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Both mental and physical health predicts one year mortality and readmissions in patients with implantable cardioverter defibrillators: findings from the national DenHeart study

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Abstract

Background: Although highly effective in preventing arrhythmic death, there is a high prevalence of anxiety, depression and reduced quality of life among patients who have received an implantable cardioverter defibrillator (ICD). Whether mortality, ICD shock and readmission are predicted by patient-reported outcomes is unknown.

Aim: The aim of this study was to describe patient-reported outcomes among patients with ICDs compared by: ICD indication and generator type (ICD or cardiac resynchronisation therapy ICD), and to determine whether patient-reported outcomes at discharge predict mortality, ICD therapy and readmission.

Methods: A national cross-sectional survey at hospital discharge (n=998) with register follow-up. Patient-reported outcomes included the Hospital Anxiety and Depression Scale, Short Form-12, HeartQoL, EQ-5D and Edmonton Symptom Assessment Scale. Register data: ICD therapy, readmissions and mortality within one year following discharge.

Results: Patients with primary prevention ICDs had significantly worse patient-reported outcomes at discharge than patients with secondary prevention ICDs. Likewise, patients with cardiac resynchronisation therapy ICDs had significantly worse patient-reported outcomes at discharge than patients without cardiac resynchronisation therapy. One-year mortality was predicted by patient-reported outcomes, with the highest hazard ratio (HR) being anxiety (HR 2.02; 1.06–3.86), but was not predicted by indication or cardiac resynchronisation therapy. ICD therapy and ventricular tachycardia/ventricular fibrillation were not predicted by patient-reported outcomes, indication or cardiac resynchronisation therapy. Overall, patient-reported outcomes predicted readmissions, e.g. symptoms of anxiety and depression predicted all readmissions within 3 months (HR 1.50; 1.13–1.98) and 1.47 (1.07–2.03), respectively).

Conclusion: Patients with primary indication ICDs and cardiac resynchronisation therapy ICDs report worse patient-reported outcomes than patients with secondary indication and no cardiac resynchronisation therapy. Patient-reported outcomes such as mental health, quality of life and symptom burden predict one-year mortality and acute and planned hospital readmissions.

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Introduction

Treatment with an implantable cardioverter defibrillator (ICD) is recommended for life-threatening ventricular arrhythmias and for the prevention of sudden cardiac death, and has reduced mortality markedly during the past 20 years.[1–7] Although highly effective in preventing arrhythmic death, there is a high prevalence of anxiety (11–63%), depression (10–36%) and reduced quality of life (QoL) among patients who have received an ICD.[2,8,9] There seems to be a number of reasons for this, including concerns about the nature and severity of the cardiac condition, uncertainty about the function and feeling of the ICD, and the unpredictable nature of receiving ICD shocks.[8] Despite conflicting results, studies support the finding that distress and psychological vulnerability may increase the risk of ventricular tachyarrhythmia and mortality in ICD patients.[10]

As a consequence of increasing treatment with ICDs on primary prevention indication, the population of patients with ICDs has gradually become more diverse. In a 2009 review, Pedersen et al.[7] identified five studies reporting patient-reported outcomes (PROs), including anxiety, depression and disease-specific and general QoL. None of these studies found associations between ICD indication and the PROs.[7] However, in a later follow-up study, Pedersen et al.[10] found that patients receiving an ICD as primary prevention experienced a decrease in concerns about the ICD, which was not rediscovered in patients receiving an ICD as secondary prevention.[3] Similar findings have been reported by Carroll and Arthur, who found higher uncertainty in patients with secondary prevention ICDs.[4] In general, earlier studies reporting data by ICD indication used small sample sizes (⩽20). A newer large-scale survey from Sweden found no difference in anxiety and depression between indications and whether cardiac resynchronisation therapy (CRT) function was included.[11] It was a survey that was posted to patients' homes regardless of the time since implantation or hospitalisation, and thus the influence of ICD indication and its association with PROs at hospital discharge remains vague.[8]

The predictive value of PROs has been established in other heart conditions by identifying associations between heart disease, self-reported health and morbidity and mortality.[12] The overall aim of this paper was to examine PROs at hospital discharge in patients with ICDs and their predictive value for adverse outcomes and readmissions.

Purpose

The objectives of this study are: (a) to describe PROs at discharge among patients with an ICD compared by: ICD indication and generator type (ICD or cardiac resynchronisation therapy ICD (CRT-D)); and (b) to determine whether PROs predict mortality, ICD therapy and readmission within one year of follow-up.

Methods

Study design

The DenHeart study was designed as a national cross-sectional survey with register follow-up. All patients across cardiac diagnostic groups who were discharged from a heart centre were asked to fill out a questionnaire to evaluate PROs. The DenHeart study is described in more detail in a published study protocol.[13]

Setting and participants

In one year (15 April 2013 to 15 April 2014) all patients discharged or transferred from one of the five Danish heart centres were included in the DenHeart study. This paper focuses on included patients discharged with an ICD regardless of whether this was the first ICD implantation, a shift of battery, shock or other reasons for admission.

