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Syncope in Patients With an Implantable Cardioverter-Defibrillator: Incidence, Prediction and Implications for Driving Restrictions

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Objectives. **This retrospective study was undertaken to provide information on occurrence, risk prediction and prevention of syncope in patients with an implantable cardioverter-defibrillator (ICD).**

Background. **ICDs effectively terminate ventricular tachycardia and fibrillation (VT/VF). Incapacitating symptoms, such as syncope, may still occur.**

Methods. **We performed a retrospective analysis of data from 421 patients (clinical history, outpatient chart reviews and episode data) with mean (±SD) follow-up of 26 ± 18 months.**

Results. **Of 421 patients, 229 (54.4%) had recurrent VT/VF, and 62 (14.7%) had syncope. The actuarial survival rate free of VT/VF was 58%, 45% and 37% and that for survival free of syncope was 90%, 85% and 81% at 12, 24 and 36 months after implantation, respectively. Once VT/VF had occurred, 76%, 68% and 62% of patients remained free of syncope during the following 12, 24 and 36 months, and 68%, 64% and 56% remained free of second syncope 12, 24 and 36 months after first syncope, respectively. In cases of syncope, the mean cycle length (CL) of VT was 251 ± 56 ms. A low baseline left ventricular ejection fraction (LVEF), induction of fast VT (CL <300 ms) during programmed ventricular stimulation and chronic atrial fibrillation (AF) were associated with an increased risk of syncope. If the LVEF was >40%, fast VT had not been induced, and patients had no chronic AF; 96%, 92% and 92% of patients remained free of syncope after 12, 24 and 36 months, respectively. Once patients had a VT recurrence, syncope during the first VT and a high VT rate were the strongest risk predictors of future syncope.**

Conclusions. **Identification of patients with an ICD with a low and high risk of syncope seems to be feasible and might help as a guide to driving restrictions in such patients.**

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Implantable cardioverter-defibrillators (ICDs) terminate ventricular tachycardia (VT) and ventricular fibrillation (VF) with high efficiency and reduce the rate of sudden cardiac death in patients with otherwise fatal arrhythmias (1–3). However, incapacitating symptoms, such as presyncope or syncope, may still occur. They may cause harm to patients and others and imply restrictions in the everyday lives of patients with an ICD, of which the ban on driving has been of considerable social interest and has been highlighted in many recent publications (4–8). Recommendations by cardiologists on driving restrictions vary between institutions and countries, and even the attendees of the two largest conferences on safety issues related to driving and arrhythmias† and the study group on ICD and Driving of the Working Groups on Cardiac Pacing and Arrhythmias of the European Society of Cardiology felt constrained by limitations of the available data with which to make recommendations (8–11).

Fatal accidents caused by patients during ICD therapy nevertheless seem to be infrequent (5,12). However, accidents may be underreported for various reasons. Liberalization of driving restrictions may better be justified if those patients with a high risk of incapacitating symptoms could be identified. Therefore, this retrospective study was undertaken to provide data on the occurrence and prediction of risk for syncope in patients with an ICD (13).

Methods

Patients. Data were retrospectively analyzed from 421 consecutive patients who received an ICD under current guidelines for ICD implantation at our institution (University of Münster) between July 1988 and January 1995 (14,15).

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Abbreviations and Acronyms

AF = atrial fibrillation
CAD = coronary artery disease
CL = cycle length
DCM = dilated cardiomyopathy
DFT = defibrillation threshold
ICD = implantable cardioverter- defibrillator
LVEF = left ventricular ejection fraction
PVS = programmed ventricular stimulation
VT = ventricular tachycardia
VF = ventricular fibrillation

Patient characteristics as well as implantation and hospital discharge data had been prospectively collected in an ICD database (Table 1). Outpatient charts were reviewed for appropriate ICD therapy, appropriate shocks, occurrence of syncope and measures taken to avoid recurrence of syncope. Prophylactic indications for ICD implantation were excluded from analysis.

All patients underwent coronary angiography and programmed ventricular stimulation (PVS) without antiarrhythmic therapy or with amiodarone before ICD implantation. PVS was performed according to the protocol presented elsewhere (16,17). Predischarge PVS was performed in 333 patients (79%) according to the same protocol.

Devices that allowed for documentation of VT intervals and intracardiac electrograms were implanted in 264 patients (62.7%), for documentation of VT intervals in 141 (33.5%) and for stored therapy counts only in 16 (3.8%). Shock energy was first programmed to a maximum of 34 J, regardless of defibrillation threshold (DFT). Antitachycardia pacing, when programmed, started with 3 and ended with 10 stimuli, with a first coupling interval of 81%.

