Background—Brugada syndrome is an arrhythmogenic disease characterized by an increased risk of sudden cardiac death (SCD) by ventricular fibrillation. At present, an implantable cardioverter-defibrillator (ICD) is the recommended therapy in high-risk patients. This multicenter study reports the outcome of a large series of patients implanted with an ICD for Brugada syndrome.

Methods and Results—All patients (n=220, 46±12 years, 183 male) with a type 1 Brugada ECG pattern implanted with an ICD in 14 centers between 1993 and 2005 were investigated. ICD indication was based on resuscitated SCD (18 patients, 8%), syncope (88 patients, 40%), or positive electrophysiological study in asymptomatic patients (99 patients, 45%). The remaining 15 patients received an ICD because of a family history of SCD or nonsustained ventricular arrhythmia. During a mean follow-up of 38±27 months, no patient died and 18 patients (8%) had appropriate device therapy (10±15 shocks/patient, 26±33 months after implantation). The complication rate was 28%, including inappropriate shocks, which occurred in 45 patients (20%, 4±3 shocks/patient, 21±20 months after implantation). The reasons for inappropriate therapy were lead failure (19 patients), T-wave oversensing (10 patients), sinus tachycardia (10 patients), and supraventricular tachycardia (9 patients). Among implantation parameters, high defibrillation threshold, high pacing threshold, and low R-wave amplitude occurred, respectively, in 12%, 27%, and 15% of cases.

Conclusion—In this large Brugada syndrome population, a low incidence of arrhythmic events was found, with an annual event rate of 2.6% during a follow-up of >3 years, in addition to a significant risk of device-related complications (8.9%/year). Inappropriate shocks were 2.5 times more frequent than appropriate ones. (Circulation. 2006;114:2317-2324.)

Key Words: death, sudden defibrillation genetics ion channels tachyarrhythmias Brugada syndrome implantable cardioverter-defibrillator

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To date, several studies have demonstrated the vast superiority of implantable cardioverter-defibrillator (ICD) implantation over antiarrhythmic medication in the prevention of SCD among this population. However, the risks and
benefits of ICD implantation in a large multicenter series of patients with Brugada syndrome have not been evaluated. The main objective of the present study was to assess both the clinical benefit and the complication rate at implantation and during follow-up in a group of Brugada syndrome patients implanted with an ICD for primary and secondary prevention of SCD.

Methods

Study Population
All patients diagnosed with Brugada syndrome and implanted with an ICD in 14 centers between 1993 and 2005 were included. The diagnosis was made after an episode of aborted cardiac arrest, during evaluation of syncope, in asymptomatic patients during routine examination with characteristic electrocardiographic patterns, or as a consequence of family screening after the diagnosis of Brugada syndrome in a family member.

Diagnosis, Clinical Data, and Electrophysiological Testing
Patients were included in this study only if they had a type 1 ECG at baseline on at least one occasion or after provocation with a class I antiarrhythmic drug. A type 1 ECG was defined as a prominent coved ST-segment elevation displaying J-wave amplitude or ST-segment elevation ≥2 mm or 0.2 mV at its peak followed by a negative T wave. The choice of class I drug was determined by its availability in the participating hospitals. Intravenous ajmaline (1 mg/kg body weight at a rate of 10 mg/min), flecainide (2 mg/kg body weight over 10 minutes with a maximum of 150 mg), or procainamide (10 mg/kg at a rate of 100 mg/min) was used. In addition, treadmill exercise testing and biochemical analysis excluded acute ischemia and metabolic or electrolyte disturbances.

Baseline EPS was recommended in all patients and was performed in 198 patients (90%). A maximum of 3 ventricular extrastimuli were delivered from 2 ventricular sites unless ventricular fibrillation or sustained ventricular tachyarrhythmia (lasting >30 seconds, causing syncope, or requiring intervention for termination) was elicited at a previous step. Premature beats were started in late diastole, and coupling intervals were then reduced in 10-ms or 20-ms decrements to 200 ms or until refractoriness was reached. Inducible ventricular arrhythmia was defined as any ventricular arrhythmia lasting >30 seconds, causing syncope/circulatory collapse, or requiring intervention to be terminated. Therefore, patients with inducible, asymptomatic, nonsustained ventricular arrhythmia that terminated spontaneously before syncope were classified as noninducible. The decision of single- versus dual-chamber ICD implantation and device manufacturer was at the discretion of the participating center.

