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Postdischarge cancer and mortality in patients with coronary artery disease: a retrospective cohort study

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ABSTRACT

BACKGROUND Our understanding of the correlation between postdischarge cancer and mortality in patients with coronary artery disease (CAD) remains incomplete. The aim of this study was to investigate the relationships between postdischarge cancers and all-cause mortality and cardiovascular mortality in CAD patients.

METHODS In this retrospective cohort study, 25% of CAD patients without prior cancer history who underwent coronary artery angiography between January 1, 2011 and December 31, 2015, were randomly enrolled using SPSS 26.0. Patients were monitored for the incidence of postdischarge cancer, which was defined as cancer diagnosed after the index hospitalization, survival status and cause of death. Cox regression analysis was used to explore the association between postdischarge cancer and all-cause mortality and cardiovascular mortality in CAD patients.

RESULTS A total of 4085 patients were included in the final analysis. During a median follow-up period of 8 years, 174 patients (4.3%) developed postdischarge cancer, and 343 patients (8.4%) died. A total of 173 patients died from cardiovascular diseases. Postdischarge cancer was associated with increased all-cause mortality risk (HR = 2.653, 95% CI: 1.727–4.076, $P < 0.001$) and cardiovascular mortality risk (HR = 2.756, 95% CI: 1.470–5.167, $P = 0.002$). Postdischarge lung cancer (HR = 5.497, 95% CI: 2.922–10.343, $P < 0.001$) and gastrointestinal cancer (HR = 1.984, 95% CI: 1.049–3.750, $P = 0.035$) were associated with all-cause mortality in CAD patients. Postdischarge lung cancer was significantly associated with cardiovascular death in CAD patients (HR = 4.979, 95% CI: 2.114–11.728, $P < 0.001$), and cardiovascular death was not significantly correlated with gastrointestinal cancer or other types of cancer.

CONCLUSIONS Postdischarge cancer was associated with all-cause mortality and cardiovascular mortality in CAD patients. Compared with other cancers, postdischarge lung cancer had a more significant effect on all-cause mortality and cardiovascular mortality in CAD patients.

Coronary artery disease (CAD) and cancer are leading causes of mortality worldwide.[1,2] CAD and cancer are traditionally viewed as distinct diseases with different clinical presentations, prognoses, and pathogenic mechanisms. However, recent evidence suggests that CAD shares common risk factors with cancer, including genetic, dietary, psychological, and environmental factors, as well as similar molecular mechanisms, such as inflammation and oxidative stress.[3–6] The risk of CAD is significantly increased in cancer patients,[7,8] and the risk of developing cancer is also notably increased in patients with CAD.[9] Patients with multiple atherosclerotic lesions have an increased risk of cancer compared with those with a single atherosclerotic lesion.[10] Patients with more complex coronary artery lesions have an increased risk of cancer.[11] Cancer and CAD are often found in the same patient, and cancer is increasingly recognized as a common comorbidity in patients with CAD.[12] However, the effect of cancer on the prognosis of CAD patients is not fully understood. There have been several established prognostic models for CAD; however, most of these models are based on traditional cardiovascular risk factors, and the studies from which those models were derived often exclude cancer patients.[13–15] Therefore, these models might not be ap-

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plicable to all CAD patients and have certain limitations.[16] The role of cancer in the long-term prognosis of CAD patients has not been duly acknowledged, and relevant studies are scarce. Elucidating the role of cancer in the long-term prognosis of CAD patients is necessary to optimize the management of patients with CAD.

This retrospective cohort study aimed to investigate the correlation of postdischarge cancer with mortality and cardiovascular mortality in CAD patients.

METHODS

Study Design and Patients

A retrospective cohort study was conducted among 19,770 patients who underwent coronary artery angiography and were diagnosed with CAD at the First Medical Center, Chinese PLA General Hospital, Beijing, China between January 1, 2011 and December 31, 2015. Patients diagnosed with coronary heart disease were selected from the medical records system. The inclusion criteria were as follows: (1) patients that were between 18 and 85 years of age; (2) received a diagnosis of CAD following a first-time coronary angiography; and (3) consented to participate in the study. All included patients had no previous history of cancer. The exclusion criteria included: (1) a history of cancer; (2) missing key data (such as follow-up information, cancer diagnosis time, survival status, etc.); (3) lost to follow-up during the study period and unable to obtain complete follow-up data; (4) presence of severe non-cardiovascular diseases (such as end-stage renal disease, cirrhosis, etc.); (5) severe mental illness that may affect study compliance; and (6) patients who refused to participate in the study or were unable to provide informed consent. Out of 18,500 patients meeting the criteria, this study utilized a stratified random sampling approach to ensure randomization. The specific method for randomly selecting 4625 patients from those who met the inclusion and exclusion criteria was by SPSS. A total of 4625 patients meeted the sample size requirements (Figure 1).