Follow-up. Patients visited the ICD outpatient clinic routinely every 3 months and were encouraged to schedule additional visits if first shocks, clusters of shocks or syncope had occurred. Patients who were no longer followed up at our or an affiliated clinic were censored at the last visit to our or the affiliated clinic because the quality of follow-up of other centers could not be checked, and thus events might have been underestimated.

At each visit, arrhythmia-related symptoms, such as palpitation, dizziness, presyncope and syncope, were documented, and printouts of arrhythmias were obtained. *Recurrence of VT* was assumed if patients reported regular palpitations of sudden onset, presyncope or syncope (ICDs with stored therapy counts); stored tachycardia RR intervals were short (<250 ms) or decreased suddenly at the onset of tachycardia and were stable (ICDs with stored RR intervals); or the configuration of stored electrograms was different from that during sinus rhythm (ICDs with intracardiac electrograms); and if ICD therapy, especially antitachycardia pacing, successfully terminated the tachycardia. *Syncope* was defined as a short loss of consciousness, either reported by the patient or a witness. In patients who reported syncope and had no VT documented in the ICD, the detection rate was reduced for 6 months, and 24-h Holter monitoring and tilt-table testing were performed.

Table 1. Baseline Characteristics of Patients

Gender	
Male	323 (76.7%)
Female	98 (23.3%)
Age (yr)	
Mean ± SD	58 ± 13
Range	17–83
Heart disease	
CAD	260 (61.8%)
DCM	87 (20.7%)
ARVD	23 (5.5%)
Valvular disease	17 (4.0%)
Other	19 (4.4%)
None	15 (3.6%)
NYHA functional class	
I	92 (21.9%)
II	189 (44.9%)
III	140 (33.2%)
LVEF (%)	
Mean ± SD	43 ± 17
Range	7–85
Atrial fibrillation	116 (27.6%)
Chronic	31 (7.4%)
Intermittent	85 (20.1%)
History of	
Cardiac arrest	164 (39.0%)
VT	135 (32.1%)
Cardiac arrest+VT	122 (28.9%)
PVS at baseline	
No VT/VF inducible	125 (29.7%)
VT inducible	
CL ≥300 ms	115 (27.3%)
CL <300 ms	133 (31.6%)
VF inducible	48 (11.4%)
PVS at discharge	
No VT/VF inducible	136 (32.3%)
VT inducible	
CL ≥300 ms	76 (18.1%)
CL <300 ms	108 (25.7%)
VF inducible	11 (2.6%)
ICD (therapy zones)	
One (shock-only devices)	220 (52.3%)
Two or three (shock+ATP)	201 (47.7%)
Detection rate (beats/min)	
Mean ± SD	177 ± 25
Range	110–210
Medication at discharge	
Class I antiarrhythmic agents	12 (2.4%)
Beta-blockers	75 (17.8%)
Amiodarone	32 (7.6%)
Sotalol	59 (14.0%)
Ca antagonists	22 (5.2%)
Digitalis	232 (55.1%)

Data presented are number (%) of patients, unless otherwise indicated. ARVD = arrhythmogenic right ventricular disease; ATP = antitachycardia pacing; CAD = coronary artery disease; CL = cycle length; DCM = dilated cardiomyopathy; ICD = implantable cardioverter-defibrillator; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association; PVS = programmed ventricular stimulation; VF = ventricular fibrillation; VT = ventricular tachycardia.

At the time of implantation and during follow-up, all patients were informed about the risk of incapacitating symptoms, and recommendations concerning dangerous occupations were provided. The legal consequences of an accident caused by a patient with a VT and an ICD were not well defined before this study was performed. Therefore, we recommended that patients should not drive.

Statistical analysis. Standard deviation was used as the index of dispersion of continuous variables. Mean values in two groups were compared by the Mann-Whitney test.

The probability of VT- and syncope-free survival was calculated according to the Kaplan-Meier method and was measured from the date of implantation, first VT or first syncope to the event (first VT, first and second syncope) or last follow-up visit (18). Differences between pairs of actuarial survival curves were tested by the log-rank test. A two-tailed probability value ≤ 0.05 was regarded as significant.

Cox regression analysis was performed for patient baseline characteristics to investigate the influence of different variables. For continuous variables, the hazard for an increase of 1 in the value of the covariate was calculated from the regression coefficient b: exp(b). For binary variables, the hazard ratio for the presence of a certain characteristic was calculated as exp(b), where b is the regression coefficient.

