Prevalence and Risk Factors of Coronary Heart Disease in Chinese Patients with type 2 Diabetes Mellitus, 2013-2018

Chenchen Wang
Southeast University Zhongda Hospital
Zuoling Xie
Southeast University Zhongda Hospital
Xi Huang
Southeast University Zhongda Hospital
Zheng Wang
Southeast University Zhongda Hospital
Haiyan Shangguan
Southeast University Zhongda Hospital
Shaohua Wang (gyjwsh@126.com)
Affiliated ZhongDa Hospital of Southeast University https://orcid.org/0000-0001-9567-6668

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Abstract

Background: Coronary heart disease (CHD) is the most common cause of death in patients with type 2 diabetes (T2DM). We aim to estimate the prevalence of CHD and cardiovascular risk factors in Chinese diabetic inpatients.

Methods: A total of 66536 diabetic inpatients from 2013 to 2018 were investigated, demographic and clinical data were gathered from 30693 patients with T2DM. The age-standardized prevalence of CHD was calculated on the basis of data from Chinese population census in 2010. Multiple imputation was used to impute missing values and logistic regression analysis was used to analyze the risk factors.

Results: The crude prevalence of CHD was estimated to be 23.5% and a standardized prevalence was 13.9% (16.0% in men and 11.9% in women). More than half of diabetic patients with CHD have 4 or above of the 5 traditional risk factors, which is much higher than 38.96% of diabetic patients ($p<0.01$). Multivariate regression analysis showed that diabetes duration, hypertension, smoking, underweight, overweight, obesity, hypoglycemia were significantly associated with a higher risk of CHD (all $p<0.05$). The odds ratio of CHD in patients having 3, 4, or 5 CHD risk factors were 2.35 (95%CI 1.81-3.04), 2.96 (95%CI 2.28- 3.85), and 5.29 (95%CI 4.04- 6.93), compared with diabetes patients without any other risk factors.

Conclusions: The prevalence of CHD was rather high in Chinese T2DM inpatients, aggregation of CHD risk factors was more seriously, hierarchical CHD prevention strategies based on risk factors are needed for them.

Background

The prevalence of diabetes mellitus in China is soaring continuously [1–4]. Chronic complications of diabetes seriously affect the quality of life of patients and even endanger their lives [5–7]. Atherosclerotic cardiovascular disease (ASCVD) is one of them. ASCVD accounts for about half of deaths occurred in patients with diabetes [8, 9]. As the most important component of ASCVD, coronary heart disease (CHD) has emerged to be one of the main causes of death in China [10], but also the leading cause of death in Chinese diabetic patients. However, previous studies on the epidemiology of CHD in diabetes population were inconsistent. For example, a cross-sectional study enrolled 25,817 adults with T2DM [11] showed that 14.6% of outpatients were suffering from cardiovascular diseases. A study reported in 2002, which was carried out in 3469 inpatients from four large cities of China, estimated that CHD occurred in 25.1% of T2DM [12]. Another study reported that this prevalence among adult patients with diabetes was as high as 55% [13]. The reason for such inconsistence and large-span of prevalence lies in the difference of research design, population and diagnostic criteria between the studies. In add, the above-mentioned data represent the prevalence of CHD during varied periods, and the latest data is lacking.

Although the role of risk factors, especially traditional metabolic risk factors, in occurrence and early intervention of CHD is clear, to which degree of these factors alone or combined contributing to CHD onset is still uncertain. 3B study showed that diabetes patients with both comorbid hypertension and dyslipidemia were 6 folds more likely to have a history of CVD compared with those with diabetes only [11]. Secondly, in 2001, the guidelines of the National Cholesterol Education Program Adult Treatment Panel proposed that diabetes mellitus is an "equivalent crisis" of CHD in all adult individuals [14]. It means that diabetic patients even without CHD have the same risk of CHD as non-diabetics with previous history of CHD [15]. It is more imperative to identify their risk factors and give them early intervention. Nevertheless, not many studies existed, especially among Chinese population.

Therefore, in this observation, the inpatients of a large-scale comprehensive tertiary hospital during a certain period of time are taken as the study populations. Their diagnosis is clear, the demographic and clinical data are relatively complete and reliable, and the clinical outcome is known. We aim to identify the prevalence, risk factors and intervention strategies, and to carry out early intervention of risk factors for high-risk groups, so as to delay or reduce the occurrence of CHD in Chinese diabetes patients, improve the quality of life and prolong the survival time.

Methods

Study population

Study population were patients hospitalized in the ZhongDa Hospital affiliated to Southeast University between July 2013 and the end of 2018. We included all patients consecutively to avoid selection bias, so a total of 66536 cases of DM were registered based on the principal discharge diagnosis. After 5411 cases with type 1 diabetes, gestational diabetes, specific type diabetes, and unreported diabetes type were excluded, 61125 cases with T2DM remained. For those patients who were hospitalized repeatedly during this period, only the first hospitalization data were used (n = 31112). 30693 inpatients (16709 men and 13984 women) were eventually included after excluding 419 patients, for their data being seriously missing. The procedure of this study was approved by the Research Ethics Committee of ZhongDa Hospital affiliated to Southeast University (Approved No. of ethic committee: 2020ZDSYLL028-P01).

Data collection

Data of each patient included their demographic variables: gender, age and ethnicity; medical history: diabetes, hypertension, CHD; smoking and drinking were identified according to the medical records of the patients; physical measurements: weight, height, body mass index (BMI; calculated as body weight (kg)/ body height^2 (m^2); basic medication information: antiplatelet, statin, insulin and metformin; Venous blood samples were collected to determine laboratory indicators. Levels of fasting blood-glucose (FBG) were examined using hexokinase method. HbA1c was determined by cationexchange high-performance liquid chromatography method. Total-cholesterol (T-CHOL) concentrations were determined by cholesterol

esterase/peroxidase enzymatic method and triglyceride by lipase glycerol kinase method. High-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured by direct-antibody separation method and elimination method, respectively. Concentrations of serum apolipoprotein-A1, apolipoprotein-B and lipoprotein-a were determined by immunoturbidimetric method. Serum blood urea nitrogen (BUN) was measured using a glutamate dehydrogenase and urease kinetic method. Levels of serum creatinine (SCr) and serum uric acid (SUA) were measured by the sarcosine oxidase and uricase methods respectively. The indicators above were detected by an automatic biochemical analyzer (AU5800, Beckman Coulter, California, USA). Prothrombin time (PT), activated partial thromboplastin time (APTT), thrombin time (TT) and fibrinogen levels were examined by coagulation method. The chromogenic substrate method was performed to determine the concentrations of antithrombin-III, while the turbidimetric assay was carried out to determine the levels of fibrinogen degradation product (FDP) and D dimer. All indicators about fibrinolytic function were determined by automated analyzer (ACLTOP 700, Beckman Coulter, California, USA). The inspection center of Zhongda Hospital Affiliated to Southeast University implements internal and external quality management procedures directed by the Chinese Laboratory Quality Control. All blood samples were analyzed by professional clinical laboratory medical staff of Zhongda hospital.