This retrospective cohort study involved phone follow-ups with patients or their family members, including the timing of cancer, type of cancer, timing of death, cause of death and therapy for CAD postdischarge. Those who were not successfully followed up on three phone calls were defined as lost to follow-up. The patients were divided into the survival group and the death group according to whether death occurred during the follow-up period. Cardiovascular death referred to fatal acute myocardial infarction, ischemic cardiomyopathy, malignant arrhythmia, sudden cardiac death, or stroke.

Baseline Data Collection

Baseline biospecimen was obtained from the electronic

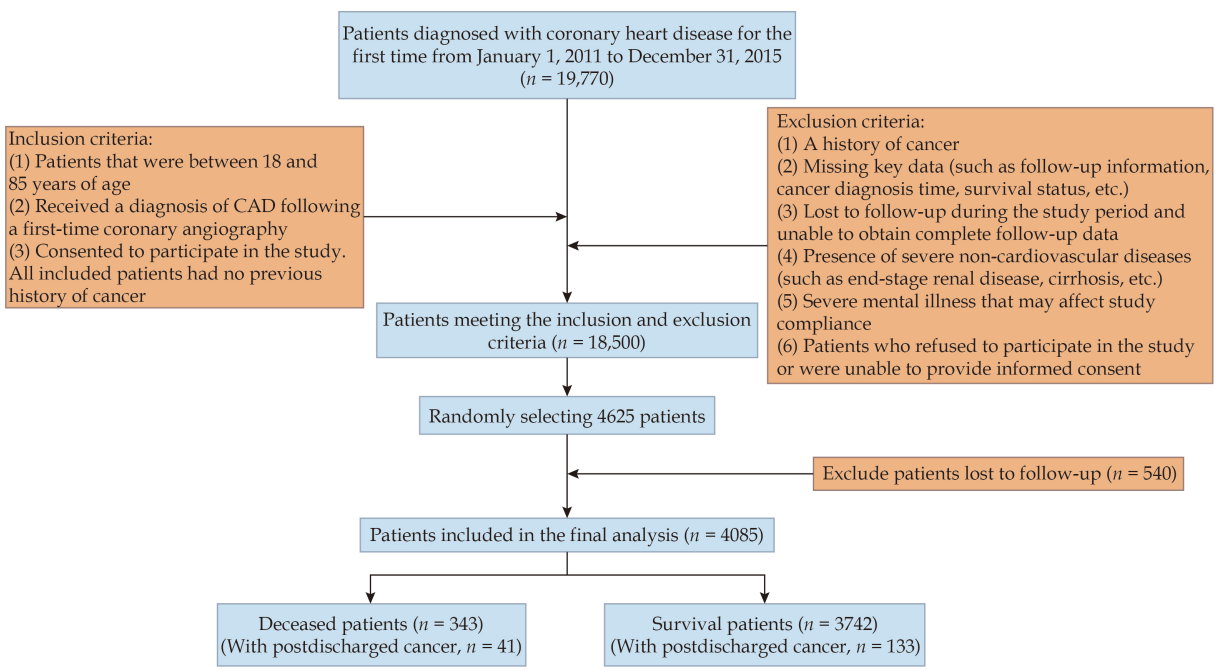

Figure 1 Flowchart of patient inclusion. CAD: coronary artery disease.

medical records, including the following classifications of CAD: stable angina, unstable angina, ST-segment elevation myocardial infarction, non-ST-segment elevation myocardial infarction, etc.; coronary angiography; whether percutaneous coronary intervention was performed; the Gensini score, which was calculated on the basis of the results of coronary angiography; left ventricular ejection fraction; cardiac troponin T; and cancer occurrence and time after discharge.

Outcomes

Outcome data were collected up to December 31, 2021. The primary endpoint was patient mortality, including cardiovascular-related deaths.

