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ORIGINAL ARTICLE

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Age differences of patients treated with wearable cardioverter defibrillator: Data from a multicentre registry

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Abstract

Background: Wearable cardioverter defibrillators (WCD) are used as a 'bridging' technology in patients, who are temporarily at high risk for sudden cardiac death (SCD). Several factors should be taken into consideration, for example patient selection, compliance and optimal drug treatment, when WCD is prescribed. We aimed to present real-world data from seven centres from Germany and Switzerland according to age differences regarding the outcome, prognosis, WCD data and compliance.

Materials and Methods: Between 04/2012 and 03/2021, 1105 patients were included in this registry. Outcome data according to age differences (old ≥45 years compared to young <45 years) were analysed. At young age, WCDs were more often prescribed due to congenital heart disease and myocarditis. On the other

Assem Aweimer and Ibrahim Akin contributed equally to this study.

hand, ischaemic cardiomyopathy (ICM) was more present in older patients. Wear days of WCD were similar between both groups ($p = .115$). In addition, during the WCD use, documented arrhythmic life-threatening events were comparable [sustained ventricular tachycardia: 5.8% vs. 7.7%, ventricular fibrillation (VF) .5% vs. .6%] and consequently the rate of appropriate shocks was similar between both groups. Left ventricular ejection fraction improvement was documented over follow-up with a better improvement in younger patients as compared to older patients (77% vs. 63%, $p = .002$). In addition, at baseline, the rate of atrial fibrillation was significantly higher in the older age group (23% vs. 8%; $p = .001$). The rate of permanent cardiac implantable electronic device implantation (CiED) was lower in the younger group (25% vs. 36%, $p = .05$). The compliance rate defined as wearing WCD at least 20 h per day was significantly lower in young patients compared to old patients (68.9% vs. 80.9%, $p < .001$). During the follow-up, no significant difference regarding all-cause mortality or arrhythmic death was documented in both groups. A low compliance rate of wearing WCD is predicted by young patients and patients suffering from non-ischaemic cardiomyopathies.

Conclusion: Although the compliance rate in different age groups is high, the average wear hours tended to be lower in young patients compared to older patients. The clinical events were similar in younger patients compared to older patients.

KEYWORDS

age-variation, age-differences, arrhythmias, Sudden cardiac death, wearable cardioverter defibrillator

1 | INTRODUCTION

Patients with a reduced left ventricular (LV) ejection fraction (EF) <35% are at risk for sudden cardiac death (SCD). This risk may decrease in case the LVEF improves, for example under optimal heart failure medication or spontaneously. Thus, current heart failure guidelines recommend optimal heart failure drug treatment first for at least 3–6 months before a permanent cardioverter defibrillator (ICD) is implanted.[1] The patients are at high risk for SCD during treatment until LVEF improves over 35%, as suggested by current guidelines.[2] In addition, despite the optimal heart failure drug treatment, some risk of SCD might still remain. For example, the PARADIGM study showed a significantly lower cardiovascular death over follow-up in the combined treatment arm with sacubitril/valsartan compared to angiotensin-converting enzyme inhibitors. Despite this significant decrease, 45% of deaths were related to SCD.[3]

Several publications reported that by using a wearable cardioverter defibrillator (WCD), a permanent ICD could be avoided in a significant part of patients.[4–6] The Vest trial investigated the benefit of WCD in 1524 patients, who suffered a myocardial infarction and developed a reduced LVEF; 778 patients were randomized for a WCD, and 746 patients did not receive a WCD. Despite treatment with WCD, the arrhythmic death was not significantly different (1.6% vs. 2.8%, $p = .18$), however, the all-cause mortality was significantly reduced (3.1% vs. 4.9%, $p = .04$). Thus, the potential benefit of WCD in reducing SCD remains obscure. Of note, dissecting the data of Vest trial showed that when patients were compared on the treatment analysis (only time wearing of WCD), the all-cause and arrhythmic mortality were significantly reduced using WCD. In general, the compliance rate was only 14 h/day, which may cause the negative result of Vest trial.[7] Recently published data by a French WCD registry reported that young age might be related to a lower compliance rate compared to older patients.[8] However, in this registry, only a short-term follow-up was reported and the outcome of patients after permanent device implantation was lacking.

Based on these data, we investigated 1105 consecutive patients from seven hospitals in Germany and Switzerland. The mean follow-up time was 615 ± 453 days. We aimed to investigate the risk of ventricular tachyarrhythmias and the success rate of termination of these by WCD use. In addition, we evaluated the compliance rate. Young patients (<45 years) were compared to older patients (≥45 years).

