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ORIGINAL RESEARCH

SCD AND VENTRICULAR FIBRILLATION

Subcutaneous Implantable Defibrillator Therapy in Patients With Brugada Syndrome

Data From a Large Multicenter Registry

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ABSTRACT

BACKGROUND The implantable cardioverter-defibrillator (ICD) is recognized as the most effective life-saving therapy in patients with Brugada syndrome (BrS). However, transvenous ICD is associated with a notable rate of complications over time. The subcutaneous implantable cardioverter-defibrillator (S-ICD) has emerged as a promising alternative to the transvenous ICD. Nevertheless, long-term data from large cohorts of BrS patients with S-ICDs are lacking.

OBJECTIVES This multicenter study aimed to assess the long-term outcomes of S-ICD therapy in patients with BrS.

METHODS The study included 450 consecutive BrS patients (mean age 43 ± 12; 86% male) who underwent S-ICD implantation between 2014 and 2024.

RESULTS During a median follow-up of 52 months (25th-75th percentile: 29-72), appropriate shocks were delivered in 3% of patients (1.2%; 95% CI: 0.2-2.2, at 12 months), with a first-shock success rate of 90% (100% with 2 shocks). Inappropriate shocks occurred in 7% of patients (1.4%; 95% CI: 0.3-2.5, at 12 months). Shock zone programmed at 250 beats/min (HR: 0.40; 95% CI: 0.18-0.89; $P = 0.025$) and more than 1 suitable vector on screening (HR: 0.39; 95% CI: 0.17-0.87; $P = 0.023$) were independent protective factors against inappropriate shock. Device-related complications were reported in 4% of patients (2.5%; 95% CI: 1.0-3.9 at 12 months). The need for antibradycardia pacing was reported in 3 patients (0.7%). No device explantation because of the need for antitachycardia pacing was noted.

CONCLUSIONS Our findings support the S-ICD as a viable alternative to the transvenous ICD for preventing sudden cardiac death in BrS patients without pacing indication (Arrhythmias Detection in a Real World Population [RHYTHM DETECT]; NCT02275637) (JACC Clin Electrophysiol. 2025;11:1572-1582) © 2025 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

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Risk stratification in Brugada syndrome (BrS) remains challenging, especially in asymptomatic patients.[1-3] Currently, the implantable cardioverter-defibrillator (ICD) is recognized as the most effective life-saving therapy.[1] Patients with BrS are usually young and exhibit a predominantly arrhythmia-related prognosis; they may therefore survive for many decades and have nearly normal life expectancy thanks to the protection against sudden cardiac death (SCD) provided by the ICD. However, transvenous ICD is associated with a considerable rate of complications over time, including lead-related complications and inappropriate shocks (ISs).[4] Consequently, it is imperative to assess the risk/benefit ratio of ICD implantation, especially in asymptomatic patients who are at lower arrhythmic risk. The subcutaneous implantable cardioverter-defibrillator (S-ICD) is now recognized as an effective alternative to the transvenous ICD for the prevention of SCD in patients who do not require pacing or cardiac resynchronization therapy.[5] The S-ICD not only offers similar efficacy in interrupting life-threatening ventricular arrhythmias but also mitigates the risk of systemic infection and lead failure—2 prevalent complications associated with transvenous ICDs that often necessitate surgical revision.[6] However, long-term data from large cohorts of BrS patients with S-ICDs are lacking. Furthermore, a key concern for BrS patients is electrocardiogram (ECG) depolarization/repolarization changes, which may increase the risk of IS delivery with S-ICD.[7-9] Thus, the aim of this multicenter study was to evaluate the long-term outcomes of S-ICD in patients with BrS.

ABBREVIATIONS AND ACRONYMS

BrS = Brugada syndrome
ECG = electrocardiogram
ICD = implantable cardioverter-defibrillator
IS = inappropriate shock
SCD = sudden cardiac death
S-ICD = subcutaneous implantable cardioverter-defibrillator

METHODS

STUDY SAMPLE. We report a retrospective analysis of data collected within the framework of the prospective "Rhythm Detect" registry. The study sample included BrS patients with spontaneous or drug-induced type 1 ECG pattern who had undergone de novo implantation of an S-ICD (Boston Scientific Inc) for the prevention of SCD at 24 Italian centers from January 2014 to January 2024, and who were followed until July 2024. BrS was diagnosed according to guidelines and/or available task force consensus statements.[1,2] BrS ECG pattern was considered diagnostic (ie, type 1 BrS ECG pattern) when showing a spontaneous coved-type ST-segment elevation ≥2 mm followed by a negative T-wave in at least 1 lead from V1 to V3 positioned in the second, third, or fourth intercostal space spontaneously. Provocative drug test using ajmaline (1 mg/kg in 5-10 minutes) or flecainide (2 mg/kg in 5 minutes) was administered intravenously to unmask the diagnostic ECG pattern of BrS in case of a non-diagnostic baseline ECG. Structural heart disease, including coronary artery disease and conditions mimicking BrS ECG abnormalities such as acute ischemia, cardiomyopathies, and metabolic or electrolytic disturbances were excluded. Family history of