Statistical Analysis

Data analyses were performed using SPSS 25.0 (SPSS Inc., IBM, Armonk, NY, USA). Normally distributed continuous data are presented as means ± SD and were compared by the Student's *t*-test. Nonnormally distributed continuous data are represented as medians (interquartile range) and were compared using the nonparametric statistical test. Categorical data are presented as counts (percentages) and were compared using the Pearson's chi-squared test. The impact of cancer on all-cause and cardiovascular mortality was analyzed using univariate and multivariate Cox hazard regression. A *P*-value less than 0.05 was considered statistically significant.

RESULTS

Clinical Characteristics of Patients

During a median follow-up period of 8 years, 4085 patients were successfully followed up and included in the final analysis. Among the 4085 participants, 343 patients died, of which 174 patients were diagnosed with cancer after discharge. The incidence rate of cancer was 4.3%, and the mortality rate was 8.4%. A total of 1052 patients (25.8%) were aged > 65 years, 2928 patients (71.7%) were males, and 3133 patients (76.9%) had a body mass index ≥ 24 kg/m^2. There were 153 patients (3.7%) with stable angina, 2214 patients (54.2%) with unstable angina, 62 patients (1.5%) with ST-segment elevation myocardial infarction, 383 patients (9.4%) with non-ST-segment elevation myocardial infarction and 25 patients (0.6%) with stroke. There were 1195 percutaneous coronary intervention patients (29.3%), 2243 patients (54.8%) with a Gensini score > 20 and 3495 patients (85.6%) with the left ventricular ejection fraction ≥ 50%. The three most common concomitant diseases were hypertension, hyperlipidemia and diabetes mellitus, accounting for 63.1%, 47.1%, and 27.5%, respectively (Table 1).

Among the 174 patients with postdischarge cancer, 50 patients (28.7%) had lung cancer, 67 patients (38.5%) had gastrointestinal cancer, and 57 patients (32.8%) had other cancers. Other cancers include all types of cancers except lung cancer and gastrointestinal tumors; we specifically included breast cancer, prostate cancer, urinary cancer, and blood system cancer, etc. Among these types of cancer, 15 cases of breast cancer, 10 cases of prostate cancer, 12 cases of urinary system cancer, 10 cases of blood system cancer, and 10 cases of other rare cancers were included. The selection of these cancer types was based on the 10th revision of the International Classification of Diseases standards and combined with the patient's pathological diagnosis results for classification.

Among the 3742 surviving patients, 133 patients (3.6%) had postdischarge cancer. Among the 343 deceased patients, 41 patients (12.0%) had postdischarge cancer. The proportion of deceased patients who developed postdischarge cancer was significantly greater than that of surviving patients (P < 0.001) (Table 1).

Comparison of Mortality Trends in CAD Patients Stratified by Postdischarge Cancer

During the follow-up period, 41 patients (23.6%) of the 174 CAD patients with postdischarge cancer died, and 302 patients (7.7%) of the 3911 CAD patients without postdischarge cancer died. All-cause mortality among CAD patients with postdischarge cancer was greater than that among CAD patient without postdischarge cancer (23.6% *vs.* 7.7%, P < 0.001). The Kaplan-Meier curve revealed that CAD patients with postdischarge cancer had significantly higher cumulative all-cause mortality than those CAD patients without postdischarge cancer (log-rank P < 0.001) (Figure 2A).

Among the 343 deceased patients, 173 patients (50.4%) passed away from cardiovascular diseases. The cardiovascular mortality of patients with postdischarge cancer (15/174, 8.6%) was greater than that of patients without postdischarge cancer (158/3911, 4.0%) (P = 0.003). Furthermore, CAD patients with postdischarge cancer had a greater incidence of fatal acute myocardial infarction (2.3% *vs.* 0.6%, P = 0.005) and fatal stroke (1.7% *vs.* 0.7%, P = 0.005) than those CAD patients without postdischarge cancer. The cumulative cardiovascular mortality was also higher in CAD

Table 1 Clinical characteristics of patients.

