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Original Research

Which Parameter Related to Low-Density Lipoprotein Cholesterol is Superior for Predicting the Recurrence of Myocardial Infarction in Young Patients with Previous Coronary Heart Disease? A Real-World Study

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Abstract

Background: Lowering low-density lipoprotein cholesterol (LDL-C) is a well-established strategy for the secondary prevention of coronary heart disease (CHD). However, the effectiveness of specific LDL-C parameters in predicting myocardial infarction (MI) recurrence in real-world settings remains inadequately explored. This study aims to examine the relationship between MI recurrence and various LDL-C parameters in young CHD patients. **Methods**: This retrospective cohort study involved 1013 patients aged 18–44 at the time of initial CHD diagnosis, collected from the cardiology department clinics at Beijing Anzhen Hospital between October 2022 and October 2023. LDL-C levels were assessed at the time of CHD diagnosis and at the final follow-up. The primary outcome was MI events, analyzed using survival analysis and logistic regression models to determine associations with LDL-C parameters. **Results**: The study included 1013 patients (mean age: 38.5 $\pm$ 3.9 years; 94.7% men), with a median follow-up time of 1.7 years. Initially, 13.6% had LDL-C levels $<$1.8 mmol/L, which increased to 37.8% by the study's end. During follow-up, 96 patients (9.5%) experienced MI. While LDL-C $<$1.8 mmol/L at baseline showed a slightly lower cumulative incidence of MI than LDL-C $\geq$1.8 mmol/L, the difference was not statistically significant (log-rank $p = 0.335$). Reductions in LDL-C levels of $\geq$50% and the patterns of change did not correlate with decreased MI risk. However, LDL-C $<$1.4 mmol/L at the final measurement was associated with a reduced MI risk (adjusted odds ratio [OR]: 0.57, 95% confidence interval [CI]: 0.33–0.98) compared with LDL-C $\geq$2.6 mmol/L. **Conclusions**: This study suggests that the most important parameter related to LDL-C for predicting the recurrence of MI in young patients with a history of CHD is the ideal target LDL-C level. Lowering LDL-C to $<$1.4 mmol/L could potentially reduce MI risk, regardless of baseline LDL-C levels.

Keywords: coronary heart disease; LDL cholesterol; myocardial infarction; secondary prevention

1. Introduction

Cardiovascular disease (CVD) is increasingly prevalent among younger individuals (aged 15–44), with the absolute number of CVD incidents and related deaths rising by 45.5% and 21.6%, respectively, from 1990 to 2019. Coronary heart disease (CHD) remains the leading cause of disability-adjusted life years (DALY) burden [1]. Previous studies have shown that individuals with a history of CHD are at an elevated risk for recurrent CHD events or cardiovascular-related hospitalizations across all age groups [2–4]. However, data on recurrent events in younger patients are scarce [5].

Lowering low-density lipoprotein cholesterol (LDL-C) is a crucial measure for both primary and secondary CHD prevention. Current evidence suggests that reducing LDL-C by $>$50% and managing other risk factors can lead to a decrease or even a disappearance of atherosclerotic plaques [6–8]. Continuous benefits have been observed in patients achieving LDL-C levels below 25 mg/dL [9–11]. Some clinical guidelines recommend lipid-lowering treatment with an LDL-C target of $<$1.8 mmol/L and a reduction of $\geq$50% from baseline for patients with CHD [12,13]. The 2024 European Society of Cardiology (ESC) Guidelines for the management of dyslipidaemia and chronic coronary syndromes advocate for a more stringent LDL-C target of $<$1.4 mmol/L [14,15]. Variations in LDL-C level changes over time are critical parameters that may indicate potential associations with CHD. However, the examination of dynamic trajectories in LDL-C levels remains underexplored in contemporary research [8]. Moreover, several studies have highlighted that elevated LDL-C levels at a young age correlate with increased CVD risks later in life, independent of subsequent adult exposures [16–18].

This real-world cohort study aimed to identify the LDL-C parameters that are most effective in predicting my-

ocardial infarction (MI) recurrence in young patients with a history of CHD. We assessed the relationship between baseline LDL-C levels, LDL-C control at the end of the study, extent of LDL-C reduction, and patterns of LDL-C changes with subsequent MI events in patients aged 18–44 years at the time of their initial hospitalization for CHD.