Definition of variables

We extracted data on patient principal diagnosis and secondary diagnoses on discharge diagnosis coded using the International Classification of Diseases (ICD)-10. Then the diagnosises were identified, including diabetes (ICD-10 codes E10-14), coronary heart disease (ICD-10 codes I20-I25) and hypertension (ICD-10 codes I10).

Hypoglycemia in diabetes patients was defined as a blood glucose level of $\leq$ 3.9 mmol/L. Elevated T-CHOL was defined as seum T-CHOL level $\geq$ 4.5 mmol/L. Low HDL-C was defined as serum HDL-C $\leq$ 1.0 mmol/L level in males or $\leq$ 1.3 mmol/L level in females. Elevated LDL-C was defined as serum LDL-C level $\geq$ 1.8 mmol/L or $\geq$ 2.6 mmol/L in patients with CHD or without CHD. Elevated triglyceride (TG) was defined as serum TG level $\geq$ 1.7 mmol/L. Underweight was defined as a BMI < 20.0 kg/m^2, whereas overweight and obesity was defined as a BMI of 25.0-29.9 kg/m^2 and $\geq$ 30.0 kg/m^2, respectively.

Statistical analysis

Approximately 8.7% data of patients were missing, assuming that information was missing at random. Multiple imputation with 5 imputations was applied to reduce this loss of values and the final estimates were obtained from the multivariate model. All analyses were conducted on the pooled data sets, which were combined according to the standard rules of Rubin [16], as complete data.

All prevalence calculations were weighted to represent the overall population of Chinese people aged 40 years or older. Weights are calculated on the basis of data from Chinese population census in 2010. SPSS 21 (SPSS Inc., Chicago, IL, USA) was used.

Numeric variables with or without normal distribution were presented as mean ± standard deviation (SD), median (interquartile range), respectively. Qualitative variables were shown as the number (percentage). Differences between groups were compared using Student's t-test for normally distributed quantitative variables, Mann-Whitney U test for asymmetrically distributed quantitative variables, and Chi-squared (χ^2) test for comparison of qualitative variables. The linear-by-linear association trend testing was used to analyse the prevalence trend among various age groups. Univariate analysis was used first, then multivariate regression analysis was carried out using binary non-conditional logistic regression. The 95% confidence intervals (CI) for prevalence rates were calculated based on the normal approximation to the binomial distribution. Thresholds of statistical significance were set at a corrected two-sided $p < 0.05$.

Results

Demographic and clinical characteristics

Table 1 shows the demographic data and clinical characteristics of the patients. In comparision with non CHD patients, individuals with CHD were older in average age, their diabetes duration were longer, they had higher levels of BMI, rate of hypertension and smoking. Many more of them used antiplatelet drug and statins. These differences were statistically significant (all $p < 0.05$). Regarding the patients with CHD, they had lower levels of HbA1C, their use rate of insulin or metformin was also lower (all $p < 0.05$). Significant difference in FBG was not found between patients with CHD and without CHD ($p > 0.05$). CHD group had significantly lower serum levels of SUA, apolipoprotein-A1, apolipoprotein-B and lipid including LDL-C, HDL-C, TG and T-CHO (all $p < 0.05$). Other clinical characteristics, including the data of gender subgroup, were detailed in Table 1(at the end of the document text file).

Table 1
Demographic and clinical characteristics in T2DM inpatients with CHD and without CHD

Characteristic	With CHD (n = 7202)			Without CHD (n = 23491)		
	All (n = 7202)	Male (n = 3997)	Female (n = 3205)	All (n = 23491)	Male (n = 12712)	Female (n = 10779)
Female, n (%)	3205/7202(44.5)[c*]			10779/23491(45.9)		
Age (y)	73.1 ± 11.1[a*], n = 7202	71.6 ± 11.8[a*], n = 3997	74.9 ± 9.8[a*], n = 3205	65.8 ± 13.0, n = 23491	64.0 ± 13.4, n = 12712	67.9 ± 12.2, n = 10779
Diabetes duration (y)	9.9 ± 3.6[a*], n = 6126	9.1 ± 3.4[a*], n = 3414	10.8 ± 3.6[a*], n = 2712	7.3 ± 3.2, n = 20018	6.9 ± 3.0, n = 10782	7.6 ± 3.3, n = 9236
Hypertension, n (%)	5916/7202(82.1)[c*]	3189/3997(79.8)[c*]	2727/3205(85.1)[c*]	14371/23491(61.2)	7553/12712(59.4)	6818/10779(63.3)
Smoking, n (%)	2081/7153(29.1)[c*]	1409/3976(35.4)	672/3177(21.2)[c*]	4725/23141(20.4)	4308/12524(34.4)	417/10617(3.9)
Drinking, n (%)	843/7153(11.8)[c*]	537/3976(14.4)[c*]	270/3177(8.5)[c*]	2997/23135(13.0)	2781/12520(22.2)	216/10615(2.0)
Height (cm)	163.3 ± 8.1[a*], n = 7202	166.8 ± 7.1[a*], n = 3997	159.0 ± 7.1[a*], n = 3205	164.3 ± 8.5, n = 23491	169.3 ± 6.7, n = 12712	158.4 ± 6.5, n = 10779
Weight (kg)	67.3 ± 12.0[a*], n = 7202	68.7 ± 11.7[a*], n = 3997	65.5 ± 12.0[a*], n = 3205	67.8 ± 12.3, n = 23491	72.3 ± 11.8, n = 12712	62.6 ± 10.8, n = 10779
BMI (kg/m^2)	25.2 ± 4.0[a*], n = 7202	24.7 ± 3.8[a*], n = 3997	25.9 ± 4.2[a*], n = 3205	25.1 ± 3.8, n = 23491	25.2 ± 3.6, n = 12712	24.9 ± 3.9, n = 10779
Antiplatelet user, n (%)	5339/6423(83.1)[c*]	2954/3571(82.7)[c*]	2385/2852(83.6)[c*]	8243/20886(39.5)	4556/11319(40.3)	3687/9567(38.5)
Statin user, n (%)	3937/6415(61.4)[c*]	2202/3566(61.7)[c*]	1735/2849(60.9)[c*]	7089/20869(34.0)	4008/11318(35.4)	3081/9551(32.3)
Insulin user, n (%)	2388/6433(37.1)[c*]	1392/3578(38.9)[c*]	996/2855(34.9)[c*]	14359/20917(68.6)	7913/11339(69.8)	6446/9578(67.3)
Metformin user, n (%)	852/6431(13.2)[c*]	490/3576(13.7)[c*]	362/2855(12.7)[c*]	5656/20914(27.0)	3217/11336(28.4)	2439/9578(25.5)
FBG (mmol/L)	10.1 ± 5.0, n = 6509	10.2 ± 5.0, n = 3621	10.0 ± 4.9, n = 2888	10.2 ± 5.1, n = 23073	10.4 ± 5.3, n = 12481	9.9 ± 5.0, n = 10592
HbA1c (%)	7.5(6.6–8.9)[b*], n = 5676	7.5(6.5–8.9)[b*], n = 3134	7.5(6.6–8.8)[b*], n = 2542	7.8(6.6–9.5), n = 17760	7.9(6.6–9.6), n = 9719	7.6(6.6–9.4), n = 8041
T-CHO (mmol/L)	4.3 ± 1.2[a*], n = 6901	4.1 ± 1.2[a*], n = 3836	4.5 ± 1.3[a*], n = 3065	4.6 ± 1.4, n = 20994	4.5 ± 1.3, n = 11491	4.8 ± 1.4, n = 9503
HDL-C (mmol/L)	1.1 ± 0.3[a*], n = 6773	1.1 ± 0.3[a*], n = 3764	1.2 ± 0.3[a*], n = 3009	1.2 ± 0.3, n = 20211	1.1 ± 0.3, n = 11062	1.2 ± 0.3, n = 9149
LDL-C (mmol/L)	2.6 ± 0.9[a*], n = 6773	2.5 ± 0.9[a*], n = 3764	2.6 ± 1.0[a*], n = 3009	2.8 ± 1.0, n = 20211	2.7 ± 0.9, n = 11062	2.9 ± 1.0, n = 9149
Triglyceride (mmol/L)	1.5(1.0-2.1)[b*], n = 6901	1.4(1.0–2.0)[b*], n = 3836	1.6(1.1–2.2), n = 3065	1.5(1.0-2.2), n = 20992	1.4(1.0-2.2), n = 11490	1.6(1.1–2.2), n = 9502
Apolipoprotein-A1 (g/L)	1.0 ± 0.3[a*], n = 6773	1.0 ± 0.3[a*], n = 3764	1.1 ± 0.3[a*], n = 3009	1.1 ± 0.3, n = 20211	1.0 ± 0.3, n = 11062	1.1 ± 0.3, n = 9149
Apolipoprotein-B (g/L)	0.8 ± 0.2[a*], n = 6773	0.7 ± 0.2[a*], n = 3764	0.8 ± 0.3[a*], n = 3009	0.8 ± 0.3, n = 20211	0.8 ± 0.3, n = 11062	0.9 ± 0.3, n = 9149