Eligibility criteria. All patients were consecutively included in the DenHeart study. Patients under 18 years of age, patients without a Danish civil registration number and patients who did not understand Danish were excluded from the study. For ethical reasons, patients who were unconscious when transferred were also excluded.

Recruitment. Patients were recruited and informed consent was obtained by a ward nurse or by a research assistant nurse. The questionnaire was distributed with a postage pre-paid envelope for the return of the questionnaire. Patients were asked to complete and return the questionnaire before they left the hospital or to do so at home within 3 days of discharge and return it by mail. Assistance with completion of the questionnaire was allowed.

Variables

The DenHeart questionnaire consisted of six validated questionnaires and a number of ancillary questions, with a total of 80 questions.

The Short Form-12 (SF-12) is a brief measure of overall health status that generates a physical component score (PCS) and a mental component score (MCS) ranging from 0 to 100 with higher scores indicating better health status.[14] The SF-12 has been validated with a Cronbach's

alpha of 0.87 and 0.84 for PCS-12 and MCS-12, respectively, in a population of coronary heart disease patients.[15]

The Hospital Anxiety and Depression Scale (HADS) is a 14-item questionnaire that assesses levels of anxiety and depression symptoms in medically ill patients; HADS-anxiety (HADS-A) and HADS-depression (HADS-D). Scores of 8 to 10 suggest the presence of a mood disorder, scores of 11 or greater indicate the probable presence of a mood disorder.[16] A mean Cronbach's alpha of 0.83 and 0.82 for the HADS-A and HADS-D, respectively, have been reported.[17]

The EuroQol Five Dimensions 5 Levels Health Status Questionnaire (EQ-5D) is a standardised instrument for use as a measure of current health status that provides a simple descriptive profile and a single index value that can be used in the clinical and economic evaluation of healthcare and in population health surveys, higher scores indicate better health status.[18] A Cronbach's alpha of 0.73 for the overall score has been found in a population of coronary heart disease patients.[15]

HeartQoL is a disease-specific questionnaire that measures QoL in cardiac patients and produces a global score and two subscales, a physical scale and an emotional scale ranging from 0 to 3, with higher scores indicating better QoL status.[19–21] The questionnaire has proved to be a reliable instrument with a Cronbach's alpha between 0.90 and 0.94 for the global score and each subscale in cardiac patients.[22,23]

The Edmonton Symptom Assessment Scale (ESAS) is a 10-item questionnaire that allows patients to rate their symptoms on a visual numeric scale, higher scores indicate the presence and intensity of the symptoms.[24] The survey also included nine questions about health and health behaviour from the Danish National Health Survey.[25,26] ESAS has proved to be a valid instrument in cancer patients, with an overall Cronbach's alpha of 0.79.[24]

Data from the DenHeart survey were combined with data from the Danish Civil Registration System[27] and the Danish National Patient Register,[28] to obtain information on diagnosis, marital status and comorbidity at baseline and on vital status and readmission after one year.

Information on comorbidity was obtained for all patients from the National Patient Register going back 10 years, not including the index discharge. Both primary and secondary diagnoses were included. The Tu comorbidity index[29] score was calculated.

Furthermore, data on ICD indication and ICD therapy were obtained from the Danish ICD Register that holds information on all national ICD and CRT-D device implantations since 1989.

Statistical methods

In order to compare means between patients with primary and secondary prevention ICDs we used Student's *t*-test (or the Cochrane method when the variances were unequal) and for comparisons of frequencies the Pearson χ^2 test was used.

Two patients did not have an address in Denmark. Hence, these two patients were not eligible for the follow-up analyses.

The associations between the potential predicting factors (PROs, ICD indication and generator type) and the risk of one-year, all-cause mortality within one year of hospital discharge were assessed using Cox proportional hazards models. Follow-up was continued until death, emigration or end of follow-up.

Cox proportional hazards models were also used to examine the associations between the potential predicting factors (PROs, ICD indication and generator type) and appropriate ICD shocks, appropriate anti-tachycardia pacing (ATP) and ventricular tachycardia/ventricular fibrillation (VT/VF), respectively, within one year of hospital discharge. The same analytical approach was used to assess the associations between the potential predicting factors (PROs, ICD indication and generator type) and the risk of readmission 0–3 and 3–12 months after discharge. Follow-up was continued until the first relevant event: death, emigration or end of follow-up.

Age was used as the underlying time scale in all models. The analyses were adjusted for sex, marital status and Tu comorbidity score. Results are reported as hazard ratios (HRs) with 95% confidence intervals (CIs).

All analyses were conducted using SAS version 9.3.

Ethics approval

The study complies with the Declaration of Helsinki. Under the terms of the relevant Danish legislation, surveys are not approved by an ethics committee system (H-4-2013-FSP) but rather by the Danish Data Protection Agency (2007-58-0015/30-0937). The use of register data was permitted by the Danish National Board of Health (FSEID-0001131). DenHeart is registered at ClinicalTrials.gov (NCT01926145) and approved by the institutional boards of the heart centres. Patients signed an informed consent. All authors had full access to all data in the study.