2 | METHODS

2.1 | Patient recruitment

A total of 1105 patients were recruited between 04/2012 and 03/2021 at seven hospitals (University Medical Center Mannheim, Frankfurt University Hospital, the Heart Center Leipzig, Bergmannsheil University Medical Center of the Ruhr University, University Medical Center Bonn, Helios Clinic Krefeld Germany and the University Hospital Zurich). Patients received a ZOLL Life Vest System. The study was approved by the local ethics committee. All analyses were performed in accordance with the relevant guidelines and regulations by including a statement in the methods section that conforms to the 1975 Declaration of Helsinki.

2.2 | The wearable cardioverter–defibrillator (WCD)

The WCD ZOLL Life Vest™system and programmed data have been recently described in depth.[5] Different points were taken into consideration for programming including the underlying heart disease and electrocardiographic patterns. In general, for older patients, the ventricular tachycardia (VT) zone was programmed at a heart rate of 150–190 bpm with a VT response time of 60 s and for younger patients, a VT zone was programmed at a heart rate of 180–190 bpm with a VT response time also of 60 s. The ventricular fibrillation (VF) zone was programmed similarly in older and younger patients at a heart rate of 200–220 bpm with a response time of 25 s. The maximum first shock energy was 150 J with a separate episode detecting when episodes were recorded with a minimum delay of 3 min. Episodes were reviewed and classified by independent physicians. Episodes were separated into one of two groups, sustained VT (lasting 30 s or longer) or VF with WCD shock therapy and non-sustained VT (lasting less than 30 s) without WCD shock. Inappropriate WCD therapy was identified as non-ventricular tachyarrhythmias or non-ventricular fibrillation episodes treated by an inappropriate WCD shock.

2.3 | Baseline and follow-up data collection

Several baseline characteristics and comorbidities were evaluated at each centre. As far as possible, the index LVEF, a follow-up LVEF at 3 months (short-term) and at 6–12 months (long-term) was evaluated and calculated by the biplane Simpson's method using echocardiography and/or cardiac magnetic resonance imaging (MRI). An improvement was accepted after recording an increase of the LVEF > 35% over follow-up. WCD use was suggested for 3 months.[2] WCDs were prescribed consistent with current guidelines and the risk was estimated and individualized by treating physicians. All data were retrospectively collected clinically and retrieved from the ZOLL Life Vest Network™. For follow-up data, treating physicians and/or patients were contacted.

The mean follow-up time of the whole cohort was 615 ± 453 days. This included the time during WCD use and the time after WCD use. Each centre and physician decided according to different aspects if a prolongation of WCD use was required. In some cases of a relevant improvement of LVEF but nevertheless LVEF < 36%, prolongation of WCD wearing was applied. This was dependent on physician–patient decision.

Optimal medical treatment (OMT) was achieved using the generally recommended heart failure drugs, for example angiotensin converting enzyme inhibitor/angiotensin receptor blocker (ACE-I/ARB), beta-blockers and mineralocorticoid receptor blocker (MRA) consistent with current heart failure guidelines.[9] Also, angiotensin receptor-neprilysin inhibitors (ARNI) were used instead of ACE-I or ARB consistent with data published recently.

3 | RESULTS

3.1 | Description the cohort

In the present cohort, 157 patients were young (defined as age < 45 years) and 948 patients were old (defined as age ≥ 45 years). The most common indication for WCD was myocarditis and congenital heart disease in young patients and ICM in old patients (Figure 1). Older patients suffered more often from cardiovascular comorbidities, for example coronary artery disease, myocardial infarction, chronic obstructive pulmonary disease, supraventricular arrhythmias including atrial fibrillation and/or atrial flutter, diabetes mellitus, arterial hypertension, and hyperlipidemia (Table 1**)**. During the in-hospital stay, the rate of pulmonary oedema and cardiogenic shock were similarly presented in both groups. Although LVEF at baseline was numerically lower in older patients compared to younger patients (23.3 ± 14.3% vs. 26 ± 20.7%, p = .114), this difference was not significant. In general, a tendency of LVEF improvement was documented in both cohorts (Figure 2),

