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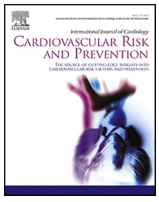

Premature coronary heart disease complicated with hypertension in hospitalized patients: Incidence, risk factors, cardiovascular-related comorbidities and prognosis, 2008–2018☆

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ABSTRACT

Background: The clinical characteristics and risk factors of all-cause mortality in young hospitalized patients with comorbid coronary heart disease and hypertension (CAD + HT) are not well-characterized.
Method: A total of 2288 hospitalized CAD patients (age<45 years) with or without hypertension in the Chinese PLA General Hospital from August 5, 2008 to June 22, 2018 were conducted. The risk factors of all-cause mortality were estimated in young CAD + HT patients by COX models.
Results: The overall prevalence of hypertension in young CAD patients was 50.83% (n = 1163). CAD + HT patients had older age, higher heart rate, BMI, uric acid, triglyceride and lower level of eGFR and HDL-C than CAD patients ($P < 0.05$). The proportion of cardiovascular-related comorbidities (including obesity, diabetes mellitus, hyperuricemia and chronic kidney disease [CKD]) in the CAD + HT group was significantly higher than that in CAD group ($P < 0.0001$). The risk of all-cause mortality was higher in CAD + HT patients, although after adjusting for all covariates, there was no significant difference between the two groups. Furthermore, CKD (HR, 3.662; 95% CI, 1.545–8.682) and heart failure (HF) (HR, 3.136; 95%CI, 1.276–7.703) were associated with an increased risk of all-cause mortality and RAASi (HR, 0.378; 95%CI, 0.174–0.819) had a beneficial impact in CAD + HT patients.
Conclusions: Hypertension was highly prevalent in young CAD patients. Young CAD + HT patients had more cardiovascular metabolic risk factors, more cardiovascular-related comorbidities and higher risk of all-cause mortality. CKD and HF were the risk factors, while RAASi was a protective factor, of all-cause mortality in CAD + HT patients.

1. Background

Hypertension is the main modifiable risk factor for cardiovascular diseases (CVD) [1]. The crude prevalence of hypertension is 4.0%, 6.1%, 15.0% among the ages 18–24, 25–34, 35–44 groups, respectively [2]. The increase of the prevalence in people ≤45 years old is more prominent than other age groups [3]. At the same time, the awareness, treatment and control rate of Chinese hypertension population with 35–45 years old are lower than older population [4]. Hypertension is associated with the morbidity and mortality of cardiovascular and cerebrovascular diseases [3,5]. Moreover, hypertensive patients with younger than 45 years of age have higher risk for CVD and all-cause mortality than that ≥45 years old [6].

CVD is the major cause of death, and coronary heart disease (CAD) is one of the three main causes of CVD deaths in China [7,8]. Report on Cardiovascular Health and Diseases in China 2022 showed that the prevalence of CVD was increasing. It was estimated that there are 11.39 million patients with CAD and 245 million cases with hypertension in 2020. And, the mortality of CAD has also been increasing year by year [9]. In addition, hypertension is the main risk factor for CAD and both the two diseases often coexist. When CAD and hypertension coexist, the risk of cardiovascular death increases. However, the prevalence of

☆ All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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young coronary heart disease with hypertension (CAD + HT) in China remains unclear. Chronic kidney disease [CKD], multivessel disease, and the absence of revascularization have been shown to be associated with a poor prognosis in patients with early-onset CAD [10]. Furthermore, the long-term control of blood pressure and improvement of other metabolic risk factors are associated with decreasing the risk of all-cause death in patients with CAD [11,12]. Therefore, early identification and intervention of risk factors, as well as long-term blood pressure control, are crucial for improving prognosis of young CAD + HT patients.

