Research: Complications

Heart failure among people with Type 2 diabetes mellitus: real-world data of 289 954 people from a diabetes database

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Abstract

Aim Comparing people with Type 2 diabetes mellitus with and without heart failure in terms of metabolic control, therapeutic regimen and comorbidities.

Methods The Prospective Diabetes Registry (DPV) is a longitudinal documentation system for demographics, medical care and outcome in people with diabetes mellitus. It consists of follow-up data from people with diabetes mellitus who have agreed to be recorded in the registry. Clinical data are submitted by general practitioners, specialists and clinics throughout Germany and Austria. Some 289 954 people with Type 2 diabetes mellitus (years 2000 to 2015) were analysed using demographic statistics and adjustment for confounders based on linear and logistic regression analysis.

Results People with Type 2 diabetes mellitus (ICD code: E11) and heart failure (ICD code: I50) (N = 14 723) were older, more often women and presented with longer diabetes duration compared with those without heart failure. After adjustment for age, gender and diabetes duration, people with heart failure showed lower HbA_{1c}, higher BMI and more intense insulin therapy. Analysis revealed that people with heart failure were more often treated with insulin, and more frequently received anti-hypertensives and lipid-lowering medication. They presented with lower systolic and diastolic BP. People with heart failure more frequently showed a history of comorbidities.

Conclusion Heart failure is common in diabetes mellitus, but the prevalence in the DPV is lower frequent than expected. The reason for improved metabolic control in heart failure may be intensified therapy with insulin, lipid-lowering medication and anti-hypertensives in this cohort.

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Introduction

Type 2 diabetes mellitus and heart failure are of growing interest in public health due to their high prevalence, high rate of hospitalization and mortality, late complications and comorbidity. Epidemiological data suggest an association between diabetes mellitus and heart failure. The Framingham

Heart Study established diabetes mellitus as a risk factor for the development of heart failure [1]. Pathogenic mechanisms are multimodal, and cardiovascular comorbidities play a central role, with people with diabetes presenting with elevated BP (1.5–2-fold), a 2–4-fold higher risk of coronary artery disease and a 34% higher risk of atrial fibrillation [2,3]. People with diabetes show an increased risk of myocardial infarction (+77%) and ischaemic stroke (+68%) [4]. Disturbed calcium-handling, activation of the renin–angiotensin–aldosterone system, exaggerated oxidative stress caused by hyperglycaemia and insulin resistance account for diabetes-specific structural cardiac remodelling resulting in morphological and functional changes, and contributing to a

failing heart [5–7]. In addition, diabetic nephropathy and obesity are independent risk factors for heart failure [8,9]. Hyperglycaemic excursions have been proven to elevate the risk of heart failure, as shown in the United Kingdom Prospective Diabetes Study; a 1% elevation in HbA_{1c} correlates with an 8% increase in heart failure risk [10]. Taken together, these factors contribute to the 5-fold increased risk of heart failure seen in people with Type 2 diabetes, compared with people without diabetes [11]. In the Framingham Heart Study, women showed a 5-fold risk elevation and men a 2.4-fold risk elevation for heart failure if diabetes was present. Comparable with people without diabetes, heart failure in diabetes shows a correlation with older age; older people (72–76 years) present with a prevalence of 22%, whereas in younger people (64–68 years) the prevalence is ~ 11% [12].

People with heart failure are prone to higher diabetes risk. The prevalence of Type 2 diabetes ranges from 24% to 38% in heart failure studies like Olmsted County or Medicare beneficiaries, respectively. In decompensated heart failure (Acute Decompensated Heart Failure National Registry; ADHERE), the incidence of Type 2 diabetes mellitus rises to 44% [13,14]. The results of the Prospective Comparison of ARNI (Angiotensin Receptor Neprilysin Inhibitor) With ACEI (Angiotensin-Converting Enzyme Inhibitor) to Determine Impact on Global Mortality and Morbidity in Heart Failure (PARADIGM-HF) study unmask the real situation: 73% of study participants presented with impaired glucose metabolism (35% Type 2 diabetes, 13% with newly diagnosed Type 2 diabetes, 25% with prediabetes) [15]. The combination of diabetes and heart failure is associated with a worse prognosis; people with Type 2 diabetes and heart failure present with a 10-fold elevated mortality risk compared with those with heart failure, but without diabetes [16].