Because patients were not randomly assigned to different drugs, any retrospective univariate analysis of the effect of drugs on the risk of syncope must be viewed with caution and is meant only to provide some insight into the prevention of syncope and to aid the design of future prospective syncope prevention trials. Drug regimes during follow-up changed considerably, according to the clinical history of the patients. Because the inclusion of drug regimes would have violated two strong assumptions of the Cox model—1) the effects of different variables must be constant over time, and 2) variables must be independent and additive—drugs were excluded from the Cox model (19).

Results

Patients. Recurrent VT/VF occurred in 229 patients (54.4%), 62 (14.7%) had syncope. The mean (±SD) follow-up period at our or an affiliated clinic was 26 ± 18 months (Table 2). The actuarial tachycardia-free survival rate was 68%, 58%, 45% and 37% after 6, 12, 24 and 36 months, respectively; 76%, 66%, 52% and 43% of patients survived without ICD shocks, and 96%, 90%, 85% and 81% survived without syncope after 6, 12, 24 and 36 months, respectively (Fig. 1).

Tachycardias that caused syncope were 240 ± 67 beats/min, and 96% were primarily >180 beats/min (Table 2). Only two incapacitating events occurred during tachycardias that were primarily slow (150 beats/min). Eighteen patients (29.0%) had syncope during the first recurrence of VT. First VTs that caused syncope were significantly faster than first VTs without syncope (270 ± 41 vs. 194 ± 39 beats/min, $p < 0.0001$).

Once VT/VF had occurred, 81%, 76%, 68% and 62% of patients remained free of syncope after 6, 12, 24 and 36 months, respectively. Once syncope had occurred, 76%, 68%, 64% and 56% of patients remained free of second syncope 6, 12, 24 and 36 months, respectively.

Most syncope (43.6%) occurred while the patients were at rest, with 25.8% occurring during everyday activity (e.g., shopping, cycling, mowing) and 6.5% during some type of sports activity (e.g., skiing, jogging, cycling). Except for two

Table 2. Tachyarrhythmias and Syncope During Follow-Up

Follow up (mo)	
Mean ± SD	26 ± 18
Range	1–79
Recurrence of VT/VF	229 (54.4%)
VT/VF treated by ICD shocks	196 (46.6%)
Syncope	62 (14.7%)
Occurred with 1st VT	18 (29.0%)
Caused by 1st VT	18 (7.9%)
CL of VT causing syncope (ms)	
Mean ± SD	251 ± 56
Range	160–420
Physical activity before syncope	
Effort/strain	4 (6.5%)
Daily activity	9 (14.5%)
Standing	7 (11.3%)
Sitting	14 (22.6%)
Lying	13 (21.0%)
Not documented	15 (24.4%)
ICD therapy during 1st syncope	
VT below detection rate	1 (1.6%)
Nonsustained fast VT	1 (1.6%)
Effective ATP	2 (3.2%)
Ineffective ATP + effective shock	2 (3.2%)
Acceleration during ATP + effective shock	6 (9.7%)
Effective 1st shock	34 (54.8%)
>1 shock for termination of VT/VF	4 (6.5%)
Incessant or cluster of VT/VF causing multiple shocks	5 (8.0%)
Inadequate ICD therapy	2 (3.2%)
Unknown	5 (8.1%)
Change of therapy	
Reduction of detection time	6 (9.7%)
Reduction of charging time	8 (12.9%)
Change of zones to avoid ATP for fast VTs	4 (6.5%)
Biphasic device to improve defibrillation efficacy	2 (3.2%)
Class III AA	6 (9.7%)
Ablation	2 (3.2%)
Other	7 (11.3%)
No change of therapy	27 (43.5%)
Recurrent syncope	17 (4.0%)

Data presented are number (%) of patients, unless otherwise indicated. AA = antiarrhythmic drug; other abbreviations as in Table 1.

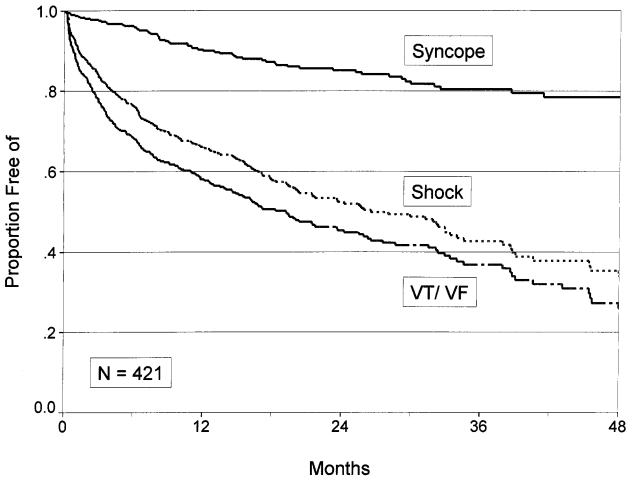


Figure 1. Survival free of syncope, appropriate ICD shock and VT/VF.