[*] Significance, $p < 0.05$. Data are mean ± SD, median (interquartile range), or n/N (% of non-missing data). [a] Student's t test for comparison of normally distributed quantitative variables between with CHD group and without CHD group. [b] Mann-Whitney U test for comparison of asymmetrically distributed quantitative variables between with CHD group and without CHD group. [c] $\chi 2$ test for comparison of qualitative variables between with CHD group and without CHD group.

Abbreviations: T2DM, type 2 diabetes mellitus; CHD, coronary heart disease; BMI, body mass index; T-CHO, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; BUN, blood urea nitrogen; SCr, serum creatinine; SUA, serum uric acid; FBG, fasting blood-glucose; HbA1c, glycosylated hemoglobin; PT, prothrombin time; APTT, activated partial thromboplastin time; TT, thrombin time; INR, international normalized ratio; ATIII, Antithrombin III; FDP, fibrinogen degradation product

Characteristic	With CHD (n = 7202)			Without CHD (n = 23491)		
	All (n = 7202)	Male (n = 3997)	Female (n = 3205)	All (n = 23491)	Male (n = 12712)	Female (n = 10779)
Lipoprotein-a (mg/L)	211.0(112.0-374.0)[b*], n = 6773	209.0(110.0-366.0)[b*], n = 3764	213.0(115.5–383.0)[b*], n = 3009	185.0(96.0-329.0), n = 20211	175.5(89.0-315.0), n = 11062	197.0(104.0-349.0), n = 9149
BUN (mmol/L)	7.5 ± 5.2[a*], n = 7059	7.7 ± 5.3[a*], n = 3920	7.3 ± 5.1[a*], n = 3139	6.6 ± 4.3, n = 22667	6.8 ± 4.5, n = 12250	6.3 ± 4.1, n = 10417
SCr (umol/L)	80.0(65.0-104.0)[b*], n = 7136	86.0(72.0-110.0)[b*], n = 3963	71.0(58.0–94.0)[b*], n = 3173	74.0(61.0–90.0), n = 23073	80.0(68.0–96.0), n = 12481	66.0(54.0–80.0), n = 10592
SUA (umol/L)	272.4 ± 161.3[a*], n = 7136	281.7 ± 163.0[a*], n = 3963	260.8 ± 158.3[a*], n = 3173	305.5 ± 109.0, n = 23073	320.4 ± 109.8, n = 12481	288.1 ± 105.5, n = 10592
PT (s)	11.7 ± 4.1[a*], n = 6535	11.9 ± 4.8[a*], n = 3640	11.5 ± 3.0, n = 2895	11.5 ± 2.6, n = 19644	11.6 ± 2.8, n = 10708	11.4 ± 2.4, n = 8936
APTT (s)	31.6 ± 9.4[a*], n = 6531	32.2 ± 10.5[a*], n = 3636	30.7 ± 7.8[a*], n = 2895	30.1 ± 5.3, n = 19642	30.4 ± 5.2, n = 10707	29.7 ± 5.4, n = 8935
TT (s)	15.6 ± 6.5[a*], n = 6531	15.6 ± 6.4[a*], n = 3637	15.5 ± 6.6[a*], n = 2894	15.2 ± 4.3, n = 19631	15.1 ± 5.0, n = 10699	15.2 ± 3.0, n = 8932
INR	1.1 ± 0.4[a*], n = 6525	1.1 ± 0.4[a*], n = 3635	1.1 ± 0.4, n = 2890	1.1 ± 0.2, n = 19599	1.1 ± 0.2, n = 10688	1.1 ± 0.2, n = 8911
ATIII (%)	96.0 ± 18.0[a*], n = 6524	94.1 ± 17.7[a*], n = 3631	98.4 ± 18[a*], n = 2893	99.1 ± 19.7, n = 19614	97.7 ± 19.3, n = 10687	100.9 ± 19.9, n = 8927
FDP (mg/L)	1.9(1.1–3.2)[b*], n = 6501	1.7(1.0–3.0)[b*], n = 3617	2.0(1.2–3.5)[b*], n = 2884	1.7(1.0-3.3), n = 19515	1.5(0.9-3.0), n = 10642	1.8(1.0-3.6), n = 8837
Fibrinogen (g/L)	3.9 ± 0.9[a*], n = 6512	3.8 ± 0.9[a*], n = 3630	3.9 ± 0.8[a*], n = 2882	3.8 ± 0.9, n = 19585	3.8 ± 1.0, n = 10677	3.8 ± 0.9, n = 8908
D dimer (ug/L)	161.0(80.0-340.0)[b*], n = 6481	149.0(71.5-316.5)[b*], n = 3606	179.0(89.0-379.0)[b*], n = 2875	142.0(50.0-405.0), n = 18289	130.0(43.0-373.0), n = 9931	157.0(58.0-446.5), n = 8358

[*] Significance, $p < 0.05$. Data are mean ± SD, median (interquartile range), or n/N (% of non-missing data). [a] Student's t test for comparison of normally distributed quantitative variables between with CHD group and without CHD group. [b] Mann-Whitney U test for comparison of asymmetrically distributed quantitative variables between with CHD group and without CHD group. [c] $\chi 2$ test for comparison of qualitative variables between with CHD group and without CHD group.

