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Meta-Analysis of Clinical Outcome After Implantable Cardioverter-Defibrillator Implantation in Patients With Brugada Syndrome

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ABSTRACT

OBJECTIVES This study sought to summarize the clinical outcome of implantable cardioverter-defibrillator (ICD) therapy in patients with Brugada syndrome.

BACKGROUND Brugada syndrome is characterized by cardiac conduction abnormalities and a high risk of ventricular arrhythmias that may result in sudden cardiac death. A complete overview of clinical outcome, appropriate and inappropriate interventions, and complications after ICD therapy in patients with Brugada syndrome is lacking.

METHODS The online MEDLINE database was searched for published reports and yielded 828 studies on outcome and complications after ICD therapy in patients with Brugada syndrome. After careful evaluation, 22 studies including a total of 1,539 patients were included in the meta-analysis.

RESULTS In total, 1,539 patients (mean age 45 years, 18% women) underwent ICD implantation for primary (79%) or secondary (21%) prevention of sudden cardiac death. During a mean follow-up of 4.9 years, the appropriate and inappropriate ICD intervention rates were 3.1 and 3.3 per 100 person-years, respectively. The cardiac mortality rate was 0.03 per 100 person-years and noncardiac mortality rate was 0.3 per 100 person-years. ICD-related complications per 100 person-years consisted of lead malfunction (1.6), psychological complication (1.3), infection (0.6), lead dislocation (0.4), and any complication (0.6).

CONCLUSIONS Patients with Brugada syndrome judged to be at high risk for ventricular arrhythmia may significantly benefit from ICD therapy, which is associated with an appropriate ICD intervention rate of 3.1 per 100 person-years and low cardiac and noncardiac mortality rates. Inappropriate ICD interventions and ICD-related complications may lead to considerable morbidity. (J Am Coll Cardiol EP 2018;■:■-■) © 2018 by the American College of Cardiology Foundation.

Brugada syndrome is an inherited cardiac conduction disorder characterized by spontaneous or inducible (in)complete right bundle branch block with ST-segment elevation in the right precordial leads and ventricular arrhythmias that may result in sudden cardiac death (SCD) (1-3). The clinical presentation of the Brugada syndrome may vary, and the diagnosis is based on criteria that have been proposed by professional societies (3). Syncope and SCD are the most significant clinical manifestations of the Brugada syndrome, with a mean age of SCD of approximately 40 years (4). Certain lifestyle changes are recommended to decrease the risk of SCD, such as avoidance of drugs that may induce or aggravate ST-segment elevation in right precordial leads, avoidance of excessive alcohol intake, and treatment of fever (5). Implantable cardioverter-defibrillator (ICD) therapy is

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ABBREVIATIONS AND ACRONYMS

AF = atrial fibrillation

ECG = electrocardiography

EPS = electrophysiological study

ICD = implantable cardioverter-defibrillator

SCD = sudden cardiac death

S-ICD = subcutaneous implantable cardioverter-defibrillator system

currently the only proven effective treatment for life-threatening ventricular arrhythmias in patients with Brugada syndrome (6,7). Unfortunately, ICD therapy is not without adverse effects (6,8–28). There is currently no overview of complications and clinical outcome after ICD therapy in patients with Brugada syndrome available. This meta-analysis will provide relevant information for clinical decision-making and counseling of patients with Brugada syndrome eligible for ICD therapy.

METHODS

SEARCH STRATEGY AND STUDY SELECTION. The online MEDLINE database was searched for published reports in December 2017 using PubMed (National Center for Biotechnology Information, U.S. National Library of Medicine, Bethesda, Maryland). The search strategy for this systematic review and meta-analysis was Brugada and defibrillator. There were no restrictions used based on publication year. All original available studies focusing on clinical outcome of ICD therapy with a given follow-up duration were included. Titles and abstracts of all articles were screened. Reviews, non-English language articles, congress abstracts, and letters to the editor were excluded. In addition, full articles and their reference lists for relevant articles were evaluated.