Nevertheless, few studies reported the clinical characteristics, risk factor distribution, other comorbidities (including obesity, CKD, diabetes mellitus [DM], hyperuricemia and heart failure [HF]), and long-term prognosis of young patients with CAD + HT. The purpose of this study is to investigate the clinical characteristics, other comorbidities and long-term all-cause mortality risk of young hospitalized patients with CAD + HT through a 10-year follow-up, in order to provide theoretical support for improving the prognosis of young hospitalized CAD + HT patients.

2. Method

Study population: This study was conducted using data from the coronary angiography register and electronic medical record database of hospitalized patients in the cardiology department of Chinese People's Liberation Army General Hospital from August 5, 2008 to July 22, 2018. A total of 2228 hospitalized CAD (ICD-10 code, I20–I22, I24–I25) patients (age<45years) with or without hypertension (ICD-10 code, I10) were enrolled. Inclusion criteria were 1): aged<45years 2), either of the following two conditions were satisfied: a) at least one coronary artery obstruction/stenosis with a diameter of ≥50% through coronary angiography, b) past history of percutaneous coronary intervention (PCI)/coronary artery bypass grafting (CABG), or old myocardial infarction (OMI). The exclusion criteria included secondary hypertension, valvular heart disease, chronic hepatic dysfunction, hypertrophy cardiomyopathy, acute infection, rheumatology and immune system diseases and other severe medical illness (Fig. 1). All patients were grouped into: CAD + HT (n = 1163) and CAD (n = 1125). The study was approved by the Ethics Committee of the Chinese People's Liberation Army General Hospital (No. S2020-172-05) and complied with the guidelines of Declaration of Helsinki. Informed consent was obtained from all patients.

Clinical data collection: A complete clinical data was gathered from all patients, including age, gender, height, weight, systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate, smoking and drinking status, and history of cardiovascular disease. Medication treatment status was recorded during hospitalization, including antihypertensive drugs (angiotensin converting enzyme inhibitors [ACEI]/angiotensin receptor blockers [ARB], β-blockers, calcium channel blockers [CCB] and diuretics), antiplatelet agents (aspirin, clopidogrel, and ticagrelor) and lipid lowering drugs (statins and cholesterol absorption inhibitors). We also recorded laboratory examinations included fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), uric acid (UA), serum sodium (Na) and serum potassium (K). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Estimated glomerular filtration rate (eGFR) were calculated using the Chronic Kidney Disease Epidemiology Collaboration creatinine equation [13]. Hypertension was defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg, or past history of hypertension diagnosed by physician. Cardiovascular-related comorbidities, including obesity (BMI ≥28 kg/m^2), DM, hyperuricemia, CKD (eGFR <60 ml/min/1.73 m^2) and HF were recorded. DM was defined as fasting blood glucose level of ≥7.0 mmol/l or past history of diabetes or use of glucose-lowering medications. Hyperuricemia refers to patients with uric acid level of >420 mmol/l or previous history of hyperuricemia or urarthritis or taking medications lowering uric acid. The diagnosis of HF must include condition 1) and 2) at least: 1) symptoms of HF, such as dyspnea, fatigue, and fluid retention and the cardiac function was diagnosed as New York Heart Association cardiac function grade II, III, IV or Killip grade II, III, IV; 2) 2-dimensional and Doppler echocardiography reported left ventricular ejection fraction <50%; 3) elevated plasma brain natriuretic peptide (BNP) levels.

Follow-up and outcomes: The follow-up was carried out by trained nurses or cardiologists through telephone communication and/or retrieval of patient information in electronic medical record systems from discharge to February 2023. All-cause mortality data were gathered as the primary outcome.

