Original Article

Guideline-directed low-density lipoprotein management in high-risk ischemic stroke or transient ischemic attack admissions in China from 2015 to 2019

Hong-Qiu Gu[1,2]^, Kai-Xuan Yang[1,2], Xin Yang[1,2], Chun-Juan Wang[1,2], Tian-Jie Lyu[1,2], Xing-Quan Zhao[1,3], Yi-Long Wang[1,3], Li-Ping Liu[1,4], Chelsea Liu[5], Hao Li[1], Yong Jiang[1], Yong-Jun Wang[1,2,3], Zi-Xiao Li[1,2,3,6,7]

[1]China National Clinical Research Center for Neurological Diseases, Beijing Tiantan Hospital, Capital Medical University, Beijing, China; [2]National Center for Healthcare Quality Management in Neurological Diseases, Beijing Tiantan Hospital, Capital Medical University, Beijing, China; [3]Vascular Neurology, Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, Beijing, China; [4]Neuro-intensive Care Unit, Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, Beijing, China; [5]Department of Epidemiology, Harvard T.H. Chan School of Public Health, Harvard University, Boston, MA, USA; [6]Chinese Institute for Brain Research, Beijing, China; [7]Research Unit of Artificial Intelligence in Cerebrovascular Disease, Chinese Academy of Medical Sciences, Beijing, China

Contributions: (I) Conception and design: HQ Gu, ZX Li; (II) Administrative support: ZX Li, YJ Wang; (III) Provision of study materials or patients: ZX Li, YJ Wang; (IV) Collection and assembly of data: X Yang, CJ Wang, Y Jiang; (V) Data analysis and interpretation: HQ Gu, KX Yang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Yong-Jun Wang, MD. Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, No. 119 West Road, Southern Fourth Ring Road, Fengtai District, Beijing, China. Email: yongjunwang@ncrcnd.org.cn; Zi-Xiao Li, MD, PhD. Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, No. 119 West Road, Southern Fourth Ring Road, Fengtai District, Beijing, China; Chinese Institute for Brain Research, Beijing, China. Email: lizixiao2008@hotmail.com.

Background: Lowering low-density lipoprotein cholesterol (LDL-C) is crucial for secondary stroke prevention in stroke patients with preexisting cardiovascular diseases (CVD) or cerebrovascular diseases (CeVD). However, data on attainment of guideline-recommended LDL-C levels are lacking.

Methods: We analyzed data from the Chinese Stroke Center Alliance (CSCA) program for patients with ischemic stroke and transient ischemic attack (TIA) hospitalized between August 2015 and July 2019. Participants were classified into different disease groups according to preexisting CeVD (stroke/TIA) or CVD [coronary heart disease (CHD) or myocardial infarction (MI)].

Results: Of 858,509 patients presenting with an acute stroke/TIA, 251,176 (29.3%) had a preexisting CeVD, 44,158 (5.1%) had preexisting CVD, 33,070 (3.9%) had concomitant preexisting CeVD and CVD, and 530,105 (61.7%) had no documented history of CeVD/CVD. Overall, only 397,596 (46.3%) met the target for LDL-C <2.6 mmol/L, 128,177 (14.9%) for LDL-C <1.8 mmol/L and 55,275 (6.4%) for LDL-C <1.4 mmol/L, and patients with concomitant CeVD and CVD had higher attainment rates than other disease groups (P<0.001). Despite improvements over time in the proportion of patients who attain LDL-C targets (P for trend <0.05), it remains suboptimal. Younger age, women, having a history of hypertension or dyslipidemia, current smoking or drinking, and being admitted to hospitals located in eastern China were associated with lower odds of meeting the LDL-C goals.

Conclusions: Overall attainment of guideline LDL-C targets in a population of stroke/TIA patients is low and indicates the need for better management of dyslipidemia, particularly for high-risk stroke patients with pre-existing CeVD or CVD.

Keywords: Lipids; cholesterol; ischemic stroke; guideline adherence; risk factors

^ ORCID: 0000-0003-1608-1856.