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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TABLE 1 Baseline Characteristics of Enrolled Patients, Implantation Variables, and Pre-discharge Device Programming (N = 450)

Male	387 (86)
Age, y	43 ± 12
Body mass index, kg/m^2	25 ± 3
Left ventricular ejection fraction, %	62 ± 5
Family history of Brugada syndrome	72 (16)
Family history of SCD	126 (28)
Secondary prevention of SCD	31 (7)
Spontaneous Brugada type 1 ECG	315 (70)
SCN5A variant	65/167 (39)
VF induction during electrophysiology study	216/299 (72)
History of syncope	167 (37)
History of atrial fibrillation	11 (2)
More than 1 passing vector on screening	392 (87)
Previous transvenous ICD	45 (10)
S-ICD generator in intermuscular pocket	409 (91)
2-incision technique	421 (94)
S-ICD generator model Emblem	436 (97)
Sensing vector	
Primary	231 (51)
Secondary	190 (42)
Alternate	29 (7)
Dual-zone programming	441 (98)
Conditional zone (beats/min)	210 (200-220)
Shock zone (beats/min)	240 (240-250)
SMART Pass ON	411 (91)

Values are n (%) unless otherwise indicated.

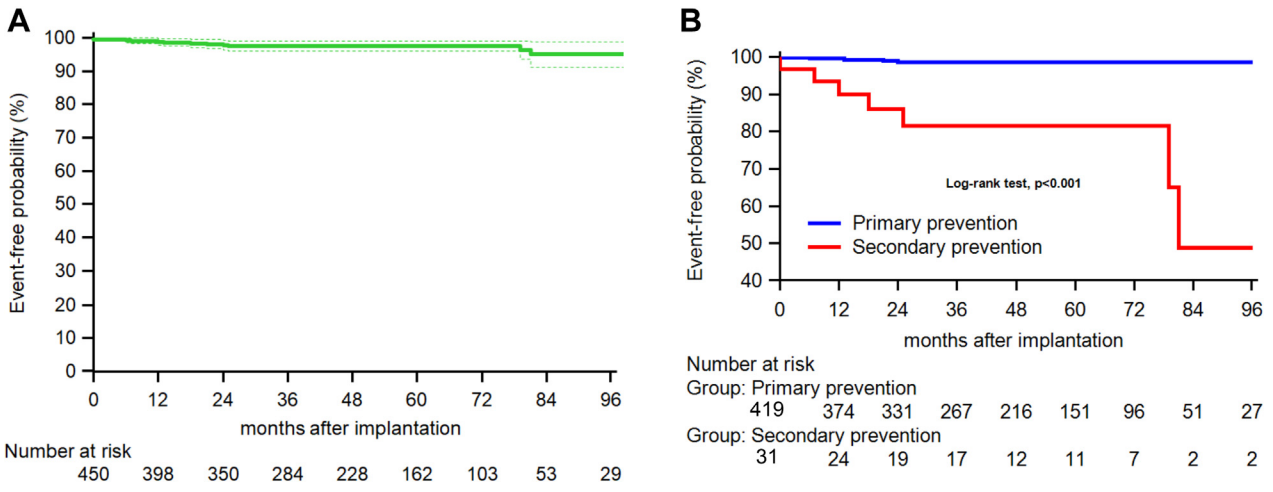
ECG = electrocardiogram; ICD = implantable cardioverter-defibrillator; SCD = sudden cardiac death; S-ICD = subcutaneous implantable cardioverter-defibrillator; VF = ventricular fibrillation.

BrS or SCD, medical history, indications for ICD implantation, and device parameters were collected in all patients. Family history of SCD was defined as a first-degree family member who died suddenly at age <45 years in the absence of known heart disease. Patients presenting with syncope were considered as symptomatic. Syncope was defined as a nontraumatic transient loss of consciousness and spontaneous complete recovery.[1] The registry was ethically approved by the host institutions and was conducted according to the Helsinki Declaration. All patients provided written informed consent for data storage and analysis.