Abbreviations: T2DM, type 2 diabetes mellitus; CHD, coronary heart disease; BMI, body mass index; T-CHO, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; BUN, blood urea nitrogen; SCr, serum creatinine; SUA, serum uric acid; FBG, fasting blood-glucose; HbA1c, glycosylated hemoglobin; PT, prothrombin time; APTT, activated partial thromboplastin time; TT, thrombin time; INR, international normalized ratio; ATIII, Antithrombin III; FDP, fibrinogen degradation product

Prevalence of coronary heart disease

The prevalence of CHD was estimated to be 23.5% (95%CI, 23.0–24.0%) in patients with T2DM, 23.9% (95%CI, 23.2%-24.6%) in men, and 22.9% (95%CI, 22.2%-23.6%) in women, with an age-standardized prevalence of 13.9% (95%CI, 13.3%-14.5%) for CHD: 16.0% (95%CI, 15.2%-16.8%) in men and 11.9% (95%CI, 11.1%-12.7%) in women. Furthermore, the prevalence of CHD in diabetic patients increased with their age ($p < 0.001$), and male patients with diabetes had higher prevalence of CHD than females at all ages (Fig. 1).

Coronary heart disease metabolic risk factors control

Regarding the control of serum lipids, the proportion of patients not achieving the goal of T-CHOL was lower in CHD patients (38.9% vs. 49.7%, $p < 0.01$), whereas 57.2% of them failed to reach the goal of HDL-C, higher than 52.1% of non-CHD patients ($p < 0.01$). In CHD patients, the proportion of failed to achieve the goal of TG control was higher than in non-CHD among patients with older age until 70 years old, when the proportion began to lower. The proportion of CHD patients with LDL levels above 2.6 mmol/L was significantly lower than that of non-CHD subjects (44.6% vs. 56.2%, $p < 0.01$). However, as the goal of LDL-C in patients with CHD is lower than that in non-CHD subjects (CHD: 1.8 mmol/L, non-CHD: 2.6 mmol/L), the proportion of patients not achieving the goal of LDL-C was far higher in CHD subjects (78.5% vs. 56.2%, $p < 0.01$) (Fig. 2, 3).

As for glycemic control, the proportion of patients not achieving the goal of HbA1c was lower in subjects with CHD (64.2% vs. 66.6%, $p < 0.01$), while 2.3% of them occurred hypoglycemia, higher than 1.3% of non-CHD patients (Fig. 4).

The results about weight were very contrasting yet interesting. In females, the proportion of overweight or obesity was significantly higher in patients with CHD than in non-CHD (57.5% vs. 47.5%, $p < 0.01$), whereas the proportion was lower in CHD patients (46.3% vs. 49.5%, $p < 0.01$) than non-CHD in males (Fig. 5).

Coronary heart disease risk factors aggregation

80% of patients with diabetes had ≥ 3 risk factors aggregation, whereas diabetic patients with CHD had a significantly more proportion of ≥ 4 risk factors aggregation (50.52% vs. 38.96%, $p < 0.01$). In the total population, the prevalence of women with 2 or 3 risk factors (19.69%, 40.39%) were higher than that of men (16.59%, 36.63%), while the proportion of women with 1 or 4 risk factors (1.26%, 38.66%) were lower than that of men (2.59%, 44.19%). (Table 2).

Table 2
Risk factors aggregation in type 2 diabetes inpatients with CHD and without CHD

	1 risk factor	2 risk factors	3 risk factors	≥ 4 risk factors
All sample				
Male	2.59 (2.35–2.83)	16.59 (16.03–17.16)	36.63 (35.9-37.36)	44.19 (43.44–44.94)
Female	1.26 (1.08–1.45)	19.69 (19.03–20.35)	40.39 (39.57–41.2)	38.66 (37.85–39.47)
Overall	1.99 (1.83–2.14)	18 (17.57–18.43)	38.34 (37.8-38.88)	41.67 (41.12–42.22)
With CHD				
Male	1.18 (0.84–1.51)	11.97 (10.97–12.98)	40.04 (38.52–41.56)	46.81 (45.27–48.36)
Female	0.79 (0.48–1.09)	10.66 (9.60-11.73)	33.40 (31.76–35.03)	55.15 (53.43–56.87)
Overall	1.00 (0.77–1.23)	11.39 (10.66–12.13)	37.08(35.97–38.20)	50.52 (49.36–51.67)
Without CHD				
Male	3.03 (2.74–3.33)	18.05 (17.38–18.71)	35.56 (34.72–36.39)	43.36 (42.50-44.23)
Female	1.41 (1.18–1.63)	22.37 (21.59–23.16)	42.46 (41.53–43.40)	33.76 (32.86–34.65)
Overall	2.29 (2.10–2.48)	20.03 (19.52–20.54)	38.73 (38.10-39.35)	38.96 (38.33–39.58)

Five classic cardiovascular risk factor include diabetes, hypertension, dyslipidaemia, being overweight or obese, and smoking. Abbreviations: CHD, coronary heart disease.

Multivariate logistic regression

Multivariate logistic regression analysis showed that diabetes duration, hypertension, smoking, underweight, overweight, obesity, hypoglycemia, elevated serum FBG, triglyceride, LPa, SCr levels, the use of antiplatelet and statins were significantly associated with a higher risk of CHD. Female sex, drinking, higher serum HbA1c, T-CHOL, SUA levels, the use of insulin and metformin were all associated with a lower risk of CHD (Table 3).