2. Methods

2.1 Participants

This retrospective cohort study involved 1013 patients aged 18–44 years who were hospitalized for their first occurrence of CHD. Data were collected from the cardiology department at Beijing Anzhen Hospital between October 2022 and October 2023. Patients with secondary diagnoses of prior CHD, previous percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), post-acute myocardial infarction (AMI) syndrome, chronic ischemic heart disease, heart failure (before or after CHD diagnosis), arteritis, congenital heart disease, and cancer, as well as those without specific information at the time of their first CHD diagnosis and those with a history of CHD <3 months prior were excluded.

The study protocol was reviewed and approved by the Ethics Committee of Beijing Anzhen Hospital. Written informed consent was obtained from all participants prior to their inclusion in the study.

2.2 Data Collection

Baseline information was collected from the hospital's electronic medical records and other medical documents by trained abstractors. Collected demographic information included sex and age, while exposure to risk factors was assessed, including obesity, medical history of hypertension and diabetes, LDL-C levels, and smoking habits. Data on secondary prevention therapies, such as the use of aspirin, β-blockers, angiotensin receptor blockers/angiotensin-converting enzyme inhibitors (ARB/ACEI), and lipid-lowering therapy, were also gathered. Biochemical indicators recorded included hemoglobin A1c (HbA1c), triglycerides (TG), total cholesterol (TC), LDL-C, and high-density lipoprotein cholesterol (HDL-C). Coronary angiographic findings were reviewed to document the presence of occlusion or stenosis in the native coronary arteries (including the left main, left anterior descending, circumflex, and right coronary arteries). Follow-up information was collected through face-to-face interviews, which included changes in smoking habits, newly diagnosed hypertension and diabetes, secondary MI events, secondary preventive therapy, and coronary revascularization. For biochemical indicators, data from the last 3 months were recorded, or blood samples were collected and measured. Anthropometric data, such as height, weight, and blood pressure, were measured following standard procedures in the clinics.

2.3 Measurements and Diagnostic Criteria

Hypertension and diabetes were defined based on documented histories in medical records. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2), with obesity defined as BMI $\geq$28 kg/m^2. Smokers were defined as those who reported smoking $>$100 cigarettes or for $>$6 months, with a cessation time of $<$6 months. The optimal target for LDL-C was set at $<$1.8 mmol/L. Baseline LDL-C levels were categorized into two groups: $<$1.8 mmol/L and $\geq$1.8 mmol/L. The last LDL-C measurements were categorized into four groups: $<$1.4 mmol/L, 1.4–1.79 mmol/L, 1.8–2.59 mmol/L, and $\geq$2.6 mmol/L. The degree of LDL-C reduction was calculated as the difference between LDL-C levels at the end of the study and at baseline divided by the LDL-C levels at baseline. This reduction was categorized into four groups: $<$0%, 0%–29.9%, 30%–49.9%, and $\geq$50%. A trajectory model was used to determine the temporal development of LDL-C levels: LDL-C-uncontrolled ($\geq$1.8 mmol/L at both baseline and end of the study), LDL-C-worsened (LDL-C $<$1.8 mmol/L at baseline and $\geq$1.8 mmol/L at the end), LDL-C-improved (LDL-C $\geq$1.8 mmol/L at baseline and $<$1.8 mmol/L at the end), and LDL-C-controlled (LDL-C $<$1.8 mmol/L at both baseline and end). Coronary artery disease was defined as the presence of significant stenosis ($\geq$50%) in the main coronary arteries, as confirmed by coronary angiography, including the left main coronary artery (LM), left anterior descending artery (LAD), left circumflex artery (LCX), and right coronary artery (RCA). Single vessel lesion was defined as a stenosis of $\geq$50% in the LAD, LCX, or RCA. Multi-vessel disease is defined as a stenosis of $\geq$50% in two or three of these vessels (LAD, LCX, and RCA) or $\geq$50% in the LM.

The primary endpoint was secondary MI events. MI was defined according to established criteria [19], which included both ST-segment elevation MI (STEMI) and non-ST-segment elevation MI (NSTEMI), with information obtained from relevant hospital records.

2.4 Statistical Analysis

Categorical variables were expressed as counts and percentages, with differences in groups compared using chi-square tests or Fisher's exact tests when any expected cell count was $<$5. Continuous variables with normal distributions were presented as mean $\pm$ standard deviation, while those with skewed distributions were presented as median (interquartile range). Student's t-test was used to compare two independent samples for normally distributed continuous variables, and the Mann-Whitney U-test was used for continuous variables with skewed distributions. Kaplan-Meier survival analysis was utilized to compare the impact of baseline LDL-C levels on MI events, with the log-rank method employed to test for significant differences between groups. Logistic regression models were utilized to examine the relationships between the extent of LDL-C reduc-

tion, pattern of LDL-C changes, and last recorded LDL-C level with MI events. These models calculated crude and adjusted odds ratios (ORs) along with corresponding 95% confidence intervals (95% CIs). All reported *p*-values were two-sided, with $p < 0.05$ considered statistically significant. Statistical analysis was conducted using IBM SPSS Statistics version 25.0 (IBM, Armonk, NY, USA).