ICD Implantation and Follow-Up
High defibrillation threshold (DFT) was defined as requiring a shock energy >21 joules to terminate ventricular fibrillation (VF). High pacing threshold was defined as requiring a device output >2 V at 0.4-ms pulse width for right ventricular capture. Low R-wave amplitude was defined as ≤0.5 mV. In the absence of symptoms or device therapy, patients were seen routinely every 3 to 6 months for clinical review and device interrogation, according to local practice. In the event of a shock, patients were seen at the ICD clinic within 24 hours and the device interrogated. Appropriate shocks were defined as shocks delivered for ventricular tachycardia (VT) or VF, and inappropriate shocks were defined as those delivered in the absence of ventricular arrhythmia. Device effectiveness was assessed by the number of patients who had an appropriate defibrillation after ICD implantation. Only the first appropriate shock was considered for analysis.

Statistical Analysis
Data were analyzed with the SPSS software package for paired and unpaired data and for survival curves. The event-rate curve was generated according to the Kaplan-Meier method. The time to occurrence of clinical events (appropriate shock, inappropriate shock, and complications) was analyzed with Cox proportional-hazards model with adjustment for age and indication for ICD when indicated. Fisher exact or χ² tests (for ethnicity, family history of SCD, history of supraventricular tachycardia, inducibility at EPS, SCN5a mutation, and ICD implantation data) were used to compare

### TABLE 1. Initial Characteristics of the 220 Patients With Brugada Syndrome According to ICD Indication

<table>
<thead>
<tr>
<th></th>
<th>Resuscitated SCD (n=18)</th>
<th>Syncope (n=88)</th>
<th>Asymptomatic (n=114)</th>
<th>P Between 3 Groups</th>
<th>Total (n=220)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (83)</td>
<td>72 (82)</td>
<td>96 (84)</td>
<td>0.64</td>
<td>183 (83)</td>
</tr>
<tr>
<td>Age, y</td>
<td>43±13</td>
<td>46±12</td>
<td>46±12</td>
<td>0.57</td>
<td>46±12</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>15 (83)</td>
<td>81 (92)</td>
<td>109 (96)</td>
<td>0.64</td>
<td>205 (93)</td>
</tr>
<tr>
<td>Asian</td>
<td>2 (11)</td>
<td>7 (8)</td>
<td>3 (3)</td>
<td>0.037</td>
<td>12 (6)</td>
</tr>
<tr>
<td>African</td>
<td>1 (6)</td>
<td>2 (1)</td>
<td>3 (1)</td>
<td>0.31</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Family history of SCD</td>
<td>6 (33)</td>
<td>23 (26)</td>
<td>62 (54)</td>
<td>0.001</td>
<td>91 (41)</td>
</tr>
<tr>
<td>History of supraventricular tachycardia</td>
<td>0 (0)</td>
<td>13 (15)</td>
<td>19 (17)</td>
<td>0.025</td>
<td>32 (15)</td>
</tr>
<tr>
<td>Spontaneous type 1 ECG</td>
<td>13 (72)</td>
<td>63 (71)</td>
<td>61 (54)</td>
<td>0.037</td>
<td>137 (62)</td>
</tr>
<tr>
<td>No. of patients with EPS</td>
<td>11 (61)</td>
<td>77 (88)</td>
<td>110 (96)</td>
<td>0.01</td>
<td>198 (90)</td>
</tr>
<tr>
<td>Inducible at EPS</td>
<td>4 (36)</td>
<td>58 (75)</td>
<td>95 (86)</td>
<td>&lt;0.001</td>
<td>157 (79)</td>
</tr>
<tr>
<td>Single-chamber ICD</td>
<td>15 (83)</td>
<td>78 (88)</td>
<td>103 (90)</td>
<td>0.55</td>
<td>196 (89)</td>
</tr>
<tr>
<td>Patients with genetic test</td>
<td>9 (50)</td>
<td>38 (43)</td>
<td>50 (44)</td>
<td>0.65</td>
<td>97 (44)</td>
</tr>
<tr>
<td>SCN5a mutation</td>
<td>5 (56)</td>
<td>6 (16)</td>
<td>18 (36)</td>
<td>0.11</td>
<td>29 (30)</td>
</tr>
</tbody>
</table>