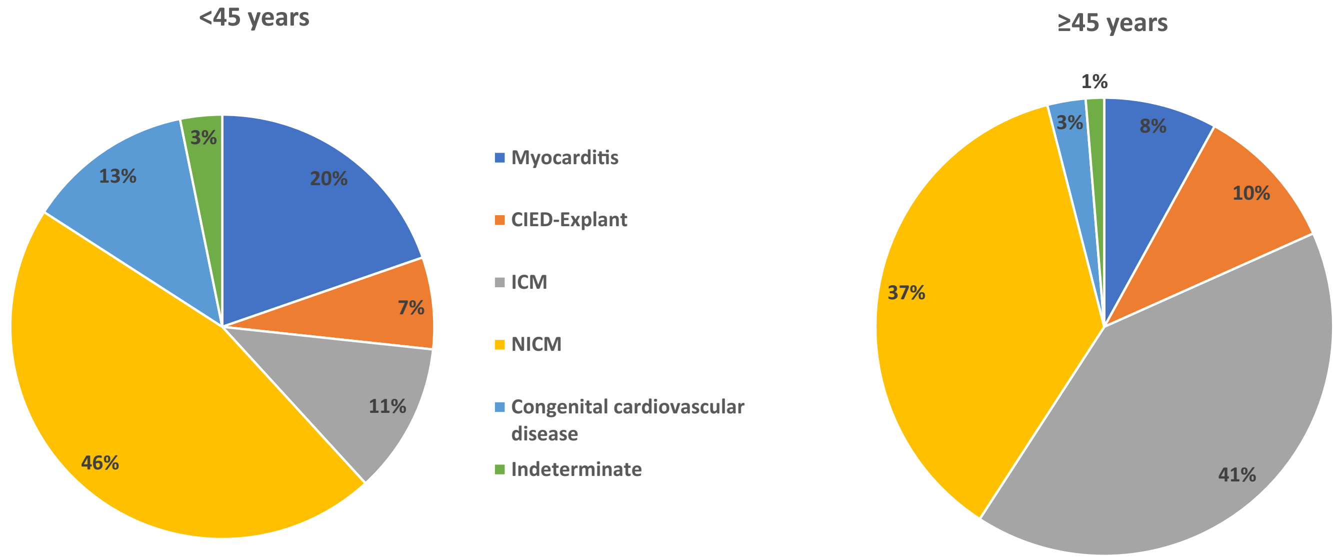

FIGURE 1 Indications for wearable cardioverter defibrillators use in a cohort of multicentre registry.

however, an improvement of LVEF > 35% was achieved in 77.4% of the young group compared to 63% of the old group ($p = .002$). At baseline and over a short-term and long-term follow-up, New York Heart Association classification was not significantly different. The adherence to drug treatment was high including the use of angiotensin-converting enzyme inhibitors or the use of sacubitril/valsartan. Even more, the use of beta-blockers and aldosterone antagonists was comparable. Remarkably, the use of amiodarone was significantly more present in old patients compared to young patients (12.6% vs. 5.2%; $p = .008$).

3.2 | WCD data and follow-up

Wear days were similar for the young and old age groups (69 ± 45 vs. 63 ± 43). Even wearing the WCD for more than 90 days was similar in young and old patients (Table 2). When average wear hours were compared, these were significantly shorter in young patients compared to old patients (20.11 ± 4.88 h vs. 21.29 ± 4.43; $p = .005$). Malignant ventricular tachyarrhythmias were similar in young and old patients [sustained ventricular tachycardia: 5.8% vs. 7.7%, ventricular fibrillation (VF) .5% vs. .6%]. Consisting with these data, the rate of appropriate WCD shocks was comparable between young and old patients (1.9% vs. 2.4%; $p = 1.000$). Reasons for stopping the WCD use were similar in both groups, for example improved LVEF, non-compliance, death and pended decision except for the rate of CIED implantation/or planned implantation, which tended to be higher in old patients (37.6% vs. 25.2%; $p = .07$). The compliance rate defined as wearing WCD for at least 20 hours was significantly higher in old patients compared to young patients (80.8% vs. 68.8%; $p < .001$; Figure 3).

3.3 | ECG data before prescription WCD

Table 3 presents several ECG parameters before the prescription of a WCD and over the follow-up.

3.4 | Detailed description of patients suffering from an appropriate WCD shock

Only three patients out of the younger group with myocarditis, after CIED explantation and with a congenital channelopathy suffered from an appropriate WCD shock. On the other hand, in the older group, 23 patients suffered from an appropriate WCD shock: ischaemic cardiomyopathy ($n = 12$), after CIED explantation ($n = 7$), non-ischaemic cardiomyopathy ($n = 2$), myocarditis ($n = 1$) and undetermined cause ($n = 1$; Table 4).

3.5 | Follow-up data of CIED

The mean follow-up time was 615 days. The rate of CIED tended to be higher in older patients compared to younger patients (36% vs. 25%, $p = .05$). Over follow-up, the rate of appropriate shocks by CIED was comparable between both groups. Consistent with these data, the rate of ventricular tachyarrhythmias or ventricular fibrillation was similar in the old and young age groups. The all-cause death was 6.8% in old patients compared to 3.8% in young

TABLE 1 Baseline characteristics of the cohort.