Table 3
Risk factors for coronary heart disease in type 2 diabetes inpatients

Risk factors [a]	OR	95%CI		p
		Lower	Upper	
Female sex	0.76	0.71	0.82	< 0.001
Age per 10y	1.00	0.97	1.04	0.941
Diabetes duration per 5y	2.88	2.67	3.11	< 0.001
Hypertension	2.22	2.04	2.41	< 0.001
Smoking	1.71	1.57	1.86	< 0.001
Drinking	0.63	0.56	0.70	< 0.001
Weight [b]				
Underweight	1.21	1.07	1.37	0.003
Overweight	1.11	1.03	1.19	0.005
Obesity	1.38	1.24	1.55	< 0.001
Antiplatelet user	4.49	4.13	4.87	< 0.001
Statin user	1.41	1.30	1.52	< 0.001
Insuling user	0.44	0.41	0.47	< 0.001
Metformin user	0.44	0.40	0.48	< 0.001
FBG per 5.1 mmol/L	1.15	1.10	1.21	< 0.001
HbA1c per 2.1	0.88	0.83	0.93	< 0.001
Hypoglycemia	1.75	1.33	2.30	< 0.001
Cholesterol				
Total per 1.3 mmol/L	0.87	0.77	0.98	0.019
HDL per 0.3 mmol/L	0.97	0.92	1.02	0.241
LDL per 1.0 mmol/L	0.92	0.84	1.02	0.109
Triglyceride per 1.8 mmol/L	1.19	1.14	1.24	< 0.001
Lipoprotein-a per 252.2 mg/L	1.12	1.08	1.16	< 0.001
SCr per 110.9 umol/L	1.06	1.03	1.10	< 0.001
SUA per 124.2 umol/L	0.71	0.68	0.73	< 0.001

[a] Numbers for continuous variables are values of 1 standard deviation; [b] Underweight was defined as a body mass index (BMI), which is calculated as weight in kilograms divided by height in meters squared, of < 20.0, while overweight and obesity was defined as a BMI of 25.0-29.9 and ≥ 30.0, respectively.

Abbreviations: FBG, fasting blood-glucose; HbA1c, glycosylated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SCr, serum creatinine; SUA, serum uric acid.

After adjustment for gender and age, the odds ratio of CHD in patients having 3, 4, or 5 CHD risk factors were 2.35 (95% CI, 1.81–3.04), 2.96 (95% CI, 2.28–3.85), and 5.29 (95% CI, 4.04–6.93; Table 4), compared with diabetes patients without other risk factors.

Table 4
Odds ratio of coronary heart disease according to risk factors

	OR (95%CI)	P
Females	0.84 (0.79, 0.89)	< 0.001
Age (10 years)	1.66 (1.62, 1.70)	< 0.001
2 risk factors	1.47 (1.12, 1.92)	0.005
3 risk factors	2.35 (1.81, 3.04)	< 0.001
4 risk factors	2.96 (2.28, 3.85)	< 0.001
5 risk factors	5.29 (4.04, 6.93)	< 0.001

Five classic cardiovascular risk factor include diabetes, hypertension, dyslipidaemia, being overweight or obese, and smoking. Abbreviations: CHD, coronary heart disease.

Discussion

This study retrospected the clinical data of Chinese patients with diabetes over the past 5 years, showed that about 13.9% of in-patients over 40 years of age had CHD, with the prevalence of 16.0% in men, higher than 11.9% in women. The prevalence increased with age in both men and women, and more than 30% for diabetic elder over 70 years old, suggesting they are high-risk population for CHD. We also found that control of metabolic risk factors was unsatisfactory, for example, more than 40% patients failed to achieve the lipid goal, more than 60% of patients had their HbA1c greater than 7%. Furthermore, the aggregation of metabolic risk factors was very popular and 80% of patients have 3 or above risk factors aggregation. Multivariate analysis showed that diabetes duration, hypertension, smoking, underweight, overweight, obesity, hypoglycemia were significantly associated with a higher risk of CHD. These data showed that the prevalence of CHD was high in diabetic in-patients in China, the determination of metabolic risk factors is very important for the identification of high-risk population and follow-up intervention.

Previous studies have shown that the prevalence of macrovascular disease was low in patients with diabetes in China [17, 18] and cardiovascular complications was lower than those from Australia and Europe [19, 20]. However, our results were inconsistent with those mentioned above. In our study, the overall estimated prevalence of CHD was similar to that reported in the Sweden [21], although the prevalence of diabetes mellitus was much lower than in China. The high prevalence of CHD was consistent with data from other studies in China recent years [11, 22]. In addition, the increased prevalence of CHD can be observed in general population and not exclusively in patients with diabetes, which was considered as an alteration in disease patterns from infectious diseases to non-infectious diseases in developing countries [23]. It has been suggested that the ageing population, the western lifestyle, the prevalence of obesity, dyslipidemia, and other metabolic disorders contribute to the disease together [24–28].

As the biggest developing country, China is facing a serious public health threat bring by metabolic diseases, such as diabetes, dyslipidemia, obesity and so on. The results of the present study revealed that the proportion of failed to achieve the goal of HbA1c was lower and the rate of occurrence of hypoglycemia was higher in CHD patients than in patients without CHD. This showed that CHD patients had tighter glycemic control and higher risk of hypoglycemia, similar to the result that intensive glucose control cannot reduce cardiovascular events [29–31]. Our data showed that patients with CHD had lower lipid levels, which probably contributed by their greater use of statins than non-CHD patients. However, due to the stricter standards of lipid control in patients with CHD, the proportion failed to achieve the goal was higher than in patients without CHD, especially LDL-C. Our research showed that in females the prevalence of overweight or obesity was higher in patients with CHD than in non-CHD, which was opposite to the findings in males. This could reflect that weight may has different effects on macrovascular complications in men and women. However, a meta-analysis showed that BMI had the same effects on the risk of CHD in both males and females [32]. These differences can be explained that compared with men, women have more subcutaneous fat but less visceral fat [33, 34], which is more strongly associated with cardiovascular disease [35]. Consistent with previous study [11, 36], the aggregation of risk factors of CHD was very popular in patients with diabetes, therefore interventions should carried out to further tighten the controllable risk factors control.

Another interesting finding was that an excellent performance in lipid control was disappearing with increasing age in women, especially after 50 to 60 years of age, the proportions of patients failed to achieve the goals of TG, T-CHOL, LDL-C were higher in women than in men, whereas no such trend was observed in men. We speculate that this is due to the protective effect of female reproductive hormones, which would disappear in postmenopausal women. Similar studies have been reported previously and a significant effect on the whole of the blood lipid profile was observed [37]. However, with worsening lipid control, the prevalence of CHD in females was not higher than in males. This suggests that maybe other stronger risk factors contribute to the CHD in females. Therefore, further research is needed in the future.

This study has the following limitations. First, the study is a single center survey, so whether our conclusions can be extended to the general diabetic population remains to be determined. However, this study was conducted in a large university-affiliated third-grade Class A hospital, the results are representative to some extent. Second, our study was cross-sectional in design, so associations between some risk factors and CHD were unexpected and further studies are needed, preferably in the form of prospective research, before causality can be inferred. Finally, we have investigated main risk factors for CHD and many other preventable and unpreventable factors have not included. Further research included a wider range of risk factors are needed.

With the rapid socioeconomic development and the aggravation of the aging process of population, the prevalence of metabolic risk factors and CHD in China is soaring continuously. Patients with diabetes is facing a more serious situation than general population, which needed more social attentions and further prevention strategies, so as to delay or reduce the occurrence of CHD, improve the quality of life and prolong the survival time.