Results

A total of 998 patients with an ICD or CRT-D (58%) answered the survey. The mean age was 63.8 years, 80% were men and 65% were married. The majority of responders (63%) had a primary prevention ICD. More non-responders had a Tu comorbidity of 3 or greater compared with responders (Table 1).

One year after hospital discharge, the overall percentage of mortality was 4.3% (n=43). In all, 313 patients (31.4%) were readmitted for any cause within 3 months of discharge and 400 patients (40.7%) were readmitted for any cause between 3 and 12 months of discharge.

Table 1. Socio-demographic and clinical profile.

	Non-responders	Responders	Primary prevention indication	Secondary prevention indication	CRT-D	ICD (no CRT)
n	732	998	625	373	322	676
Male, %	82	80	80	80	82	79
Age, mean	63.2	63.8	65.3	61.5	67.9	61.9
Married, %	59	65	63	69	63	66
Diagnosis, %						
Arrhythmogenic right ventricle	1	1	1	1	0	2
Cardiomyopathy	22	21	22	20	29	17
Congenital heart disease	2	2	1	3	1	2
Idiopathic ventricular fibrillation	2	3	1	8	1	4
Ischaemic heart disease	63	64	70	53	66	63
Other/ unknown	11	9	5	16	4	11
Tu comorbidity score, %						
0	11	12	7	19	3	15
1	21	25	25	26	17	30
2	36	36	38	34	40	34
⩾3	32	27	30	22	40	21
Life style factors, %*						
BMI<18.5		1	1	1	1	1
BMI⩾25		66	66	65	68	65
BMI⩾30		25	27	23	28	24
Ever smoked		74	77	69	76	73
Smokes daily		11	12	11	10	12
Alcohol intake above high risk limit#		6	6	7	7	6

*Information about BMI, smoking and alcohol consumption was included in the DenHeart questionnaire. Therefore, these parameters are only presented for the responders.
The Danish National Board of Health defines the high risk limit for alcohol consumption as a weekly intake of more than 21 standard drinks for men and more than 14 standard drinks for women.

Differences in PROs at discharge by ICD indication and generator type

Significant differences were found on the SF-12 PCS between patients with primary prevention ICDs and secondary prevention ICDs, with secondary prevention reporting the best score ($P<0.001$) (Table 2). Similar results were found for QoL measured by EQ-5D and the HeartQoL scales. Patients with primary prevention ICDs reported significantly worse scores on HADS-D ($P<0.001$) and symptom burden ($P=0.05$) (Table 2).

Patients with ICDs reported significantly better SF-12 PCS compared with patients with CRT-D ($P<0.001$) (Table 2). The same was the case for the EQ-5D and HeartQoL scales. Furthermore, patients with CRT-D reported significantly worse HADS-D scores ($P<0.001$) and significantly worse symptom burden ($P=0.002$) compared with patients with ICDs (Table 2).

Predictors of mortality

Mortality after one year was predicted by self-rated health as a one-point increase on SF-12 PCS, and SF-12 MCS showed a reduced mortality risk of 6% and 4%, respectively. The mortality risk among patients with HADS-A of 8 or greater was shown to be double that of patients with HADS-A of 8 or less. An increase on the EQ-5D visual analogue score (VAS) scale and the HeartQoL global scale was also shown to be associated with a reduced risk of mortality of 3% and 58%, respectively. Furthermore, a one-point increase in ESAS was associated with an increase in mortality risk of 4% (Table 3). Further adjustment for smoking behaviour eliminated HADS-A as a

Table 2. Quality of life, anxiety and depression among all patients with an ICD and by ICD indication and generator type.

	ICD population	Primary prevention indication	Secondary prevention indication	p (1)	CRT-D	ICD	p (1)
SF-12, PCS *mean (SD)*	39.2 (11.0)	37.7 (10.7)	41.7 (11.0)	<0.001	35.3 (9.9)	41.1 (10.9)	<0.001
SF-12, MCS *mean (SD)*	48.3 (10.9)	47.8 (10.9)	49.1 (11.0)	0.11	47.8 (11.4)	48.5 (10.7)	0.34
EQ-5D 5L crosswalk *mean (SD)*	0.73 (0.16)	0.72 (0.17)	0.75 (0.14)	0.015	0.70 (0.16)	0.75 (0.16)	<0.001
EQ-5D VAS *mean (SD)*	64.3 (20.3)	61.9 (20.4)	68.3 (19.4)	<0.001	59.4 (20.8)	66.7 (19.6)	<0.001
HADS-A *mean (SD)*	5.5 (4.2)	5.5 (4.2)	5.4 (4.2)	0.54	5.7 (4.3)	5.4 (4.1)	0.28
HADS-A (%)							
0-7	71	70	72	0.70	70	71	0.68
8-10	18	18	16		17	18	
⩾11	12	12	12		13	11	
HADS-D *mean (SD)*	4.5 (3.8)	4.8 (3.9)	4.0 (3.4)	<0.001	5.3 (4.0)	4.2 (3.6)	<0.001
HADS-D (%)							
0-7	81	79	83	0.05	76	83	0.02
8-10	11	11	11		13	10	
⩾11	8	10	6		11	7	
HeartQoL global *mean (SD)*	1.66 (0.78)	1.55 (0.76)	1.84 (0.79)	<0.001	1.39 (0.72)	1.79 (0.78)	<0.001
HeartQoL physical *mean (SD)*	1.48 (0.88)	1.35 (0.84)	1.70 (0.90)	<0.001	1.14 (0.78)	1.64 (0.88)	<0.001
HeartQoL emotional *mean* (SD)	2.12 (0.83)	2.08 (0.84)	2.20 (0.81)	0.03	2.04 (0.86)	2.16 (0.82)	0.03
ESAS Score mean (SD)	22.6 (16.9)	23.5 (16.8)	21.3 (16.9)	0.055	25.2 (16.5)	21.5 (16.9)	0.002