Patient characteristics	Total (n = 4085)	Survival outcome		P-value	Postdischarge cancer status		P-value
		Deceased patient (n = 343)	Survival patients (n = 3742)		With postdischarge cancer (n = 174)	Without postdischarge cancer (n = 3911)	
Age > 65 yrs	1052 (25.8%)	191 (55.7%)	861 (23.0%)	< 0.001	46 (26.4%)	1006 (25.7%)	0.859
Male	2928 (71.7%)	253 (73.8%)	2675 (71.5%)	0.382	117 (67.2%)	2811 (71.9%)	0.197
Body mass index ≥ 24 kg/m^2	3133 (76.9%)	253 (73.8%)	2880 (77.2%)	0.160	135 (78.0%)	2998 (76.9%)	0.782
Smoking	2035 (49.8%)	212 (61.8%)	1823 (48.7%)	< 0.001	99 (56.9%)	1936 (49.5%)	0.063
Drinking	1698 (41.6%)	106 (30.9%)	1592 (42.5%)	< 0.001	81 (46.6%)	1617 (41.3%)	0.182
Atrial fibrillation	143 (3.5%)	18 (5.2%)	125 (3.3%)	0.089	5 (2.9%)	138 (3.5%)	0.833
Hypertension	2578 (63.1%)	239 (69.7%)	2339 (62.5%)	0.008	100 (57.5%)	2478 (63.4%)	0.127
Diabetes mellitus	1123 (27.5%)	159 (46.4%)	964 (25.8%)	< 0.001	55 (31.6%)	1068 (27.3%)	0.224
Hyperlipemia	1923 (47.1%)	140 (40.8%)	1783 (47.6%)	0.018	79 (45.4%)	1844 (47.1%)	0.698
Renal insufficiency	110 (2.7%)	25 (7.3%)	85 (2.3%)	< 0.001	3 (1.7%)	107 (2.7%)	0.629
Emphysema/Bronchitis	53 (1.3%)	15 (4.4%)	38 (1.0%)	< 0.001	2 (1.1%)	51 (1.3%)	1.000
Gastroenteritis/Gastric ulcer	194 (4.7%)	16 (4.7%)	148 (4.8%)	1.000	8 (4.6%)	186 (4.8%)	1.000
Stable angina	153 (3.8%)	17 (5.2%)	136 (4.1%)	0.310	3 (1.7%)	150 (4.3%)	0.214
Acute coronary syndrome	2659 (65.1%)	231 (67.3%)	2428 (64.9%)	0.375	101 (58.0%)	2558 (65.4%)	0.051
Old myocardial infarction	255 (6.2%)	31 (9.5%)	224 (6.7%)	0.067	14 (8.0%)	241 (6.2%)	0.258
Stroke	25 (0.6%)	24 (7.0%)	0	< 0.001	3 (1.7%)	22 (0.6%)	0.080
Percutaneous coronary intervention	1195 (29.3%)	108 (33.2%)	1087 (32.6%)	0.853	43 (24.7%)	1152 (29.5%)	0.252
Gensini score > 20	2243 (54.9%)	239 (69.7%)	2004 (53.6%)	< 0.001	99 (56.9%)	2144 (54.8%)	0.641
Left ventricular ejection fraction ≥ 50%	3495 (85.6%)	302 (92.9%)	3193 (95.8%)	0.024	149 (85.6%)	3346 (85.6%)	0.320
Troponin T, ng/L	9.00 (5.00–34.00)*	16.50 (8.00–103.75)*	9.00 (5.00–29.00)*	< 0.001	10.00 (5.75–129.50)*	9.00 (5.00–33.00)*	0.180
Hemoglobin, g/L	140.23 ± 16.24	134.67 ± 18.04	140.74 ± 15.97	< 0.001	136.64 ± 19.05	140.39 ± 16.09	0.003
Prothrombin activity	99.49 ± 14.04	94.95 ± 14.04	99.90 ± 13.69	< 0.001	100.01 ± 16.23	99.47 ± 13.94	0.589
Fibrinogen	3.33 ± 0.87	3.54 ± 0.95	3.30 ± 0.85	< 0.001	3.35 ± 0.93	3.33 ± 0.86	0.768
Glutamic pyruvic transaminase, U/L	22.50 (15.40–35.40)*	20.00 (13.48–30.90)*	23.30 (15.80–28.60)*	< 0.001	20.60 (13.40–33.20)*	23.10 (15.70–36.70)*	0.059
Glutamic oxaloacetic transaminase, U/L	19.10 (15.40–26.60)*	18.60 (14.58–26.10)*	19.40 (15.50–28.60)*	0.060	18.20 (14.15–26.65)*	19.40 (15.50–28.40)*	0.126

Data are presented as means ± SD or n (%). *Presented as median (interquartile range).

patients with postdischarge cancer than in CAD patients without postdischarge cancer (log-rank P < 0.001) (Figure 2B).

Associations between Postdischarge Cancer Incidence and Mortality in CAD Patients

Univariate Cox regression revealed that total postdischarge cancer increased the risk of all-cause death in patients with CAD (HR = 3.211, 95% CI: 2.308–4.467, P < 0.001). After adjustment for all relevant factors, postdischarge cancer was still significantly associated with the risk of all-cause death in CAD patients (HR = 2.653, 95% CI: 1.727–4.076, P < 0.001) (Table 2).