Statistical analysis: Continuous variables were expressed as mean ± standard deviation. The baseline characteristics of CAD + HT and CAD subjects were compared using analysis of variance (ANOVA) for continuous variables with normal distribution. Non-normally distributed measurement data were expressed as median and inter-quartile range (IQR), and Wilcoxon Rank-Sum test was used for comparison. Categorical variables were expressed as frequency (percentage) and compared using Chi-squared tests or Fisher test. Kaplan–Meier analysis was performed to present the cumulative incidence of all-cause mortality. COX Proportional Hazard models were used to calculate the hazard ratios (HRs) and 95% confidence intervals (CIs) of hypertension for all-cause mortality adjusting for covariates, including gender, age, smoking status, drinking status, heart rate, TG, LDL-C, history of OMI, acute myocardial infarction (AMI), obesity, DM, hyperuricemia, CKD,

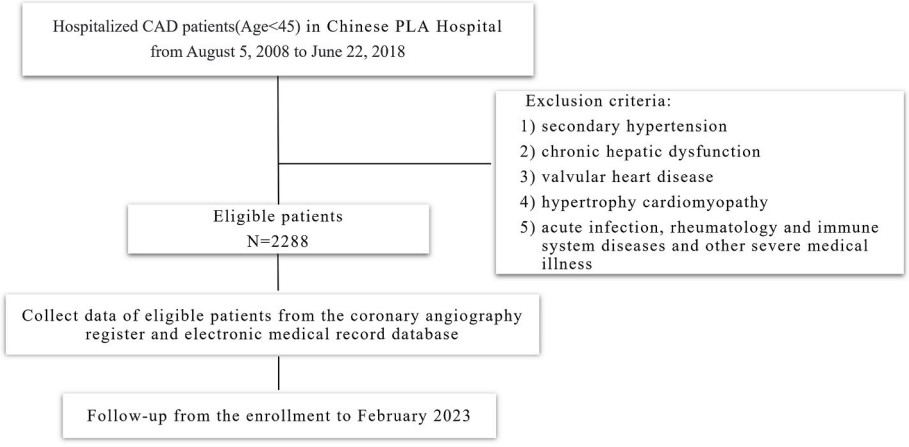

Fig. 1. Eligibility of young CAD in the study. **Legend:** The flowchart of the eligibility of 2288 young CAD patients enrolled in the current study. Abbreviations: CAD: coronary heart disease.

HF, PCI, CABG, and use of β-blockers, CCB, ACEI/ARB, diuretic and statins. And, the risk factors of all-cause mortality in young CAD + HT patients were also conducted by COX models. Statistical analysis was performed using SAS (Version 9.4; SAS Institute, Cary, NC). Two-tailed *P* values < 0.05 was considered to be statistically significant.

3. Result

Among 2288 young CAD patients, 1163 (50.83%) had hypertension. The baseline clinical characteristics of participants were shown in Table 1. Compared with CAD patients, CAD + HT patients had older age (40.75 ± 3.74 vs 39.71 ± 4.70 years, $P < 0.0001$), higher heart rate (77.86 ± 12.33 vs 76.06 ± 12.15 beats/min, $P = 0.0004$), and higher BMI (28.29 ± 3.77 vs 26.43 ± 3.57 kg/m^2, $P < 0.0001$). In addition, young patients with CAD + HT had more cardiovascular metabolism related risk factors, including higher level of UA and TG (all $P < 0.0001$), and lower level of HDL-C and eGFR (all $P < 0.05$) than those with CAD.

Table 1
Baseline clinical characteristics of young CAD patients.