ICD = implantable cardioverter defibrillator; CRT = cardiac resynchronization therapy; SF-12 = Short Form-12; PCS = Physical Component Summary; MCS = Mental Component Summary; SD =standard deviation; HADS-A = Hospital Anxiety and Depression Scale-Anxiety; HADS-D = Hospital Anxiety and Depression Scale-Depression, ESAS = Edmonton Symptom Assessment Scale.
T-test using the Cochran approximation when variances were unequal and pooled method when variances were equal. Differences in proportions were tested by the chi2-test.

predictor of mortality, but otherwise did not change the results (data not shown).

Predictors of ICD shocks, ATP, VT/VF

None of the tested PROs predicted ICD shocks, ATP and VT/VF (see Supplementary Table 1 online).

Predictors of readmission 0–3 months after discharge

Self-rated health predicted readmission as a one-point increase on SF-12 PCS was associated with a 2% reduced risk of acute cardiac readmission 0–3 months after discharge. An increase on SF-12 MCS also reduced the risk of all readmissions by 2% as well as acute and planned (scheduled) cardiac readmissions by 3% and 2%, respectively. Having scores of 8 or greater on HADS-A or HADS-D increased the risk of all readmissions by approximately 50%. A 10-point increase in EQ-5D VAS indicated a decreased risk of all, acute and planned, cardiac readmissions of 1%, 1% and 2%, respectively (Table 4). A one-point increase on HeartQoL was associated with a reduced risk of all readmissions of 28%, 31% for acute cardiac readmissions and 41% for planned cardiac readmissions. Furthermore, a higher symptom burden showed an increased risk of all readmissions and acute and planned cardiac readmissions. Patients with primary prevention ICDs were almost twice as likely to experience planned cardiac readmission compared with patients with secondary prevention ICDs (HR 1.81). No predictors of acute non-cardiac readmissions were found (Table 4). After further adjustment for smoking behaviour, HADS-A of 8 or greater also predicted acute non-cardiac readmissions while primary prevention with ICDs increased the risk of all readmissions by 31% (data not shown).

Table 3. Predictors of one year mortality.

	Unadjusted (1)	Adjusted (2)
SF-12, PCS (3)	0.93 (0.89-0.96)**	0.94 (0.91-0.98)*
SF-12, MCS (3)	0.95 (0.92-0.98)**	0.96 (0.93-0.99)*
HADS-A⩾8	2.34 (1.24-4.39)*	2.02 (1.06-3.86)*
HADS-D⩾8	2.02 (1.05-3.88)*	1.56 (0.81-3.05)
EQ-5D VAS (4)	0.97 (0.95-0.98)**	0.97 (0.96-0.99)**
HeartQoL global (3)	0.34 (0.21-0.55)**	0.42 (0.25-0.68)**
ESAS (3)	1.04 (1.02-1.06)**	1.04 (1.02-1.05)**
Primary vs. secondary prevention indication	0.83 (0.44-1.60)	0.71 (0.37-1.37)
CRT-D vs. ICD	1.87 (1.00-3.48)*	1.50 (0.78-2.86)

SF-12 = Short Form-12; PCS = Physical Component Summary; MCS = Mental Component
Summary; HADS-A = Hospital Anxiety and Depression Scale-Anxiety; HADS-D = Hospital Anxiety and Depression Scale-Depression; CRT = cardiac resynchronization therapy, ESAS = Edmonton Symptom Assessment Scale.
*, $p<0.05$; **, $p<0.001$.
(1) Cox regression model with age as underlying time.
(2) Cox regression model with age as underlying time and adjusted for sex, marital status, and Tu co-morbidity index score.
(3) The effect of increase by 1 on the on the SF-12, HeartQoL and ESAS.
(4) The effect of increase by 10 on the EQ-VAS scale.

Predictors of readmission 3–12 months after discharge

An increase in PCS was shown to reduce the risk of all readmissions within 3–12 months by 2%, 3% for acute cardiac readmissions, 2% for planned cardiac readmissions and 3% for acute non-cardiac readmissions. MCS predicted acute non-cardiac readmissions only. Increases in EQ-5D VAS and HeartQoL resulted in a reduced risk of all, acute and planned cardiac and non-cardiac readmissions. A one-point increase on ESAS resulted in an increased risk of all, acute cardiac and acute and planned non-cardiac readmissions of 1% (Table 4).