Furthermore, the associations between postdischarge cancer incidence and cardiovascular mortality in CAD patients were investigated. Postdischarge cancer was found to be significantly associated with cardiovascular mortality (HR = 2.169, 95% CI: 1.255–3.749, P = 0.006). After adjustment for all relevant factors, postdischarge cancer increased the cardiovascular mortality risk of death for CAD

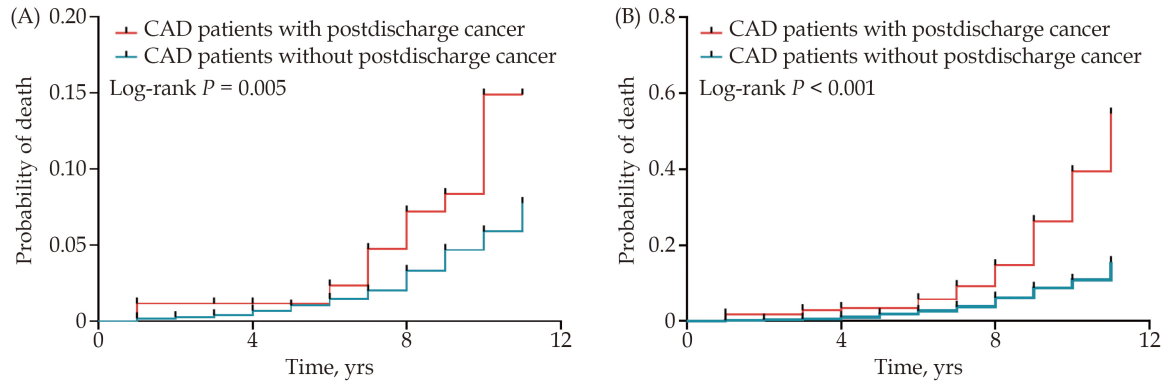

Figure 2 Kaplan-Meier analysis of mortality outcomes in CAD patients. (A): Kaplan-Meier estimated all-cause mortality; and (B): Kaplan-Meier estimated cardiovascular mortality. CAD: coronary artery disease.

Table 2 Factors influencing the risk of all-cause mortality in CAD patients.

	Unadjusted HR (95% CI)	*P*-value	Adjusted HR (95% CI)	*P*-value
Age > 65 yrs	3.858 (3.114–4.780)	< 0.001	3.529 (2.696–4.620)	< 0.001
Male	0.888 (0.698–1.130)	0.336		
Body mass index ≥ 24 kg/m^2	0.851 (0.669–1.083)	0.188		
Smoking	1.659 (1.333–2.064)	< 0.001	2.336 (1.739–3.139)	< 0.001
Drinking	0.634 (0.504–0.799)	< 0.001	0.571 (0.424–0.770)	< 0.001
Atrial fibrillation	1.546 (0.961–2.485)	0.072		
Hypertension	1.340 (1.064–1.689)	0.013	1.106 (0.842–1.453)	0.470
Diabetes mellitus	2.349 (1.898–2.908)	< 0.001	1.622 (1.262–2.084)	< 0.001
Hyperlipemia	0.784 (0.632–0.973)	0.027	0.893 (0.694–1.150)	0.380
Renal insufficiency	3.109 (2.069–4.672)	< 0.001	1.667 (1.009–2.754)	0.046
Emphysema/Bronchitis	3.970 (2.365–6.662)	< 0.001	0.851 (0.424–1.709)	0.650
Gastroenteritis/Gastric ulcer	1.395 (0.959–2.029)	0.082		
Stable angina	1.074 (0.649–1.776)	0.782		
Acute coronary syndrome	1.093 (0.872–1.371)	0.441		
Old myocardial infarction	1.478 (1.021–2.141)	0.039	1.015 (0.677–1.523)	0.942
Stroke	21.354 (14.182–32.154)	< 0.001	6.573 (3.739–11.555)	< 0.001
Percutaneous coronary intervention	1.148 (0.910–1.448)	0.244		
Gensini score > 20	1.998 (1.584–2.519)	< 0.001	1.004 (1.001–1.007)	0.003
Left ventricular ejection fraction ≥ 50%	0.664 (0.427–1.034)	0.070		
Troponin T	1.021 (0.994–1.050)	0.130		
Hemoglobin	0.981 (0.975–0.987)	< 0.001	0.996 (0.988–1.005)	0.387
Prothrombin activity	0.974 (0.968–0.981)	< 0.001	0.988 (0.980–0.996)	0.003
Fibrinogen	1.312 (1.182–1.456)	< 0.001		
Glutamic pyruvic transaminase	1.000 (0.998–1.002)	0.181		
Glutamic oxaloacetic transaminase	1.000 (0.998–1.002)	0.872		
Cancer	3.211 (2.308–4.467)	< 0.001	2.653 (1.727–4.076)	< 0.001