S-ICD IMPLANTATION TECHNIQUE, DEFIBRILLATION TESTING, AND DEVICE PROGRAMMING. Before implantation, all patients were screened for eligibility for S-ICD by means of the Boston Scientific screening tool, which is based on the surface ECG limb lead recording over the left and/or right parasternal regions to simulate the 3 S-ICD sensing vectors. Patients enrolled before 2017 were screened using the manual ECG morphology tool available at the time. The automatic screening tool, developed to enhance the screening process, was subsequently used for all remaining patients. To be eligible for S-ICD implantation, at least 1 vector must pass the test in both the standing and supine postures. Implantation was performed in an electrophysiology laboratory under standard sterile conditions and general anesthesia, local anesthesia with conscious sedation, or ultrasound-guided serratus anterior plane block, as previously reported.[10] All S-ICD implantations were performed by experienced operators. According to physician preference, the pulse generator was positioned in a subcutaneous pocket or in an intermuscular position (between the serratus anterior and the latissimus dorsi muscles) as previously reported in detail.[11,12] For lead deployment, physicians adopted the 3-incision technique, that is, pocket incision, xiphoid incision, and superior incision at the sternomanubrial junction, or the 2-incision technique, that is, the superior incision is avoided by positioning the lead by means of a peel-away sheath introducer. The position of the lead and pulse generator relative to the heart silhouette was checked by means of fluoroscopy. At the end of the procedure, the decision to perform defibrillation testing was left to the discretion of the implanting physician. Testing was considered successful if the device detected and terminated the induced ventricular fibrillation by using ≤65 J shock energy. Programming of the parameters for the detection of ventricular tachycardia or fibrillation was also left to the discretion of the implanting center. Physicians were free to set parameters on hospital discharge and adjust them during follow-up to fit the specific characteristics of the patient and based on the best available evidence. The sensing vector (primary, secondary, or alternate) was automatically selected by the device at the time of implantation and optimized during supine and upright positions before discharge. After implantation, patients were followed up in accordance with the standard practice of the participating centers.

DEFINITION OF OUTCOMES. The endpoints of the study included the following rates: 1) appropriate shocks; 2) IS; and 3) device-related complications. For the analysis of therapy efficacy, we reported when the first shock successfully converted the ventricular arrhythmias to sinus rhythm and the final efficacy. An S-ICD shock was classified as inappropriate when it was delivered for any rhythm other than ventricular tachycardia or fibrillation, including supraventricular arrhythmias, cardiac/noncardiac oversensing, or device or lead malfunction. Complications were defined as events that led to intervention or prolongation of

FIGURE 1 Kaplan-Meier Estimates of Time to First Appropriate Shock



(A) Kaplan-Meier estimates of time to first appropriate shock in the overall sample (with 95% CIs). (B) Kaplan-Meier estimates of time to first appropriate shock in patients stratified according to primary or secondary prevention of sudden cardiac death.

hospitalization, and included device infection, lead repositioning or replacement, other complications related to the lead or generator, and need for pacing. The rates of endpoints were evaluated at 12 months, and cumulative survival rates were also measured over the entire follow-up period.

STATISTICAL ANALYSIS. Descriptive statistics are reported as means ± SD for normally distributed continuous variables, or medians and IQR (25th-75th percentile) in the case of skewed distribution. Normality of distribution was tested by means of the nonparametric Kolmogorov-Smirnov test. Categorical variables are reported as percentages. Differences were compared by means of Mann-Whitney or Wilcoxon nonparametric tests for non-Gaussian variables. Differences in proportions were compared by means of a chi-square analysis. Analysis of the cumulative survival rates was made by means of the Kaplan-Meier method, and the distributions of the groups were compared by means of a log-rank test. The proportional hazards assumption was assessed by means of Schoenfeld residuals test. Cox proportional hazards models were used to determine the association between patients' baseline characteristics and the occurrence of events during the follow-up period, and to estimate the HRs and 95% CIs of an episode. All variables associated with a statistical significance such as P value <0.05 were considered for multivariable analysis. A P value <0.05 was considered significant for all tests. All statistical analyses were performed by means of R: a language and environment for statistical computing (R Foundation for Statistical Computing).

RESULTS

STUDY SAMPLE AND DEVICE IMPLANTATION. A total of 450 consecutive patients were enrolled. During the observation period, 6 patients were lost to follow-up. Table 1 shows the baseline clinical and implantation characteristics of enrolled patients. A total of 315 (70%) patients had a spontaneous Brugada type 1 ECG. A family history of BrS or SCD was ascertained in 72 (16%) and 126 (28%) patients, respectively. A total of 167 (37%) patients had a history of syncope and 31 (7%) patients had a previous cardiac arrest (secondary prevention of SCD). A genetic test was performed in 167 (37%) patients, and a pathogenic variant of SCN5A was documented in 65 (39%) patients. Of 299 patients (66%) who had undergone an electrophysiology study with programmed ventricular stimulation up to 2 extra-stimuli, 216 (72%) were inducible. The screening protocol was performed in all patients under resting conditions, without the administration of ajmaline or flecainide. At least 1 suitable S-ICD vector was identified in all patients, whereas 2 or 3 vectors were suitable in 391 (87%) patients. The S-ICD generator was positioned in a standard subcutaneous