Discussion

Patients with primary prevention ICDs had significantly worse PROs at discharge compared with patients with secondary prevention ICDs. Likewise, patients with CRT-D had significantly worse PROs at discharge compared with patients without CRT. This was seen in all outcomes measured except for anxiety, in which frequencies of 28–30% were found across all subgroups. One-year mortality was predicted by patient-reported physical and mental health, anxiety, QoL and symptom burden, but was not predicted by indication or generator type. ICD shock, ATP and VT/VF were not predicted by PROs, indication or generator type. PROs predicted readmission.

Strengths and weaknesses

Patients who were too ill or did not speak or understand Danish were excluded. Furthermore, responders and non-responders have similar sociodemographic and clinical characteristics. There were higher mortality rates among non-responders.[30]

Study population. The five heart centres implant most of the ICDs in Denmark; however, they also treat the most critically ill patients, which is why they may be slightly overrepresented in the study. Patients were included in the study at hospital discharge. Some patients were admitted for first ICD implantation, others for upgrade or change of battery, and others again due to a cardiac event. Even though all had an ICD, patients were at different stages of disease and treatment.

Variables. The majority of the outcome measures included in the questionnaire were validated and standardised instruments used to assess PROs, which enhances the validity of the results. However, in the interpretation of the results, it must be taken into account that patients differ regarding how much their health status and/or health behaviour had changed prior to admission to hospital, and that some of the instruments have long recall, up to 4 weeks.

Confounding factors. Self-reported outcomes are by nature not objective and, therefore, sources of bias may exist. Social desirability bias can be an issue, as respondents answer according to what they believe is socially acceptable.[31,32] Data were received from the National Patient Register, which is internationally recognised to be the most comprehensive of its kind and is a very important register for biomedical and public health research.[28]

Non-response. Age plays a significant role in non-response.[26] The patients treated at the heart centres are often aged and severely ill, which may be reflected in the response rate of 58%. Furthermore, some questionnaires were not handed out by the nurses when the clinic was too busy.

Even though the responders and the non-responders were similar regarding sociodemographic data, a much higher mortality rate was found among non-responders.[30] It is natural that the most severely ill would be overrepresented among non-responders and that they have more comorbidity.

Interpretation and implications

The prevalence of anxiety and depression symptoms are rather high. In the present study the prevalence was 30%, mean score 5.5 for anxiety. This confirms previous findings in which the prevalence of anxiety was found to be 19.2%,[11] 16%,[33] 26%[34] and mean scores on HADS-A of 3.96[34] and 3.84 were found.[35] We found depression to be 19% and the mean score 4.5. This is also in line with the previously found high prevalence of 18%,[36] 19%,[33] 20%[34]

Table 4. Predictors of readmissions within 0-3 and 3-12 months after discharge.

	All readmissions	Acute cardiac readmissions	Planned cardiac readmissions	Acute or planned non-cardiac readmissions
	HR (CI) (1)	HR (CI) (1)	HR (CI) (1)	HR (CI) (1)
Readmissions within 0-3 months after discharge				
SF-12, PCS (2)	0.99 (0.97-1.00)	0.98 (0.96-1.00)*	0.98 (0.96-1.01)	0.97 (0.95-1.00)
SF-12, MCS (2)	0.98 (0.97-1.00)*	0.97 (0.96-0.99)*	0.98 (0.96-1.00)*	0.98 (0.95-1.00)
HADS-A⩾8	1.50 (1.13-1.98)*	1.29 (0.90-1.84)	1.45 (0.92-2.27)	1.59 (1.00-2.55)
HADS-D⩾8	1.47 (1.07-2.03)*	1.37 (0.92-2.04)	1.79 (1.09-2.95)*	1.30 (0.74-2.26)
EQ-5D VAS (3)	0.99 (0.98-1.00)*	0.99 (0.98-1.00)*	0.98 (0.97-0.99)**	0.99 (0.98-1.00)
HeartQoL global (2)	0.72 (0.60-0.86)**	0.69 (0.55-0.87)*	0.59 (0.44-0.79)**	0.80 (0.58-1.11)
ESAS (2)	1.01 (1.01-1.02)*	1.02 (1.01-1.03)*	1.01 (1.00-1.03)*	1.01 (0.99-1.02)
Primary vs. secondary prevention indication	1.32 (1.00-1.76)	1.26 (0.87-1.82)	1.81 (1.13-2.90)*	1.01 (0.62-1.64)
CRT-D vs. ICD	1.11 (0.84-1.47)	1.20 (0.85-1.72)	0.83 (0.52-1.33)	1.23 (0.75-2.01)
Readmissions within 3-12 months after discharge				
SF-12, PCS (2)	0.98 (0.96-0.99)**	0.97 (0.96-0.99)**	0.98 (0.96-1.00)*	0.97 (0.95-0.98)**
SF-12, MCS (2)	0.99 (0.98-1.00)	0.99 (0.98-1.01)	0.99 (0.97-1.00)	0.98 (0.97-1.00)*
HADS-A⩾8	1.18 (0.94-1.49)	1.25 (0.92-1.70)	0.95 (0.65-1.37)	1.33 (0.97-1.81)
HADS-D⩾8	1.20 (0.93-1.55)	1.19 (0.84-1.66)	1.36 (0.92-2.01)	1.20 (0.85-1.68)
EQ-5D VAS (3)	0.99 (0.99-1.00)*	0.99 (0.98-1.00)**	0.99 (0.98-1.00)*	0.99 (0.98-1.00)*
HeartQoL global (2)	0.72 (0.62-0.83)**	0.65 (0.53-0.80)**	0.78 (0.63-0.97)*	0.66 (0.54-0.81)**
ESAS (2)	1.01 (1.00-1.02)*	1.01 (1.01-1.02)*	1.01 (1.00-1.02)	1.01 (1.00-1.02)*
Primary vs. secondary prevention indication	1.09 (0.88-1.36)	1.21 (0.89-1.64)	1.30 (0.91-1.85)	1.11 (0.82-1.50)
CRT-D vs. ICD	0.95 (0.75-1.19)	1.11 (0.82-1.50)	0.94 (0.65-1.35)	0.77 (0.56-1.06)