CAD: coronary artery disease.

patients by 2.756 times (95% CI: 1.470–5.167, P = 0.002) (Table 3).

In this study, lung cancer and gastrointestinal cancer were the two most common cancers. In order to further investigate the effects of different cancers on the mortality of CAD patients, we divided cancer patients into three groups: the lung cancer group, the gastrointestinal cancer group and the other cancer group.

After adjusting for relevant factors, both lung cancer (HR = 5.497, 95% CI: 2.922–10.343, P < 0.001) and gasttrointes-

tinal cancer (HR = 1.984, 95% CI: 1.049–3.750, P = 0.035) were associated with all-cause mortality in CAD patients. Other cancers were not significantly associated with all-cause mortality (HR = 1.657, 95% CI: 0.526–5.223, P = 0.388).

Lung cancer was associated with cardiovascular mortality (HR = 4.979, 95% CI: 2.114–11.728, P < 0.001). However, there was no significant correlation between cardiovascular mortality and either gastrointestinal cancer (HR = 0.966, 95% CI: 0.311–2.996, P = 0.952) or other cancers (HR = 0.894, 95% CI: 0.124–6.448, P = 0.911) (Table 4).

DISCUSSION

The present study revealed that both cardiovascular mo-

Table 3 Factors influencing the risk of cardiovascular mortality in CAD patients.

	Unadjusted HR (95% CI)	*P*-value	Adjusted HR (95% CI)	*P*-value
Age > 65 yrs	3.921 (2.893–5.314)	< 0.001	3.255 (2.236–4.740)	< 0.001
Male	0.871 (0.618–1.229)	0.432		
Body mass index ≥ 24 kg/m^2	0.843 (0.599–1.185)	0.326		
Smoking	1.383 (1.019–1.876)	0.037	1.470 (0.974–2.219)	0.066
Drinking	0.722 (0.525–0.994)	0.046	0.819 (0.537–1.249)	0.355
Atrial fibrillation	1.195 (0.561–2.547)	0.645		
Hypertension	1.430 (1.026–1.994)	0.035		
Diabetes mellitus	2.262 (1.671–3.062)	< 0.001	1.465 (1.033–2.079)	0.032
Hyperlipemia	0.735 (0.540–1.001)	0.051		
Renal insufficiency	3.533 (2.044–6.105)	< 0.001	1.555 (0.767–3.152)	0.221
Emphysema/Bronchitis	4.814 (2.459–9.423)	< 0.001	0.668 (0.257–1.736)	0.408
Gastroenteritis/Gastric ulcer	1.004 (0.545–1.850)	0.990		
Stable angina	1.654 (0.918–2.979)	0.094		
Acute coronary syndrome	1.012 (0.739–1.386)	0.942		
Old myocardial infarction	1.616 (0.978–2.672)	0.061		
Stroke	41.639 (26.724–64.878)	< 0.001	21.025 (10.976–40.274)	< 0.001
Percutaneous coronary intervention	0.962 (0.686–1.349)	0.824		
Gensini score > 20	2.501 (1.769–3.536)	< 0.001	1.571 (1.039–2.375)	0.032
Left ventricular ejection fraction ≥ 50%	0.454 (0.267–0.773)	0.004	0.583 (0.318–1.067)	0.080
Troponin T	1.032 (0.997–1.068)	0.073		
Hemoglobin	0.977 (0.969–0.985)	< 0.001	0.996 (0.984–1.007)	0.450
Prothrombin activity	0.976 (0.966–0.985)	< 0.001	0.987 (0.975–0.999)	0.041
Fibrinogen	1.448 (1.263–1.659)	< 0.001	1.257 (1.053–1.499)	0.011
Glutamic pyruvic transaminase	0.984 (0.975–0.994)	0.001	0.999 (0.995–1.002)	0.452
Glutamic oxaloacetic transaminase	1.000 (0.997–1.002)	0.825		
Cancer	2.169 (1.255–3.749)	0.006	2.756 (1.470–5.167)	0.002

CAD: coronary artery disease.