The aim of this study was to evaluate the prevalence of heart failure in a large cohort of people with Type 2 diabetes and to compare the characteristics, medical treatment and comorbidities of those with and without heart failure.

Participants and methods

The Prospective Diabetes Registry (Diabetes-Patienten-Verlaufsdokumentation; DPV), a longitudinal standardized documentation system for demographics, medical care and outcome in people with all diabetes types, was used for data evaluation. It consists of follow-up data from more than 400 centres [general practitioners (GPs), specialists and clinics] throughout Germany and Austria, with one each in Luxembourg and Switzerland (http://buster.zibmt.uni-ulm.de/dpv/dateien/DPV-Flyer.pdf). The DPV is one of the largest registries in Europe for people with diabetes. Every 6 months, locally documented data are anonymized and analysed at the University of Ulm. The DPV Initiative was approved by the ethics committee of the University of Ulm (process number 202/09) and data collection was approved by local review boards. The DPV is thus representative of current German and German-speaking diabetes care, and it is part of large cohort analyses worldwide like the Comparative Effectiveness of Cardiovascular Outcomes in New Users of SGLT-2 Inhibitors (CVD-REAL) study [17] or analyses describing regional differences in diabetes treatment and outcomes in Germany [18]. For the presented analysis, data from 289 954 adults with Type 2 diabetes treated between 2000 and 2015 were included. Classification of diabetes type and comorbidity was performed using ICD coding (E11 for Type 2 diabetes mellitus and I50 for heart failure status) by the treating physician. Diagnosis of heart failure followed evaluation of clinical signs and symptoms, or laboratory values such as brain natriuretic peptide. Variables included in the analysis were: demographic data (age, gender, diabetes duration, age at diabetes diagnosis), clinical data (HbA_{1c}, lipid variables, liver enzymes, BMI, BP), medical treatment (lipid-lowering medication, anti-hypertensive and anti-diabetic medication) as well as cardiovascular status and diabetic late complications. eGFR was calculated following the Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease 2012 (CKD-EPI). For each individual, the last documented examination was taken into consideration.

Statistical analysis

People with diabetes were categorized by age (< 40, 40–59, 60–79, ≥ 80 years). Median values with lower (Q1) and upper quartiles (Q3) were calculated for continuous variables, categorical data like comorbidities and medical treatment were assessed as percentages. To compare the two groups of people, those with vs. those without heart failure, the χ^2 test was used for categorical variables and the Wilcoxon rank sum test for continuous variables. Adjustment of P-values for multiple comparisons was done using the false discovery rate [19]. Following adjustment for age, gender and duration of diabetes between the groups, separate linear regression models were fitted for HbA$_{1c}$, BMI, systolic and diastolic BP, insulin dose, age (< 40, 40–59, 60–79, ≥ 80 years) and diabetes duration (< 10, 10–19, 20–29, ≥ 30 years). To prevent over-adjustment, the analysis includes these three variables as confounders only. Separate logistic regression models were applied to analyse the proportion of

people treated with insulin, the frequency of anti-hypertensive and lipid-lowering medication, and comorbidities. Results of linear and logistic regression models were presented as adjusted estimates (LSmeans) with lower and upper confidence limits (95% CI).

For statistical analysis, SAS v. 9.4 (SAS Institute Inc., Cary, NC, USA) was used. All two-sided P-values < 0.01 were considered statistically significant.