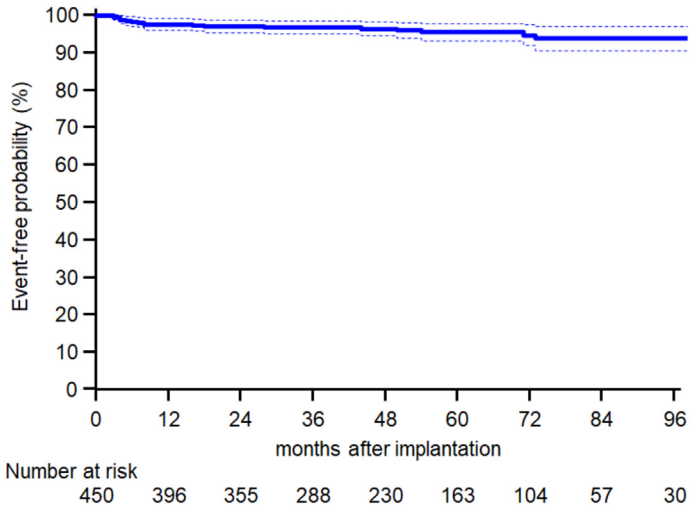
TABLE 2 Univariable Analysis of Factors Associated With the Appropriate Therapies

	Event Group (n = 12)	Non-Event Group (n = 438)	HR	95% CI	*P* Value
Male	10 (83)	377 (86)	0.74	0.16-3.38	0.702
Age, y	42 ± 13	43 ± 12	0.99	0.94-1.04	0.638
Body mass index, kg/m^2	25 ± 3	25 ± 3	0.98	0.81-1.19	0.873
Family history of SCD	1 (8)	125 (28)	0.23	0.03-1.76	0.158
Secondary prevention of SCD	7 (58)	24 (5)	21.46	6.84-67.30	<0.001
Spontaneous Brugada type 1 ECG	6 (50)	309 (71)	0.41	0.13-1.27	0.124
VF induced during EP study[a]	5/6 (83)	256/293 (87)	1.94	0.23-16.40	0.546
History of syncope	4 (33)	163 (37)	0.90	0.27-2.96	0.860
Shock zone programmed at 250 beats/min	8 (67)	209 (48)	3.15	0.86-11.56	0.086

Values are n (%), mean ± SD, or n/N (%) unless otherwise indicated. [a]Among the 299 patients who underwent the electrophysiology study.
EP = electrophysiology; SCD = sudden cardiac death; other abbreviations as in Table 1.

pocket in 41 (9%) patients and in an intermuscular pocket in 409 (91%) patients. The 2-incision technique was adopted in 421 (94%) procedures. In 45 (10%) patients, the S-ICD was implanted after extraction of a previous transvenous ICD for infection/lead failure. Cardioversion at a shock energy of ≤65 J was tested in 392 (87%) patients. In patients who underwent defibrillation test, success was reported in 370 (95%) cases at a shock energy of ≤65 J and in all patients at ≤80 J. On pre-discharge programming, the median conditional zone cutoff rate was 210 beats/min (25th-75th percentile: 200-220) and the shock zone cutoff was 240 beats/min (25th-75th percentile: 240-250). The primary vector (Lead III) was selected most frequently (51%). All patients had the SMART Pass filter activated at the time of hospital discharge, except for the first 39 (9%) enrolled patients, who were implanted with devices that did not have this feature enabled.

FIGURE 2 Kaplan-Meier Estimates of Time to First Inappropriate Shock (With 95% CIs)



OUTCOME ANALYSIS. During a median follow-up of 52 months (25th-75th percentile: 29-72), 1 noncardiac death occurred. Twenty-two ventricular arrhythmic episodes (20 discrete and 2 storms) treated with appropriate shocks were delivered in 12 (3%) patients during follow-up. The first shock was effective in 18 of 20 (90%) discrete episodes, and the second one in the remaining 2. In the 2 cases of arrhythmic storms, the first shock was always effective in all arrhythmic episodes. The rate of appropriate shocks at 12 months was 1.2% (95% CI: 0.2-2.2). The Kaplan-Meier analysis of time to first appropriate shock for all patients and for patients stratified by primary or secondary prevention is shown in Figure 1. At univariable analysis, the only predictor of appropriate shocks during follow-up was secondary prevention of SCD (HR: 21.46; 95% CI: 6.84-67.30; $P < 0.001$) (Table 2).