Values are n (%) or mean±SD.
TABLE 2. Outcome of the 220 Patients With Brugada Syndrome According to ICD Indication

<table>
<thead>
<tr>
<th></th>
<th>Asymptomatic vs Syncope</th>
<th>Asymptomatic vs Resuscitated SCD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resuscitated SCD</strong></td>
<td><strong>HR (95% CI) P</strong></td>
<td><strong>HR (95% CI) P</strong></td>
</tr>
<tr>
<td>(n=18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median follow-up,* mo</td>
<td>25.5 (10.5-49.5)</td>
<td>39.5 (19.5-59)</td>
</tr>
<tr>
<td>Patients with appropriate shocks</td>
<td>4 (22)</td>
<td>9 (10)</td>
</tr>
<tr>
<td>Median delay to first shock, mo</td>
<td>2.5 (2-7.5)</td>
<td>24 (6.5-48)</td>
</tr>
<tr>
<td>Median shock</td>
<td>5.5 (1-10.75)</td>
<td>6 (2-17)</td>
</tr>
<tr>
<td>Patients with complications</td>
<td>5 (28)</td>
<td>22 (25)</td>
</tr>
<tr>
<td>Patients with inappropriate shocks</td>
<td>3 (17)</td>
<td>19 (22)</td>
</tr>
<tr>
<td>ICD implantation data available</td>
<td>17 (94)</td>
<td>78 (88)</td>
</tr>
<tr>
<td>High DFT</td>
<td>2 (12)</td>
<td>12 (15)</td>
</tr>
<tr>
<td>High pacing threshold</td>
<td>5 (29)</td>
<td>19 (24)</td>
</tr>
<tr>
<td>Low R-wave amplitude</td>
<td>1 (6)</td>
<td>9 (12)</td>
</tr>
</tbody>
</table>

**TABLE 3. Predictive Factors of Appropriate Shocks**

<table>
<thead>
<tr>
<th></th>
<th>Appropriate Shock, n (%) (n=18)</th>
<th>Unadjusted HR (95% CI)</th>
<th>P</th>
<th>Adjusted HR* (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male</td>
<td>16 (89)</td>
<td>0.58 (0.13-2.53)</td>
<td>0.47</td>
<td>0.47 (0.10-2.22) 0.34</td>
<td></td>
</tr>
<tr>
<td>Family history of SCD</td>
<td>5 (28)</td>
<td>0.31 (0.10-0.96)</td>
<td>0.04</td>
<td>0.33 (0.10-1.07) 0.07</td>
<td></td>
</tr>
<tr>
<td>History of supraventricular tachycardia</td>
<td>2 (11)</td>
<td>1.03 (0.23-4.61)</td>
<td>0.97</td>
<td>1.52 (0.32-7.26) 0.60</td>
<td></td>
</tr>
<tr>
<td>Spontaneous type 1 ECG</td>
<td>15 (83)</td>
<td>1.40 (0.45-4.32)</td>
<td>0.56</td>
<td>0.95 (0.29-3.09) 0.93</td>
<td></td>
</tr>
<tr>
<td>No. of patients with EPS</td>
<td>15 (83)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inducible at EPS</td>
<td>13 (87)</td>
<td>1.30 (0.63-2.60)</td>
<td>0.50</td>
<td>0.86 (0.40-1.86) 0.70</td>
<td></td>
</tr>
<tr>
<td>Patients with genetic test</td>
<td>8 (44)</td>
<td></td>
<td>0.73 (0.34-1.60)</td>
<td>0.44</td>
<td>0.63 (0.27-1.45) 0.27</td>
</tr>
<tr>
<td>SCN5A mutation</td>
<td>2 (25)</td>
<td></td>
<td></td>
<td>0.73 (0.34-1.60)</td>
<td>0.44</td>
</tr>
<tr>
<td>ICD implantation data available</td>
<td>16 (89)</td>
<td></td>
<td>0.73 (0.34-1.60)</td>
<td>0.44</td>
<td>0.63 (0.27-1.45) 0.27</td>
</tr>
<tr>
<td>High DFT</td>
<td>2 (13)</td>
<td>0.45 (0.09-2.20)</td>
<td>0.32</td>
<td>0.38 (0.06-2.33) 0.30</td>
<td></td>
</tr>
<tr>
<td>High pacing threshold</td>
<td>6 (38)</td>
<td>1.69 (0.61-4.69)</td>
<td>0.31</td>
<td>2.00 (0.72-5.56) 0.19</td>
<td></td>
</tr>
<tr>
<td>Low R-wave amplitude</td>
<td>2 (13)</td>
<td>0.76 (0.17-3.45)</td>
<td>0.72</td>
<td>1.46 (0.30-7.19) 0.65</td>
<td></td>
</tr>
</tbody>
</table>