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Introduction

Stroke is a leading cause of death and disability globally, accounting for almost 5% of all disability-adjusted life-years and 10% of all deaths worldwide (1). China has the highest incidence and lifetime risk of stroke among all countries, and the burden is still increasing (2,3). Lowering low-density lipoprotein cholesterol (LDL-C) levels is an essential measure of stroke prevention (4), as evidence from clinical trials have shown that the LDL-C-lowering therapies can reduce the risk of major vascular events (5,6). Scientific associations including the American Heart Association, American Stroke Association, American College of Cardiology, National Lipid Association, Chinese Stroke Association, European Society of Cardiology and European Atherosclerosis Society have established guidelines to reflect the importance of risk factor assessment and management, and most guidelines focus on LDL-C as the primary therapeutic target with LDL-C goals of <2.6, <1.8, or <1.4 mmol/L depending on the risk level of the population (7-12).

Despite the well-established efficacy of lipid-lowering therapy, limited data are available on guideline attainment among high-risk stroke/TIA patients, such as those with a history of cerebrovascular diseases (CeVD; stroke and TIA) and cardiovascular diseases [CVD; coronary heart disease (CHD) and myocardial infarction (MI)]. Using data from the Chinese Stroke Center Alliance (CSCA), we aimed to evaluate the proportion and determinants of patients admitted with stroke/TIA meeting LDL-C guidelines, and conduct subgroup analyses among patients with different levels of risk based on their history of CeVDs and CVDs.

We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/atm-21-1467).

Methods

Study cohort

The CSCA is a national, hospital-based, multicenter, voluntary, multifaceted intervention and continuous quality improvement initiative. This program is made available to all Chinese secondary and tertiary hospitals. Details of the CSCA Program have been published previously (13). In brief, patients were enrolled if they had a primary diagnosis of stroke/TIA and were then confirmed by brain CT or MRI. Hospitals were instructed to record data of patient demographics, medical history, medications before admission, diagnostic tests, treatment, and in-hospital outcomes. Data were collected via a web-based patient data collection and management tool, which subsequently checks for data quality to ensure that the reported data are complete and internally consistent.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Beijing Tiantan Hospital (approval number: KY2018-061-02), and individual consent for this retrospective analysis was waived.

Study population

We evaluated all patients with acute ischemic stroke or TIA enrolled in the CSCA project from August 1, 2015, to July 31, 2019 for potential inclusion in our analysis. Patients with missing data on low-density lipoprotein and other relevant clinical information were excluded. We classified patients into the following groups: (I) patients with preexisting stroke/TIA (group CeVD); (II) patients with preexisting CHD/MI (group CVD); (III) patients with concomitant preexisting CVD and CeVD; and (IV) patients with no documented history of CeVD or CVD.

Management measures

The 2016 Chinese guidelines for the management of dyslipidemia in adults (11) and Chinese Stroke Association guidelines for clinical management of cerebrovascular disorders (12) recommended the same target LDL-C (<2.6 mmol/L) for patients with ischemic stroke or TIA and comorbid atherosclerosis. A lower target (<1.8 mmol/L) was recommended for high-risk patients to achieve maximal benefit. The latest guidelines for dyslipidemia management issued by the European Society of Cardiology and European Atherosclerosis Society recommended an LDL-C goal of <1.4 mmol/L for very high-risk patients (9). In this study, we first assessed the attainment of the recommended level LDL-C <2.6 mmol/L for the general stroke/TIA patient

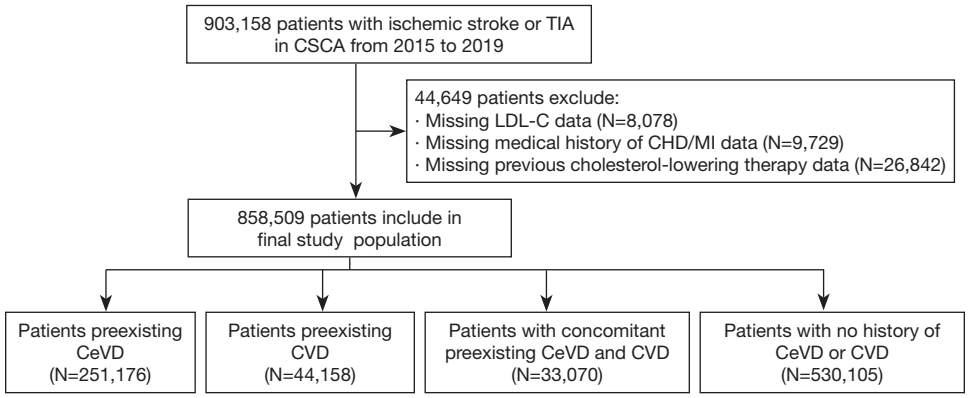

Figure 1 Study flow chart. TIA, transient ischemic attack; CSCA: the Chinese Stroke Association Alliance; CHD/MI, coronary heart disease or myocardial infarction; CeVD, cerebrovascular disease; CVD, cardiovascular disease; LDL-C, low-density lipoprotein cholesterol.

population and LDL-C <1.8 mmol/L for high-risk patients at admission. In addition, we assessed the attainment of LDL-C <1.4 mmol/L at admission and prescription of cholesterol-lowering agents at discharge.