Thirty-two (7%) patients experienced IS. Five of them received more than 1 shock at the time of the event. The rate of IS at 12 months was 1.4% (95% CI: 0.3-2.5). The most common reason for IS was noncardiac oversensing (59%, 19 of 32), followed by T-wave oversensing (38%, 12 of 32) and paroxysmal supraventricular tachycardia (3%, 1 of 32). In 2 cases, T-wave oversensing resulting in ISs was attributable to BrS ST-segment elevation. The source of noncardiac oversensing was myopotentials (n = 10) and other sources (n = 9). The Kaplan-Meier analysis of time to first IS is shown in Figure 2. Only 1 patient (3%) required S-ICD explantation to manage IS after

TABLE 3 Univariable Analysis of Factors Associated With the Inappropriate Therapies

	Event Group (n = 32)	Non-Event Group (n = 418)	HR	95% CI	*P* Value
Male	31 (97)	356 (85)	4.98	0.69-36.09	0.114
Age, y	42 ± 10	43 ± 12	0.98	0.95-1.01	0.285
Body mass index, kg/m^2	25 ± 3	25 ± 3	1.02	0.92-1.15	0.680
Spontaneous Brugada type 1 ECG	26 (81)	289 (69)	1.71	0.70-4.14	0.239
History of AF	1 (3)	10 (2)	1.03	0.14-7.54	0.976
Shock zone programmed at 250 beats/min	9 (28)	208 (50)	0.35	0.16-0.78	0.010[a]
More than 1 suitable vector on screening	22 (69)	370 (89)	0.04	0.18-0.91	0.029[a]
S-ICD generator in inter/sub-muscular pocket	29 (91)	380 (91)	3.17	0.73-13.79	0.126
2-incision technique	30 (94)	391 (94)	4.32	0.58-32.26	0.156
Programmed sensing vector					
Primary	17 (53)	214 (51)	1.04	0.52-2.08	0.911
Secondary	12 (38)	178 (43)	0.80	0.39-1.64	0.551
Alternate	3 (9)	26 (6)	1.92	0.58-6.31	0.286
SMART Pass ON	27 (84)	384 (92)	1.33	0.45-3.98	0.610

Values are n (%) or mean ± SD. [a]Multivariable analysis for inappropriate therapies: More than 1 suitable vector = HR: 0.39; 95% CI 0.17-0.87; *P* = 0.023; Shock zone programmed at 250 beats/min = HR: 0.40; 95% CI: 0.18-0.89; *P* = 0.025.

AF = atrial fibrillation; other abbreviations as in Table 1.

an initial reprogramming attempt. Among the remaining patients, 24 underwent S-ICD reprogramming and the remaining 7 underwent drug therapy adjustment or no actions. After the first IS, 2 of 32 patients experienced additional episodes. At univariable analysis, shock zone programmed at 250 beats/min and more than 1 suitable vector on screening were both protective against IS (Table 3). In the multivariable model, these variables were confirmed as protective factors (HR: 0.40; 95% CI: 0.18-0.89; *P* = 0.025 and HR: 0.39; 95% CI: 0.17-0.87; *P* = 0.023, respectively).

Device-related complications were reported in 20 (4%) patients during follow-up. The rate of complications at 12 months was 2.5% (95% CI: 1.0-3.9). The Kaplan-Meier analysis of time to first device-related complication is shown in Figure 3. At univariable analysis, there were no predictors of device-related complications (Table 4). The details of the events that occurred and their management are reported in Table 5. No sequelae were reported. Most complications were pocket-associated (2.4%, 11 of 20), and occurred more frequently with subcutaneous (7%, 3 of 41) than intermuscular implantation (2%, 8 of 409; *P* = 0.069). The need for antibradycardia pacing was reported in 3 (0.7%) patients (1 symptomatic sinus bradycardia, 1 advanced atrioventricular block, 1 sinus arrest), and required device explantation in 2 patients (see Table 5 for details). An additional case of sinus arrest event was diagnosed in a patient who refused interventions. No device explantation because of the need for antitachycardia pacing was noted. Furthermore, 63 (14%) patients underwent device replacement for battery depletion during follow-up. Fifty-two replacements for battery depletions occurred among the 138 patients who had received S-ICD generators subject to the 2020 premature battery depletion safety notification (38%, 52 of 138, vs 4%, 11 of 312 not affected generators; *P* < 0.001).

FIGURE 3 Kaplan-Meier Estimates of Time to First Device-related Complication (With 95% CIs)

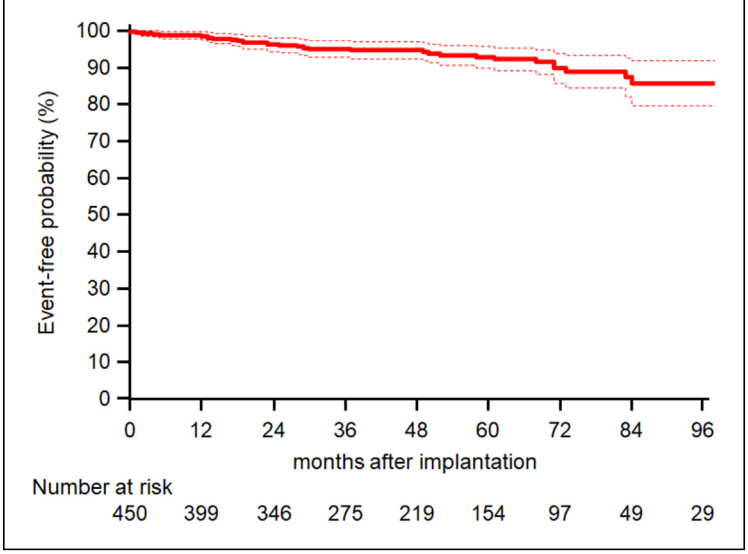


TABLE 4 Univariable Analysis of Factors Associated With Device-related Complications