Conclusions

Our data indicated that the prevalence of CHD was rather high in T2DM inpatients in China, the control of metabolic risk factors were unsatisfactory, and aggregation of CHD risk factors was very popular. Comprehensive determination of risk factors will help to achieve effective intervention for high-risk groups.

Abbreviations

CHD: Coronary heart disease; T2DM: Type 2 diabetes; ASCVD: Atherosclerotic cardiovascular disease; BMI: Body mass index; FBG: Fasting blood-glucose; T-CHOL: Total-cholesterol; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; BUN: Blood urea nitrogen; SCr: Serum creatinine; SUA: Serum uric acid; PT: Prothrombin time; APTT: Activated partial thromboplastin time; TT: Thrombin time; FDP: Fibrinogen degradation product; ICD: International Classification of Diseases; SD: Standard deviation; CI: Confidence intervals.

Declarations

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Authors' contributions

Chenchen Wang was the main contributor to the writing of the manuscript. Xi Huang have collected and analysed data. Zuoling Xie, Zheng Wang and Haiyan Shangguan contributed to the planning and interpretation of the research. As the corresponding authors, Shaohua Wang was responsible for the overall content of this manuscript. All authors read and approved the fnal manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study complied with the principles of the Declaration of Helsinki and was approved by the Research Ethics Committee of ZhongDa Hospital affiliated to Southeast University (Approved No. of ethic committee: 2020ZDSYLL028-P01).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1] Department of Endocrinology, the Affiliated ZhongDa Hospital of Southeast University, Nanjing, China. [2] School of Medicine, Southeast University, Nanjing, China.

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Figures

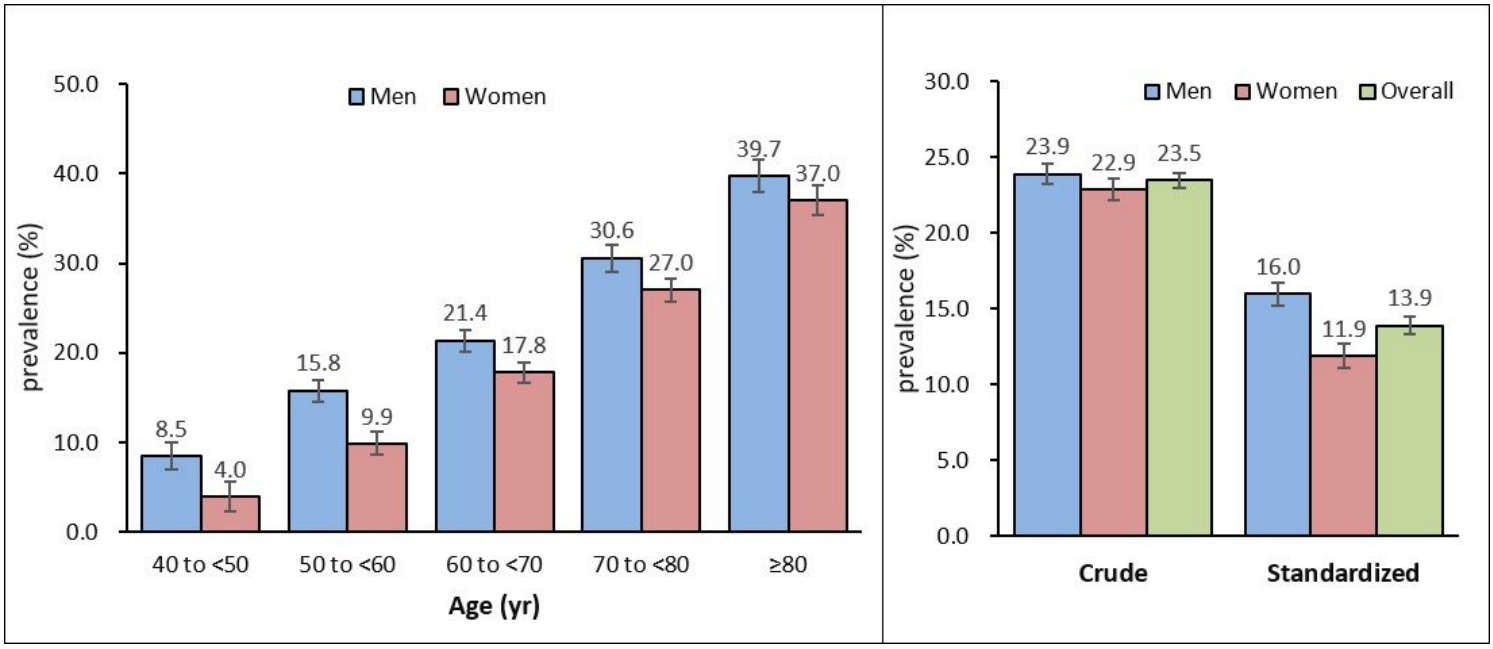

Figure 1

Age-specific prevalences of CHD in type 2 diabetes inpatients 40 years of age or older.