SF-12 = Short Form-12; PCS = Physical Component Summary; MCS = Mental Component.
Summary; HADS-A = Hospital Anxiety and Depression Scale-Anxiety; HADS-D = Hospital Anxiety and Depression Scale-Depression; CRT = cardiac resynchronization therapy, ESAS = Edmonton.
Symptom Assessment Scale.
*, $p<0.05$; **, $p<0.001$.
(1) Cox regression model with age as underlying time adjusted for sex, marital status and Tu co-morbidity index score.
(2) The effect of increase by 1 on SF-12, HeartQoL and ESAS.
(3) The effect of increase by 10 on the EQ-VAS scale.

and mean scores of 2.99[35] and 3.51.[34] Perceived health was also affected with SF-12 scores of 39.2 points on PCS, which is close to a previous report of 40.8 points.[37] Mental health also seems to be affected, with a MCS score of 48.3 points compared with previous reports of 45.5 points.[37] QoL measured by HeartQoL was 1.66 points compared with 1.94 points in a previous study.[34] In summary, the present scores were in line with previous findings, with a tendency towards marginally worse outcome scores.

The present study showed significant differences in PROs between patients with ICDs implanted for primary versus secondary prevention. Previous studies have shown conflicting results, with most studies showing no difference between groups,[7,37] but the largest showed no difference.[11] The timing of the survey might be relevant as our study finds a difference at hospital discharge and maybe the difference disappears after return to home.[11] Primary prevention patients and patients with CRT function have heart failure, which is known to be the most burdensome diagnostic group.[38] Heart failure patients are especially vulnerable and should be offered referral to rehabilitation, heart failure clinics, home care nursing or other relevant initiatives.

Anxiety, QoL and perceived health, but not depression or indication predicted one-year mortality, which confirms our previous findings in a smaller study.[34] Also, high levels of ICD concerns have previously been found to predict mortality.[39]

We did not find PROs to predict ICD shock, ATP or VT/VF. This confirms our previous study.[34] Conflicting evidence exists about the effect of shock on QoL.[10]

To our knowledge this is the first study to investigate the predictive value of PROs at discharge on readmission in patients with ICDs. Both acute and planned readmissions were predicted by both physical and mental outcomes at discharge.

Although there are diagnostic tests that can help quantify physical status, most aspects of patient health status are best captured by patients' self-reporting.[12] In addition, there may be significant discrepancies between provider-assessed and patient-reported health status,[12,40] and screening tools might be used better to guide outpatient care and follow-up. The biomedical approach to risk factor evaluation in which only physical factors such as left ventricular ejection fraction and diagnoses are evaluated as risk factors for mortality[41] is not adequate and misses the full picture. Patient involvement in disease management is critical and mental factors should not be overlooked. Symptoms of anxiety and depression at hospital discharge must be recognised and treated in this patient population, as evidence of an association with mortality and readmission is building. The discovery of symptoms after discharge and the opportunity for intervening is increasingly difficult due to home monitoring and fewer face-to-face visits with healthcare providers. This calls for alternative strategies in which technology might be helpful, with apps or other electronic systems used to organise screening and facilitate contact with staff. ICD rehabilitation or cognitive therapy might be helpful strategies.[42–44]

Generalisability

This national study was carried out in Denmark where international guidelines for ICD treatment are followed. The response rate was 58%, which is not unexpected in a population of severely ill patients; however, this may cause concerns regarding representativeness.

Conclusion

Patients with primary indication ICDs and with CRT-D have worse PROs than patients with secondary indication ICDs and ICDs without CRT. PROs at discharge such as mental health, QoL and symptom burden predict one-year mortality and acute and planned hospital readmissions. Patient involvement in disease management is critical and mental factors must be considered and treated.