	Device-related Complications				
	Event Group (n = 20)	Non-Event Group (n = 430)	HR	95% CI	*P* Value
Male	17 (85)	370 (86)	0.89	0.47-1.68	0.721
Age, y	38 ± 13	43 ± 12	1.01	0.99-1.03	0.606
Body mass index, kg/m^2	24 ± 5	25 ± 3	1.08	0.99-1.17	0.064
S-ICD generator in inter/sub-muscular pocket	16 (80)	393 (91)	1.00	0.60-1.70	0.999
2-incision technique	18 (90)	403 (94)	1.16	0.65-2.05	0.618

Values are n (%) or mean ± SD.
Abbreviation as in Table 1.

DISCUSSION

This multicenter study provides valuable insights into the long-term performance of S-ICDs, from the largest sample of BrS patients studied to date. The main findings are as follows (Central Illustration):

1. Over a median follow-up period of 52 months, 3% of patients received appropriate and effective shocks (1.2% at 12 months), confirming the efficacy of the S-ICD for both primary and secondary prevention of SCD in BrS patients.
2. ISs were observed in 7% of patients during follow-up (1.4% at 12 months), primarily due to noncardiac oversensing (59%). Events were managed in most cases through device reprogramming without the need for surgical revision.
3. Device-related complications requiring surgical revision occurred in 4% of patients (2.5% at 12 months), with no associated sequelae.
4. The need for antibradycardia pacing requiring transvenous device implantation was low, occurring in 0.7% of patients.
5. No device explantations and transvenous ICD reimplantations due to the need for antitachycardia pacing were reported during the follow-up period.

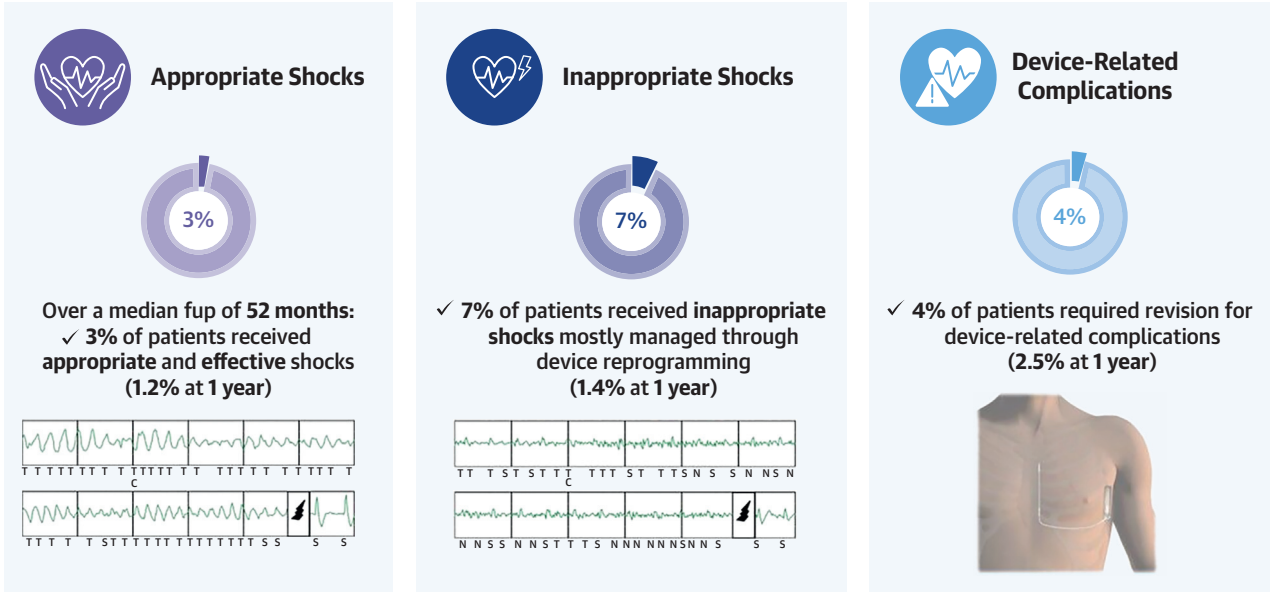
Risk stratification and indications to ICD therapy for the prevention of SCD in patients with BrS remain important challenges. According to current international guidelines, ICD therapy is recommended for patients who survived cardiac arrest due to ventricular fibrillation or those who experienced an arrhythmic syncope because of their proven malignant outcome.[1] Asymptomatic patients represent most newly diagnosed BrS patients with an incidence of arrhythmic events of 0.4% per year.[13] Although multiple prognostic markers have been proposed for improving the risk stratification,[14-16] the main