Table 4 Association between different cancers and mortality rates.

	All-cause mortality			Cardiovascular mortality		
	HR	95% CI	*P*-value	HR	95% CI	*P*-value
Patients without cancer	Reference			Reference		
Lung cancer	5.497	2.922–10.343	< 0.001	4.979	2.114–11.728	< 0.001
Gastrointestinal cancer	1.984	1.049–3.750	0.035	0.966	0.311–2.996	0.952
Others	1.657	0.526–5.223	0.388	0.894	0.124–6.448	0.911

Association between different cancers and all-cause mortality, adjusted for age, smoking, drinking, hypertension, diabetes mellitus, hyperlipemia, renal insufficiency, emphysema/bronchitis, old myocardial infarction, stroke, Gensini score, N-terminal pro-B-type natriuretic peptide, hemoglobin, platelet, total cholesterol, low-density lipoprotein cholesterol, prothrombin activity, and creatinine. Association between different cancers and cardiovascular mortality, adjusted for age, smoking, drinking, diabetes mellitus, renal insufficiency, emphysema/bronchitis, stroke, Gensini score, left ventricular ejection fraction, N-terminal pro-B-type natriuretic peptide, hemoglobin, platelet, low-density lipoprotein cholesterol, prothrombin activity, fibrinogen, glutamic pyruvic transaminase, and creatinine.

rtality and all-cause mortality were greater in CAD patients with postdischarge cancer than in CAD patients without postdischarge cancer. Postdischarge cancer was associated with all-cause mortality and cardiovascular mortality in CAD patients. Postdischarge lung cancer had a more significant impact on all-cause mortality and cardiovascular mortality than other cancers in CAD patients. The results indicated that higher all-cause mortality may be attributed to higher cardiovascular mortality in CAD patients with cancer, and more studies are needed to optimize clinical management to decrease cardiovascular mortality for CAD patients with cancer, especially for CAD patients with lung cancer.

Previous studies have shown that the incidence of cancer in patients with CAD is significantly greater than that in patients without CAD.[17] The presence of polyvascular disease may be associated with the incidence of cancer in patients with CAD.[18] In a cohort study, the incidence of new cancers in patients with atherosclerotic cardiovascular disease was more than twice that in patients with nonatherosclerotic cardiovascular disease.[19] According to the latest data from the Chinese National Cancer Center, the age-standardized incidence rate of cancer in the general population in China in 2022 is approximately 208.6 per 100,000 individuals.[20] In the context of our study, we take the 2022 population division of China published by the United Nations as the standard population[21] and calculate the population proportion every five years as an age group. The age-standardized incidence rate of cancer in this study population is approximately 301.7 per 100,000 people. The age standardized incidence rate of cancer in patients with coronary heart disease is 44.65% higher than that in the general population. Previous studies on prognostic evaluation models for patients with CAD have likely included hypertension, diabetes mellitus, obesity, smoking, dyslipidemia, cardiac troponin T, N-terminal pro-B-type natriuretic peptide and other biomarkers.[22] However, current research shows that tumors often occur in patients with CAD, thus evaluating the prognosis of CAD patients while excluding cancer patients may be insufficient. Clarifying how cancer affects mortality in CAD patients is important, particularly in regard to cardiovascular mortality in patients with CAD. Some studies have reported the mortality rate of cancer in patients with CAD and the impact of CAD on the all-cause mortality rate in cancer patients.[22,23] However, there is currently no research on the impact of cancer on cardiovascular mortality in patients with CAD. In the long-term management strategy of patients with CAD, whether it is necessary to strengthen cancer screening and how to manage it have not been considered.

New cancers increase the risk of death in patients with CAD, which may be related to the following reasons: (1) the incidence of cancers in patients with CAD is higher than that in the general population, increasing the probability of death due to cancers;[24] (2) the occurrence and development of cancers increase cardiovascular events and the risk of cardiovascular death in patients with CAD;[25] and (3) CAD and cancer coexist in the same individual, and the difficulty of treatment and intervention is increased for both CAD and cancer, which further worsens the prognosis of patients.[26]