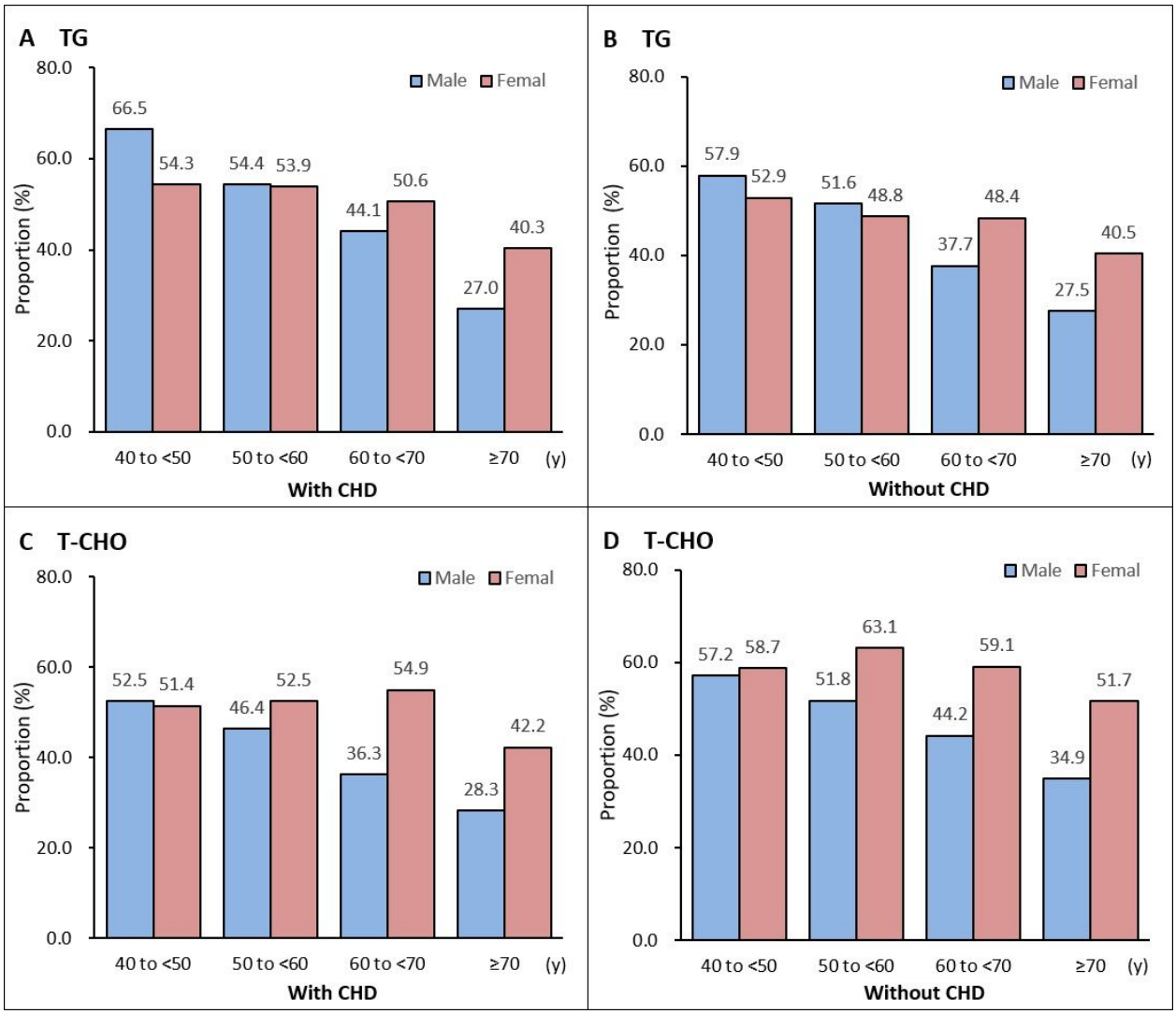

Figure 2

Proportion of patients (%) failed to achieve the goal of TG or T-CHO control, with CHD (Panel A and C) and without CHD (Panel B and D). Abbreviations: CHD, coronary heart disease; TG, triglyceride; T-CHO, total cholesterol. Failed to achieve the goal was defined as a serum TG level of ≥1.7 mmol/L, T-CHO of ≥4.5 mmol/L.

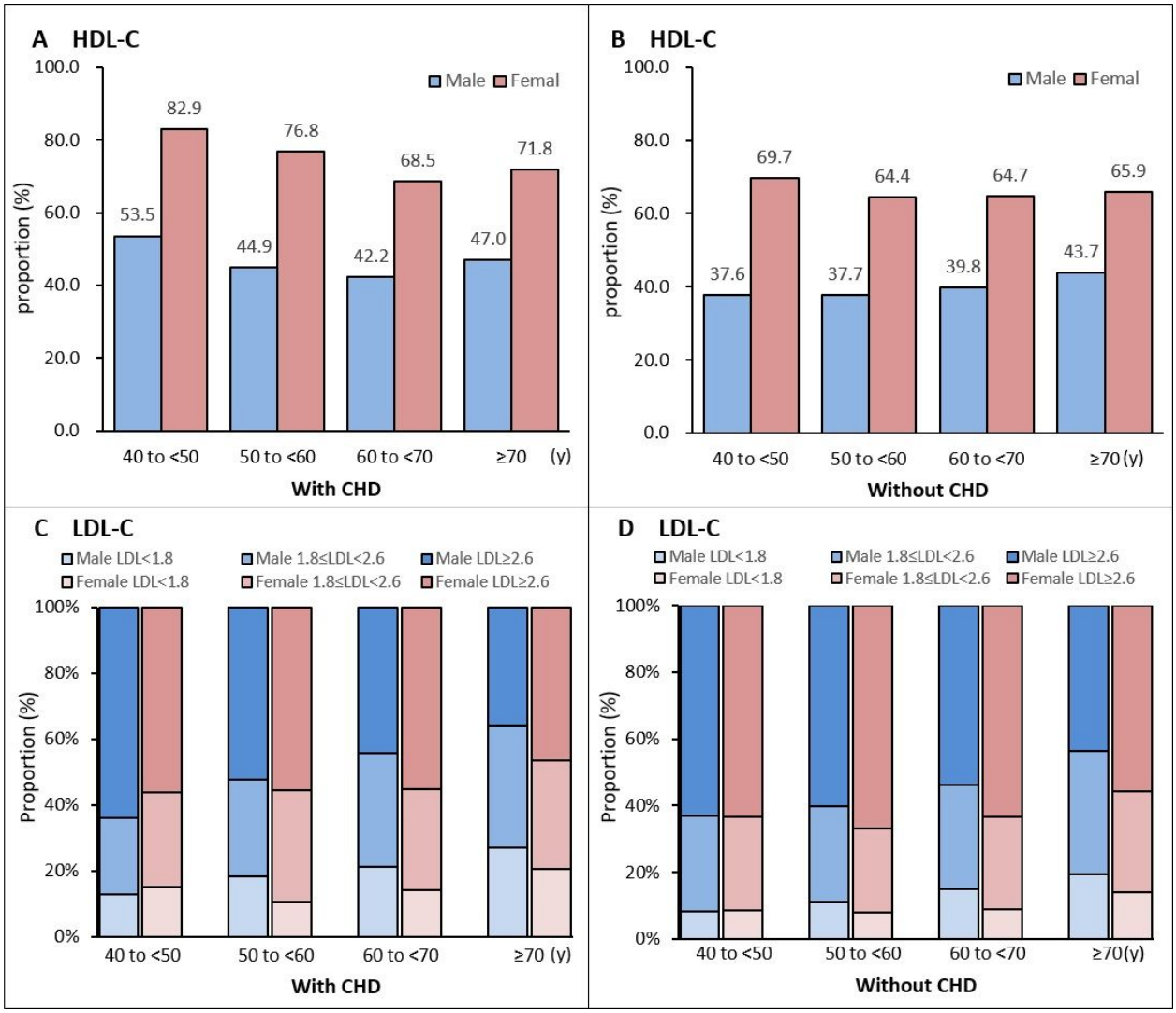

Figure 3

Proportion of patients (%) failed to achieve the goal of HDL-C or LDL-C control, with CHD (Panel A and C) and without CHD (Panel B and D). Abbreviations: CHD, coronary heart disease; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol. Failed to achieve the goal was defined as a serum HDL-C level of ≤ 1.0 mmol/L in males or ≤ 1.3 mmol/L in females.