TABLE 5 Details of Device-Related Complications Reported During Follow-Up

		Management
Any complication	20 (4.0)	
Pocket-associated complications		
Infection/erosion	5 (1.1)	Surgical pocket revision (n = 1); explantation (n = 4)
Pain/discomfort/risk of generator extrusion	6 (1.3)	Surgical pocket revision (n = 6)
Lead-associated complications		
Lead failure	1[a] (0.2)	Explantation (n = 1)
Lead infection	3 (0.7)	Explantation (n = 3, 1 S-ICD reimplantation, 1 transvenous ICD implantation, 1 patient refused reimplantation)
Pain/discomfort/risk of lead extrusion	2 (0.4)	Surgical revision (n = 2)
Need for antibradycardia pacing	3 (0.7)	Explantation and transvenous ICD implantation (n = 2); Pacemaker implantation (n = 1)
Additional events/clinical needs		
Battery depletion	63 (14.0)	Device replacement (n = 63; battery advisory = 52)
New-onset atrial fibrillation	12 (2.7)	Cardioversion (n = 1); atrial fibrillation catheter ablation (n = 3)
Atrioventricular nodal/Atrioventricular reentrant tachycardia	4 (0.9)	Catheter ablation (n = 4)
Sinus arrest event	1 (0.2)	No intervention (transvenous ICD considered but refused by the patient)

Values are n (%). [a]Detected after inappropriate shock occurrence.
Abbreviations as in Table 1.

CENTRAL ILLUSTRATION **Safety and Efficacy of S-ICD in Brugada Patients (N = 450)**



Migliore F, et al. JACC Clin Electrophysiol. 2025;11(7):1572-1582.

Study endpoints over a median follow-up period of 52 months. fup = follow-up; S-ICD = subcutaneous implantable cardioverter-defibrillator.

concern is associated with the risk of possible ICD-related complications, especially in young individuals.[4]

The S-ICD demonstrated noninferior efficacy in terminating ventricular arrhythmias and lower risk of serious and lead-related complications compared with transvenous ICD.[6] This may be particularly beneficial for younger patients with inherited arrythmia syndromes who do not need pacing therapy, such as patients with BrS. The clinical advantage of the S-ICD over transvenous ICD seemed partially offset by the higher frequency of IS, most frequently due to T-wave oversensing.[17] However, S-ICD therapy has evolved over the years, and more recent data showed that the use of high arrhythmia detection cutoff rates, modern filtering technologies, discrimination algorithms, and new implantation techniques have significantly reduced IS rates.[12,18-21]

In patients with cardiomyopathies and channelopathies, there are concerns regarding the dynamic nature of ECG patterns that may trigger IS. Indeed, small studies have reported that the ajmaline challenge could unmask S-ICD screening failure in 15% to 24% of BrS patients,[7-9] who may experience IS during follow-up. However, in the EFFORTLESS (Evaluation oF FactORs ImpacTing CLinical Outcome and Cost EffectiveneSS of the S-ICD) study cohort of S-ICD patients with channelopathies (BrS = 83), the incidence of IS was 8.5% over 3.2 years of follow-up and the annualized IS rate was lower among S-ICD than transvenous ICD patients (2.7%/year vs 3.8%/year).[22] In a more recent study, Migliore et al[23] assessed the long-term outcome of S-ICD patients (n = 628) with cardiomyopathies and channelopathies, and demonstrated a low rate of IS in patients with channelopathies (1.1% at 12 months). In the present study, the rate of IS with S-ICD in patients with BrS was low (ie, 1.4% at 12 months). Noncardiac oversensing was the leading cause of IS in our study, confirming the ability of the SMART Pass filter in attenuating cardiac oversensing due to T-wave. The annual incidence rate of IS in our sample appears 2 times lower than that reported in a 2019 metanalysis of 22 studies on BrS patients who received transvenous ICD.[24] However, it is important to highlight that in recent years transvenous ICDs have also seen improvements, with a progressive decrease in reported IS rates (1.6-1.9/year in recent studies).[25,26] Notably, most ISs were successfully managed through device reprograming in this study; only 1 patient required surgical revision

for IS. The very low incidence of IS in our cohort confirms the overall effectiveness of the screening process already adopted in clinical practice, even without the suggested ajmaline challenge.[8,9] However, optimized programming and more rigorous screening protocols can further reduce IS in BrS. Indeed, programming a high-rate detection cutoff and having >1 suitable vector at preimplantation screening were protective factors against IS shocks in our study.