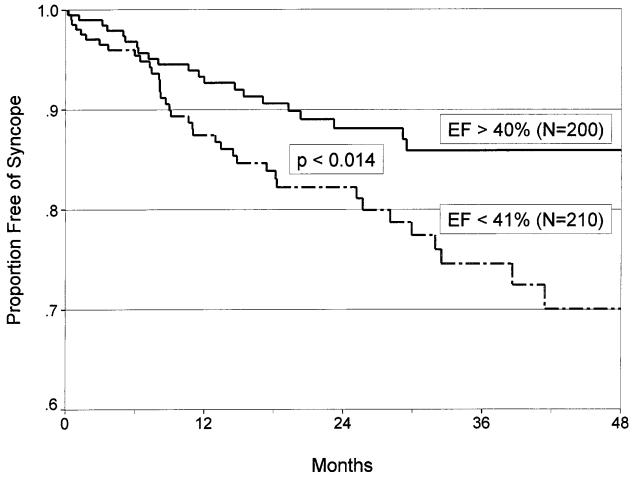


Figure 2. Syncope-free survival and LVEF. In 11 patients, determination of LVEF was technically impossible or invalid.

patients who died, only minor injuries occurred. One patient had syncope while riding a bicycle. He was taking warfarin for anticoagulation and died 2 weeks later because of cerebral bleeding. Another patient had syncope while driving a car. He died due to incessant VT shortly after syncope. An accident was prevented by a frontseat passenger. No harm to others as a result of incapacitating events has come to our attention.

Most syncope (54.8%) occurred despite immediate and successful delivery of a first 34-J shock. In these cases, the capacitor charging time was 9.4 ± 2.7 s (range 6.1 to 15.7). In 6.5% of patients, a first shock failed. VTs that were initially treated by antitachycardia pacing were a rare cause of syncope (16.1%) and were frequently caused by acceleration of VT during antitachycardia pacing (9.7%); 8.0% of syncope occurred due to incessant or clusters of VTs. One syncope was caused by a VT below the detection rate, one by a nonsustained, fast VT. The cause of syncope remained unknown in five patients, either because ICD stores were exhausted (n = 2) or no VT was documented at all (n = 3). No cause for syncope could be defined in the latter three patients despite a reduction of the detection rate, Holter monitoring and tilt table testing. In particular, no bradycardia or pacemaker-induced syncope could be verified (Table 2).

Predictors of risk. Patients with a left ventricular ejection fraction (LVEF) ≤40% had a significantly higher risk of syncope than patients with an LVEF >40% (p = 0.014): 95%, 87%, 82% and 75% of patients with a low LVEF remained free of syncope, whereas 97%, 93%, 88% and 86% of patients with a high LVEF survived free of syncope after 6, 12, 24 and 36 months, respectively (Fig. 2). In the Cox regression model, a 1% increase in LVEF implied a decrease of risk of syncope by 2% (Table 3).

Induction of fast VT (cycle length [CL] <300 ms) during baseline PVS indicated a syncope-free survival rate of 94%, 82%, 78% and 73%, whereas induction of no or slow VT or VF indicated a syncope-free survival rate of 96%, 94%, 88% and 84% after 6, 12, 24 and 36 months, respectively (p = 0.0438) (Fig. 3). There was no significant difference between actuarial syncope-free survival of patients with inducible slow VT/VF and those with no inducible VT. Similar results could be obtained from predischarge PVS with even higher significance (p = 0.0048). By Cox regression analysis, induction of a fast VT during PVS indicated a 2.2-fold increase in risk (95% confidence interval 1.3 to 3.7) (Table 3). The induced VT CL significantly correlated with the recurrent VT CL: For baseline PVS and first recurrent VT CL, R = +0.4565, p < 0.0001; for predischarge PVS, R = +0.5456, p < 0.0001.

Patients with chronic AF had a significantly higher risk of syncope than those with intermittent or no AF: 91%, 86% and 82% of patients without chronic AF survived free of syncope, whereas only 84%, 74% and 48% of patients with chronic AF remained free of syncope after 12, 24 and 36 months, respectively (p = 0.006) (Fig. 4). By multivariate Cox regression analysis, the presence of chronic AF implied a 3.6-fold increase in risk (95% confidence interval 1.8 to 7.4, p = 0.0004) (Table 3).