3. Results

3.1 Main Characteristics at Baseline and Study End

Our study included 1013 patients, with a mean age of 38.5 $\pm$ 10.8 years at the time of CHD diagnosis. The majority of participants were male (94.7%). Among these patients, 547 (54.0%) presented with multi-vessel disease, 786 (77.6%) underwent PCI, 155 (15.3%) were managed solely with medication, and 72 (7.1%) underwent CABG.

At baseline, the prevalence rates of hypertension (48.0% vs. 55.0%) and diabetes (19.6% vs. 26.7%) were lower than those at the end of the study. Conversely, the prevalence rates of smoking (75.1% vs. 36.2%) and obesity (37.9% vs. 34.2%) were higher at baseline. Among the patients who smoked at baseline, 51.8% (394 of 761) quit smoking during the study period. Significant improvements were observed in the mean levels of HbA1c, diastolic blood pressure (DBP), TC, LDL-C, HDL-C, non-HDL-C, and TG at the end of the study (all $p < 0.05$). Specifically, the mean LDL-C decreased from 2.83 $\pm$ 1.10 mmol/L to 2.28 $\pm$ 0.93 mmol/L, while the mean non-HDL-C decreased from 2.59 $\pm$ 1.10 mmol/L to 1.98 $\pm$ 1.07 mmol/L. A high percentage of patients received secondary preventive therapy, particularly by the end of the study. At baseline, 88.4% of patients were prescribed a statin, 8.5% were taking ezetimibe, and none were on a proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitor. By the end of the study, these percentages increased to 91.2%, 36.2%, and 3.8%, respectively (Table 1).

3.2 Lipid Indicators across Different Years after Discharge

Lipid levels, including LDL-C, non-HDL-C, HDL-C, and TG, were assessed at various time points following discharge (Table 2). Compared with baseline, all lipid indicators showed significant improvements. The percentage of patients achieving ideal targets for LDL-C, non-HDL-C, and TG peaked in the first year post-discharge, followed by a subsequent decline ($p < 0.05$). In contrast, no significant differences in HDL-C levels were observed across the different years following discharge ($p = 0.169$). Initially, 4.6% of patients had LDL-C levels $<$1.4 mmol/L, while 13.6% had levels $<$1.8 mmol/L. These percentages increased to 17.2% and 37.8%, respectively, within the first year, before slightly decreasing to 12.5% and 28.6%, respectively, 3 years later.

3.3 Parameters Related to LDL-C

At the study's outset, 138 of 1013 individuals achieved the ideal LDL-C target of $<$1.8 mmol/L. By the end of the study, the proportion of individuals meeting this target significantly increased: 71.7% of those with baseline LDL-C $<$1.8 mmol/L compared with 28.1% of those with LDL-C $\geq$1.8 mmol/L at baseline ($p < 0.001$). The patterns of LDL-C changes were categorized as follows: LDL-C-uncontrolled (62.1%), LDL-C-worsen (3.8%), LDL-C-improved (24.3%), and LDL-C-controlled (9.8%).

We calculated the difference between baseline LDL-C and the endpoint levels, revealing the distribution of LDL-C reductions: 26.9% of patients experienced an increase in LDL-C (reduction $<$0%), 39.6% had a reduction of 0%–29.9%, 23.9% had a reduction of 30%–49.9%, and 9.6% had a reduction of $\geq$50%.

3.4 Impact of Baseline LDL-C Levels on the Occurrence of MI Events

During a median follow-up period of 1.7 years (interquartile range: 1.0–3.0 years), 96 new cases of MI were identified. The crude rates of MI events over time were as follows: 1-year MI rate: 2.1%, 3-year rate: 5.8%, 5-year rate: 8.2%, and $\geq$8-year rate: 9.7% (Fig. 1).

Kaplan-Meier survival analysis curves (Fig. 2) illustrated the cumulative incidence of MI events in two groups, based on a baseline LDL-C threshold of 1.8 mmol/L. The group with LDL-C levels $<$1.8 mmol/L exhibited a slightly lower cumulative incidence of MI events than those with LDL-C levels $\geq$1.8 mmol/L. However, this difference did not reach statistical significance (log-rank $p = 0.335$).