Like other investigators,[22,27,28] we observed a relatively low rate of appropriate shocks in S-ICD patients with BrS. Only 3% of patients experienced appropriate shocks during follow-up, with 1.2% occurring within the first 12 months. This is lower than the rate reported in the metanalysis by Dereci et al,[24] which included patients with BrS who received transvenous ICDs (3.3%/year). The high-rate cutoff programmed and the long charging time of the S-ICD (to store 80 J energy) may explain the low number of appropriate interventions, as many episodes were likely able to self-terminate (non-life-threatening arrhythmic events).

A potential limitation of the S-ICD is its inability to deliver antitachycardia pacing. In a multicenter study by Rodríguez-Mañero et al,[29] monomorphic ventricular tachycardia occurred in 4.2% of BrS patients over a mean follow-up of 6 years, with 43% of episodes successfully treated by antitachycardia pacing. This raises possible concerns about the use of S-ICD in patients with BrS. In our study, no device explantations and transvenous ICD reimplantations due to the need for antitachycardia pacing were reported during the follow-up period, questioning the clinical benefit of antitachycardia pacing in BrS patients.

In our study, device-related complications requiring surgical revision were relatively infrequent, occurring in 4% of patients over a median follow-up of 52 months (2.5% at 12 months), with no associated long-term sequelae. In comparison, the rate of S-ICD-related complications was approximately 4% at 1 year in the PRAETORIAN (Prospective Randomized Comparison of Subcutaneous and Transvenous Implantable Cardioverter Defibrillator Therapy) study.[5] The low rates of pocket and lead complications in our study can be attributed to the frequent use of intermuscular pulse generator implantation, rather than the traditional subcutaneous pocket, along with the 2-incision technique for lead deployment. These approaches have been shown to reduce device-related complications in unselected S-ICD recipients.[11,12] In addition, 14% of patients required system revision due to battery depletion. Many of these patients had received the EMBLEM S-ICD, which was subject to a safety notification regarding an increased risk of rapid battery depletion (Boston Scientific urgent field action REF.92400926-FA).

STUDY LIMITATIONS. Study limitations are primarily related to the low prevalence of BrS, the low event rate, the relatively short follow-up period, and the retrospective study design. It is important to emphasize that these limitations are consistent with those of previous follow-up studies on BrS; however, this study is the largest to date that includes BrS patients treated with S-ICD. Although the follow-up period in our study is longer than in other S-ICD studies, the relatively small number of events may have led to imprecise estimates and wide CIs and limited our ability to identify potential predictors. Furthermore, no direct comparison was made between transvenous ICDs and S-ICDs, which limits our ability to determine the clinical benefits or risks associated with each device. Finally, we included only patients deemed suitable for S-ICD implantation based on screening assessments. Variations in screening protocols across centers cannot be excluded, and we were unable to assess the rate of S-ICD screening failure in BrS patients who were excluded from implantation. Despite these limitations, the data presented are unique in several respects and contribute significantly to the limited published literature on the clinical performance of S-ICD in patients with BrS.

CONCLUSIONS

This multicenter study demonstrated low rates of both appropriate shocks and ISs, as well as device-related complications, in BrS patients receiving an S-ICD. Our results suggest that the S-ICD should be considered a valuable alternative to the transvenous ICD for preventing SCD in BrS.

DATA AVAILABILITY STATEMENT. The experimental data used to support the findings of this study are available from the corresponding author on request.

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This was an independent study. No external funding was received for this project. Dr Migliore received speaker fees from Boston Scientific, research or educational grants from Boston Scientific, and fees as a scientific consultant from Cook Medical. Dr Ottaviano is a consultant for Boston Scientific. Dr Rordorf received speaker fees from Abbot and Boston Scientific. Dr Francia received speaker fees and educational grants from Boston Scientific and research grants from Abbott. Dr Ziacchi received speaker fees and educational grants from Abbott, Boston Scientific, Biotronik, and Edwards Lifesciences. Dr Botto received speaker fees from Abbott, Biotronik, Boston Scientific, Medtronic, and Microport. Ms Lovecchio and Mr Valsecchi are employees of Boston Scientific. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: This study provides real-world evidence of S-ICD long-term performance even in challenging patient subgroups such as those with BrS. These findings highlight the S-ICD as a reliable and safe alternative to transvenous ICDs, offering a viable option for BrS patients requiring SCD prevention.

TRANSLATIONAL OUTLOOK: As the utility of defibrillators in SCD prevention is often debated in BrS patients exposed to a modest arrhythmic risk, these findings support a positive reassessment of the risk-benefit balance, reaffirming the role of defibrillators in clinical practice. Future research should focus on refining patient selection and leveraging these insights to optimize outcomes and expand the application of ICDs.

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