Implications for practice

- Patients with primary indication implantable cardioverter defibrillators and with cardiac resynchronisation therapy implantable cardioverter defibrillators have worse patient-reported outcomes than patients with secondary indication implantable cardioverter defibrillators and implantable cardioverter defibrillators without cardiac resynchronisation therapy.
- Mortality and readmissions were predicted by both physical and mental outcomes at discharge.
- Patient involvement in disease management is critical and mental factors should not be overlooked. Anxiety and depression must be treated and taken seriously in this patient population as evidence of an association with mortality and readmission is building.

Author contribution

SKB conceived the idea for the study. All authors designed the study. KJ and OE performed the statistical analyses. SKB wrote the first draft of the manuscript. All authors revised the manuscript critically. All authors have given their final approval of the version to be published.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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References

1. Al-Khatib SM, Sanders GD, Carlson M, et al. Preventing tomorrow's sudden cardiac death today: dissemination of effective therapies for sudden cardiac death prevention. *Am Heart J*. 2008; 156: 613–622.
2. Dunbar SB, Dougherty CM, Sears SF, et al. Educational and psychological interventions to improve outcomes for recipients of implantable cardioverter defibrillators and their families: a scientific statement from the American Heart Association. *Circulation* 2012; 126: 2146–2172.
3. Pedersen SS, Hoogwegt MT, Jordaens L, et al. Pre implantation psychological functioning preserved in majority of implantable cardioverter defibrillator patients 12 months post implantation. *Int J Cardiol* 2013; 166: 215–220.
4. Carroll SL and Arthur HM. A comparative study of uncertainty, optimism and anxiety in patients receiving their first implantable defibrillator for primary or secondary prevention of sudden cardiac death. *Int J Nurs Stud* 2010; 47: 836–845.
5. Theuns DA, Schaer BA, Soliman OI, et al. The prognosis of implantable defibrillator patients treated with cardiac resynchronization therapy: comorbidity burden as predictor of mortality. *Europace* 2011; 13: 62–69.
6. Bhavnani SP, Coleman CI, Guertin D, et al. Evaluation of the Charlson comorbidity index to predict early mortality in implantable cardioverter defibrillator patients. *Ann Noninvasive Electrocardiol* 2013; 18: 379–388.
7. Pedersen SS, Sears SF, Burg MM, et al. Does ICD indication affect quality of life and levels of distress? *Pacing Clin Electrophysiol* 2009; 32: 153–156.
8. Magyar-Russell G, Thombs BD, Cai JX, et al. The prevalence of anxiety and depression in adults with implantable cardioverter defibrillators: a systematic review. *J Psychosom Res* 2011; 71: 223–231.
9. Gostoli S, Bonomo M, Roncuzzi R, et al. Psychological correlates, allostatic overload and clinical course in patients with implantable cardioverter defibrillator (ICD). *Int J Cardiol* 2016; 220: 360–364.
10. Pedersen SS, Brouwers C and Versteeg H. Psychological vulnerability, ventricular tachyarrhythmias and mortality in implantable cardioverter defibrillator patients: is there a link? *Expert Rev Med Devices* 2012; 9: 377–388.
11. Lang S, Becker R, Wilke S, et al. Anxiety disorders in patients with implantable cardioverter defibrillators: frequency, course, predictors, and patients' requests for treatment. *Pacing Clin Electrophysiol* 2014; 37: 35–47.
12. Rumsfeld JS, Alexander KP, Goff DC Jr, et al. Cardiovascular health: the importance of measuring patient-reported health status: a scientific statement from the American Heart Association. *Circulation* 2013; 12): 2233–2249.
13. Berg SK, Svanholm J, Lauberg A, et al. Patient-reported outcomes at hospital discharge from heart centres, a national cross-sectional survey with a register-based follow-up: the DenHeart study protocol. *BMJ Open* 2014; 4: e004709.
14. Ware J Jr, Kosinski M and Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 1996; 34: 220–233.
15. De Smedt D, Clays E, Doyle F, et al. Validity and reliability of three commonly used quality of life measures in a large European population of coronary heart disease patients. *Int J Cardiol* 2013; 167: 2294–2299.
16. Zigmond AS and Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 1983; 67: 361–370.
17. Bjelland I, Dahl AA, Haug TT, et al. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. *J Psychosom Res* 2002; 52: 69–77.
18. Rabin R and de Charro F. EQ-5D: a measure of health status from the EuroQol Group. *Ann Med* 2001; 33: 337–343.
19. Oldridge N, Hofer S, McGee H, et al. The HeartQoL: Part I. Development of a new core health-related quality of life questionnaire for patients with ischemic heart disease. *Eur J Prev Cardiol* 2014; 21: 90–97.
20. Oldridge N, Hofer S, McGee H, et al. The HeartQoL: Part II. Validation of a new core health-related quality of life questionnaire for patients with ischemic heart disease. *Eur J Prev Cardiol* 2014; 21: 98–106.
21. Oldridge N, Saner H and McGee HM; HeartQoL Study Investigators. The Euro Cardio-QoL Project. An international study to develop a core heart disease health-related quality of life questionnaire, the HeartQoL. *Eur J Cardiovasc Prev Rehabil* 2005; 12: 87–94.
22. Zangger G, Zwisler AD, Kikkenborg Berg S, et al. Psychometric properties of HeartQoL, a core heart disease-specific health-related quality of life questionnaire, in Danish implantable cardioverter defibrillator recipients. *Eur J Prev Cardiol* 2018; 25: 142–149.
23. Kristensen MS, Zwisler AD, Berg SK, et al. Validating the HeartQoL questionnaire in patients with atrial fibrillation. *Eur J Prev Cardiol* 2016; 23: 1496–1503.
24. Chang VT, Hwang SS and Feuerman M. Validation of the Edmonton Symptom Assessment Scale. *Cancer* 2000; 88: 2164–2171.
25. Ekholm O, Hesse U, Davidsen M, et al. The study design and characteristics of the Danish national health interview surveys. *Scand J Public Health* 2009; 37: 758–765.
26. Christensen AI, Ekholm O, Glumer C, et al. The Danish National Health Survey 2010. Study design and respondent characteristics. *Scand J Public Health* 2012; 40: 391–397.
27. Pedersen CB. The Danish Civil Registration System. *Scand J Public Health* 2011; 39 (7 Suppl.): 22–25.
28. Lynge E, Sandegaard JL and Rebolj M. The Danish National Patient Register. *Scand J Public Health* 2011; 39 (7 Suppl.): 30–33.
29. Tu JV, Austin PC, Walld R, et al. Development and validation of the Ontario acute myocardial infarction mortality prediction rules. *J Am Coll Cardiol* 2001; 37: 992–997.
30. Berg SK, Thorup CB, Borregaard B, et al. Patient-reported outcomes are independent predictors of one-year mortality and cardiac events across cardiac diagnoses: findings from the national DenHeart survey. *Eur J Prev Cardiol* 2018; 112: 66–72.
31. Rothman KJ, Greenland S and Lash TL. *Modern Epidemiology*, 3rd edn. Philadelphia: Lippincott Williams & Wilkins, 2008.
32. Anker SD, Agewall S, Borggrefe M, et al. The importance of patient-reported outcomes: a call for their comprehensive integration in cardiovascular clinical trials. *Eur Heart J* 2014; 35: 2001–2009.
33. Versteeg H, Timmermans I, Meine M, et al. Prevalence and risk markers of early psychological distress after ICD implantation in the European REMOTE-CIED study cohort. *Int J Cardiol* 2017; 240: 208–213.