Univariate Cox regression analysis indicated no significant association between baseline LDL-C levels and the risk of MI occurrence (HR = 0.99, 95% CI: 0.84–1.17). After adjusting for age, sex, history of AMI, three-vessel disease, and treatment measures (Model 2), as well as for hypertension, diabetes, smoking status, HDL-C, TG, and BMI (Model 3), LDL-C levels remained insignificantly associated with MI risk (all $p > 0.05$). Sensitivity analyses using categorical variables showed that LDL-C levels $<$1.8 mmol/L did not significantly reduce the risk of MI compared with LDL-C levels $\geq$1.8 mmol/L, regardless of confounding adjustments (Table 3).

3.5 Association between other Parameters Related to LDL-C and MI Occurrence

We analyzed the relationship between the pattern of LDL-C changes and the risk of MI events, using LDL-C-uncontrolled as the reference group. Both univariate and multivariate analyses failed to demonstrate a significant correlation between the trajectory of LDL-C changes (including LDL-C-worsen, LDL-C-improved, and LDL-C-controlled) and the occurrence of MI events (Table 4).

We also compared the risk of MI based on the degree of LDL-C level reduction, using a reduction of 0–29.9% as the reference group. The findings indicated that reductions

Table 1. Main characteristics at baseline and end of the study.

Parameters	Baseline	Study end	*p* value
Risk factors			
Hypertension, n (%)	486 (48.0)	557 (55.0)	0.002
Diabetes, n (%)	199 (19.6)	270 (26.7)	<0.001
BMI ≥28, n (%)	384 (37.9)	346 (34.2)	0.079
Current smoker, n (%)	761 (75.1)	367 (36.2)	<0.001
HbA1c (%)	6.2 ± 1.3	6.1 ± 1.2	0.011
SBP (mmHg, $\bar{x} \pm s$)	125 ± 17	124 ± 14	0.154
DBP (mmHg, $\bar{x} \pm s$)	79 ± 12	78 ± 11	0.004
TC (mmol/L, $\bar{x} \pm s$)	4.53 ± 1.41	3.90 ± 1.18	<0.001
LDL-C (mmol/L, $\bar{x} \pm s$)	2.83 ± 1.10	2.28 ± 0.93	<0.001
HDL-C (mmol/L, $\bar{x} \pm s$)	0.90 ± 0.21	0.94 ± 0.21	<0.001
Non-HDL-C (mmol/L, $\bar{x} \pm s$)	2.59 ± 1.10	1.98 ± 1.07	<0.001
TG (mmol/L, median [IQR])	1.93 (1.37, 2.81)	1.66 (1.15, 2.40)	<0.001
Drug use for secondary prevention			
Aspirin, n (%)	942 (93.0)	964 (95.2)	0.038
Beta receptor blocker, n (%)	772 (76.2)	855 (84.4)	<0.001
ARB/ACEI, n (%)	604 (59.6)	735 (72.6)	<0.001
Statin, n (%)	895 (88.4)	924 (91.2)	0.033
Ezetimibe, n (%)	86 (8.5)	367 (36.2)	<0.001
PCSK9 inhibitor, n (%)	0	38 (3.8)	<0.001

ARB/ACEI, angiotensin receptor blocker/angiotensin-converting enzyme inhibitor; BMI, body mass index; DBP, diastolic blood pressure; HbA1c, hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LDL-C, low-density lipoprotein cholesterol; PCSK9, proprotein convertase subtilisin/kexin type 9; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride.

Table 2. Lipid levels across different years after discharge [n (%)].

Lipid parameters	Baseline (n = 1013)	Years from discharge				
		≤1 (n = 472)	1–3 (n = 349)	>3 (n = 192)	χ^2	*p* value
LDL-C group (mmol/L)					5.973	0.016
<1.4	47 (4.6)	81 (17.2)	43 (12.3)	24 (12.5)		
1.4–1.79	91 (9.0)	97 (20.6)	69 (19.8)	31 (16.1)		
1.8–2.59	341 (33.7)	181 (38.3)	122 (35.0)	66 (34.4)		
≥2.6	534 (52.7)	113 (23.9)	115 (33.0)	71 (37.0)		
HDL-C group (mmol/L)					1.888	0.169
<1.0	747 (73.7)	302 (64.0)	229 (65.6)	134 (69.8)		
≥1.0	266 (26.3)	170 (36.0)	120 (34.4)	58 (30.2)		
Non-HDL-C group (mmol/L)					27.440	<0.001
<2.6	199 (19.6)	333 (49.4)	146 (41.8)	67 (34.9)		
2.6–3.39	311 (30.7)	146 (30.9)	92 (26.4)	57 (29.7)		
3.4–4.09	210 (20.7)	51 (10.8)	48 (13.8)	24 (12.5)		
≥4.1	293 (28.9)	42 (8.9)	63 (18.1)	44 (22.9)		
TG group (mmol/L)					20.374	<0.001
<1.7	409 (40.4)	281 (59.5)	165 (47.3)	81 (42.2)		
1.7–2.29	225 (22.2)	86 (18.2)	75 (21.5)	44 (22.9)		
≥2.3	379 (37.4)	105 (22.2)	109 (31.2)	67 (34.9)		

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglyceride.

of 30–49.9% or ≥50% were not associated with a decreased risk of MI events (Table 4).