	Total (n = 2288)	CAD + HT (n = 1163)	CAD (n = 1125)	*P* value
Age, years	40.24 ± 4.27	40.75 ± 3.74	39.71 ± 4.70	<0.0001
Male, n (%)	2143(93.66)	1095(94.15)	1048(93.16)	0.3275
SBP, mmHg	127.04 ± 17.64	132.65 ± 18.49	121.24 ± 14.62	<0.0001
DBP, mmHg	77.75 ± 13.03	81.74 ± 13.53	73.63 ± 11.07	<0.0001
Heart rate, bpm	76.97 ± 12.27	77.86 ± 12.33	76.06 ± 12.15	0.0004
BMI, kg/m^2	27.38 ± 3.79	28.29 ± 3.77	26.43 ± 3.57	<0.0001
Ever smokers, n (%)	1439(66.71)	719(65.78)	720(67.67)	0.3525
Ever drinkers, n (%)	1196(55.81)	629(57.81)	567(53.74)	0.0580
FBG, mmol/L	5.27 (4.71,6.68)	5.31(4.75,6.84)	5.23 (4.68,6.43)	0.1139
TG, mmol/L	1.67 (1.21,2.44)	1.77(1.29,2.55)	1.58 (1.11,2.30)	<0.0001
TC, mmol/L	4.27 ± 1.28	4.24 ± 1.18	4.31 ± 1.37	0.2344
LDL-C, mmol/L	2.47 (1.91,3.19)	2.48(1.93,3.15)	2.47 (1.88,3.24)	0.5608
HDL-C, mmol/L	0.95 ± 0.25	0.93 ± 0.26	0.96 ± 0.25	0.0138
UA, μmol/L	376.82 ± 99.39	392.37 ± 103.63	360.49 ± 91.99	<0.0001
eGFR, ml/min/1.73m^2	102.81 ± 18.44	99.00 ± 21.18	106.76 ± 14.03	<0.0001
Na, mmol/L	141.15 ± 2.81	141.33 ± 2.79	140.96 ± 2.81	0.0016
K, mmol/L	3.87 ± 0.38	3.85 ± 0.41	3.89 ± 0.34	0.0233
OMI, n (%)	331(14.47)	158(13.59)	173(15.38)	0.2231
AMI, n (%)	749(32.74)	310(26.66)	439(39.02)	<0.0001
PCI, n (%)	1545(68.03)	785(68.08)	760(67.98)	0.9573
CABG, n (%)	56(2.47)	29(2.52)	27(2.42)	0.8777
Diuretic, n (%)	305(13.34)	192(16.51)	113(10.05)	<0.0001
β-blockers, n (%)	1766(77.22)	951(81.77)	815(72.51)	<0.0001
ACEI/ARB, n (%)	1028(44.93)	742(63.80)	286(25.42)	<0.0001
CCB, n (%)	639(27.94)	479(41.19)	160(14.23)	<0.0001
SAPT, n (%)	262(11.46)	144(12.38)	118(10.50)	0.1574
DAPT, n (%)	2003(87.58)	1005(86.41)	998(88.79)	0.0850
statins, n (%)	2157(94.32)	1096(94.24)	1061(94.40)	0.8720

Abbreviations: ACEI: angiotensin converting enzyme inhibitors, AMI: argent myocardial infarction, ARB: angiotensin receptor blockers, BMI: body mass index, CABG: coronary artery bypass grafting, CAD: coronary heart disease; CAD + HT: coronary heart disease and hypertension, CCB: calcium channel blockers, DAPT: double antiplatelet agents, DBP: diastolic blood pressure, eGFR: estimated glomerular filtration rate, FBG: fasting blood glucose, HDL-C: high-density lipoprotein cholesterol, K: serum potassium, LDL-C: low-density lipoprotein cholesterol, Na: serum sodium, OMI: old myocardial infarction, PCI: percutaneous coronary intervention, SAPT: single antiplatelet agents, SBP: systolic blood pressure, TG: triglyceride, TC: total cholesterol, UA: uric acid.

Moreover, the proportion of AMI was much higher in CAD than CAD + HT.

Further analysis showed that only 42.51% of hypertensive patients with CAD had SBP <130 mmHg, and 66.09% had SBP <140 mmHg, indicating that 57.49% of hypertensive patients with CAD did not reach the target blood pressure. Similarly, the proportions of LDL-C <1.8 mmol/L in CAD + HT and CAD patients were 20.95% and 21.99%, respectively. And, only 3.61% and 5.16% of CAD + HT and CAD patients had heart rate <60 beats/minute. The proportions of UA <300 mmol/L in CAD + HT and CAD patients were 16.99% and 24.77%, respectively (Supplementary Table 1). The above findings indicate that metabolic related risk factors should be identified and intervened in young CAD + HT and CAD patients as early as possible.