Statistical analysis

Patients' baseline characteristics were described using frequencies and percentages for categorical variables and means and standard deviations (SD) for continuous variables. Due to the large sample size, we did not provide P values when comparing baseline characteristics across groups. Pearson chi-squared tests were used to test differences across the four patient groups for outcome measures. Temporal trends in meeting LDL-C targets were assessed using the Cochran Armitage trend test. Multivariable logistic regression models were performed to determine the independent predictors of meeting LDL-C targets, using the generalized estimating equations approach to account for within-hospital clustering. Covariates in the multivariable analysis included patient age, sex, medical history (hypertension, diabetes, dyslipidemia, atrial fibrillation, heart failure, PVD, smoking, drinking or stroke/TIA), medication history (antiplatelets, anticoagulants, antihypertensives, antihyperglycemics, or antihyperlipidemics) and hospital characteristics (hospital grade and geographical region). Medical history was self-reported disease prior to the index hospitalization, and medication history was defined as self-reported medication used from the index hospitalization up to 6 months ago.

SAS version 9.4 (SAS Institute, Cary, NC, USA) was used for all analyses. The macro %ggBaseline was used to generate statistical tables (14). A value of P<0.05 was considered statistically significant.

Results

A total of 903,158 patients presenting with an acute stroke/TIA were initially enrolled. After excluding patients with missing data on low-density lipoprotein and other relevant clinical information, 858,509 patients were enrolled in the study (*Figure 1*). Of 858,509 patients with acute ischemic stroke or TIA, 251,176 (29.3%) had preexisting CeVD, 44,158 (5.1%) had preexisting CVD, 33,070 (3.9%) had both, and 530,105 (61.7%) had neither. Overall, the mean age (SD) was 66.0 (12.0) years, and 324,402 (37.8%) were women. A total of 62,094 (7.2%) of patients were TIA, whereas the remaining 796,415 (92.8%) were stroke (*Table 1*). The mean (SD) LDL-C was 2.76 (1.35), 2.70 (1.17), 2.70 (1.31), 2.85 (1.19) mmol/L in patients in group CeVD, CVD, both CeVD and CVD, neither CeVD nor CVD, respectively (*Figure 2*).

Characteristics

Compared with other groups, especially with patients without a history of CeVD/CVD, patients with preexisting CeVD and CVD were older, more likely to have a history of hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation, heart failure or peripheral vascular disorder, and were more likely to have a medication history of antiplatelets, anticoagulants, antihypertensives,