Results

Demographic data and basic characteristics are summarized in Table 1. In total, 289 954 people (52% men) were available for analysis, median age was 70 years (Q1;Q3: 61;78 years), median age at diabetes diagnosis was 59 (49;69) years and median diabetes duration was 8 (3;15) years. The prevalence of heart failure based on ICD coding was 5.1%, and was closely correlated with age (Fig. 1).

Table 1 Demographic data and clinical characteristics of the participants

	All		People without heart failure		People with heart failure		P-value*
	N	Median (Q1; Q3)	N	Median (Q1; Q3)	N	Median (Q1; Q3)	
Men, %	289 954	52	275 231	53	14 723	47	< 0.0001
Age (years)	289 954	70 (61;78)	275 231	70 (60;77)	14 723	77 (70;83)	< 0.0001
Age at diagnosis (years)	289 954	59 (49;69)	275 231	59 (49;68)	14 723	65 (55;73)	< 0.0001
Diabetes duration (years)	289 954	8 (3;15)	275 231	8 (3;14)	14 723	11 (5;16)	< 0.0001
BMI (kg/m^2)	255 983	30 (26;34)	243 628	30 (26;34)	12 355	30 (26;35)	> 0.05
HbA$_{1c}$ (mmol/mol)	258 478	54 (45;68)	245 516	54 (45;69)	12 962	54 (45;65)	< 0.0001
HbA$_{1c}$ (%)	258 478	7.1 (6.3;8.4)	245 516	7.1 (6.3;8.4)	12 962	7.1 (6.3;8.1)	< 0.0001
Systolic BP (mmHg)	265 184	132 (120;145)	251 490	132 (120;145)	13 694	130 (120;140)	< 0.0001
Diastolic BP (mmHg)	265 095	80 (70;80)	251 406	80 (70;80)	13 689	75 (70;80)	< 0.0001
LDL-cholesterol (mmol/l)	173 652	2.8 (2.1;3.6)	165 346	2.8 (2.2;3.6)	8 306	2.6 (2.0;3.4)	< 0.0001
HDL-cholesterol (mmol/l)	177 241	1.1 (1.0;1.4)	168 915	1.1 (0.9;1.4)	8 326	1.1 (0.9;1.4)	< 0.0001
Triglycerides (mmol/l)	192 287	1.8 (1.2;2.5)	182 826	1.8 (1.2;2.6)	9 461	1.6 (1.1;2.3)	< 0.0001
Alanine aminotransferase (U/l)	59 972	24 (17;37)	54 402	24 (17;37)	5 570	22 (15;32)	< 0.0001
Gamma glutamyl-transferase (U/l)	61 355	38 (23;74)	55 922	38 (23;72)	5 433	46 (26;93)	< 0.0001
eGFR (ml min^{-1} 1.73 m^{-2})†	247 535	68 (47;87)	234 038	69 (49;88)	13 497	48 (32;66)	< 0.0001

Medication and comorbitity	All (N = 289 954)	People without heart failure (N = 275 231)	People with heart failure (N = 14 723)	P-value*
	Prevalence (%)	Prevalence (%)	Prevalence (%)	< 0.0001
Lifestyle only	24	24	19	< 0.0001
Oral antidiabetic drugs only	26	26	20	< 0.0001
Insulin only	30	29	42	< 0.0001
Oral antidiabetic drugs + Insulin	20	31	18	< 0.0001
Oral antidiabetic drugs/GLP-1 receptor agonist	46	47	38	< 0.0001
Insulin	51	50	61	< 0.0001
Anti-hypertensives	51	50	72	< 0.0001
Lipid-lowering drugs	26	25	33	< 0.0001
Coronary heart disease	123	11	36	< 0.0001
Myocardial infarction	9	9	15	< 0.0001