*Adjusted for age and indication of ICD.

Results

Clinical Characteristics and Indication for ICD Implantation

The study population characteristics are summarized in Table 1 (220 patients; 83% male; mean age 46±12 years at diagnosis; median age 46 years; range 7 to 75 years). The vast majority of patients were white (93%), with Asian and African ethnicity accounting for 6% and 1% of patients, respectively. In 137 individuals (62%), a spontaneous coved-type ECG (type 1 ECG) was found at baseline. In the remaining individuals, class I antiarrhythmic drug administration unmasked the diagnostic type 1 ECG. A spontaneous type 1 ECG was more frequently seen in symptomatic (71%) than in asymptomatic patients (54%; P=0.02). The SCN5A mutation was found in 29 of 97 patients in whom the results of genetic testing were available.

At diagnosis, 114 patients (52%) were asymptomatic, 88 patients (40%) had previously had at least 1 episode of syncope with no clear extracardiac cause, and 18 patients (8%) had been resuscitated from VF. Among the 114 asymptomatic patients, indications included: (1) a type 1 Brugada ECG pattern and inducible ventricular arrhythmias (n=99); (2) a type 1 Brugada ECG pattern without inducible arrhythmias but with a family history of Brugada syndrome and SCD (n=11); and (3) a type 1 Brugada ECG pattern and spontaneous nonsustained ventricular arrhythmia (n=4). A family history of SCD was found in 91 patients (41%). Supraventricular arrhythmias were described in 32 (15%) patients (atrial fibrillation, n=23; atrial flutter, n=3; junctional tachycardia, n=4; and atrial tachycardia, n=2).

A single-chamber ICD was implanted in 196 patients, whereas 24 patients received a dual-chamber device. Implantation data (DFT, pacing threshold, and R-wave amplitude) were available in 196 patients.
When analyzed according to the indication for ICD implantation (resuscitated SCD, a history of syncope, or asymptomatic), a significant difference between the groups was found with regard to family history of SCD, spontaneous type 1 ECG pattern, and inducibility during EPS (Table 1).

Outcome
During a mean follow-up of 38±27 months (median 31 months; range 1 to 150 months) after ICD implantation, no death occurred (Table 2). Eight percent of this population experienced appropriate shocks. Between the 3 groups defined according to ICD indication, only the rate of appropriate shocks received was statistically different (SCD 22%, syncope 10%, asymptomatic 4%; P=0.025) during follow-up. A total of 289 ICDs have been implanted in the 220 Brugada patients studied (1.3±0.5 devices/patient; 1 device in 157 patients, 2 in 57 patients, and 3 in 6 patients). Complications occurred in 28% of the patients, including inappropriate shocks in 20% of the cases.

Effectiveness of ICD
The effectiveness of ICD therapy, defined as the percentage of patients with at least 1 appropriate shock, is 8% in this large series of high-risk patients. The average annual rate of appropriate shocks is 2.6% (1.5% in asymptomatic patients). Kaplan-Meier analysis demonstrated differences in the time to the first appropriate shocks depending on symptoms (Figure 1). Two patients had shocks for monomorphic VT (cycle length 350 and 280 ms), and 16 patients had shocks for polymorphic VT or VF (mean cycle length 199±37 ms [range 160 to 260 ms]). Patients with appropriate therapy had 10±15 shocks (median 4, range 1 to 65 shocks) occurring 26±33 months (median 16, range 1 to 140 months) after ICD implantation.