Table 1 Baseline characteristics of patients with stroke or TIA by risk-groups

Variables	Total (N=858,509)	Preexisting CeVD (N=251,176)	Preexisting CVD (N=44,158)	Preexisting concomitant CeVD and CVD (N=33,070)	No history of CeVD/ CVD (N=530,105)
Demographic					
Age, year	66.0±12.0	66.8±11.3	69.8±11.3	70.1±10.7	65.0±12.4
Women	324,402 (37.8)	90,070 (35.9)	20,152 (45.6)	13,748 (41.6)	200,432 (37.8)
Medical history					
Hypertension	547,317 (63.8)	183,423 (73.0)	29,367 (66.5)	25,882 (78.3)	308,645 (58.2)
Diabetes mellitus	180,545 (21.0)	63,013 (25.1)	10,621 (24.1)	10,300 (31.1)	96,611 (18.2)
Dyslipidemia	66,685 (7.8)	36,183 (14.4)	2,758 (6.2)	6,732 (20.4)	21,012 (4.0)
Atrial fibrillation	43,894 (5.1)	13,793 (5.5)	5,969 (13.5)	4,836 (14.6)	19,296 (3.6)
Heart failure	8,831 (1.0)	2,247 (0.9)	1,996 (4.5)	2,034 (6.2)	2,554 (0.5)
PVD	14,929 (1.7)	8,663 (3.4)	771 (1.7)	2,406 (7.3)	3,089 (0.6)
Current smoking	204,570 (23.8)	53,803 (21.4)	7,946 (18.0)	5,800 (17.5)	137,021 (25.8)
Index event					
AIS	796,415 (92.8)	232,902 (92.7)	40,733 (92.2)	30,587 (92.5)	492,193 (92.8)
TIA	62,094 (7.2)	18,274 (7.3)	3,425 (7.8)	2,483 (7.5)	37,912 (7.2)
Medication history					
Antiplatelets	184,896 (21.5)	112,020 (44.6)	12,087 (27.4)	17,679 (53.5)	43,110 (8.1)
Anticoagulants	34,983 (4.1)	19,990 (8.0)	2,695 (6.1)	4,275 (12.9)	8,023 (1.5)
Antihypertensives	403,354 (47.0)	146,776 (58.4)	23,097 (52.3)	21,927 (66.3)	211,554 (39.9)
Antihyperglycemics	142,918 (16.6)	52,250 (20.8)	8,486 (19.2)	8,707 (26.3)	73,475 (13.9)
Antihyperlipidemics	135,556 (15.8)	83,112 (33.1)	7,779 (17.6)	13,356 (40.4)	31,309 (5.9)
Hospital characteristics					
Hospital grade					
Secondary	334,548 (39.0)	105,261 (41.9)	16,712 (37.8)	14,074 (42.6)	198,501 (37.4)
Tertiary	523,961 (61.0)	145,915 (58.1)	27,446 (62.2)	18,996 (57.4)	331,604 (62.6)
Region					
Eastern	395,203 (46.0)	108,832 (43.3)	20,626 (46.7)	14,817 (44.8)	250,928 (47.3)
Center	288,835 (33.6)	92,839 (37.0)	15,813 (35.8)	12,736 (38.5)	167,447 (31.6)
Western	174,471 (20.3)	49,505 (19.7)	7,719 (17.5)	5,517 (16.7)	111,730 (21.1)

CeVD, cerebrovascular disease; CVD, cardiovascular disease; PVD, peripheral vascular disorder; AIS, acute ischemic stroke; TIA, transient ischemic attack.

antihyperglycemics, or antihyperlipidemics (*Table 1*).

Management measures

Overall, 46.3% (n=397,596) met the target for LDL-C <2.6 mmol/L, 14.9% (n=128,177) for LDL-C <1.8 mmol/L and 6.4% (n=55,275) for LDL-C <1.4 mmol/L. Although 33.1% (n=83,112) of patients with preexisting CeVD were receiving antihyperlipidemics at admission, only 49.7% (n=124,927) met the LDL-C <2.6 mmol/L target, 17.9% (n=45,008) met the LDL-C <1.8 mmol/L target, and 7.9% (n=19,932) met the LDL-C <1.4 mmol/L target.

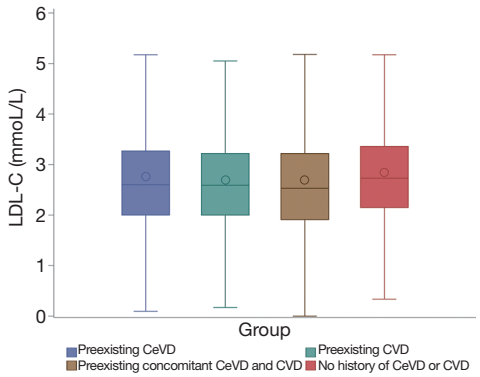

Figure 2 Box-plot representing low-density lipoprotein cholesterol (LDL-C) values on admission for each disease group. CeVD, cerebrovascular disease; CVD, cardiovascular disease; and LDL-C, low-density lipoprotein cholesterol.

Similarly, 17.6% (n=7,779) patients with preexisting CVD who were receiving antihyperlipidemics at admission, only 50.3% (n=22,193), 17.4% (n=7,676) and 7.6% (n=3,349) met the LDL-C <2.6 mmol/L, LDL-C <1.8 mmol/L and the LDL-C <1.4 mmol/L targets, respectively. Among patients with preexisting concomitant CeVD and CVD, the proportion that met the LDL-C <2.6 mmol/L, LDL-C <1.8 mmol/L and LDL-C <1.4 mmol/L targets were 52.5%, 20.7% and 9.2%, respectively. Notably, nearly 90% of patients, overall and in each group, were discharged on statins after their index hospitalization (*Table 2*).