Data are medians (Q1;Q3) unless otherwise indicated
*Wilcoxon test for continuous variables, and chi-square test for binary variables; P-values adjusted for multiple comparisons by false discovery rate.
†eGFR was calculated following the Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease 2012 (CKD EPI).
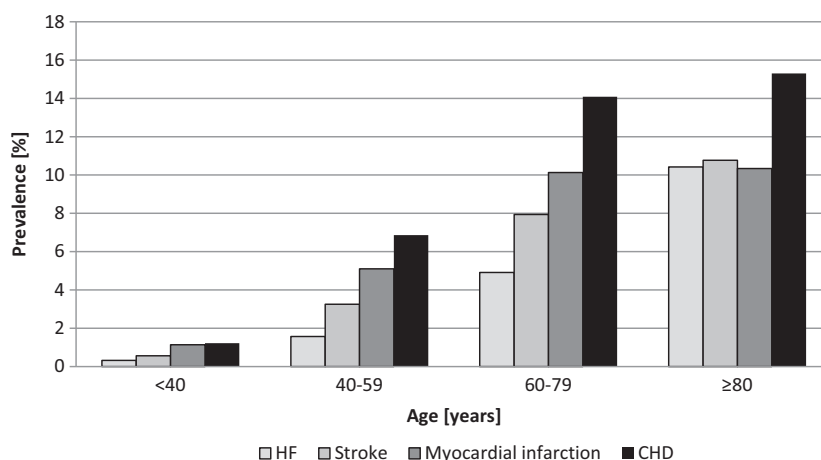
FIGURE 1 Prevalence of heart failure (HF) and other cardiovascular diseases (CVD) in the DPV.

Table 2 Data analyses adjusted for age, sex and diabetes duration

	People without heart failure (N = 275 231) Mean (lower mean–upper mean)	People with heart failure (N = 14 723) Mean (lower mean–upper mean)	*P*-value*
HbA$_{1c}$ (mmol/mol)	61 (60–62)	59 (58–61)	< 0.0001
HbA$_{1c}$ (%)	7.7 (7.6–7.8)	7.6 (7.5–7.7)	< 0.0001
BMI (kg/m^2)	30.4 (30.3–30.6)	31.8 (31.7–32.0)	< 0.0001
Insulin dose (IU/kg body weight)	0.59 (0.57–0.61)	0.63 (0.60–0.67)	0.0141
Systolic BP (mmHg)	137 (136–137)	134 (133–135)	< 0.0001
Diastolic BP (mmHg)	78 (77–78)	76 (76–77)	< 0.0001
eGFR (ml min^{-1} 1.73 m^{-2})†	68 (67–69)	58 (58–59)	< 0.0001
Coronary heart disease (%)	10 (10–11)	32 (31–32)	< 0.0001
Myocardial infarction (%)	8 (8–8)	13 (12–13)	< 0.0001
Angina pectoris (%)	0.5 (0.4–0.5)	2 (2–2)	< 0.0001
Stroke (%)	6 (6–6)	10 (10–11)	< 0.0001
Diabetic foot (%)	6 (5–6)	11 (10–11)	< 0.0001
Diabetic neuropathy (%)	44 (44–44)	46 (45–47)	< 0.0001
Microalbuminuria (%)	31 (31–31)	29 (29–30)	< 0.0005
Antihypertensives (%)	50 (50–50)	70 (69–70)	< 0.0001
Lipid-lowering drugs (%)	25 (25–25)	32 (31–33)	< 0.0001
Insulin therapy (%)	50 (50–51)	58 (57–59)	< 0.0001

Linear and logistic regression models were applied to analyse the data, adjusted means with lower and upper confidence interval (95% CI) are given.

*P-values for continuous variables are from *F*-tests from multiple regressions

†eGFR was calculated following the Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease 2012 (CKD EPI).

Demographic, clinical and therapeutic data

People with heart failure were significantly older [median 76 (Q1;Q3: 70;83) vs. 70 (60;77) years), *P* < 0.0001], more often women (47% vs. 53%, *P*<0.0001), with longer diabetes duration [11 (5;16) vs. 8 (3;14) years, *P* < 0.0001] and higher age at diabetes diagnosis [65 (55;73) vs. 59 (49;68) years, *P* < 0.0001] (Table 1). For the age categories < 40, 40–59, 60–79 and ≥ 80 years, the proportion of women with heart failure was 48%, 33%, 46% and 67%, respectively, showing that the gender distribution of heart failure correlates strongly with increasing age and is reversed

in people aged 80 or older. This accounts for the high number of women with heart failure in the registry.