Additionally, we examined the association between LDL-C levels at the last recorded measurement and MI risk, with LDL-C ≥2.6 mmol/L as the reference group. Results showed that individuals with LDL-C <1.4 mmol/L had a significantly decreased risk of MI events, with a crude OR of 0.45 (95% CI: 0.27–0.75) and an adjusted OR of 0.57

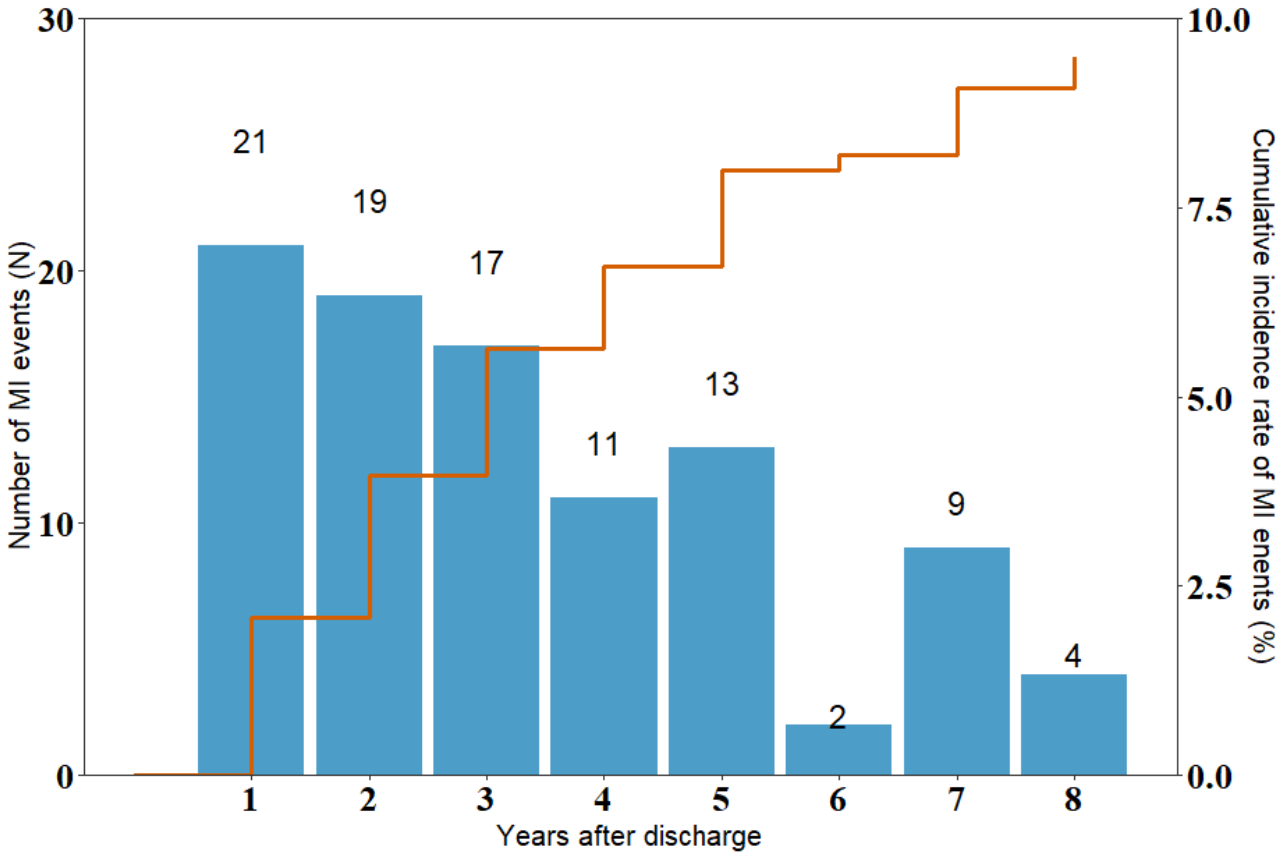

Fig. 1. Distribution of myocardial infarction (MI) events during a median follow-up period of 1.7 years.