Temporal trends

We assessed the temporal trends in the proportion of patients meeting the LDL-C target from 2015 to 2019. Small increases over time were observed in the proportion that met the LDL-C <1.8 mmol/L target among patients with preexisting CeVD (relative increase by 11.5%, from 17.4% to 19.4%), among patients with preexisting CVD (relative increase by 27.7%, from 17.3% to 22.1%), and among patients with preexisting concomitant CeVD and CVD (relative increase by 12.3%, from 21.9% to 24.6%), but not in patients without a medical history of CeVD or CVD (*Figure 3* and *Table 3*).

Factor associated with meeting LDL-C targets

Multivariable analysis using generalized estimating equations to account for within-hospital clustering showed that younger age, being female, having a history of hypertension or dyslipidemia, current smoking or drinking, and being admitted to hospitals located in eastern China were associated with lower odds of meeting the LDL-C goals. Atrial fibrillation, heart failure, and concomitant CeVD or CVD were associated with higher odds of achieving of LDL-C goals (*Table 4*).

Discussion

In this study of more than 850,000 patients with an acute ischemic stroke or TIA who were enrolled in CSCA, we evaluated attainment of guideline-recommended LDL-C targets in four different groups: patients with previous CeVD, CVD, both, and neither. We found that the attainment rates of guideline LDL-C targets in patients with stroke or TIA remain low. Overall, high-risk patients with concomitant preexisting CeVD and CVD were more likely to attain the LDL-C targets compared to other groups. We also identified independent factors associated with attainment to the LDL-C guidelines among high-risk patients, and found that younger age, being female, having a history of hypertension or dyslipidemia, currently smoking or drinking, and being admitted to hospitals located in eastern China were associated with lower odds of attaining the recommended LDL-C targets.

Large epidemiologic studies have shown that dyslipidemia is associated with an increased risk of unfavorable outcomes, and lower LDL-C levels are associated with lower rates of major coronary events (5,15-17). In accordance with these findings, most guidelines recommend lowering LDL-C to 2.6, 1.8 or 1.4 mmol/L, or alternatively to achieve ≥50% LDL-C reduction from baseline. Our study provides an assessment of the efficacy of real-world clinical practice on guideline-based cholesterol management in high-risk ischemic stroke patients with concomitant preexisting CeVD or CVD. We observed significant gaps between recommendations from evidence-based medicine and data from real-world clinical practice.

In our study, significant gaps were found between guideline recommendations and real-world clinical practice. Previous studies also reported significant gaps between evidence-based medicine and real-world clinical practice (18-21). For example, in DYSIS II, only 29.4 % of the patients attained the LDL-C target of <1.8 mmol/L (22). In the French cohort from DYSIS II, 67.7 % and 28.4% of the CHD patients attained the LDL-C targets of <2.6 and <1.8 mmol/L, respectively (23). The attainment rates to the recommended LDL-C targets in the CSCA program was

Table 2 Attainment of guideline LDL-C targets by patient disease group

Variables	Total (N=858,509)	Preexisting CeVD (N=251,176)	Preexisting CVD (N=44,158)	Preexisting concomitant CeVD and CVD (N=33,070)	No history of CeVD/ CVD (N=530,105)	P value
LDL-C targets						
<2.6 mmol/L	397,596 (46.3)	124,927 (49.7)	22,193 (50.3)	17,375 (52.5)	233,101 (44.0)	<0.001
<1.8 mmol/L	128,177 (14.9)	45,008 (17.9)	7,676 (17.4)	6,856 (20.7)	68,637 (12.9)	<0.001
<1.4 mmol/L	55,275 (6.4)	19,932 (7.9)	3,349 (7.6)	3,030 (9.2)	28,964 (5.5)	<0.001
Discharged on statins	766,681 (89.3)	222,328 (88.5)	39,440 (89.3)	29,414 (88.9)	475,499 (89.7)	<0.001

CeVD, cerebrovascular disease; CVD, cardiovascular disease; LDL-C, low-density lipoprotein cholesterol.