Lower levels for LDL-cholesterol [2.6 (2.0;3.4) vs. 2.8 (2.2;3.6) mmol/l] and triglycerides [1.6 (1.1;2.3) vs. 1.8 (1.2;2.6) mmol/l, *P* < 0.0001] were detected among people with heart failure. Regarding liver enzymes, people with heart failure presented with elevated values for gamma-glutamyl transferase [46 (26;93) vs. 38 (23;72) U/l, *P* < 0.0001], but lower values for alanine aminotransferase [22 (15;32) vs. 24 (17;37) U/l, *P* < 0.0001] (Table 1).

Following adjustment for age, gender and diabetes duration, people with heart failure showed improved blood

glucose control [HbA$_{1c}$, mean 59 (95% CI 58–61) vs. 61 (60–62) mmol/mol; 7.6 (7.5–7.7)% vs. 7.7 (7.6–7.8)%, $P < 0.0001$]. Analysis revealed lower levels for systolic BP [134 (133–135) vs. 137 (136–137) mmHg, $P < 0.0001$] and diastolic BP [76 (76–77) vs. 78 (77–78) mmHg, $P < 0.0001$]. BMI was higher in people with heart failure [31.8 (31.7–32.0) vs. 30.4 (30.3–30.6) kg/m^2, $P < 0.0001$] (Table 2). People with heart failure present with worse renal function [eGFR, CKD EPI: 58 (58–59) vs. 68 (67–69) ml min^{-1} 1.73 m^{-2}, $P < 0.0001$] (Table 2).

Medical treatment

People with heart failure were treated more often with insulin (61% vs. 50%, $P < 0.0001$) and less frequently with oral anti-diabetic drugs (OAD) alone or in combination with glucagon-like peptide 1 (GLP-1) receptor agonists (38% vs. 47%, $P < 0.0001$) or lifestyle intervention (19% vs. 24%, $P < 0.0001$) (Table 1). Younger people with heart failure (< 40 years) were treated with OAD (43%) more often than

people without heart failure in the same group, for whom lifestyle interventions were more frequent (32%). Insulin therapy was used more often in people without heart failure than in people with heart failure in this age group (29% vs. 40%, $P < 0.0001$). All other people with heart failure were more often treated with insulin only, whereas in the non-heart failure group, OAD and lifestyle intervention were common in all age groups (Fig. 2).

Adjusted analysis revealed that people with diabetes and heart failure received higher insulin doses than their counterparts without heart failure [mean 0.63 (95% CI 0.60–0.67) vs. 0.59 (0.57–0.61) IU/kg body weight, $P = 0.0141$]. Regarding treatment for cardiovascular comorbidities, people with heart failure more often received anti-hypertensive treatment (70% vs. 50%), and lipid-lowering medication (32% vs. 25%) (Table 2).