DATA EXTRACTION. Relevant patient characteristics, ICD implantation for primary or secondary prevention, and risk factors for ventricular arrhythmias or SCD were registered. Furthermore, ICD characteristics and device programming were noted. The following clinical outcomes were extracted from each included study: appropriate ICD intervention; inappropriate ICD intervention; follow-up duration; cardiac mortality; noncardiac mortality; and device-related complications including lead malfunction, infection, lead dislocation, psychological implications, and any other complication. Both early and late complications were included. Relevant patient characteristics associated with appropriate or inappropriate ICD intervention were extracted if available. Studies with overlapping data or patient cohort were selected, and only the largest or most recent study was included.

STATISTICAL ANALYSIS. Statistical analysis was performed using Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington). Heterogeneity among the studies was assessed using the *Q*-test and I^2 index. A fixed-effects model was used to calculate summary estimates of the outcome data. Meta-analysis of the outcome data was performed. Sample size–weighted event rates and sample size–weighted annualized event rates were calculated. The follow-up duration was weighted for sample size. The meta-analysis was performed with the assumption that all patients contributed person-time that was equivalent to the mean or median follow-up duration. Event rates were expressed as the number of events per 100 person-years. Forest plots were constructed to present data on appropriate and inappropriate ICD intervention (29).

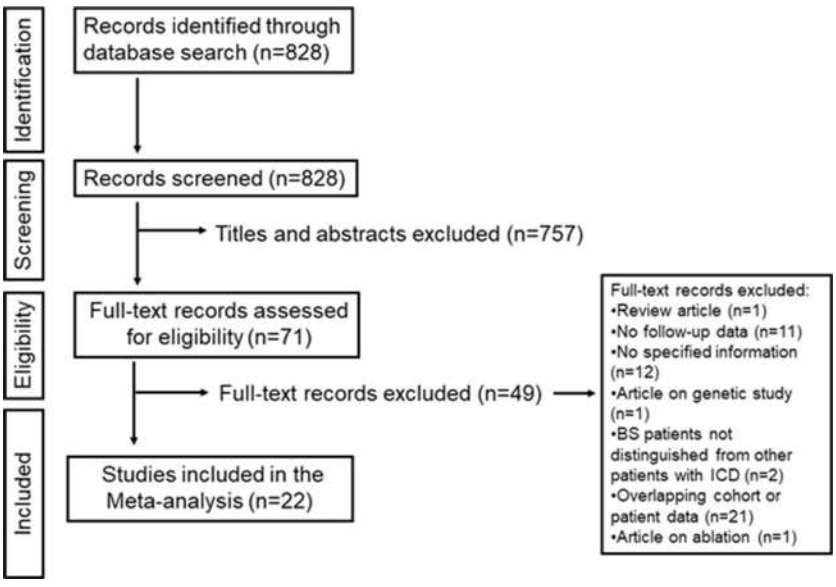
RESULTS

SEARCH RESULTS. The search strategy identified 828 articles (**Figure 1**). After review and exclusion, a total of 22 studies were included in the meta-analysis (**Table 1**). Two of the 22 studies (9,11) in the meta-analysis included only Brugada patients who received an ICD for primary prevention of SCD, and 1 study (8) included only patients having an ICD for secondary prevention of SCD. The remaining 19 studies included patients with Brugada syndrome who received an ICD for primary or secondary prevention of SCD.

PATIENT CHARACTERISTICS. In total, 1,539 patients (mean age 45 years, 18% women) with Brugada syndrome and ICD were included in the analysis. The majority of this group received an ICD for primary prevention (79%). Risk factors for SCD were inducible ventricular arrhythmias during an electrophysiological study (EPS) (72%), spontaneous type-1 Brugada electrocardiography (ECG) (51%), syncope (49%), family history of SCD (28%), *SCN5A* mutation (21%), and history of atrial fibrillation (AF) (10%). However, only 6 studies (6,11,14,15,18,28) provided information on history of AF. Approximately one-third of all patients was asymptomatic.

ICD INDICATIONS AND CHARACTERISTICS. Online Table 1 on the Online Appendix summarizes information regarding the indication for ICD implantation, the use of single-chamber or dual-chamber devices, and programmed shock zones. The indication for ICD implantation was specified in 11 of the 22 studies (50%) and included aborted SCD, history of ventricular arrhythmia, syncope, agonal or abnormal respiration, seizure-like symptoms, positive family history of SCD, inducible ventricular arrhythmia during EPS, spontaneous type-1 Brugada ECG, or patient preference. Two studies reported that they followed the recommendations for ICD implantation of the second Brugada consensus conference (6,23). Hermida et al.

