Studies are
/shown these parameters to be no different in patients
With the latter arrhythmia. Nevertheless, inducible polymorphic VT after tetralogy repair
Should not be disregarded as nonspecific. Although not assessed in the present study, inducible nonsustained VT has also been associated with decreased survival in a mixed cohort of congenital heart patients.

Although the value of inducible VT as a risk factor after tetralogy of Fallot repair has been demonstrated, questions about patient selection for screening and the timing and frequency of testing remain to be elucidated. Test sensitivity, specificity, and likelihood ratios, increasingly considered the best available indexes to evaluate diagnostic tests, are independent of prevalence assumptions.

Subgroup analyses have shown these parameters to be no different in patients routinely screened compared with those with clinical indications for testing. However, positive and negative predictive values are influenced by pretest probability. Studies are currently assessing whether risk assessment based on noninvasive parameters may be helpful in preselecting patients for further testing with programmed ventricular stimulation. Finally, because risk increases with age and changes in underlying substrate may occur over time, careful follow-up is warranted.

Study Limitations

Given that selection criteria for electrophysiological testing were not standardized, marginal distributions are not random, and prevalence values reflect the heterogeneous patient population. Although this may increase generalizability, prevalence estimates and positive and negative predictive values should be interpreted in this context. Unlike prognostic values, diagnostic test characteristics reflect a particular time point (ie, 18.5 ± 9.6 years after corrective surgery) and may vary with duration of follow-up.

Medical and catheter-based therapeutic decisions were influenced by results of electrophysiological testing and were not randomly allocated. However, direction of this potential bias is expected to result in underestimation of the predictive value of programmed ventricular stimulation because inducible patients are more likely to receive therapy directed toward reducing risk of VT and SCD. Analyses were performed with and without adjustment for antiarrhythmic therapy but not β-blockers (insufficient data) and were repeated after exclusion of the few patients with primary VT ablation. Results were robust and essentially unaltered.

In contrast to other therapies, ICD implantation should theoretically not reduce incidence of the combined primary outcome because ICD therapy for sustained ventricular arrhythmias qualifies as an end point. However, ICD implantation may result in a detection bias that overestimates the predictive ability of programmed ventricular stimulation because patients with inducible VT are more likely to receive these devices that detect and record ventricular arrhythmias. Nonetheless, analyses performed in patients with and without ICDs yielded similar results (RR, 4.7 versus 4.9).

Conclusions

In this multicenter cohort study, programmed ventricular stimulation was of diagnostic value and prognostic significance in risk stratifying patients with repaired tetralogy of Fallot. Inducible sustained polymorphic VT enhanced the diagnostic yield and predictive ability and therefore should not be disregarded as a nonspecific finding. Electrophysiological testing predicted future clinical VT and SCD above and beyond known noninvasive risk factors. These results suggest that electrophysiological testing may contribute importantly to risk-stratification algorithms designed to guide therapy to prevent clinical VT and SCD.

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References


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