The most pronounced effect was seen in the youngest age group: 67% of these received anti-hypertensive medication and only 33% lipid-lowering treatment, compared with 21% and 10% in people without heart failure, respectively.
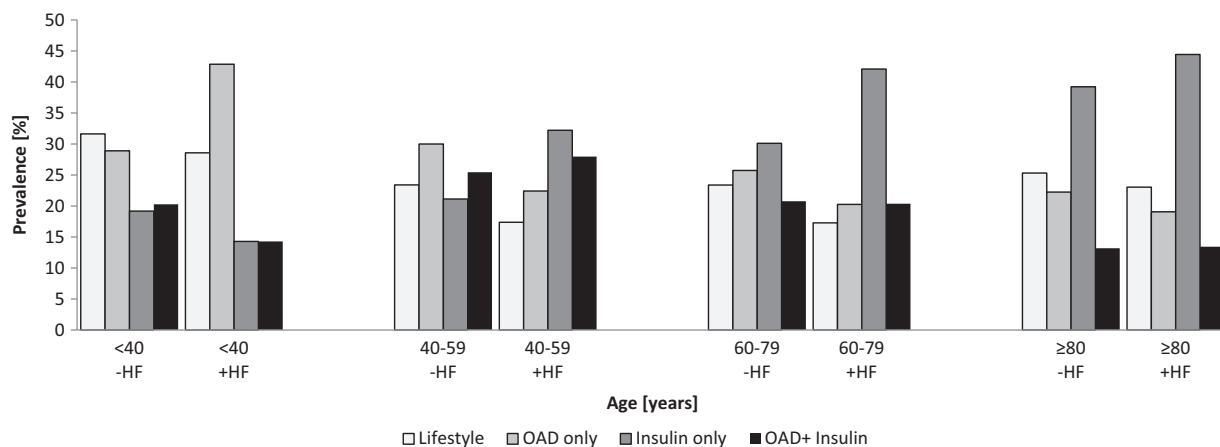
FIGURE 2 Anti-diabetic treatment according to age and heart failure (HF) status. OAD, oral anti-diabetic drug.
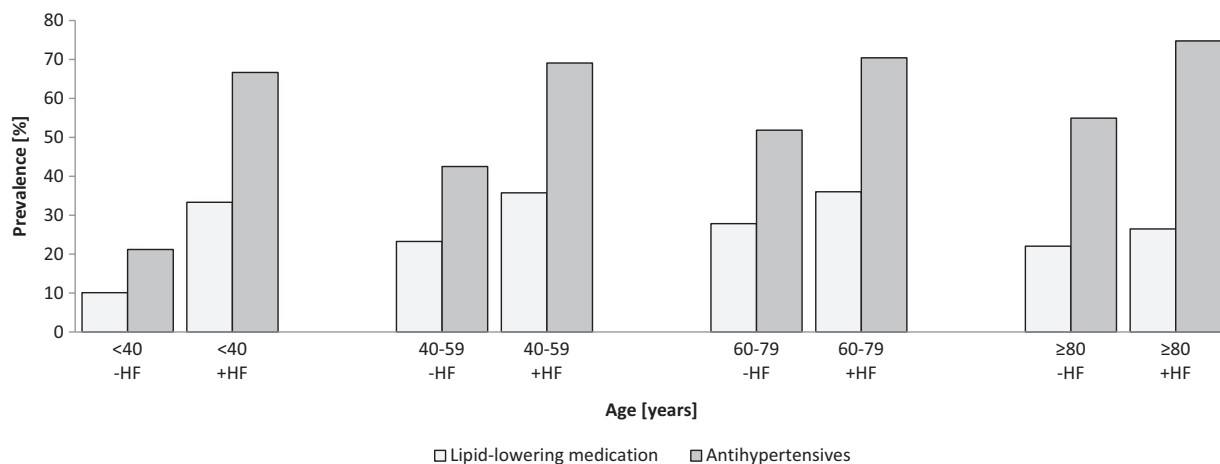
FIGURE 3 Lipid-lowering and anti-hypertensive therapy in people with Type 2 diabetes according to age and heart failure (HF) status.

The differences in the proportions who received anti-hypertensive medication and lipid-lowering treatment between people with heart failure or without heart failure were less profoundly different with increasing age categories (Fig. 3).

Comorbidities

Following adjustment for age, gender and diabetes duration, coronary artery disease (32% vs. 10%), myocardial infarction (13% vs. 8%), angina (2% vs. 0.5%) and stroke (10% vs. 6%) were present more often in people with heart failure compared with those without ($P < 0.0001$ for all variables; Table 2). The same applied to diabetic late complications like diabetic neuropathy (46% vs. 44%) and diabetic foot (11% vs. 6%, $P < 0.0001$ for all variables), but not for microalbuminuria, which was reported more often for people without heart failure (29% vs. 31%, $P < 0.0005$) (Table 2).