FIGURE 1 Flow Chart of Articles Included in the Meta-Analysis



Flow chart of identified, screened, and included articles in the meta-analysis. BS = Brugada syndrome; ICD = implantable cardioverter-defibrillator.

(9) included patients who received ICD because of failure of hydroquinidine to prevent induction of ventricular arrhythmias during EPS or patients with intolerance for hydroquinidine. Only 7 studies (6,11,14-16,18,28) reported information on the use of single-chamber or dual-chamber devices. The majority of the patients received a single-chamber ICD (72%).

ICD INTERVENTIONS AND OUTCOME. During a mean follow-up of 4.9 years, 277 patients (18%) experienced an appropriate ICD intervention and 230 (18%) had an inappropriate ICD intervention (Table 2). The appropriate ICD intervention rate was 3.1 per 100 person-years (Figure 2). The inappropriate ICD intervention rate was 3.3 per 100 person-years (Figure 3). Mortality data after ICD therapy was available in 10 studies (8,12,14,15,18,19,22-24,28). Overall, 1 cardiac death was reported due to electrical storm during lead extraction procedure 3 years after ICD implantation (28). This patient received an ICD for primary prevention after recurrent syncope and positive family history of SCD. Five noncardiac deaths were reported. The cardiac mortality rate was 0.03 per 100 person-years, and the noncardiac mortality rate was 0.3 per 100 person-years.

COMPLICATIONS. Sixteen studies (73%) provided information on ICD-related complications (Table 2). The majority of the device-related complications included lead malfunction (1.6 per 100 person-years). Other device-related complications were infection and lead dislocation. Infection rate was 0.6 per 100 person-years and lead dislocation rate was 0.4 per 100 person-years. Six studies including 251 patients (16%) have, in addition to device-related complications, focused on the psychological implications of ICD therapy; of those 251 patients, 15 (6%) suffered from psychological complications. The incident rate of psychological complication was 1.3 per 100 person-years. Other complications of ICD therapy occurred in 26 patients including pneumothorax (0.9%), device migration (0.6%), ventricle perforation (0.6%), pain from device requiring changing its location (0.4%), lead thrombus (0.3%), hematoma (0.3%), brachial plexus injury (0.1%), subclavian vein thrombosis (0.1%), pericarditis (0.1%), Twiddler syndrome (0.1%), and endocarditis (0.1%).

DISCUSSION

This meta-analysis demonstrates that patients with Brugada syndrome judged to be at high risk for ventricular arrhythmias have a favorable outcome after ICD therapy. The appropriate ICD intervention rate was 3.1 per 100 person-years, thereby probably preventing SCD. This is also underlined by the low

TABLE 1 Summary of the Studies Reporting ICD Therapy in Patients With Brugada Syndrome