Variables	Age ≥ 45 (*n* = 948)	Age < 45 (*n* = 157)	*p* Value[a]
Demographics			
Male, *n* (%)	764/947 (80.7%)	112/157 (71.3%)	.007
Age, mean ± SD	64 ± 10	33 ± 8	<.001
Comorbidities			
Coronary artery disease, *n* (%)	247/458 (53.9%)	15/92 (16.3%)	<.001
Myocardial infarction, *n* (%)	224/621 (36.1%)	17/120 (14.2%)	<.001
CABG, *n* (%)	67/619 (10.8%)	4/120 (3.3%)	.011
Chronic obstructive pulmonary disease, *n* (%)	76/458 (16.6%)	3/92 (3.3%)	<.001
Chronic kidney disease/Dialysis	68/458 (14.8%)	8/92 (8.7%)	.119
Atrial fibrillation or atrial flutter, *n* (%)	250/827 (30.2%)	23/154 (14.9%)	<.001
TIA/Stroke, *n* (%)	43/458 (9.4%)	3/92 (3.3%)	.062
Diabetes mellitus, *n* (%)	177/564 (31.4%)	10/93 (10.8%)	<.001
Smoker, *n* (%)	247/565 (43.7%)	39/93 (41.9%)	.919
Hypertension, *n* (%)	358/725 (49.4%)	23/121 (19%)	<.001
Hyperlipidemia, *n* (%)	265/458 (57.9%)	20/92 (21.7%)	<.001
Overweight, *n* (%)	388/588 (66%)	71/112 (63.4%)	.596
BMI kg/m^2, mean ± SD	27.9 (±5.6)	29.4 (±9.4)	.128
Family history of cardiovascular disease	67/461 (14.5%)	16/91 (17.6%)	.531
Hospital side parameters			
Cardiogenic shock at diagnosis, *n* (%)	97/458 (21.2%)	21/92 (22.8%)	.725
Pulmonary oeodema, *n* (%)	89/458 (19.4%)	23/92 (25%)	.226
Days of hospitalization, mean ± SD	14 ± 12	15 ± 14	.939
Drug treatment			
ACE inhibitors	441/622 (70.9%)	81/120 (67.5%)	.455
ARNI	86/622 (13.8%)	23/120 (19.2%)	.134
Aldosterone antagonist	391/622 (62.9%)	71/120 (59.2%)	.445
ß Blocker	763/827 (92.3%)	136/154 (88.3%)	.104
Amiodarone	105/834 (12.6%)	8/155 (5.2%)	.008
Clinic treatment results			
Magnetic resonance imaging, *n* (%)	209/512 (40.8%)	55/92 (59.8%)	<.001
Late gadolinium enhancement, *n* (%)	130/508 (25.6%)	23/91 (25.3%)	.949
LVEF and NYHA classification			
EF Improvement >35%	537/842 (63.8%)	106/137 (77.4%)	.002
Improved LVEF			
No improvement, *n* (%)	262/842 (31.1%)	31/137 (22.6%)	.141
Improvement in 3 months, *n* (%)	403/842 (47.9%)	75/137 (54.7%)	.385
Improvement in 6–12 months, *n* (%)	73/842 (8.7%)	14/137 (10.2%)	.631
Declined LVEF, *n* (%)	104/842 (12.4%)	17/137 (12.4%)	1000
NYHA at index			
1	84/605 (13.9%)	16/107 (15%)	.767
2	161/605 (26.6%)	32/107 (30%)	.576
3	271/605(44.8%)	38/107 (35.5%)	.283
4	89/605 (14.7%)	21/107 (19.5%)	.262

(Continues)

TABLE 1 (Continued)

Variables	Age ≥ 45 ($n = 948$)	Age < 45 ($n = 157$)	p Value[a]
NYHA short-term			
1	139/470 (29.6%)	33/83 (39.8%)	.192
2	208/470 (44.2%)	45/83 (54.2%)	.354
3	117/470 (24.9%)	4/83 (4.8%)	<.001
4	6/470 (1.3%)	1/83 (1.2%)	1000
NYHA long-term			
1	51/122 (41.8%)	13/17 (76.5%)	.141
2	49/122 (40.2%)	3/17 (17.6%)	.289
3	15/122 (12.3%)	1/17 (5.9%)	.696
4	7/122 (5.7%)	0/17 (0%)	1000
BNP at baseline (pg/mL), mean ± SD	1857.4 ± 4321.1	9309.2 ± 39.936.9	.252
BNP short-term (pg/mL), mean ± SD	2626.1 ± 8068.1	1491.5 ± 3115.2	.375
BNP long-term (pg/mL), mean ± SD	2235.8 ± 7205.9	572.1 ± 969.6	.285

Abbreviations: ACE, angiotensin-convetrting-enzyme; BMI, body-mass-index; COPD, chronic obstructive pulmonary disease; ECG, electrocardiogram; EF, ejection fraction.

[a]p Values for the comparison between patients aged 45 and older and patients aged 44 and younger.