34. Berg SK, Thygesen LC, Svendsen JH, et al. Anxiety predicts mortality in ICD patients: results from the Cross-Sectional National Copenheart Survey with Register Follow-Up. *Pacing Clin Electrophysiol* 2014; 37: 1641–1650.
35. Thylen I, Dekker RL, Jaarsma T, et al. Characteristics associated with anxiety, depressive symptoms, and quality-of-life in a large cohort of implantable cardioverter defibrillator recipients. *J Psychosom Res* 2014; 77: 122–127.
36. Whang W, Albert CM, Sears SF Jr, et al. Depression as a predictor for appropriate shocks among patients with implantable cardioverter-defibrillators: results from the Triggers of Ventricular Arrhythmias (TOVA) study. *J Am Coll Cardiol* 2005; 45: 1090–1095.
37. Magnusson P, Morner S, Gadler F, et al. Health-related quality of life in hypertrophic cardiomyopathy patients with implantable defibrillators. *Health Qual Life Outcomes* 2016; 14: 62–016–0467-x.
38. Berg SK, Rasmussen TB, Thrysoee L, et al. DenHeart: differences in physical and mental health across cardiac diagnoses at hospital discharge. *J Psychosom Res* 2017; 94: 1–9.
39. Pedersen SS, van den Broek KC, Erdman RA, et al. Pre-implantation implantable cardioverter defibrillator concerns and type D personality increase the risk of mortality in patients with an implantable cardioverter defibrillator. *Europace* 2010; 12: 1446–1452.
40. Versteeg H, van 't Sant J, Cramer MJ, et al. Discrepancy between echocardiographic and patient-reported health status response to cardiac resynchronization therapy: results of the PSYHEART-CRT study. *Eur J Heart Fail* 2014; 16: 227–234.
41. Bergau L, Tichelbacker T, Kessel B, et al. Predictors of mortality and ICD shock therapy in primary prophylactic ICD patients – a systematic review and meta-analysis. *PLoS One* 2017; 12: e0186387.
42. Berg SK, Pedersen PU, Zwisler AD, et al. Comprehensive cardiac rehabilitation improves outcome for patients with implantable cardioverter defibrillator. Findings from the COPE-ICD randomized clinical trial. *Eur J Cardiovasc Nurs* 2015; 14: 34–44.
43. Berg SK, Herning M, Svendsen JH, et al. The Screen-ICD trial. Screening for anxiety and cognitive therapy intervention for patients with implanted cardioverter defibrillator (ICD): a randomised controlled trial protocol. *BMJ Open* 2016; 6: e013186.
44. Maia AC, Braga AA, Soares-Filho G, et al. Efficacy of cognitive behavioral therapy in reducing psychiatric symptoms in patients with implantable cardioverter defibrillator: an integrative review. *Braz J Med Biol Res* 2014; 47: 265–272.