Cohort	Region	Authors	Year	n	Mean Age (yrs)	Women (%)	Primary Prevention (%)	EPS Inducible VA (%)	FH of SCD (%)	Syncope (%)	*SCN5A*+ (%)	Type-1 ECG (%)	History of AF (%)
Multicenter	Taiwan	Juang et al. (8)	2003	8	45	0	0	86	0	63	33	100	NA
Amiens, Paris	France	Hermida et al. (9)	2004	10	NA	NA	100	100	NA	NA	NA	NA	NA
Tehran	Iran	Kharazi et al. (10)	2007	12	47	8	75	100	17	58	NA	25	NA
Aalst	Belgium	Sarkozy et al. (11)	2007	47	45	26	100	83	55	55	NA	49	11
Multicenter	Israel	Rosso et al. (12)	2008	59	44	10	81	88	NA	53	NA	97	NA
Osaka, Suita	Japan	Takigawa et al. (13)	2008	62	48	7	NA	81	31	NA	11	NA	NA
Mannheim	Germany	Veltmann et al. (14)	2010	61	43	33	89	77	28	41	23	43	3
Vienna	Austria	Schukro et al. (15)	2010	17	48	18	77	100	6	41	NA	71	6
Okinawa	Japan	Maesato et al. (16)	2011	5	44	20	NA	NA	NA	NA	NA	NA	NA
Boston	USA	Steven et al. (17)	2011	33	46	9	91	56	55	70	100	55	NA
Multicenter	Gulf Cooperation Council countries	Daoulah et al. (18)	2012	25	32	0	76	100	32	56	0/0	88	4
Copenhagen	Denmark	Holst et al. (19)	2012	35	NA	NA	74	NA	NA	46	NA	74	NA
Mexico City, Paris	Mexico, France	Marquez et al. (20)	2012	6	40	0	NA	NA	NA	NA	NA	8	NA
Amsterdam	Netherlands	Olde Nordkamp et al. (21)	2013	75	46	12	39	79	45	70	52	NA	NA
Tokyo, Ibaraki	Japan	Miyazaki et al. (22)	2013	41	48	21	78	94	7	37	NA	NA	NA
Lisbon	Portugal	Dores et al. (23)	2015	36	42	17	83	85	39	31	NA	69	NA
Suita	Japan	Kamakura et al. (24)	2015	120	47	4	70	78	23	45	25	71	NA
Multicenter	Europe and Japan	Rodriguez-Manero et al. (25)	2015	480	46	24	91	NA	15	51	27	43	NA
Brussels	Belgium	Conte et al. (6)	2015	176	43	33	86	44	51	60	22	21	14
Seoul	South Korea	Kim et al. (26)	2015	117	43	2	37	NA	NA	20	3	NA	NA
Nanjing	China	Shen et al. (27)	2017	10	39	0	NA	NA	NA	100	NA	60	NA
Barcelona	Spain	Hernandez-Ojeda et al. (28)	2017	104	46	13	90	68	34	47	24	63	8
Summary estimate (22 cohorts)				1,539	45	18	79	72	28	49	21	51	10

AF = atrial fibrillation; ECG = electrocardiography; EPS = electrophysiological study; FH = family history; ICD = implantable cardioverter-defibrillator; NA = not available; SCD = sudden cardiac death; VA = ventricular arrhythmia.

cardiac mortality rate of 0.03 per 100 person-years. Inappropriate ICD interventions with an incidence rate of 3.3 per 100 person-years and ICD-related complications may lead to considerable morbidity. There was a low heterogeneity for appropriate and inappropriate intervention rates between the studies. The relatively high incidence of complications is a serious concern, because most patients with Brugada syndrome are otherwise healthy and relatively young individuals. Because of the young age at implantation (mean age was 45 years) and the occurrence of atrial fibrillation (AF) in 10%, patients with Brugada syndrome may be more vulnerable to inappropriate shocks. Information on the incidence of device-related complications, such as lead malfunction (1.6 per 100 person-years), psychological implications (1.3 per 100 person years), infection (0.6 per 100 person-years), lead dislocation (0.4 per 100 person-years), and any complication (0.6 per 100 person-years) may be discussed during patient counseling in patients eligible for an ICD. The psychological impact of ICD implantation and therapy in these young individuals was evaluated in 6 of 22 studies (27%) and was mostly related to inappropriate shocks that may affect their quality of life. A careful individual risk assessment, selection of patients, and counseling of the patient with Brugada syndrome is needed before ICD implantation. The 2017 American Heart Association/American College of Cardiology/Heart Rhythm Society guidelines give a Class I recommendation for ICD implantation in Brugada syndrome patients with cardiac arrest, sustained ventricular arrhythmia, or a recent history of syncope presumed due to ventricular arrhythmia (30). The 2018 European Society of Cardiology guidelines on syncope give a Class IIa recommendation for an implantable loop recorder, instead of an ICD, for Brugada patients with recurrent episodes of unexplained syncope who are at low risk of SCD, based on a multiparametric analysis that takes into account the other known risk factors for