Seven patients presented with an arrhythmic storm (≥3 episodes within 24 hours) and were treated as previously described6,7 with quinidine or ablation (4 patients) in the event of quinidine failure. They had frequent ventricular ectopies similar to the initiating one during this period of time. In 2 patients, ventricular arrhythmia storms occurred in
the context of infection with shocks occurring both night and day. In the 11 remaining patients with isolated shocks, 4 patients had shocks at night (midnight to 6 AM), 6 patients had shocks during the day (6 AM to midnight), and 1 patient had shocks during both periods.

In the syncope group (n=88), 9 patients (10%) experienced appropriate shock(s) during a median follow-up of 39.5 months. During that time, 6 patients (7%) had syncope recurrence without any arrhythmia recorded on the ICD data log (5 cases were due to neurocardiogenic syncope and 1 to a confirmed epileptic seizure).

With regard to the 5 asymptomatic patients who experienced appropriate therapies, 4 patients had a spontaneous type 1 Brugada ECG pattern at baseline, whereas 1 patient did not. All had sustained inducible ventricular arrhythmia at EPS.

Of note, the 11 asymptomatic patients with no inducible ventricular arrhythmia at pre-implantation EPS and a history of SCD in a brother or father did not experience appropriate shock(s) during a median follow-up of 56 months.

In this population, a Cox proportional hazards model failed to find any factor predictive of appropriate device discharge (Table 3) except for the presence of symptoms (resuscitated SCD) before implantation (Table 2).

### Complications of ICD

Complications occurred in 62 patients (28%). Early complications, which occurred during the first months, included pneumothorax (3 patients), pericardial effusion (2 patients), reintervention for lead displacement (5 patients), vein thrombosis (with pulmonary embolism in 1) (2 patients),

lead dysfunction (19 patients) (Figure 2), T-wave oversensing (10 patients), sinus tachycardia (10 patients), and supraventricular arrhythmias (9 patients). One patient suffered an inappropriate shock that induced VF that could not be terminated by the device because of lead failure. External defibrillation was successful.

High DFT was documented in 24 (12%) of 196 patients and high pacing threshold in 53 (27%) of 196 patients at implantation or during follow-up. Mean R-wave amplitude was 10.4 mV, and 29 (15%) of 196 patients had low R-wave amplitude. Patients with shocks due to T-wave oversensing were more likely to have low R-wave amplitude (70% versus 24%, P=0.02) at implantation.

Factors predictive of inappropriate shocks were a history of supraventricular tachycardia (P=0.02), T-wave oversensing (P<0.001), and a low R-wave amplitude (P=0.007) (Table 4). Patients with inappropriate shocks tended to be younger (age 43±13 years versus 47±12 years, P=0.07).

### Discussion

The aim of this study was to evaluate long-term outcome in a large series of patients implanted with an ICD for a diagnosis of Brugada syndrome. The major finding of this study is that during a follow-up period of >3 years after implantation, there is a 2.5-fold greater frequency of inappropriate (20%) than appropriate shocks (8%), with an overall complication rate of 28%. No arrhythmic death occurred at implantation or during follow-up in this young, otherwise healthy population.

### Patient Selection for Device Implantation

Appropriate shocks were more frequent in symptomatic than in asymptomatic patients (12% versus 4%; P=0.05). These data are relevant to and in agreement with other reports on SCD risk stratification. Although there is a consensus to implant ICDs in symptomatic patients, the choice of appropriate treatment for asymptomatic patients is fraught with difficulty, principally because of a limited ability to identify those individuals at high risk for SCD. Identification of late potentials has been proposed, and, although EPS is the only tool used to stratify risk of SCD in asymptomatic patients in the Second Consensus Conference, the role of EPS remains controversial. In the 18 patients implanted with ICDs after
a resuscitated SCD, 11 patients had EPS, and only 4 of these patients had an inducible ventricular arrhythmia (Table 1). It is difficult to reconcile the prediction of ventricular arrhythmia by EPS in asymptomatic patients with a negative study in patients with resuscitated SCD. This is in agreement with Kanda et al,14 who reported that EPS is unable to predict arrhythmic events in symptomatic patients.