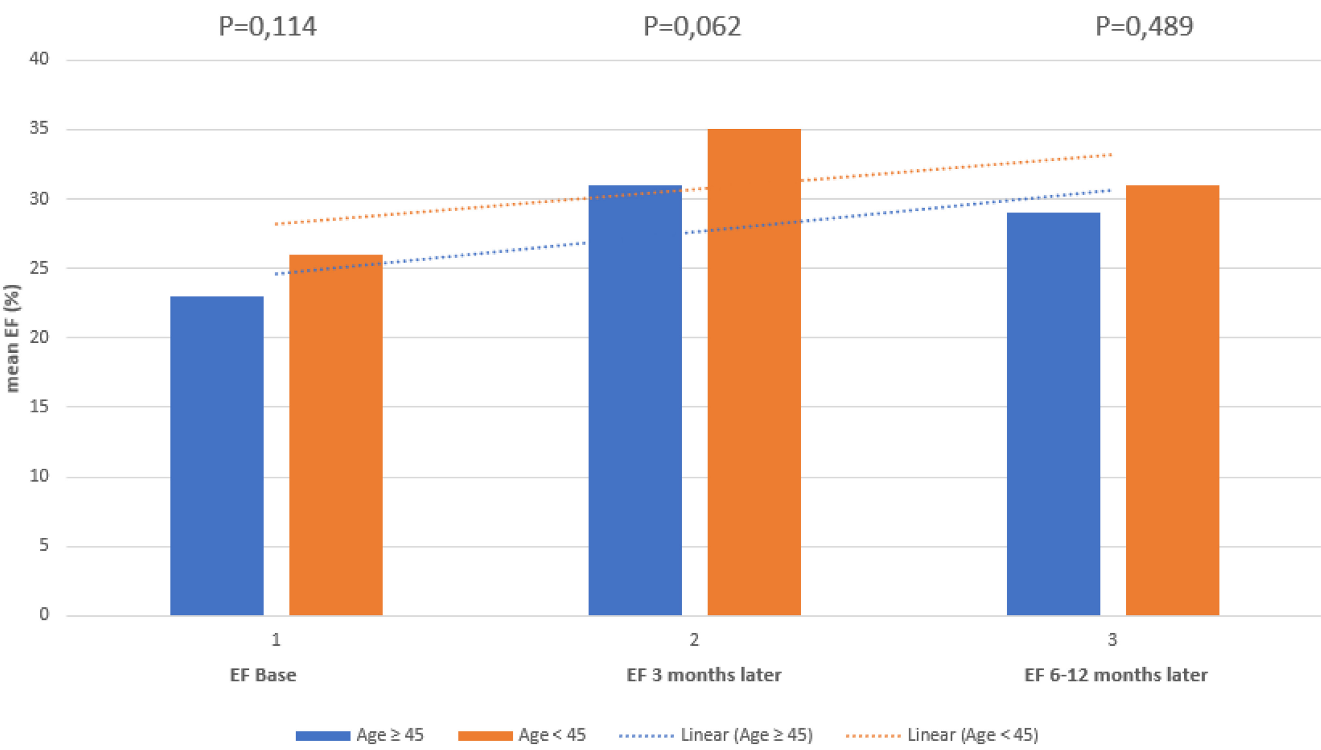

FIGURE 2 LVEF at baseline and over follow-up in young patients compared to older patients.

patients; $p = .0214$. The rate of arrhythmic death was low and comparable between both groups .4% versus .7%. Hospitalization due to cardiovascular causes (related to stroke, cardiac arrest, congestive heart failure, and atrial fibrillation) was similar in both groups 23.4% versus 25% (Table 5).

3.6 | Predictors of compliance

Table 6 presents a stepwise Cox regression analysis for predictors of compliance. In the stepwise multivariable regression analysis, NICM (OR .7, 95%CI .5–.9; $p < .01$) was associated with reduced compliance and male gender (OR

TABLE 2 Age differences regarding Lifevest use.