Young CAD + HT patients were more frequently complicated with obesity (51.12% vs 30.33%), DM (35.51% vs 27.29%), hyperuricemia (36.03% vs 22.04%) and CKD (8.51% vs 1.51%) than CAD patients (Fig. 2). Furthermore, the number of cardiovascular-related comorbidities was greater in CAD + HT group than in CAD group, including obesity, DM, hyperuricemia, CKD and HF (Supplementary Table 2).

During the follow-up (total: 15592.6 person-years, median: 7.57 years), 60 (3.02 %) all-cause mortality events were documented. The cumulative incidence of all-cause mortality was significantly higher in CAD + HT patients than that in CAD patients (Fig. 3). As presented in Table 2, young patients with CAD + HT were at a higher risk of all-cause mortality relative to young CAD patients (HR, 2.127; 95 % CI, 1.235–3.665). However, after adjusting for potential confounders, including gender, age, smoking status, drinking status, heart rate, TG, LDL-C, OMI, AMI, cardiovascular-related comorbidities (obesity, DM, hyperuricemia, CKD and HF), PCI, CABG, β-blockers, CCB, ACEI/ARB, diuretic and statins, there was no significant difference in all-cause mortality risk between the two groups. Through multivariate COX regression analysis, we found that CKD (HR, 3.662; 95 % CI, 1.545–8.682) and HF (HR, 3.136; 95% CI, 1.276–7.703) were the risk factors of all-cause mortality in young CAD + HT patients, while renin angiotensin aldosterone system inhibitors (RAASi) (HR, 0.378; 95 % CI, 0.174–0.819) was a significant protective factor of all-cause mortality (Table 3).

4. Discussion

The present study found that the prevalence of hypertension in young CAD patients is 50.83%. Compared with CAD patients, CAD + HT patients had more cardiovascular metabolic risk factors, more cardiovascular related complications (such as obesity, DM, hyperuricemia and CKD) and higher risk of all-cause mortality. CKD and HF were major risk

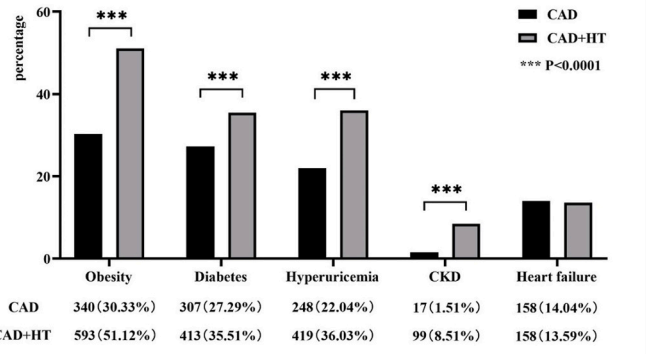

Fig. 2. Prevalence of Cardiovascular-related comorbidities in CAD + HT and CAD group. **Legend:** Five Cardiovascular-related comorbidities were included: obesity, diabetes mellitus, hyperuricemia, clinical kidney disease and heart failure. Abbreviations: CKD: clinical kidney disease, DM: diabetes mellitus, HF: heart failure.