Table 3. Cox regression analysis of the association between baseline LDL-C and MI events.

Variable	Model 1			Model 2			Model 3		
	HR	95% CI	*p* value	HR	95% CI	*p* value	HR	95% CI	*p* value
Continuous LDL-C level	0.99	0.84–1.17	0.898	0.98	0.85–1.13	0.791	0.96	0.83–1.12	0.608
LDL-C group									
≥1.8 mmol/L	ref			ref			ref		
<1.8 mmol/L	0.72	0.35–1.42	0.340	0.63	0.36–1.09	0.100	0.64	0.36–1.12	0.119

Model 1: unadjusted; Model 2: adjusted for age, sex, history of AMI, three-vessel disease, and treatment measures; Model 3: adjusted for age, sex, history of AMI, three-vessel disease, treatment measures, hypertension, diabetes, current smoking, HDL-C, TG, and BMI at baseline. AMI, acute myocardial infarction; BMI, body mass index; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; HR, hazard ratio; LDL-C, low-density lipoprotein cholesterol; MI, myocardial infarction; TG, triglyceride.

(95% CI: 0.33–0.98). However, no significant reductions in MI risk were observed among individuals with LDL-C levels of 1.8–2.59 mmol/L and 1.4–1.79 mmol/L (Table 4).

4. Discussion

Lowering LDL-C is a critical strategy for the secondary prevention of CHD. This study aimed to assess the association between various LDL-C parameters and MI incidence among young patients with a history of CHD. Our findings revealed no correlation between baseline LDL-C levels, extent of LDL-C reduction, or pattern of LDL-C changes and the risk of secondary MI events. However, individuals with LDL-C levels <1.4 mmol/L at the end of the study experienced a 43% reduced risk of secondary MI events compared with those with levels ≥2.6 mmol/L. These results suggest that maintaining LDL-C <1.4 mmol/L can effectively decrease the risk of secondary MI, regardless of initial LDL-C levels.

Previous studies have shown that elevated LDL-C levels at a young age may have a stronger association with CHD than lower LDL-C levels in adulthood [16–18]. This emphasizes the importance of baseline LDL-C levels before the onset of CHD. Moreover, increasing evidence suggests that reducing and maintaining LDL-C <1.8 mmol/L, alongside strict control of risk factors, can prevent both the onset and progression of atherosclerosis at younger ages