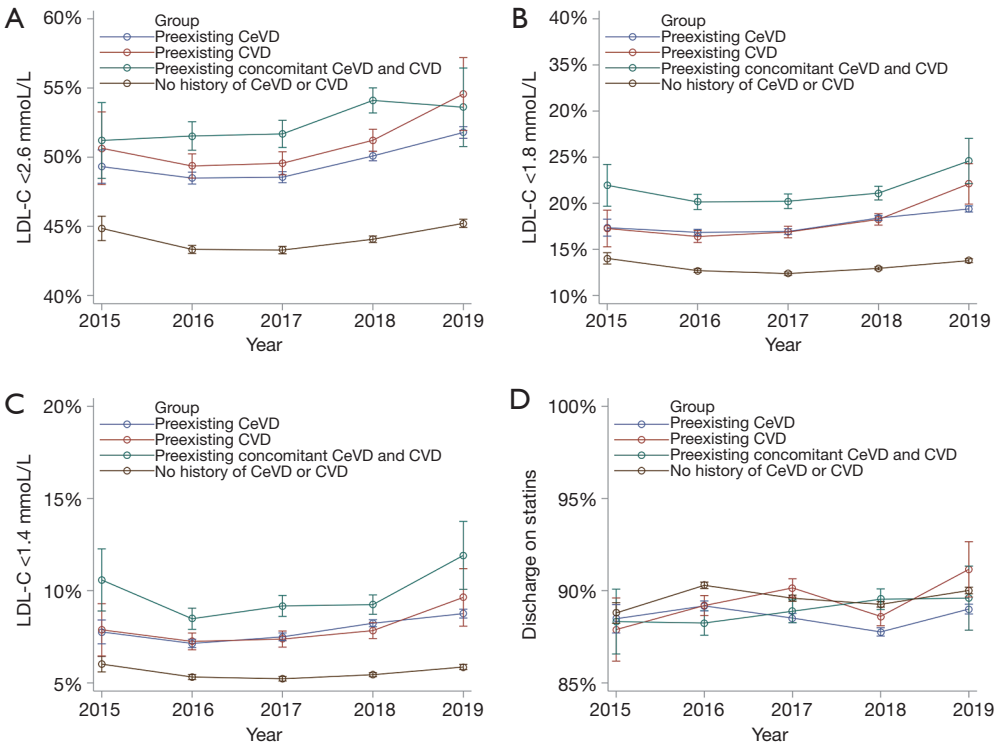

Figure 3 Temporal trend of attainment of LDL-C targets in CSCA program. (A) Trend of admission LDL-C <2.6 mmol/L from 2015 to 2019 for each disease group; (B) trend of admission LDL-C <1.8 mmol/L from 2015 to 2019 for each disease group; (C) trend of admission LDL-C <1.4 mmol/L from 2015 to 2019 for each disease group; (D) trend of discharge on statins from 2015 to 2019 for each disease group. CeVD, cerebrovascular disease; CVD, cardiovascular disease; LDL-C, low-density lipoprotein cholesterol.

lower than those in the Get-With-The-Guidelines-Stroke Registry several years ago with 51.3% for <2.6 mmol/L and 19.8% for <1.8 mmol/L (18). Encouragingly, however, temporal trend analysis showed there is an increasing trend for the attainment rates of LDL-C <2.6 mmol/L, LDL-C <1.8 mmol/L, LDL-C <1.4 mmol/L and prescription of cholesterol-lowering agents at discharge, though the increase was only marginal. One possible reason was that high-level evidence to support these guideline recommendations were not available until the release of results from the Treat Stroke to Target trial in 2020 (6).

Our study also showed that patients with history of CeVD or CVD were more likely to meet the LDL-C level recommended by the guidelines than other groups,

Table 3 Temporal trends of attainment of guideline LDL-C targets among different risk groups