For a low LVEF (≤40%), documented chronic AF and fast

Table 3. Stepwise Cox Regression of Risk of Syncope and Baseline Characteristics of Patients*

	Regression Coefficient (b)	Exp(b) (95% CI)	p Value
LVEF	−0.02	0.98 (0.96–0.99)	0.0155
Chronic AF	+1.29	3.62 (1.77–7.39)	0.0004
Inducible fast VT (CL <300 ms)	+0.78	2.17 (1.26–3.73)	0.0050

*Variables tested in a stepwise manner without significant influence on hazard of syncope were age, gender, heart disease, functional class, documented intermittent atrial fibrillation, arrhythmic history (ventricular tachycardia, cardiac arrest), antiarrhythmic intervention (ablation, antitachycardia surgery), site of infarction and bypass surgery in patients with coronary artery disease, type of implantable cardioverter-defibrillator, number of zones programmed, detection rate; discharge medication was excluded from analysis because it was dependent on other variables. CI = confidence interval; other abbreviations as in Table 1.

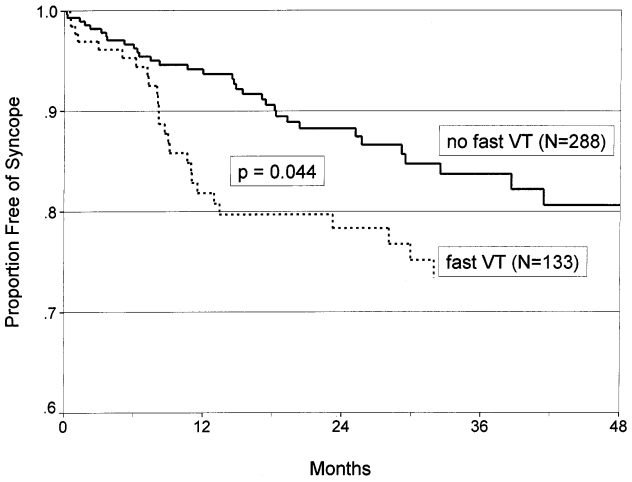


Figure 3. Syncope-free survival and results of baseline ventricular stimulation: patients in whom fast VTs (CL <300 ms) were induced versus patients who had no or only slow VT (CL ≥300 ms) induced or in whom only VF was inducible.

Table 4. Stepwise Cox Regression Analysis of Risk of Syncope After First Ventricular Tachycardia/Atrial Fibrillation and Baseline Characteristics of Patients*

	Regression Coefficient (b)	Exp(b) (95% CI)	p Value
LVEF	−0.01	0.99 (0.97–1.01)	0.1376
Chronic AF	+0.73	2.07 (0.97–4.44)	0.0599
Inducible fast VT (CL <300 ms)	+0.52	1.69 (0.97–2.92)	0.0619
CL of recurrent VT	−0.01	0.99 (0.98–1.00)	0.0164
1st VT caused syncope	+1.36	3.88 (2.15–7.01)	< 0.0001

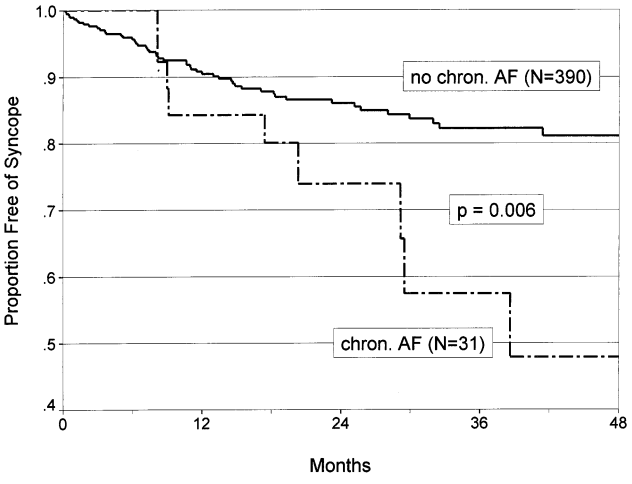
*Variables tested in a stepwise manner without significant influence on hazard of syncope were age, gender, heart disease, functional class, documented intermittent atrial fibrillation, arrhythmic history (ventricular tachycardia, cardiac arrest), antiarrhythmic intervention (ablation, antitachycardia surgery), site of infarction and bypass surgery in patients with coronary artery disease, type of implantable cardioverter-defibrillator, number of zones programmed, detection rate; discharge medication was excluded from analysis because it was dependent on other variables. Abbreviations as in Tables 1 and 3.