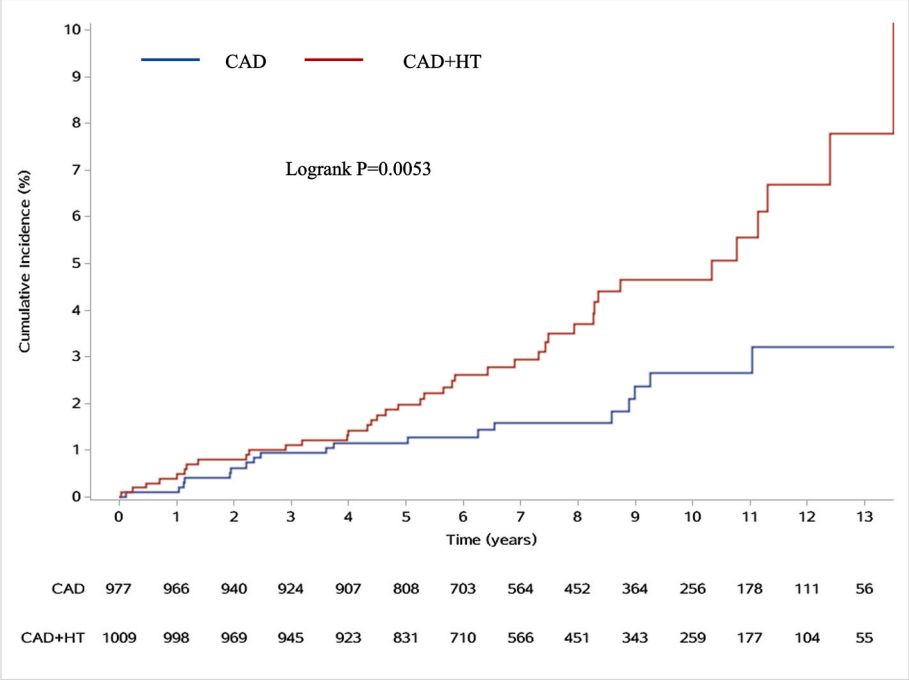

Fig. 3. Kaplan-Meier estimates of cumulative incidence of all-cause mortality. **Legend:** The Kaplan-Meier estimates of cumulative incidence were based on crude model. The average duration of follow-up was 7.57 years. Abbreviations: CAD: coronary heart disease; CAD + HT: coronary heart disease and hypertension.

Table 2
Hazard ratios (95% CI) of all-cause mortality according to hypertension in young CAD patients.

	HR (95% CI)	P value
Crude model	2.127 (1.235,3.665)	0.0065
Model 1	2.140(1.236,3.704)	0.0066
Model 2	1.242(0.651,2.371)	0.5102
Model 3	1.391(0.710,2.728)	0.3361

Model 1. Adjusted gender and age.
Model 2. Adjusted gender, age, smoke, drink, heart rate, TG, LDL-C, OMI, AMI, obesity, DM, hyperuricemia, CKD and HF.
Model 3. Adjusted gender, age, smoke, drink, heart rate, TG, LDL-C, OMI, AMI, obesity, DM, hyperuricemia, CKD, HF, PCI, CABG, β-blockers, CCB, ACEI/ARB, diuretic and statins.
Abbreviations: CI: confidence interval, HR: hazard ratio.

factors of all-cause mortality, while RAASi was a protective factor of all-cause mortality.

More than half young patients with CAD had hypertension. and the vast majority of young CAD patients were males. Consistent findings were reported in a retrospective observational study of 3655 patients younger than 50 years with CAD enrolled from 1995 to 2013, in which the prevalence of hypertension was 52.8% [10]. Similarly, Vikulova DN et al. analyzed 12,519 patients with premature CAD showed that the prevalence of hypertension was 42.5% [14]. Apparently, the prevalence of hypertension in young CAD participants was higher than that in general people aged below 45-year-old [3]. The potential reason is that young CAD patients generally have more traditional risk factors of hypertension, such as male, obesity, family history of HT, smoking and drinking [2]. Moreover, our study found that the vast majority of young CAD patients were males, which might be explained as following: First, estrogen can protect female from cardiovascular disease before menopause [15,16]. Second, men may have more cardiovascular risk factors, such as unhealthy lifestyles (including unhealthy diet, smoking, drinking and psychological stress), and cardiovascular-related comorbidities, which may lead to poor prognosis in young patients with CAD[10, 14, 17–21].