Variables	Age ≥ 45 (*n* = 948)	Age < 45 (*n* = 157)	*p* Value[a]
Recorded Lifevest data			
Wear days, mean ± SD	63 ± 43	69 ± 45	.115
Average wear hours, mean ± SD	21.29 ± 4.43	20.11 ± 4.88	.005
More than 90 wear days, *n* (%)	224/940 (23.8%)	45/156 (28.8%)	.178
Arrhythmic episodes during WCD			
Ventricular tachycardia, *n* (%)	49/841 (5.8%)	12/155 (7.7%)	.369
Ventricular fibrillation, *n* (%)	5/841 (.5%)	1/155 (.6%)	1.000
Non-sustained ventricular tachycardia, *n* (%)	30/841 (3.6%)	4/155 (2.6%)	.808
WCD shocks			
Appropriate, *n* (%)	23/944 (2.4%)	3/156 (1.9%)	1.000
Inappropriate, *n* (%)	2/944 (.2%)	1/156 (.6%)	.265
Inhibitions of shocks, *n* (%)	221/729 (3.3%)	37/123 (3.1)	.958
Recorded atrial fibrillation or atrial flutter by WCD, *n* (%)	18/585 (3.1%)	4/116 (3.4%)	.773
Recorded AV Block or asystole by WCD, *n* (%)	11/583 (1.9%)	3/117 (2.6%)	.714
Reason for stopping WCD			
Improved LVEF, *n* (%)	247/625 (39.5%)	59/119 (49.6%)	.206
Implantation/planned implantation, *n* (%)	235/625 (37.6%)	30/119 (25.2%)	.07
Incompliance, *n* (%)	16/625 (2.6%)	0/119 (0%)	.153
Death, *n* (%)	4/625 (.6%)	3/119 (2.5%)	.09
Unkown, *n* (%)	70/625 (11.2%)	12/119 (10.1%)	.874
Decision pending, *n* (%)			
Compliance is defined as wearing WCD at least 20 h per day	24/625 (3.8%)	10/119 (8.4%)	.056
Compliance, *n* (%)	766/948 (80.8%)	108/157 (68.8%)	<.001

Abbreviations: ACE, angiotensin-convetring enzyme; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ECG, electrocardiogram; EF, ejection fraction; SD, standard deviation.

[a]*p* Values for the comparison between patients aged 45 and older and patients aged 44 and younger.

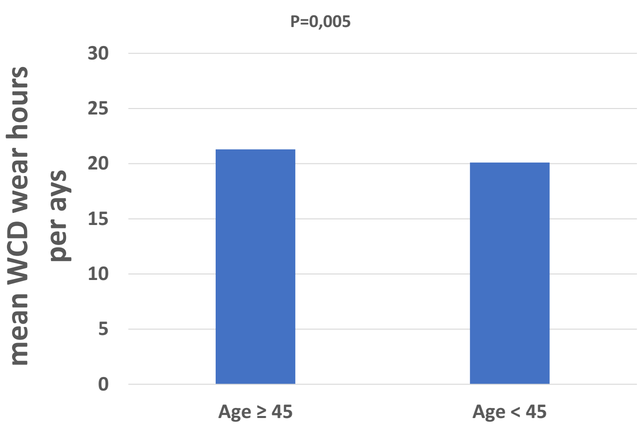

FIGURE 3 Average mean wearable cardioverter defibrillators wear hours per day.

1.8, 95%CI 1.2–2.8; $p < .01$), age ≥ 45 years (OR 1.9, 95%CI 1.3–2.8; $p < .01$) and CIED explantation (OR 2.0, 95%CI 1.1–4.0; $p = .03$) were associated with increased compliance.

4 | DISCUSSION

Our WCD registry data show (i) wear days are comparable between young and old patients, but nevertheless the average wear hours in young patients are shorter compared to old patients; (ii) myocarditis and congenital heart diseases were the most relevant indications for WCD use in young patients, ICM was in old patients and (iii) the compliance rate of WCD use is lower in patients with NICM and at young age.

TABLE 3 ECG data characteristics of the wearable cardioverter defibrillators.

Variables	Cohort		p Value[a]
	Age ≥ 45 (n = 948)	Age < 45 (n = 157)	
ECG data			
Left bundle branch block, n (%)	118/447 (26.4%)	8/87 (9.2%)	.003
Right bundle branch block, n (%)	42/447 (9.4%)	8/87 (9.2%)	1.000
Sinus arrest/high-grade AV block, n (%)	3/447 (.7%)	0/87 (0%)	1.000
Trifaszicular block, n (%)	1/447 (.2%)	0/87 (0%)	1.000
QRS at baseline (ms), mean ± SD	115 ± 29	103 ± 23	<.001
QRS Short-term (ms), mean ± SD	114 ± 30	104 ± 41	.029
QRS Long-term (ms), mean ± SD	115 ± 37	105 ± 46	.103
QTc at baseline (ms), mean ± SD	447 ± 50	438 ± 43	.131
QTc Short-term (ms), mean ± SD	437 ± 48	418 ± 42	.003
QTc Long-tern (ms), mean ± SD	443 ± 43	404 ± 51	<.001
PQ at baseline (ms), mean ± SD	169 ± 31	157 ± 25	.002
PQ Short-term (ms), mean ± SD	174 ± 34	160 ± 27	.003
PQ Long-term (ms), mean ± SD	174 ± 30	156 ± 21	<.001

Abbreviations: ACE, angiotensin-convetring enzyme; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ECG, electrocardiogram; EF, ejection fraction; SD, standard deviation.