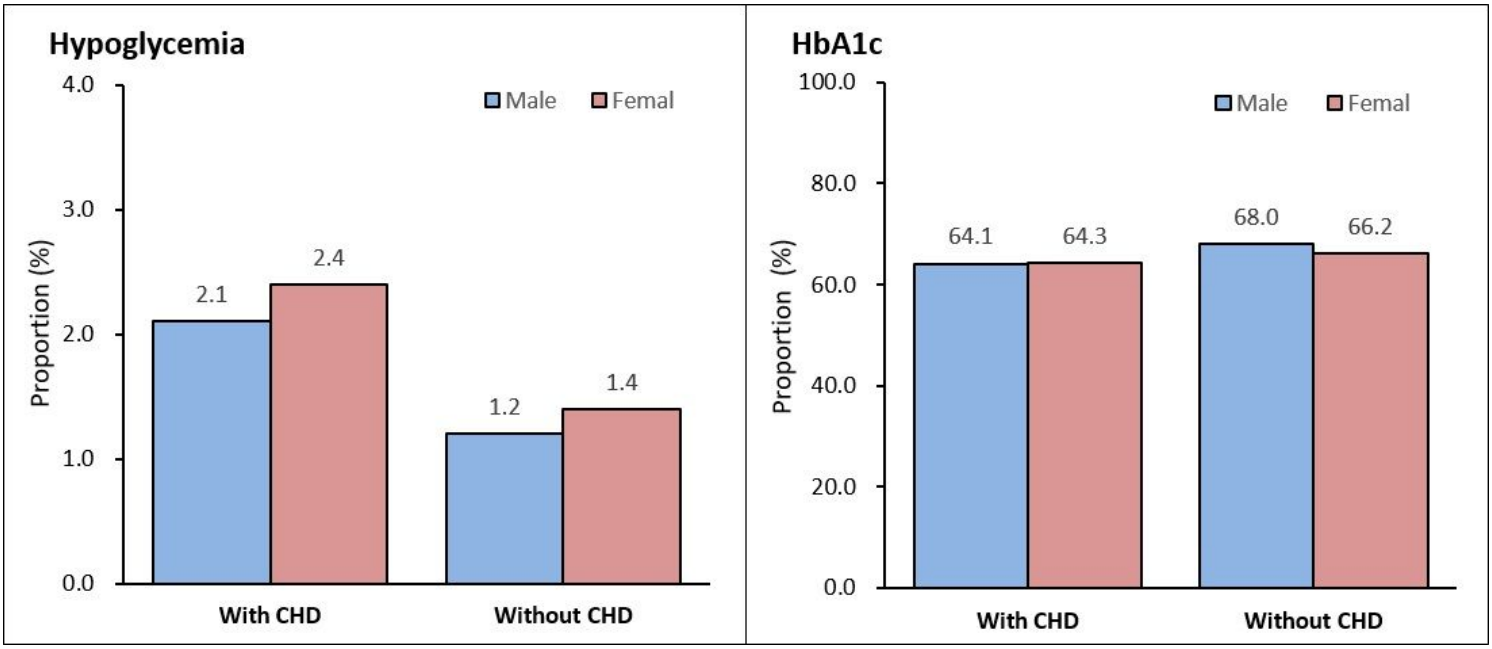

Figure 4

Proportion of patients (%) hypoglycemia and failed to achieve the goal of HbA1c control, with CHD and without CHD. Abbreviations: CHD, coronary heart disease; HbA1c, glycosylated hemoglobin. Hypoglycemia was defined as a serum blood-glucose level ≤ 3.9 mmol/L and failed to achieve the goal of HbA1c control was defined as serum HbA1c level of ≥ 7.0%.

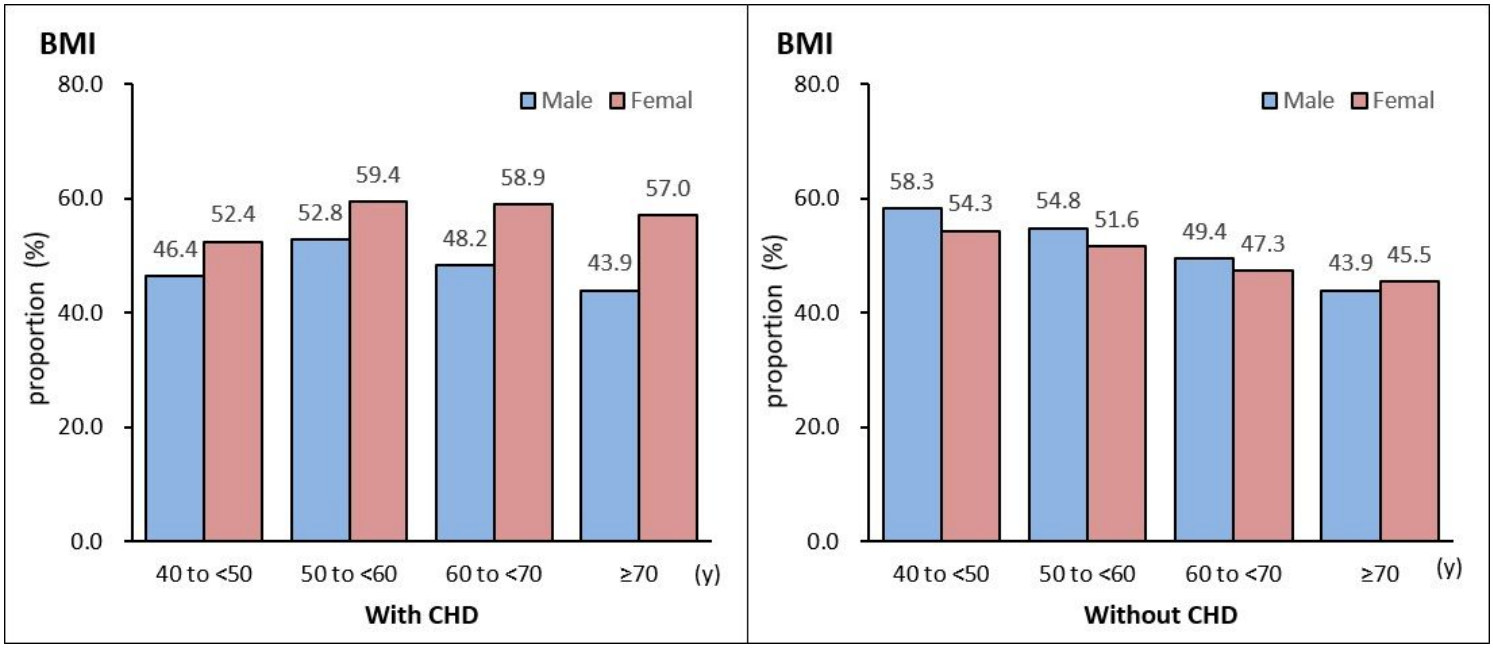

Figure 5

Proportion of patients (%) failed to achieve the goal of BMI control, with CHD and without CHD. Abbreviations: CHD, coronary heart disease; BMI, body mass index. Failed to achieve the goal of BMI control was defined as a BMI index of ≥25.