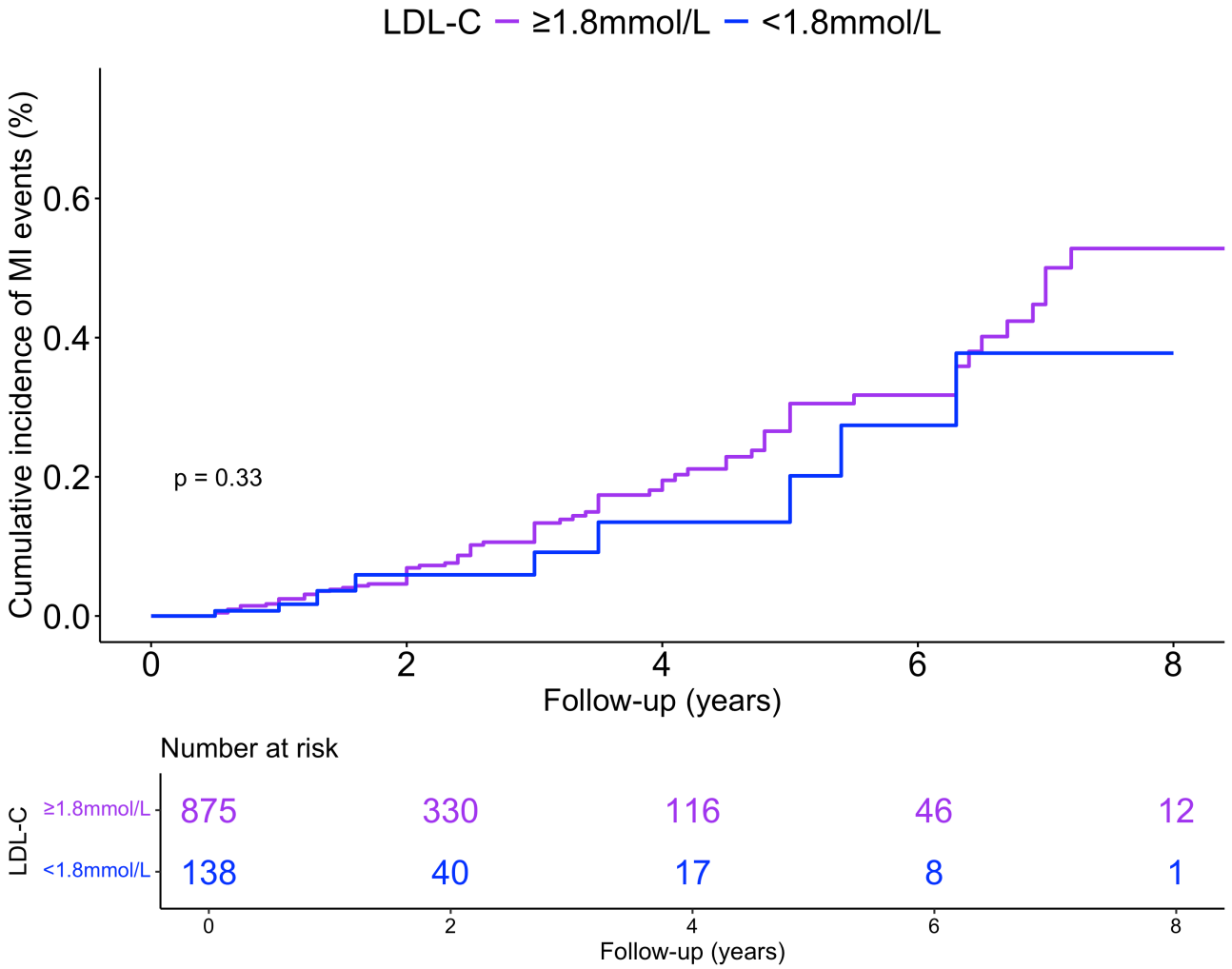

Fig. 2. Kaplan-Meier survival analysis curves for myocardial infarction (MI) events. LDL-C, low-density lipoprotein cholesterol.

[6,7]. Additionally, significant benefits have been observed in patients achieving very low LDL-C levels (<25 mg/dL) [9–11]. Our findings indicated that LDL-C levels during admission were not associated with an elevated risk of secondary MI events among patients with CHD; however, lowering LDL-C levels can reduce this risk, with greater reductions leading to improved outcomes.

It is important to note that baseline LDL-C status does not represent time-varying exposure. During the follow-up period, LDL-C levels can be modified through interventions, such as LDL-C-lowering therapies and lifestyle changes [7]. Therefore, investigating the associations between dynamic changes in LDL-C status and the risks of secondary CHD eventsis essential [8]. Previous studies have examined the impact of dynamic changes in metabolic syndrome on CVD outcomes, finding that these changes can significantly affect long-term prognosis [20,21]. In our study, participants were categorized into four groups based on LDL-C changes; however, the results indicated that these dynamic changes did not significantly alter the risks of MI events.

Clinical practice guidelines recommend aggressive LDL-C-lowering strategies with optimal targets, such as <1.8 mmol/L (70 mg/dL) and a 50% reduction for patients with very-high-risk atherosclerotic cardiovascular disease (ASCVD) [12,13]. The 2019 guidelines from the European Society of Cardiology and the European Atherosclerosis Society suggest even stricter goals: targets of <1.4 mmol/L (<55 mg/dL) for very-high-risk patients or those with clinically evident ASCVD, and <1.0 mmol/L (<40 mg/dL) for very-high-risk patients who have experienced a secondary vascular event within the past 2 years [14,15]. A study conducted on Japanese patients with CHD identified a potential threshold of 1.8 mmol/L for primary composite outcomes [22]. In our current study, we found that reducing LDL-C levels by ≥50% was not associated with a decreased risk of MI events. However, lowering LDL-C to <1.4 mmol/L appeared to decrease the risk of MI, irrespective of the baseline LDL-C level.

Despite improvements in guideline-recommended secondary prevention treatments, approximately 30% of patients with CHD achieved target reductions in LDL-C

Table 4. Association between other parameters related to LDL-C and the occurrence of MI.