VT induced during predischarge test were assumed to be predictors of risk of syncope. Patients with no risk factor differed significantly from patients with one (p = 0.0078) and two risk factors (p = 0.0002). Patients with two risk factors showed a trend toward a higher risk of syncope than patients with one risk factor (p = 0.1078). If patients had no risk factor, 99%, 96%, 92% and 92% remained free of syncope, whereas only 94%, 80%, 77% and 65% with two risk factors survived free of syncope after 6, 12, 24 and 36 months, respectively (p = 0.0002).

Nine patients had syncope despite the absence of any risk predictor, three with CAD, two with dilated cardiomyopathy, two with the long QT syndrome, one with no heart disease and one with VF induced by coronary spasm. All had had cardiac arrest at least once before ICD implantation.

Once patients had developed their first VT after ICD implantation, predictors of risk of future syncope were the occurrence of syncope during the first recurrence of VT and a rapid heart rate during the first VT. A trend for higher risk in patients with chronic AF, inducible fast VT and a low LVEF remained (Table 4).

Figure 4. Syncope-free survival and chronic (chron.) AF.



Antiarrhythmic medication at hospital discharge. Of 12 patients discharged with class I antiarrhythmic drugs, 10 had recurrent VTs (mean CL of the first recurrent VTs was 311 ± 61 ms), and none had syncope. The 75 patients discharged with beta-adrenergic blocking agents, showed a trend toward reduction of risk of recurrent VT (p = 0.083) and syncope (p = 0.094) that was still visible after correction for other risk factors. Of 32 patients discharged with amiodarone, 17 had recurrent VTs (mean CL of the first VTs was 395 ± 100 ms), and only 3 had syncope. Actuarial syncope-free survival was 90% and 81% after 12 and 24 months, respectively. No syncope occurred beyond the second year of follow up. In 59 patients discharged with sotalol, the risk of syncope was not significantly different from patients with other antiarrhythmic drugs or no antiarrhythmic medication. The 22 patients discharged with calcium antagonists had a higher risk of syncope than patients without calcium antagonists (p = 0.049). The actuarial survival rate free of syncope was 96%, 91%, 86% and 80% without and 96%, 83%, 76% and 63% with calcium antagonists after 6, 12, 24 and 36 months, respectively. After correction for AF, this difference remained but lost significance. Ninety-seven percent, 94%, 91% and 86% of patients without digitalis remained free of syncope, whereas only 95%, 87%, 81% and 76% of patients with digitalis (n = 232) survived free of syncope after 6, 12, 24 and 36 months, respectively (p = 0.006). Even after correction for LVEF and AF, this difference was still present but was no longer significant (p = 0.063).

Change of therapy after syncope. Of 62 patients with syncope, therapy was not changed in 27 (43.5%). In eight patients (12.8%), first shock energy was reduced to defibrillation threshold (DFT) plus a 10-J safety margin to shorten

capacitator charging time (Table 2). In six patients (9.7%), detection time was reduced from 2.5 to 1 s to reduce therapy time; in six patients (9.7%), a class III antiarrhythmic agent was prescribed, and in four patients (6.5%), detection zones were changed (i.e., the detection rate for primary shock therapy was reduced from 200 to 180 beats/min). Recurrent syncope occurred in three of six patients in whom detection time was reduced, two of eight patients in whom first shock energy was reduced and none of six patients in whom class III antiarrhythmic agents were prescribed after first syncope. The two patients with syncope after reduction of shock energy needed a second shock for termination of tachycardia; 5 of the 27 patients with no change of therapy had recurrent syncope.

Discussion

Occurrence of syncope. Several studies have analyzed the occurrence of incapacitating symptoms in patients with an ICD (20–23). Grimm et al. (21) found no, mild and severe symptoms (presyncope/syncope) preceding spontaneous ICD shocks in 20 (30%), 33 (49%) and 27 (40%) patients, respectively, with electrocardiographically documented VT or VF during a follow-up period of 24 ± 20 months. Because there is no clear-cut definition of presyncope, contrary to that study we did not include presyncope in our analysis to avoid overestimation of incapacitation during ICD treatment. The fact that in one study (5), only 10.5% of ICD discharges were found to cause accidents, and all fatal accidents were due to syncope, favors this approach (5).

In a study by Kou et al. (22) in 180 patients with an ICD, the incidence of unconsciousness was 9% after a follow-up period of 16 ± 12 month, which is close to our event rate after 1 year. Kou et al. seem to underestimate the occurrence of severe incapacitating events, possibly because of a shorter follow-up period.