In this study, the distribution of fatal causes revealed that cardiovascular-related diseases accounted for 52.6% of death. These findings indicate that cardiovascular diseases are the leading cause of mortality among patients with CAD. Compared with patients without postdischarge cancer, those with cancer face a greater risk of death from cardiovascular diseases. In addition to cancer-related death, cancer can promote death due to myocardial infarction and other ischemic cardiovascular disease, for which there are many factors, including cancer therapy; a number of medications and techniques used to treat cancer, including radiation, chemotherapy, and targeted therapy pharmaceuticals, can be harmful to the heart.[27,28] Chronic inflammation and immune responses are linked to the development of both cardiovascular disease and cancer, potentially impairing heart function and increasing the risk of cardiovascular death.[29] Cancer can also trigger a hypercoagulable state in patients, which is closely associated with cardiovascular-related deaths. This hypercoagulable state can lead to the formation of blood clots within the cardiovascular system, blocking blood flow and causing severe cardiac events such as myocardial infarction, sudden cardiac death and cardiac arrest, ultimately leading to cardiogenic death.[30,31] Finally, psychological and lifestyle factors can also affect the mortality rate of patients. Heart health may be impacted by anxiety and depression experienced by cancer patients,[32] and unhealthy lifestyles, such as a lack of exercise and an unbalanced diet, can also have a negative impact on heart health.[33]

The association between lung cancer and cardiovascular mortality is most significant and may be related to multiple biological mechanisms. First, lung cancer patients often have chronic hypoxia,[34] which can lead to pulmonary arterial hypertension and right heart dysfunction, thereby increasing the risk of cardiovascular death. In addition, lung cancer patients may develop paraneoplastic syndromes that affect cardiac function, such as a syndrome involving inappropriate secretion of antidiuretic hormone, which can lead to hyponatremia and cellular edema, affecting cardiac function.[35] Finally, lung cancer treatments such as surg-

ery, chemotherapy, and radiation therapy may also have direct or indirect toxic effects on the cardiovascular system.[36] For example, chest radiation therapy can lead to radiation-induced pericarditis and coronary artery damage, whereas chemotherapy drugs may cause myocardial cell apoptosis and myocardial fibrosis.[37,38] For CAD patients with postdischarge cancer, it is crucial to assess cardiovascular risk before starting treatment, considering their personal and family medical histories and current heart health. A collaborative approach involving various specialists is necessary for comprehensive care. Healthy habits such as quitting smoking, limiting alcohol consumption, exercising, and eating well should be encouraged. Given the cardiac effects of chemotherapies and targeted therapies, treatments should be adjusted to minimize risks. Regular cardiac monitoring, such as electrocardiograms and blood pressure checks, is vital, especially for patients receiving treatments such as anthracyclines that can affect heart function.

LIMITATIONS

There are several limitations of this study. Firstly, our conclusion that lung cancer has a more significant effect on all-cause and cardiovascular mortality in postdischarge coronary heart disease patients than other cancers may be biased because 70% of the population in our study was male. Considering the strong correlation between male sex and lung cancer, our findings should be interpreted with caution. Future research should include more female patients to verify the impact of lung cancer on mortality across different sexes. Secondly, we performed a sensitivity analysis on the 540 patients who were lost to follow-up and compared their basic characteristics with those of the patients who remained in the study through descriptive statistical analysis. The results indicated that there were no significant differences in baseline characteristics between the lost and retained patients, and the impact of the loss to follow-up status on the main research outcomes was minimal. Future research should strive to minimize follow-up losses as much as possible to increase the reliability of the findings. Thirdly, we did not collect detailed cancer treatment data, which may have overlooked factors influencing cardiovascular outcomes. Cancer therapies, especially chemotherapy and radiation, can increase cardiovascular event risk. Future studies should gather this information and adjust for confounders to better assess the relationship between cancer incidence and cardiovascular mortality. Last but not least, the small sample size of the other cancers subgroup (n = 57) limited the efficacy of our statistical analysis. The lack of a significant association between other cancers and cardiovascular mortality should be interpreted cautiously because of the limited sample size. Future research should increase the sample size to improve the statistical power of subgroup analyses.

CONCLUSIONS

In summary, this study revealed that postdischarge cancer was associated with increased all-cause mortality and cardiovascular mortality in CAD patients. Moreover, compared with other cancers, postdischarge lung cancer may present a greater risk of all-cause mortality and cardiovascular mortality in CAD patients. The results indicated that higher all-cause mortality may be attributed to higher cardiovascular mortality in CAD patients with cancer. In the future, more studies are needed to optimize clinical management to decrease cardiovascular mortality in CAD patients with cancer, especially CAD patients with lung cancer.

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