Variables	Total (N=858,509)	2015 (N=21,504, 2.5%)	2016 (N=183,177, 21.3%)	2017 (N=214,133, 24.9%)	2018 (N=275,810, 32.1%)	2019 (N=163,885, 19.1%)	Relative increase rate (%)	P for trend
Preexisting CeVD								
LDL-C <2.6 mmol/L	124,927 (49.7)	3,245 (49.3)	24,962 (48.5)	28,909 (48.6)	40,142 (50.1)	27,669 (51.8)	5.1	<0.0001
LDL-C <1.8 mmol/L	45,008 (17.9)	1,142 (17.4)	8,673 (16.8)	10,086 (16.9)	14,748 (18.4)	10,359 (19.4)	11.5	<0.0001
LDL-C <1.4 mmol/L	19,932 (7.9)	511 (7.8)	3,677 (7.1)	4,464 (7.5)	6,601 (8.2)	4,679 (8.8)	12.8	<0.0001
Discharged on statins	222,328 (88.5)	5,822 (88.5)	45,908 (89.2)	52,703 (88.5)	70,338 (87.8)	47,557 (89.0)	0.6	0.0207
Preexisting CVD								
LDL-C <2.6 mmol/L	22,193 (50.3)	707 (50.6)	6,181 (49.4)	6,859 (49.6)	7,693 (51.2)	753 (54.6)	8.0	0.0002
LDL-C <1.8 mmol/L	7,676 (17.4)	241 (17.3)	2,053 (16.4)	2,336 (16.9)	2,741 (18.2)	305 (22.1)	27.7	<0.0001
LDL-C <1.4 mmol/L	3,349 (7.6)	110 (7.9)	908 (7.3)	1,021 (7.4)	1,177 (7.8)	133 (9.6)	21.5	0.0138
Discharged on statins	39,440 (89.3)	1,227 (87.9)	11,169 (89.2)	12,477 (90.2)	13,309 (88.6)	1,258 (91.2)	3.8	0.9931
Preexisting concomitant CeVD and CVD								
LDL-C <2.6 mmol/L	17,375 (52.5)	658 (51.2)	4,679 (51.5)	5,120 (51.7)	6,279 (54.1)	639 (53.6)	4.7	0.0001
LDL-C <1.8 mmol/L	6,856 (20.7)	282 (21.9)	1,829 (20.1)	2,003 (20.2)	2,449 (21.1)	293 (24.6)	12.3	0.0265
LDL-C <1.4 mmol/L	3,030 (9.2)	136 (10.6)	770 (8.5)	909 (9.2)	1,073 (9.2)	142 (11.9)	12.3	0.0456
Discharged on statins	29,414 (88.9)	1,135 (88.3)	8,013 (88.2)	8,806 (88.9)	10,392 (89.5)	1,068 (89.6)	1.5	0.0028
No history of CeVD/CVD								
LDL-C <2.6 mmol/L	233,101 (44.0)	5,491 (44.9)	47,708 (43.3)	56,636 (43.3)	74,490 (44.1)	48,776 (45.2)	0.7	<0.0001
LDL-C <1.8 mmol/L	68,637 (12.9)	1,717 (14.0)	13,979 (12.7)	16,196 (12.4)	21,877 (12.9)	14,868 (13.8)	–1.4	<0.0001
LDL-C <1.4 mmol/L	28,964 (5.5)	737 (6.0)	5,860 (5.3)	6,836 (5.2)	9,206 (5.4)	6,325 (5.9)	–1.7	<0.0001
Discharged on statins	475,499 (89.7)	10,871 (88.8)	99,408 (90.3)	117,228 (89.6)	150,886 (89.3)	97,106 (90.0)	1.4	0.0402

CeVD, cerebrovascular disease; CVD, cardiovascular disease; LDL-C, low-density lipoprotein cholesterol.

indicating that patients with more vascular risk factors might pay more attention to their health management. Additionally, we found that patients with no history of CeVD or CVD had the lowest attainment rates. This suggests that clinicians should not overlook lipid management for low-risk populations. Consistent with previous studies (22,24-26), our results showed that patients who are younger, female, have a history of hypertension or dyslipidemia, or are currently smoking or drinking had lower odds of attaining recommended LDL-C targets. More attention should be paid to these groups to improve their lipid management.

In Preexisting CeVD group, a higher proportion of anticoagulants use than that of atrial fibrillation were observed in our study. One possible reason is that self-reported medical history of atrial fibrillation was under-reported. Another possible reason is, except for stroke patients with atrial fibrillation, stroke patients with other cardio-embolic reason (e.g., valvular heart disease, deep vein thrombosis, etc.) are recommend taking anticoagulants in clinical practice. The proportions of antihyperlipidemics use were higher than those of dyslipidemia in all groups. Two possible reasons may account for it. First, self-reported medical history of dyslipidemia was under-reported. Second, with the recognition ASCVD (atherosclerotic cardiovascular disease), patients with history of stroke/TIA or CHD/MI would be recommend taking statins for prevention of stroke recurrence, according to the Chinese Stroke Association guidelines (27).