Our data suggest that occurrence of syncope is a frequent clinical problem in patients with an ICD. More than one-third of patients with recurrent VT will have at least one episode of syncope, and almost half of these (44%) will have a second episode during 3 years of follow-up. The risk of syncope proved to be highest during the first year of ICD therapy (10%) and decreased in the second year (5%) but remained considerable in the third year (4%). Most syncope occurred shortly after the first ICD intervention.

Except for two patients who died, only minor injuries occurred. One patient was taking warfarin for anticoagulation and died of cerebral bleeding after a bicycle accident; the other died of incessant VT shortly after syncope. No harm to others has come to our attention.

Predictors of risk. Two studies so far have failed to demonstrate that prediction of incapacitating events may be feasible: Kou et al. (22) found that the absence of syncope during one ICD shock did not predict the absence of syncope during subsequent shocks. Accordingly, in our study only 29% of syncope occurred with the first ICD therapy. In the study by Kou et al., syncope could not be predicted by age, gender, history of syncope, left ventricular function, type of underlying heart disease, electrophysiologic findings, rate of VT, antiarrhythmic medications or type of pulse generator implanted, possibly because of smaller patient numbers, a lower event rate and a shorter follow-up period.

Similarly, Schoels et al. (23) found that LVEF was significantly lower in 12 patients with than in 89 patients without syncope during a follow-up period of 19.3 ± 10.5 months (LVEF 32 ± 14% vs. 41 ± 13%). However, the predictive value was low because there was great overlap between LVEF in patients with and without syncope (23).

In contrast, our study shows that chronic AF, which Kou et al. (22) and Schoels et al. (23) did not analyze, a low LVEF, fast VT induced during either baseline or predischarge PVS indicate an increased risk of syncope. The predictive value of left ventricular function may be due to the finding that a depressed LVEF indicates a higher risk of recurrent VT (24,25). The overlap between the LVEF of patients with and without syncope in the study by Schoels et al. (23) may be due to the presence or absence of other risk factors.

Patients with fast VT (CL <300 ms) induced by PVS had a higher risk of syncope during follow-up than patients in whom no or slow VT or VF (the latter may be considered nonspecific) had been induced. Most incapacitating events occurred in patients with inducible fast VT. The predictive value of PVS may be due to the positive correlation between CLs of induced and recurrent VT demonstrated in the present study. However, patients with slow, monomorphic VT are at considerable risk for fast VT or VF during follow-up (3). Previous studies did not consider PVS predictive of syncope, possibly because they did not differentiate between slow and fast VT.

Patients with chronic AF had a significantly higher risk of syncope even after correction for LVEF and the results of PVS, possibly because they have a hemodynamic disadvantage during VT and thus are slow to recover from tachycardia after ICD therapy. Furthermore, it has been demonstrated (26) that patients with AF may also be predisposed to an abnormal neural response during both sinus rhythm and arrhythmia.

The absence of all three risk factors in 129 patients signified a syncope-free survival rate of 93% after 18 months and 92% after 36 months. Four of nine patients in the “no-risk” group had a rare condition, such as the long QT syndrome (n = 2), VF triggered by coronary spasm (n = 1) or idiopathic VF (n = 1). Therefore, predictors of risk should not or only with caution be applied to patients with a rare condition.

Prevention. Most tachycardias that caused syncope were primarily fast. First shocks were successful in 54.8% of patients, implying that the risk of syncope can be decreased if the tachycardia rate is slowed or the duration of therapy for fast VT (detection time plus charging time) is shortened. Charging time in patients in whom a first shock terminated the tachycardia was 9.4 ± 2.7 s. Syncope still occurred with a charging time as low as 6.1 s. A charging time <6 s would imply a DFT well below 15 J if a 10-J margin between shock energy and DFT is to be maintained. Maintaining such a DFT seems to be feasible with modern devices and electrode configurations

(27). A low DFT should be sought and used as an implantation criterion, especially in patients with a high risk of syncope. Shock therapy is usually applied to VTs >200 to 220 beats/min. Therapy time may also be reduced in some cases of fast VT if antitachycardia pacing is applied to fast VT during charging.

Antiarrhythmic therapy in addition to ICD treatment may be the approach of choice. The favorable outcome of patients with class I antiarrhythmic therapy and amiodarone who experienced few episodes of syncope, even though many of them had recurrent but mainly slow tachycardias, may favor this approach. None of the six patients with class III antiarrhythmic therapy prescribed after their first syncope had recurrent syncope. However, the prescription of amiodarone and some class I antiarrhythmic drugs may cause an increase in DFT and expose the patient to an increased risk of syncope because of the need to increase shock energy and charging time (28). Furthermore, Kou et al. (29) found that untested antiarrhythmic drugs or those previously demonstrated to be ineffective during electropharmacologic testing failed to reduce the probability of ICD discharges over the short term (mean 14 months) in 74 patients and even seemed to increase the risk of syncope during ICD discharge. Because the results of PVS appeared to predict the risk of syncope, serial drug testing may help to identify the appropriate antiarrhythmic therapy. The target of drug therapy in patients with syncope should be to induce no or only slow VTs.