TABLE 2 Summary of Clinical Outcome

Authors	Follow-Up (yrs)	Appropriate Intervention	Inappropriate Intervention	Complications					Mortality	
				Lead Malfunction	Infection	Lead Dislocation	Psychological	Any	Cardiac	Noncardiac
Juang et al. (8)	2.6	14.4	NA	NA	NA	NA	NA	NA	0	4.8
Hermida et al. (9)	1.1	9.1	NA	NA	NA	NA	NA	NA	NA	NA
Kharazi et al. (10)	2.3	7.2	18.0	NA	NA	NA	NA	NA	NA	NA
Sarkozy et al. (11)	4	3.8	9.1	3.2	0.5	NA	NA	1.1	NA	NA
Rosso et al. (12)	3.8	2.3	7.2	4.5	0.4	NA	3.6	1.3	0	0.4
Takigawa et al. (13)	5.8	5.3	NA	NA	NA	NA	NA	NA	NA	NA
Veltmann et al (14)	4	2.9	2.1	NA	0.4	0.8	NA	NA	0	0
Schukro et al. (15)	4.8	2.5	5.0	1.2	0	0	0	0	0	NA
Maesato et al. (16)	2.4	8.5	17.0	0	0	0	0	0	NA	NA
Steven et al. (17)	7.9	0.8	1.9	0.8	0.8	NA	NA	NA	NA	NA
Daoulah et al. (18)	3.4	3.5	3.5	1.2	0	1.2	2.4	NA	0	0
Holst et al. (19)	3.9	6.6	2.2	3.7	NA	NA	NA	NA	0	0
Marquez et al. (20)	4	20.8	4.2	4.2	NA	NA	NA	NA	NA	NA
Olde Nordkamp et al. (21)	5.2	1.8	NA	NA	NA	NA	NA	NA	NA	NA
Miyazaki et al. (22)	6.3	1.9	3.9	1.5	1.2	0.4	0.8	1.2	0	0.4
Dores et al. (23)	6.2	3.2	3.6	0.4	0.4	NA	NA	NA	0	0
Kamakura et al. (24)	8.5	3.0	2.1	0.6	1.0	0.2	NA	0.3	NA	0.2
Rodriguez-Manero et al. (25)	6.2	2.5	2.9	NA	NA	NA	NA	NA	NA	NA
Conte et al. (6)	7	2.3	2.7	1.1	0.4	0.6	NA	0.4	NA	NA
Kim et al. (26)	6	5.3	NA	0.9	0.3	NA	NA	0.7	NA	NA
Shen et al. (27)	3.4	2.9	NA	NA	2.9	NA	NA	NA	NA	NA
Hernandez-Ojeda et al. (28)	9.3	2.2	0.9	1.2	0.7	0	0.2	0.5	0.1	0.2
Summary estimate (95% confidence interval)		3.1 (2.4–4.1)	3.3 (2.4–4.4)	1.6 (0.9–2.5)	0.6 (0.2–1.2)	0.4 (0.1–1.3)	1.3 (0.4–3.5)	0.6 (0.2–1.5)	0.03 (0.0–1.0)	0.3 (0.1–1.1)

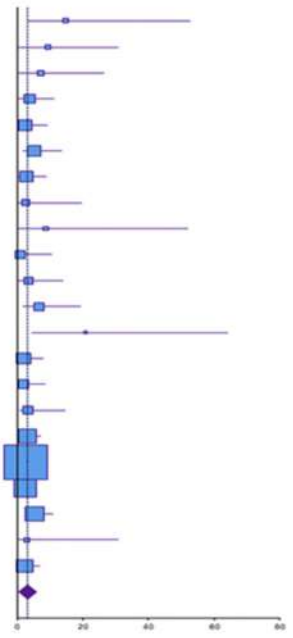
All event rates are presented as number of events per 100 person-years.
NA = not available.