Our study has several limitations. First, participation

Table 4 Factors associated with meeting different levels of LDL-C targets

Variables	OR (95% CI)		
	LDL-C <2.6 mmol/L	LDL-C <1.8 mmol/L	LDL-C <1.4 mmol/L
Demographics			
Age, per 10 y	1.09 (1.08, 1.10)	1.09 (1.08, 1.10)	1.07 (1.05, 1.09)
Women (*vs.* men)	0.70 (0.69, 0.71)	0.72 (0.70, 0.73)	0.74 (0.72, 0.76)
Medical history			
Hypertension	0.92 (0.89, 0.94)	0.92 (0.90, 0.95)	0.91 (0.87, 0.95)
Diabetes mellitus	0.93 (0.90, 0.95)	1.04 (1.01, 1.08)	1.13 (1.08, 1.18)
Dyslipidemia	0.59 (0.56, 0.62)	0.66 (0.62, 0.69)	0.67 (0.63, 0.71)
Atrial fibrillation	1.62 (1.57, 1.68)	1.65 (1.60, 1.70)	1.59 (1.53, 1.67)
Heart failure	1.11 (1.03, 1.19)	1.14 (1.06, 1.23)	1.19 (1.08, 1.31)
PVD	1.02 (0.95, 1.10)	1.00 (0.93, 1.08)	1.00 (0.91, 1.09)
Current smoking	0.93 (0.91, 0.95)	0.88 (0.85, 0.90)	0.84 (0.80, 0.87)
Drinking	0.97 (0.94, 1.00)	0.98 (0.95, 1.01)	0.98 (0.94, 1.03)
Medication history			
Antiplatelets	1.15 (1.11, 1.20)	1.18 (1.13, 1.23)	1.20 (1.14, 1.26)
Anticoagulants	0.89 (0.84, 0.94)	0.92 (0.86, 0.98)	1.02 (0.94, 1.12)
Antihypertensives	1.06 (1.03, 1.09)	1.07 (1.04, 1.11)	1.07 (1.03, 1.11)
Antihyperglycemics	1.12 (1.09, 1.16)	1.13 (1.09, 1.17)	1.11 (1.06, 1.17)
Antihyperlipidemics	1.31 (1.25, 1.36)	1.42 (1.35, 1.49)	1.36 (1.28, 1.44)
Disease group			
No history of CeVD/CVD	Ref.	Ref.	Ref.
Preexisting CeVD	1.14 (1.10, 1.17)	1.24 (1.19, 1.28)	1.25 (1.19, 1.30)
Preexisting CVD	1.15 (1.11, 1.19)	1.20 (1.15, 1.26)	1.20 (1.14, 1.27)
Preexisting concomitant CeVD and CVD	1.21 (1.15, 1.27)	1.36 (1.29, 1.43)	1.33 (1.25, 1.42)
Tertiary *vs.* secondary	0.98 (0.91, 1.05)	1.04 (0.95, 1.12)	1.05 (0.96, 1.15)
Region			
Center *vs.* Western	1.02 (0.92, 1.13)	0.91 (0.81, 1.03)	0.84 (0.73, 0.97)
Eastern *vs.* Western	0.84 (0.77, 0.92)	0.75 (0.68, 0.83)	0.67 (0.59, 0.76)

PVD, peripheral vascular disorder; CeVD indicates cerebrovascular disease; CVD, cardiovascular disease.

in CSCA was voluntary and this study did not have an elaborately designed sampling frame. The participating hospitals were more likely to be larger teaching hospitals with a strong interest in stroke care improvement. However, the large sample size and similar profile of patient characteristics to other registries may help improve the robustness and generalizability of our findings. Second, LDL-C measurements were not performed in a central core laboratory. However, this reflects real-world practice where physicians initiate or titrate therapy based on available test results. Third, the database does not contain information on prestroke cholesterol drug class or dose, and therefore we could not assess LDL-C reduction relative to baseline values. Finally, we were not able to assess post-discharge

lipid-lower drugs adherence and persistence or clinical outcomes since no follow-up data were collected.

Conclusions

The proportion of patients with stroke/TIA who meet the guideline targets for LDL-C are suboptimal for the overall population and for high-risk subgroups. At the time of admission, only 1 in 6 of stroke/TIA patients met the target for LDL-C <1.8 mmol/L, and less than half met the target for LDL-C <2.6 mmol/L. Although high-risk patients with concomitant preexisting stroke/TIA and CHD/MI were more likely to attain LDL-C targets, levels are still relatively low and may require intervention to improve management.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics board of Beijing Tiantan Hospital (approval number: KY2018-061-02), and individual consent for this retrospective analysis was waived.

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