Beta-adrenergic blocking agents showed a tendency to reduce recurrent VT and syncope, in line with the suggestion that beta-blockers decrease the frequency of ICD therapy delivery and may also improve general outcome (30). The favorable effect of beta-blockers may also hint at the importance of autonomic tone for the occurrence of VT and syncope.

Dangerous occupations and driving restrictions. Most studies suggest a ban on driving for a certain event-free period during follow-up after ICD implantation or tachycardia (4,6,8–11). Some working groups have suggested (4) estimating the risk of fatal accidents on the basis of a "worst case" scenario; that is, all VTs in patients with an ICD may compromise consciousness and result in an accident. However, according to Curtis (5), only 10.5% of shocks delivered during driving resulted in an accident. Therefore, the risk of any VT or shock may overestimate the risk of a patient with an ICD causing an accident. The reported risk of accidents is ~25/100,000 patient-years, with a fatality rate of 7.5/100,000 patient-years (5). In the present report, private and commercial driving were not considered separately. All fatal accidents were related to patient unconsciousness. We therefore suggest estimating patients fitness to drive on the basis of the risk of syncope.

Based on the formula TD × V × SCI × Ac, suggested by the Canadian Cardiovascular Society (where TD is the time behind the wheel [1 h/day for private, 6 h for commercial driving], V a constant based on the type of vehicle driven [0.28 for private, 1.0 for commercial driving], SCI the risk of unconsciousness and Ac the risk of producing a fatal or injury-producing accident [Ac = 0.02]), we estimated the number of extra accidents/100,000 patient-years based on the risk of syncope for patients driving privately [commercially], if driving were not prohibited until first syncope (31). All patients with an ICD would cause 2.3 [50] accidents/100,000 patients in the first, 1.2 [25] in the second and 0.9 [20] in the third year.

One hundred thousand patients with no risk factor (no chronic AF, LVEF >40%, no inducible fast VT) would cause ~0.9 [20] accidents in the first and second years and <0.2 [5] accidents in the third year; 100,000 patients with an LVEF <40% would cause 3 [65] accidents in the first, 1.2 [25] in the second and 1.5 (35) in the third year. The numbers for patients with chronic AF would be 3.7 [65] in the first, 2.3 [50] in the second and 6 [120] in the third year. For patients with inducible fast VT, the number of extra accidents would be 3.3 [70] in first, 0.9 [20] in the second and 1.2 [25] in the third year. During the first, second and third years after a first VT, 100,000 patients would cause 3.3 [70], 1.9 [40] and 1.4 [30] accidents, respectively. After the first syncope, the numbers are 7.5 [160] for the first, 0.9 [20] for the second and 1.9 [40] for the third year.

If society will tolerate 10 extra accidents/100,000 patient-years, all patients could be allowed to drive privately, and patients without any risk predictor could even be allowed to drive commercially after 2 years of event-free follow-up until a first syncope occurs. If only 1 extra accident/100,000 patient-years is acceptable, then commercial driving could not be allowed at all, and the following patients should not drive privately: patients with chronic AF at any time and patients with a low LVEF and fast inducible VTs for at least 1 year. After the first VT, patients should not drive for 2 years and after syncope for 1 year. With these recommendations, ~1.2 extra accidents would occur/100,000 patient-years due to syncope in patients with an ICD.

Major restrictions of the study. Although patients were explicitly asked at every follow-up visit whether syncope or related symptoms had occurred, some episodes of syncope may not have come to our attention because patients may not remember or report episodes of syncope for various reasons. However, follow-up has been very close (3-month intervals) and patients, relatives and witnesses have been interviewed.

Patients with many different ICD systems and generations, both monophasic and biphasic, were included in this study. Nowadays, with biphasic ICDs that allow a lower DFT and first-shock energy, the risk of syncope may be lower than that assumed in this study.

Conclusions. Syncope occurs frequently in patients with an ICD. Major predictors of syncope are a low LVEF, inducible fast VT and chronic AF. After the first recurrence of VT, major risk predictors of future syncope are a fast heart rate or syncope at first VT. Recommendations for patients' daily lives should be based on risk stratification and follow up.

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