In this series of patients, the annual rate of appropriate shocks is 1.5% among patients who are asymptomatic. The number of patients needed to treat (NNT) to save 1 life would then be 23 patients. Had we strictly adhered to the Second Consensus criteria for device implantation in Brugada syndrome,12 the 16 asymptomatic patients who did not have a spontaneous type 1 ECG pattern nor a family history of SCD would not have undergone EPS and should not have received an ICD. Another 15 patients (11 patients with a family history of SCD but no inducible ventricular arrhythmia at EPS and 4 patients with spontaneous nonsustained ventricular arrhythmia) also would not have been implanted with ICDs. Therefore, if patients had been treated according to the Second Consensus criteria, the mean annual appropriate shock rate in our study would have been 1.9% in asymptomatic patients (NNT=17), which is lower than the mean annual event rate of trials dealing with primary prevention of SCD in structural heart disease (5.1% for patients recruited in the Sudden Cardiac Death in Heart Failure Trial [SCD-HeFT]).15 However, in our young population, if we assume 35 additional years of life and a mean annual event rate of 1.9%, 66.5% of the patients would experience appropriate device therapy.

Furthermore, although there is a consensus to implant symptomatic patients with ICDs, it is difficult to be certain of the true cause of syncope in all cases of Brugada syndrome. In the present study, a clear history of syncope in the context of a manifest or drug-revealed type I ECG led to the diagnosis of Brugada syndrome and device implantation in 88 patients. After a median follow-up of 39.5 months, 17% of this group had a recurrence of syncope. Intriguingly, device interrogation revealed no arrhythmia in 7% and ventricular arrhythmia in 10%. The development of an objective tool to better stratify the risk of arrhythmic events would contribute greatly to the management of patients with a diagnosis of Brugada syndrome.

Timing of Appropriate Device Discharge
Among the 18 patients with appropriate shock, 7 patients experienced arrhythmic storms with multiple shocks delivered during both the day and night. The 11 other patients had isolated ventricular arrhythmias, which were nocturnal (n=4), diurnal (n=6), or both (n=1). These results are not in accordance with the study by Matsuo et al,16 who found that two thirds of arrhythmic events occurred between midnight and 6 AM in 6 patients. Although some of the events may have happened during periods of relative vagal predominance, ventricular arrhythmias may also occur without vagal stimulation in Brugada patients.
Complications
Complications of ICD implantation occurred in 62 patients (28%). The first concern is that the population with ICDs is young and active, with a long life expectancy leading to multiple device replacements. One of the major problems in this population is lead dysfunction; not only did this result in inappropriate shocks, but it also increased the frequency of lead extraction and replacement (9%). Strict adherence to a cephalic approach could be a way to minimize the risk, but there are no objective data to support this hypothesis. Most of the inappropriate shocks for sinus tachycardia or supraventricular tachycardia occurred before 2004. More recently, we programmed only 1 VF zone above 210 to 220 bpm to avoid inappropriate shocks in these young active patients who may also have supraventricular tachycardias.17 Particular attention should be paid to R- and T-wave amplitudes during implantation. In our study, patients with shocks related to T-wave oversensing more often had low R-wave amplitude at implantation (70% versus 24%; P=0.02). When available, T-wave oversensing algorithms should be used. Daily transtelephonic home monitoring may also be helpful, as was the case in 2 patients where T-wave oversensing and myopotentials were interpreted as VF, leading to the devices charging but aborting therapy on redetection of sinus rhythm before defibrillation. Remote interrogation facilitated an expedited clinic visit and device reprogramming, thereby preventing the inevitable delivery of an inappropriate therapy.

An important concern is the deleterious psychological impact of ICD implantation on young asymptomatic patients. Anxiety and psychological distress are more frequent in young patients with an ICD,18 especially if the diagnosis was made during a fortuitous ECG. In our series, 2 asymptomatic patients developed severe psychological difficulties leading to the loss of employment.

ICD Implantation Parameters
With regard to implantation data, it has been suggested that Brugada patients have high DFTs21 and high pacing thresholds. We found that 12% of the patients had a DFT >21 joules, whereas 4.6%20 to 6.2% of patients with structural heart disease21 are reported to have a high DFT. A previous study by Watanabe et al19 found 18% of 22 Brugada patients with a DFT >25 joules versus 0% in the group implanted with ICDs for structural heart disease. Two hypotheses have been proposed to explain these findings. First, the right ventricular outflow tract seems to be a critical area in Brugada patients,22 and the energy required to achieve an adequate current density to prolong refractoriness in the majority of the myocardium and especially in the epicardium of the right ventricular outflow tract may be more important. Secondly, the refractoriness of the myocardium induced by the defibrillation shock may fail to prevent VF reinitiation because of a short VF cycle length and short ventricular refractory period19 in this population.