[a]p Values for the comparison between patients aged 45 and older and patients aged 44 and younger.

TABLE 4 Patients who received appropriate wearable cardioverter defibrillators (WCD) shocks.

Gender	Age	WCD indication	LVEF base	Shock appropriate	Arrhythmic episode	ICD implant
M	66	ICM	35	Yes	VT/VF	Yes
M	48	ICD explant	30	Yes	VT/VF	Yes
M	53	ICM	25	Yes	VT/VF	Yes
M	64	ICM	35	Yes	VT/VF	Yes
M	75	ICM	20	Yes	VT/VF	Yes
F	73	ICM	30	Yes	VT/VF	Yes
F	87	ICM	25	Yes	VT/VF	Yes
M	64	ICD explant	25	Yes	VT/VF	Yes
M	71	ICD explant	27	Yes	VT/VF	Yes
M	60	NICM	13	Yes	VT/VF	Yes
M	64	ICD explant	40	Yes	VT/VF	Patient denied
F	83	ICM	35	Yes	VT/VF	No
M	62	ICD explant	20	Yes	VT/VF	Yes
W	55	Indeterminate	55	Yes	VT/VF	Patient denied
M	84	ICM	27	Yes	VT/VF	No
M	78	NICM	30	Yes	VT/VF	Planed
M	64	ICD explant	40	Yes	nsVT	No
W	74	Channelopathy	16	Yes	VT/VF	Yes
W	61	Myocarditis	25	Yes	VT/VF	Planed
M	67	ICD explant	35	Yes	VT/VF	Yes
M	77	ICM	29	Yes	VT/VF	No
M	82	ICM	20	Yes	VT/VF	Yes
M	51	ICM	33	Yes	VT/VF	Yes
M	55	ICM	49	Yes	VT/VF	Yes
F	31	Myocarditis	53	Yes	VT/VF	Yes
M	25	Channelopathy	60	Yes	VT/VF	Patient denied
F	44	ICD Explant	75	Yes	VT/VF	Yes

TABLE 5 Age differences regarding Lifevest use.

Variables	Age ≥ 45 (*n* = 948)	Age < 45 (*n* = 157)	*p* Value[a]
Cardiac implantable electronic devices			
Device implantation, *n* (%)	322/890 (36.1%)	37/148 (25%)	.058
Planed implantation, *n* (%)	25/890 (2.8%)	4/148 (2.7%)	1.000
Died before implantation, *n* (%)	33/890 (3.7%)	0/148 (0%)	.011
Patient denied, *n* (%)	48/890 (5.4%)	13/148 (8.8%)	.136
Reported shocks, *n* (%)	45/810 (5.6%)	7/142 (4.9%)	1.000
Arrhythmic episodes post-CIED			
Ventricular tachycardia, *n* (%)	17/688 (2.5%)	0/117 (0%)	.152
Ventricular fibrillation, *n* (%)	9/688 (1.3%)	1/117 (.9%)	1.000
Others, *n* (%)	15/688 (2.2%)	3/117 (2.6%)	.737
Unknown, *n* (%)	20/688 (2.9%)	3/117 (2.6%)	1.000
Non-sustained ventricular tachycardia, *n* (%)	42/719 (5.8)	5/125 (4%)	.407
Follow-up data			
Death during the follow-up, *n* (%)	64/946 (6.8%)	6/157 (3.8%)	.214
Arrhythmic death, *n* (%)	3/781 (.4%)	1/150 (.7%)	.505
Indetermine death, *n* (%)	9/781 (1.2%)	1/150 (.7%)	1.505
Rehospitalization, *n* (%)	184/472 (39%)	31/81 (38.3%)	1.000
Cardiovascular cause of rehospitalization, *n* (%)	102/436 (23.4%)	19/74 (25.7%)	.776
Stroke	5/436 (1.1%)	0/74 (0%)	1.000
Ventricular tachycardia/ventricular fibrillation, *n* (%)	23/601 (3.8%)	7/102 (6.9%)	.195
Congestive heart failure, *n* (%)	14/436 (3.2%)	2/74 (2.7%)	1.000
Atrial fibrillation, *n* (%)	23/436 (5.3%)	4/74 (5.4%)	1.000

Abbreviations: ACE, angiotensin-convetring enzyme; BMI, body mass index; COPD, chronic obstructive pulmonary disease; ECG, electrocardiogram; EF, ejection fraction; SD, standard deviation.

[a] *p* Values for the comparison between Patients aged 45 and older and Patients aged 44 and younger.