SCD (i.e., spontaneous type-1 Brugada ECG pattern, family history of SCD, inducible ventricular tachycardia/ventricular fibrillation, fractionated QRS, early repolarization in the peripheral leads, increased T_{peak}-T_{end} interval, and long PR interval) (31). There is still controversy on the role of programmed ventricular stimulation for risk stratification in asymptomatic Brugada patients. Although the FINGER (France, Italy, Netherlands, Germany) and PRELUDE (Programmed Electrical Stimulation Predictive Value) studies did not show a predictive value of programmed ventricular stimulation, a recent pooled analysis study of 1,312 patients demonstrated that inducibility of ventricular arrhythmia during EPS was associated with future ventricular arrhythmia risk (32–34). The 2017 American Heart Association/American College of Cardiology/Heart Rhythm Society guidelines give a Class IIb recommendation for an electrophysiological study with programmed ventricular stimulation using single and double extrastimuli in asymptomatic Brugada patients with a spontaneous type-1 Brugada ECG pattern (30). In the present analysis, 79% of the patients with Brugada syndrome received an ICD for primary prevention of SCD. However, clear information regarding the decision strategy before ICD implantation for primary prevention was often not reported. The majority of the included patients in this meta-analysis was considered to be at high risk of SCD, because 72% had inducible ventricular arrhythmias during EPS, 51% had spontaneous type-1 Brugada ECG, 49% had syncope, and 28% had a positive family history of SCD. An *SCN5A* pathogenic mutation was present in 21% of the patients who had a genetic screening. Relatively few women (18%) were included in the studies. The prevalence of Brugada syndrome of female sex is approximately 28% in the entire Brugada population (33).

Most of the studies included in this meta-analysis used a conventional transvenous single-chamber ICD system. The entirely subcutaneous implantable cardioverter-defibrillator system (S-ICD) may eliminate well-known transvenous lead-related complications, such as endocarditis, cardiac perforation, or difficult lead extraction. However, inappropriate shock mostly due to cardiac oversensing still remains a major cause of morbidity in patients with S-ICD,

FIGURE 2 Forest Plot of Appropriate ICD Intervention

Author	Appropriate ICD intervention/total patients	Appropriate ICD intervention per 100 person-years	95% CI
Juang (8)	3/8	14.4	3.2 - 52.7
Hermida (9)	1/10	9.2	0.3 - 30.9
Kharazi (10)	2/12	7.2	0.2 - 36.5
Sarkozy (11)	7/47	3.8	0.5 - 11.3
Rosso (12)	5/59	2.3	0.4 - 9.1
Takigawa (13)	19/62	5.3	1.8 - 13.5
Veltmann (14)	7/61	2.9	0.4 - 8.8
Schukro (15)	2/17	2.5	0.2 - 19.5
Maesato (16)	1/5	8.5	0.5 - 52.2
Steven (17)	2/33	0.8	0.1 - 10.6
Daoulah (18)	3/25	3.5	0.1 - 13.7
Holst (19)	9/35	6.6	1.8 - 19.2
Marquez (20)	5/6	20.8	4.3 - 64.1
Olde Nordkamp (21)	7/75	1.8	0.3 - 7.2
Miyazaki (22)	5/41	1.9	0.1 - 8.6
Dores (23)	7/36	3.2	0.7 - 14.5
Kamakura (24)	31/120	3.0	0.9 - 7.1
Rodriguez-Manero (25)	74/480	2.5	1.3 - 4.1
Conte (6)	28/176	2.3	0.9 - 5.7
Kim (26)	37/117	5.3	2.4 - 10.8
Shen (27)	1/10	2.9	0.3 - 30.9
Hernandez-Ojeda (28)	21/104	2.2	0.6 - 6.8
Summary estimate		**3.1**	2.4 - 4.1

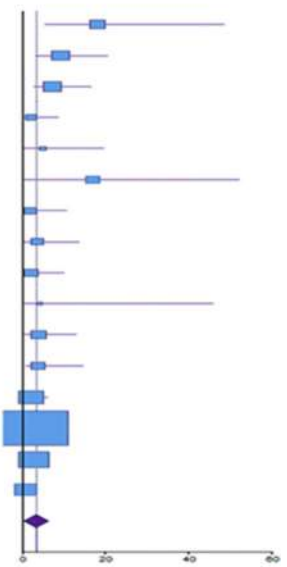


Fixed effects model Q = 8 I^2 = 0%

Forest plot of appropriate implantable cardioverter-defibrillator (ICD) intervention per 100 person-years. CI = confidence interval.