Changes in LDL-C	Model 1			Model 2			Model 3		
	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value
Pattern of LDL-C changes									
LDL-C- uncontrolled	1			1			1		
LDL-C-worsen	0.22	0.03–1.61	0.135	0.26	0.03–1.94	0.188	0.31	0.04–2.36	0.260
LDL-C-improved	0.69	0.41–1.18	0.172	0.80	0.46–1.39	0.429	0.83	0.47–1.44	0.497
LDL-C-controlled	0.73	0.34–1.56	0.411	0.84	0.38–1.87	0.672	0.93	0.41–2.09	0.853
Degree of LDL-C lowing (mmol/L)									
Continuous LDL-C lowing	0.996	0.99–1.00	0.302	0.996	0.99–1.00	0.303	0.98	0.99–1.00	0.247
Group									
By 0–29.9%	1			1			1		
By 30–49.9%	1.03	0.60–1.79	0.907	1.02	0.58–1.80	0.944	1.12	0.63–1.99	0.691
By ≥50%	0.65	0.23–1.58	0.342	0.62	0.25–1.55	0.307	0.63	0.25–1.59	0.325
By <0%	1.22	0.73–2.02	0.452	1.15	0.68–1.94	0.616	1.26	0.74–2.16	0.402
Last LDL-C measurement level (mmol/L)									
Continuous LDL-C level	1.39	1.15–1.68	0.001	1.32	1.08–1.61	0.006	1.24	1.02–1.52	0.035
Group									
≥2.6	1			1			1		
1.8–2.59	0.43	0.21–0.95	0.022	0.53	0.25–1.12	0.097	0.55	0.26–1.17	0.161
1.4–1.79	0.56	0.31–1.02	0.057	0.71	0.39–1.32	0.283	0.78	0.41–1.47	0.437
<1.4	0.45	0.27–0.75	0.002	0.53	0.32–0.92	0.023	0.57	0.33–0.98	0.043

Model 1: Unadjusted; Model 2: Adjusted for sex and age, history of MI, multi-vessel disease, treatment measures, and duration of CHD; Model 3: adjusted for sex and age, history of MI, multi-vessel disease, treatment measures, and duration of CHD, smoking status, BMI, hypertension, diabetes, TG, HDL-C at the end of the study. BMI, body mass index; CHD, coronary heart disease; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MI, myocardial infarction; OR, odds ratio; TG, triglyceride.

levels [2,8,23–25]. In China, only 13% of patients with very-high-risk ASCVD aged <45 years achieved the target LDL-C level of <1.4 mmol/L, whereas 24% of other patients with ASCVD reached the <1.8 mmol/Ltarget [23]. In our study, only 17.2% of patients had LDL-C <1.4 mmol/L, and 37.8% had LDL-C <1.8 mmol/L. Several factors contribute to the challenges in meeting LDL-C goals. First, despite high rates of statin therapy, the use of high-intensity statins or maximally tolerated statin treatment may often be insufficient [11,26,27]. Second, the use of ezetimibe and PCSK9 inhibitors has been inadequate [28]. Finally, medication adherence is a common issue, with significant declines in the use of LDL-C-lowering drugs observed after discharge among patients with acute coronary syndrome [29]. Therefore, more effective lipid-lowering strategies should be developed, focusing on LDL-C levels prior to admission rather than those measured during hospitalization [30]. Early combination therapy, such as high-intensity statins combined with either ezetimibe or PCSK9 inhibitors, is recommended [14,15,31].

5. Limitations

This study has some potential limitations. First, it was conducted at a single center with a relatively small sample size, which may increase the risk of sampling bias and limit the generalizability of the findings. Second, the study included only patients who could provide hospital medical records for their initial CHD diagnosis and who consented to participate. This may introduce selection bias, potentially rendering the findings unrepresentative of all young patients with CHD. Third, we did not consider the type and dosage of statins and other medications used for LDL-C reduction, which limits our ability to assess the impact of different lipid-lowering strategies. Fourth, we did not collect data on lifestyle changes, such as dietary modifications and physical activity after discharge. These lifestyle factors can significantly influence cardiovascular outcomes and may serve as confounding variables when evaluating the impact of LDL-C-related indicators on MI. Finally, larger observational studies are needed to enhance the clinical implications of our findings.

6. Conclusions

In conclusion, this study suggests that the most important parameter related to LDL-C for predicting the recurrence of MI in young patients with a history of CHD is focusing on the ideal target LDL-C level. When LDL-C levels are reduced to sufficiently low levels, such as <1.4 mmol/L, the benefits in preventing the recurrence of MI significantly outweigh those of other parameters, including baseline LDL-C levels, extent of LDL-C reduction, and pattern of LDL-C changes.

Availability of Data and Materials

The raw dataset analyzed in the current study are available from the corresponding author on reasonable request.

Author Contributions

HJZ and XTS conceived and designed the study. FX, HXY, JWW and HRX collected and analyzed data. HJZ contributed to interpreted results. FX and HRX wrote the manuscript. HJZ, XTS, HXY and JWW revised the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University (KS2022070). Written consent was obtained from all participants.

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Conflict of Interest

The authors declare no conflict interest.

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