Discussion

The aim of our data analysis was to evaluate the prevalence and treatment of heart failure as well as comorbidities among a large Type 2 diabetes cohort. The DPV consists mainly of German and Austrian data. The prevalence of heart failure in the DPV was 5.1% and showed a significant association with age. Comparative data are available from the Framingham Study (prevalence of heart failure 2.5%, determined by clinical signs and symptoms, comparable with documentation in the DPV) and the National Health and Nutrition Examination Survey (prevalence of heart failure 1.9%, determined by individual's self-reporting). In population-based national registries such as the Kaiser Permanente Northwest Registry, 14.2% of the population with diabetes presented with heart failure, identified by heart failure-related therapeutic regimen changes. An US-based cohort of people with diabetes and age > 65 years pointed to a 22.3% prevalence of heart failure as assessed by the New York Heart Association (NYHA) state evaluation. Compared with these data, the prevalence of heart failure might be underestimated in the DPV. Reasons for this might be diagnosis criteria used, which in the DPV result from ICD coding of the disease only, without unselected screening, whereas in other cohorts, heart failure screening was done by discrete clinical evaluation.

Within the DPV, women are more often affected by heart failure, although the distribution between genders differed by age group. Up to age 79 years, the diagnosis was more frequent in men, from age 80 years, more women were diagnosed. This is in line with observations from other studies [20,21].

Within the DPV, people with diabetes and heart failure are older and have longer diabetes duration. These facts were taken into account by adjusting for age and diabetes duration. People with heart failure presented with slightly better metabolic control in terms of glucose and cholesterol values. Intensified diabetes treatment of people with heart failure is obvious; insulin alone is the most frequent treatment option (42%), followed by OAD alone (20%) or OAD plus insulin (18%). People with heart failure receive significantly higher doses of insulin per kg body weight (1.1-fold higher compared with those without heart failure when adjusted for age, sex and diabetes duration). People without heart failure are treated less often with insulin (29%), and more often with OAD (26%) or lifestyle intervention (24%).

Comorbidities may influence the therapeutic decision in heart failure. Diabetic nephropathy with reduced eGFR was frequent in people with heart failure, limiting the use of OAD. Also, in cases of heart failure, more stringent metabolic control is aimed for, resulting in more frequent use of insulin. Therefore, the better metabolic control in people with heart failure could be a result of more aggressive insulin use. In addition, heart failure is known to be closely correlated with underlying insulin resistance, and insulin resistance is a contributor to the development of heart failure, leading to increased insulin requirements [22]. The causal relationship between heart failure and insulin requirement cannot be answered by this data evaluation. In a meta-analysis of 37 229 people, Castagno et al. showed that intensive glycaemic control had no impact on the risk of heart failure in people with Type 2 diabetes [23]. Udell and co-workers found that glucose-lowering drugs or strategies increased the risk of heart failure compared with standard care, and the magnitude of this effect varied with the method of glucose-lowering used, with the highest risk being associated with the use of peroxisome proliferator-activated receptor agonists followed by an intermediate risk with dipeptidyl peptidase-4 inhibitors and no risk with insulin glargine [24]. The positive association between glucose-lowering therapy and increased risk of heart failure may be caused by therapy-induced weight gain. Target-based intensive glycaemic control strategies and intensive weight loss were also not associated with the development of heart failure.

In addition, people with Type 2 diabetes and heart failure in the DPV present with significantly lower levels of LDL-cholesterol and lower levels of triglycerides. This is closely correlated with more intense lipid-lowering therapy among people with heart failure. However, people with Type 2 diabetes do not reach the guideline recommendation of LDL < 2.6 mmol/l, or < 1.8 mmol/l if cardiovascular disease is present, and this shows clear and clinically relevant undertreatment with lipid-lowering drugs.