FIGURE 3 Forest Plot of Inappropriate ICD Intervention

Author	Inappropriate ICD intervention/total patients	Inappropriate ICD intervention per 100 person-years	95% CI
Kharazi (10)	5/12	18.0	5.5 - 48.4
Sarkozy (11)	17/47	9.1	3.6 - 20.4
Rosso (12)	16/59	7.2	2.8 - 16.5
Veltmann (14)	5/61	2.1	0.4 - 8.8
Schukro (15)	4/17	5.0	0.2 - 19.5
Maesato (16)	2/5	17.0	0.5 - 52.5
Steven (17)	5/33	1.9	0.1 - 10.6
Daoulah (18)	3/25	3.5	0.1 - 13.7
Holst (19)	3/35	2.2	0.1 - 10
Marquez (20)	1/6	4.2	0.4- 45.9
Miyazaki (22)	10/41	3.9	0.6 - 12.9
Dores (23)	8/36	3.6	0.7 - 14.5
Kamakura (24)	21/120	2.1	0.5 - 5.9
Rodriguez-Manero (25)	88/480	2.9	1.8 - 4.9
Conte (6)	33/176	2.7	0.9 - 5.7
Hernandez-Ojeda (28)	9/104	0.9	0.0 - 3.5
Summary estimate		**3.3**	2.4 - 4.4



Fixed effects model Q = 10 I^2 = 0%

Forest plot of inappropriate implantable cardioverter defibrillator (ICD) intervention per 100 person-years. Abbreviations as in Figure 2.

which might be addressed by specific device programming. The recently published Smart Pass (Boston Scientific, Natick, Massachusetts) algorithm showed a significant reduction of inappropriate shocks by S-ICD (35). Unfortunately, S-ICD screening failure occurs more often in Brugada patients than in other cardiac channelopathies (36). In 11 of the 22 included studies, information on ICD programming was available and programming was frequently left at the discretion of the treating cardiologist. The lower limit of the programmed ventricular fibrillation zone varied mainly between 180 and 220 beats/min. Veltmann et al. (14) demonstrated that the use of a single ventricular fibrillation zone (222 beats/min) was associated with a low inappropriate shock rate of 2.07 per 100 person-years, mostly due to T-wave oversensing. Furthermore, the use of integrated bipolar ICD leads may lead to a reduction in inappropriate shocks due to T-wave oversensing when compared with true bipolar ICD leads (25). The challenge for the future will be to improve device technology, new implantation techniques, and strategic ICD programming of arrhythmia detection (37). Information given in this meta-analysis will be essential for the clinical decision-making process and stimulates a good collaboration and counseling process between patient and cardiologist before ICD implantation.

STUDY LIMITATIONS. First, some studies were excluded, because the analysis of ICD therapy was based on mixed patient groups or because no follow-up duration was reported. Second, one-half of the included studies did not report a clear decision strategy before ICD implantation for primary prevention. Third, probably there is a selection bias, because patients who have received an ICD were considered to be at high risk of SCD. Fourth, most studies in this meta-analysis did not provide details on the implanted defibrillator leads, hence it cannot be excluded that the inappropriate shock rate in this meta-analysis may have been influenced by the use of advisory defibrillator leads, the Medtronic Sprint Fidelis, and St. Jude Riata leads, in the included studies (38). Finally, the time frame between the first and last published study is 14 years, and over the years, substantial progress in ICD diagnostics, devices, programming, and experience have evolved.

CONCLUSIONS

Patients with Brugada syndrome judged to be at high risk for ventricular arrhythmia may significantly benefit from ICD therapy, which is associated with an appropriate ICD intervention rate of 3.1 per 100 person-years and low cardiac and noncardiac mortality rates. Inappropriate ICD interventions with an incidence rate of 3.3 per 100 person-years and ICD-related complications may lead to considerable morbidity. These data may inform counseling and decisions on ICD implantation in patients with Brugada syndrome.

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: This meta-analysis provides an overview on clinical outcome after ICD implantation in patients with Brugada syndrome. These data may inform counseling and decisions on ICD implantation in patients with Brugada syndrome.

TRANSLATIONAL OUTLOOK: Prospective studies are needed to further improve device technology and strategic ICD programming of arrhythmia detection to minimize ICD-related complications including inappropriate shocks.

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KEY WORDS Brugada syndrome, complication, counseling, implantable cardioverter-defibrillator, outcome

APPENDIX For supplemental material, please see the online version of this paper.