In the present study, we also found that CAD + HT patients had more cardiovascular risk factors and higher prevalence of cardiovascular-related comorbidities, including obesity, DM, hyperuricemia and CKD, than CAD patients. Prior studies reported that individuals with a higher hypertension grade had more cardiovascular risk factors, such as higher BMI, FBG and proportion of smokers, which synergistically increase the risk of cardiovascular disease [22]. It is well known that hypertension is a major leading cause of cardiovascular mortality and all-cause mortality. So do young hypertension patients [23–26]. In our present study, we found that the cumulative incidence of all-cause mortality in young CAD + HT patients was higher than that in CAD patients. Although further COX regression analysis showed no significant statistical disparities of all-cause mortality risk between CAD + HT patients and CAD patients after fully adjusting multiple confounding factors, the cumulative incidence curve of all-cause mortality in CAD + HT and CAD separated at the fourth year of follow-up. The possible potential explanation is that the absolute risk of all-cause mortality was generally lower in younger individuals than that in older individuals, even in populations with CVD. The significant statistical difference may appear after a longer follow-up.

In addition, we observed that CKD and HF were major risk factors of all-cause mortality in CAD + HT patients, while the use of RAASi has a protective effect. CKD is considered as one of the major risk factors affecting the prognosis of CVD. Previous study showed that the prevalence of CKD in CAD patients ranged from 22.1% to 35.74%, and low eGFR was an independent risk factor of cardiovascular events (including recurrent angina, recurrent myocardial infarction, target vessel revascularization, re-admission for heart failure and cardiac death) and all-cause mortality for CAD patients and individuals without CVD[21, 27–31]. In our study, the prevalence of CKD was relatively low, as all subjects were under 45 years old. However, the consistent results showed that CKD was a risk factor for all-cause mortality in CAD + HT. In addition, HF is also a leading cause of cardiovascular morbidity and mortality [32]. CAD patients with heart failure had a high risk of recurrent myocardial infarction and death [33,34]. Our study showed that HF was a major independent risk factor of all-cause mortality in young CAD + HT patients, which was consistent of a previous cohort

Table 3
Hazard ratios (95% CI) of risk factors of all-cause mortality in CAD + HT group.

	Univariate COX model		Multivariate COX model	
	HR (95%CI)	P value	HR (95%CI)	P value
Age	1.037(0.947,1.136)	0.4367	1.082 (0.968,1.209)	0.1651
Male	2.642 (0.363,19.210)	0.3370	1.178 (0.145,9.585)	0.8780
Ever smokers	1.067(0.545,2.091)	0.8489	1.183 (0.485,2.885)	0.7121
Ever drinkers	0.851(0.450,1.609)	0.6187	0.819 (0.353,1.898)	0.6410
OMI	2.160(1.031,4.527)	0.0413	1.277 (0.445,3.663)	0.6490
AMI	1.612(0.854,3.044)	0.1409	1.878 (0.737,4.786)	0.1869
SBP	1.001(0.984,1.018)	0.9350	0.981 (0.954,1.009)	0.1870
DBP	1.009(0.987,1.032)	0.4270	1.015 (0.979,1.053)	0.4178
Heart rate	1.031(1.008,1.055)	0.0084	1.012 (0.986,1.039)	0.3608
TG	0.991(0.782,1.255)	0.9386	1.058 (0.795,1.408)	0.6992
LDL-C	1.316(1.024,1.690)	0.0318	1.279 (0.908,1.801)	0.1598
Obesity	1.027(0.552,1.910)	0.9335	1.036 (0.494,2.172)	0.9249
DM	1.654(0.894,3.060)	0.1087	1.381 (0.668,2.855)	0.3839
Hyperuricemia	1.569(0.849,2.900)	0.1506	1.223 (0.551,2.716)	0.6209
CKD	5.755 (2.931,11.297)	<0.0001	3.662 (1.545,8.682)	0.0032
HF	4.674(2.471,8.843)	<0.0001	3.136 (1.276,7.703)	0.0127
PCI	0.717(0.375,1.370)	0.3138	0.573 (0.243,1.350)	0.2027
CABG	1.066(0.146,7.767)	0.9497	0.401 (0.043,3.711)	0.4210
β-blockers	1.183 (0.524,2.669)	0.6856	1.204 (0.427,3.395)	0.7255
CCB	1.437(0.773,2.672)	0.2514	1.715 (0.775,3.796)	0.1834
ACEI/ARB	0.579(0.314,1.069)	0.0809	0.378 (0.174,0.819)	0.0137
Diuretic	2.291(1.145,4.583)	0.0191	1.680 (0.638,4.423)	0.2936
Statins	0.634(0.226,1.784)	0.3885	0.788 (0.258,2.409)	0.6759