In the present analysis, we focus on two different age groups. The mean age of young patients is 33 years and of old patients 64 years. No data have been published yet regarding age differences in the context of WCD. An improvement of LVEF > 35% is more frequently observed in young patients. This may be related to the aetiology of the disease (myocarditis) and to the short duration of illness in some younger patients compared to older patients. Accordingly, more cardiac MRI were done in young patients because of the suspected diagnosis of myocarditis.

In general, the average wear days were comparable between old and young patients. However, the wear hours per day were on average 1 h lower in young patients. This may be explained by the quick improvement of several symptoms regarding use of drugs. This is in agreement with recently published French Registry showing that young age is a predictor for low compliance in WCD patients.[8] The improvement of LVEF in younger patients might be associated with decreased arrhythmogenicity, which in turn decreases their SCD risk. This might counter-balance the decreased wear time of the vest.

This difference in daily wear hours may have several reasons, among others a fast recovery of symptoms in younger patients, wearing discomfort, inadequate education, lack of high-risk warning, undiligent follow-up and being physically more active. Moreover, false alarms due to wear discomfort and electrocardiogram noise might also be reasons.[10] The 'symptom' in heart failure might not only be depicted by NYHA class but also should be multifactorial (subjective feeling, blood biomarkers like BNP, Creatinin and objective clinical parameters like EF, 6-MWT, Spirometry).

To understand the compliance rate of patients, we defined well compliance by wearing the WCD for at least 20 h per day. In the stepwise multivariable Cox regression analysis, young age and NICM were associated with a low compliance rate. Previously published data to define factors, which are associated with the likelihood of

TABLE 6 Predictors for compliance in univariate and stepwise multivariable logistic regression analysis.

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p* Value	OR	95% CI	*p* Value
Male	1.6	1.1–2.4	.01	1.8	1.2–2.8	<.01
NICM	.6	.4–.8	<.01	.6	.4–.9	<.01
ICM	1.1	.8–1.5	.30			
CIED explantation	2.5	1.3–4.7	<.01	2.1	1.1–4.0	.03
Former VT/VF	1.2	.7–1.7	.60			
Index left ventricular EF	1.1	.9–1.0	.15			
Age ≥ 45 years	1.9	1.3–2.7	<.01	1.9	1.3–2.8	<.01
WCD shocks	1.3	.5–3.2	.57			
Wearing WCD > 90 days	.83	.6–1.1	.28			
Rehospitalization for CV	1.1	.6–1.8	.63			
Myocarditis	.8	.5–1.3	.54			

Abbreviations: CIED, cardiac implantable electronic device; CV, cardiovascular; EF, ejection fraction; ICM, ischaemic cardiomyopathy; NiCM, not ischaemic cardiomyopathy; OR, odds ratio; WCD, wearable cardioverter defibrillator.

medication non-adherence among Medicare low-income subsidy recipients with type 2 diabetes, hypertension or heart failure showed that both young age and male gender are associated with low compliance.[11] Recently published descriptive data showed that the compliance rate regarding wearing a WCD is comparable in males and females.[12,13]

A further important aspect is that NICM is also associated with low compliance. Of note, recently published data suggest that a prolonged period of OMT and a prolonged WCD use in newly diagnosed NICM and ICM is increasing the rate of patients who may not need ICD implantation.[14,15] Future studies may focus on guiding patients in the use of WCD and adherence to HF medication. It appears reasonable to assume that through frequent and systematic guiding of patients, the rate of patients who avoid permanent ICD implantation could be increased. In addition, telemonitoring programs may help to identify patients with low compliance.

Finally, we present in the current study long-term data of young patients compared to old patients regarding arrhythmic events and appropriate permanent ICD shocks. No significant differences were seen. In addition, all-cause death, arrhythmic death and cardiovascular hospitalization were not different.

5 | CONCLUSION

Gender, patient age and the disease aetiology may predict the compliance to wear a WCD and these aspects should be taken into consideration when patients are discharged. Young patients need a frequent follow-up and should be educated about the need of compliance when WCD is prescribed.

5.1 | Study limitation

Despite the advantages of the present Registry, some limitations should be highlighted, firstly, the retrospective character of the data collection and analysis, secondly, the heterogeneity of data since patients are included in several centres in two European countries. Thirdly, no questionnaire was evaluated systematically to understand the low compliance rate. This point could be a part of the research project in the future. Fourthly, the VT zone was not similar in old and young patients. Finally, a predictor analysis for predicting the risk of VT/VF and subsequently appropriate ICD shock was not done due to the low number of patients with this event. In our study, no telemonitoring function of the WCD system was systematically used. Finally, there are no data regarding the grade of heart failure and the correlation between symptoms. This might be biased by the impaired mobility with increasing heart failure. There are no standardized tests to figure this out (spirometry, 6-MWT).

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CONFLICT OF INTEREST

None declared.

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