Hypertension and BP control are critical in diabetes treatment. Up to 66% of the population with diabetes present with hypertension as a part of the metabolic syndrome [25]. For risk reduction, the common ESC/EASD guideline suggests a BP target of < 140/85 mmHg. In the DPV, both groups on average fulfil the recommendation; people with heart failure, however, presented with significantly lower BP and greater use of anti-hypertensive agents.

Regarding further components of the metabolic syndrome, obesity is of central influence in disease progression, both for diabetes and heart failure [3]. Following the adjustment for age, gender and diabetes duration, people with heart failure presented with a significantly higher BMI, especially younger people. Obviously, BMI has a higher impact in these people.

The observed differences in both groups reach statistical significance due to the large numbers of people. In clinical routines, the differences (0.1% in HbA_{1c} or 0.2 mmol/l in LDL cholesterol) are not considered major. But even if this is recognized, the analysis clearly shows that the comorbidity heart failure is not properly taken into account in diabetes treatment.

In several prospective studies, additional cardiovascular diseases turned out to be predictive of heart failure development and progression [26]. In the DPV, after adjustment for age, gender and diabetes duration, nearly one third of people with heart failure showed coronary heart disease (3-fold increase compared with those without heart failure), with 13% having had a myocardial infarction (1.6-fold increase), 70% of people with heart failure present with medication for hypertension (1.4-fold increase), and 10% were post stroke (1.6-fold increase). The prevalence of comorbidities increased with age.

By contrast, other cardiovascular diseases occur more often at a younger age in people with heart failure. In total, diabetes seems have a greater impact in people with heart failure, with substantial harm to metabolism and the micro- and macrovascular system, as both micro- and macrovascular defects are significantly more often detected in people with heart failure.

Current data suggest that anti-diabetic therapy needs to be individualized and comorbidities have to be treated earlier and more aggressively. Anti-hyperglycaemic medications should be considered in terms of not only their blood sugar-lowering properties, but also their cardiovascular safety [27–30].

Limitations of the study

As with every real-world data collection, the quality of the data relies strongly on data provision. In the DPV, GPs, diabetologists and clinics enter data upon evaluation. The data are therefore heterogeneous and disease diagnosis may correspond to signs and symptoms as well as specialized analyses like echocardiography or laboratory results. Most of the people in the DPV are followed regularly and the last documented data available for the described time span was taken into account in the analysis. The data are not influenced by any study-related inclusion and exclusion criteria which results in a real-world scenario.

Given the large number of people, even small – clinical irrelevant – differences reach statistical significance. The comorbidity panel is highly different in the heart failure cohort, as is the occurrence of treatment for hypertension and dyslipidaemia, but treatment results in terms of vital and laboratory parameters are similar and do not reach guideline recommendations. Therefore, the obvious weakness of registry data turns out to be a strong signal towards the need for control of therapeutic success.

The authors are aware that the statistical analysis adjusts only for age, gender and diabetes duration, and that other age-dependent confounders like renal function may influence the analysis. To not over-adjust with other age-dependent confounders, we decided to use only the very basic variables into the statistic model.

Conclusion

The prevalence of diagnosed and documented heart failure by ICD coding in the DPV is 5.1% and might be underestimated if compared with other national registries or studies. Heart failure prevalence potentiates with increasing age. As expected, people with diabetes mellitus and heart failure are older, multimorbid and present with more diabetes-associated late complications. With regard to this, multifaceted and more aggressive treatments are required and actually used among the critical ill people, resulting in better metabolic control in terms of glucose and lipid control as well as BP.

Competing interests

None declared.

Author contributions

D.S. and B.S. wrote the manuscript and researched data. D.T. contributed to the discussion and reviewed/edited the manuscript. R.W.H. performed statistical analysis. A.S., R.W.H., N.H., S.M, H.J.Z. researched data and contributed to discussion and reviewed/edited the manuscript.

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