Abbreviations: ACEI: angiotensin converting enzyme inhibitors, AMI: argent myocardial infarction, ARB: angiotensin receptor blockers, CABG: coronary artery bypass grafting, CCB: calcium channel blockers, CI: confidence interval, CKD: clinical kidney disease, DAPT: double antiplatelet agents, DBP: diastolic blood pressure, DM: diabetes mellitus, HF: heart failure, HR: hazard ratio, LDL-C: low-density lipoprotein cholesterol, OMI: old myocardial infarction, PCI: percutaneous coronary intervention, SAPT: single antiplatelet agents, SBP: systolic blood pressure, TG: triglyceride.

study of young patients with CAD [14]. This may be explained by that the synergistic effect of concurrent CKD or HF with hypertension increased the risk of death in CAD patients.

In terms of secondary prevention drugs of CAD patients, statin and antiplatelet therapy were widely used in our study. And, most CAD + HT patients received treatment with antihypertensive drugs (including ACEI/ARB, CCB, diuretics and β-blockers), but only 42.51% of them had systolic blood pressure controlled less than 130 mmHg, indicating that the antihypertensive treatment was not sufficient in patients with CAD + HT. Furthermore, 81.77% of CAD + HT patients and 72.51% of CAD patients received β-Blocker therapy, but the proportion of heart rate controlled <60 bpm was 3.61% and 5.16% respectively, indicating the dosage of β-blockers is far from sufficient. Therefore, intensive blood pressure and heart rate intervention should be strengthened in CAD + HT patients to decrease the risk of long-term cardiovascular events and all-cause death. As expected, RAASi was a protective factor of all-cause mortality in young CAD + HT patients. The above indicates that CAD + HT patients should strengthen the management of blood pressure and heart rate in clinical practice.

The strength of this study was the study design of a cohort study with a long follow-up. The data quality was highlighted, for example, CAD was diagnosed based on strict coronary angiography examination, and all clinical data of patients were obtained from inpatient electronic medical records, which avoided diagnostic bias. Meanwhile, several limitations must be considered. First, the study was a single-center study. However, the patients of our study were from 31 provinces/autonomous regions in China. The study patients might still be nationally representative to a certain extent. Second, the endpoint event of this study was all-cause mortality. We did not collect data on cardiovascular events or cause of death considering the data accuracy in telephonic follow-up. Further studies on cardiovascular events and cardiovascular death in young patients with CAD + HT are still warranted.

5. Conclusions

In conclusion, hypertension is highly prevalent in young patients with CAD. Young CAD + HT patients have more cardiovascular risk factors, more cardiovascular-related comorbidities and higher risk of all-cause mortality. CKD and HF are the major risk factors, while RAASi is a protective factor, of all-cause mortality in young patients with CAD + HT. The intensive management of blood pressure, heart rate, cardiovascular risk factors and cardiovascular-related comorbidities should be strengthened to prevent from premature death.

Author contributions

Yanjie Li and Hao Xue concepted and designed this study. Yanjie Li drafted the first version of the manuscript. Yanjie Li, Chi Wang and Hao Xue provided critical revision of the manuscript for crucial intellectual content. Yanjie Li, Chi Wang, Zekun Feng, Lu Tian, Siyu Yao, Miao Wang, Maoxiang Zhao and Lihua Lan carried out data acquisition, data curation, statistical analysis, or interpretation of data. Hao Xue provided the funding support.

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Data availability statement

The data that support the findings of this study is not publicly available due to privacy and ethical restrictions. The data are available on reasonable request from the corresponding author.

Declaration of generative AI in scientific writing

The authors did not use generative AI or AI-assisted technologies in the writing process.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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