A high pacing threshold at implantation or during follow-up is seen in up to 27% of Brugada patients. This surprising observation may be explained by 3 phenomena: (1) pacing is rarely necessary in Brugada patients, and the implanting physician focuses more attention on obtaining a low DFT than a low pacing threshold; (2) although only 5 patients needed reintervention for lead displacement in this population, a higher rate of microdisplacement may account for the increased pacing threshold observed; and (3) the myocardium of Brugada patients may require a higher energy to be depolarized.

Finally, according to these findings, only single-chamber ICDs should be implanted in these patients, and dual-chamber ICDs should be reserved for patients with an indication for atrial or ventricular pacing. Moreover, to avoid complications, particular attention to lead placement is required, and 1 single VF zone >210 bpm should be programmed. A monitoring zone >180 bpm could be used.

Study Limitations
This is a retrospective study, and the population included was identified across 14 different centers. Although every effort was made to collect the data in a uniform and thorough manner, some measurement bias may have occurred. Furthermore, device programming was not uniform in all centers. In patients with a mean age of 46±12 years, a follow-up of 3 years is relatively short to comment on their true long-term outcome.

Because of the low number of events during follow-up, statistical analysis of survival times may suffer from low power. Conclusions on predictors of appropriate shocks cannot be drawn from the present data, but the observed differences indicate important trends that are of clinical relevance.

Conclusion
This study reports data in a large cohort of patients implanted with an ICD for Brugada syndrome. A low incidence of arrhythmic events (ie, an annual appropriate shock rate of 2.6%) was found after the ECG abnormality was diagnosed and/or the first clinical event. The complication rate was 28% during a follow-up of 3 years. Inappropriate shocks were found to be 2.5 times more frequent (20%) than appropriate shocks (8%) during this period. Therefore, particular attention to ICD implantation technique and subsequent device programming is required to minimize the occurrence of inappropriate shocks.

Appendix
No. of Patients Included at Each Center
Centre hospitalier universitaire (CHU) de Bordeaux, 49; CHU de Nantes, 44; CHU de Tours, 25; CHU de Lille, 21; CHU de Toulouse, 19; CHU de Rennes, 12; CHU de Brest, 11; Tsuchuira Kyodo Hospital, 10; CHU de Grenoble, 8; CHU de Clermont-Ferrand, 6; CHU de Montpellier, 5; CHU de Poitiers, 5; Clinique Pasteur, 3; and Yokohama Rosai Hospital, 2.

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Disclosures
None.

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CLINICAL PERSPECTIVE

With increasing awareness of Brugada syndrome among both physicians and cardiologists, the incidence of this cardiac channelopathy is continuing to grow. The present therapeutic approach is either follow-up with no treatment or implantation of an implantable cardioverter-defibrillator (ICD). Although there is a consensus to implant symptomatic patients with ICDs, the choice of appropriate treatment for asymptomatic patients is fraught with difficulty, principally because of a limited ability to identify those individuals at high risk of sudden cardiac death. As a consequence of improved recognition of this condition and advances in ICD technology, implantation rates among the young are increasing. Although the successful prevention of sudden cardiac death by device implantation is often paramount in the cardiologist’s mind, our study shows that the decision to offer ICDs to these patients is not straightforward—patient selection, device implantation, and programming must be meticulous to minimize the morbidity burden associated with both the diagnosis and its treatment. With a mean follow-up of 38±27 months, 8% of patients had an appropriate shock, and 28% had complications, with 20% having inappropriate shock. In the group given ICDs because of syncope, 10% had an appropriate shock and 7% had a recurrence of syncope without any arrhythmic event. An objective tool to better stratify the risk of arrhythmic events in Brugada syndrome is eagerly awaited.
Outcome After Implantation of a Cardioverter-Defibrillator in Patients With Brugada Syndrome: A Multicenter Study

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