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Research article

High levels of blood lipid and glucose predict adverse prognosis in patients with aneurysmal subarachnoid hemorrhage

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ABSTRACT

Objective: We conducted a retrospective study on the prognostic factors of aneurysmal subarachnoid hemorrhage (aSAH) patients in the author's Hospital from January 2019 to May 2023. To discuss the association of the blood lipid and glucose levels of patients with the prognosis of aSAH, and verify that high blood lipid and glucose levels are important factors affecting adverse prognosis.

Methods: All patients with aSAH were collected as the case group, which was divided into two groups according to the modified Rankin Scores (mRS), the good prognosis group (Group A, mRS < 3) and the adverse prognosis group (Group B,mRS ≥ 3). The clinical data of age, gender, accompanied chronic diseases (hypertension, diabetes), smoking, drinking, Glasgow Coma Scale (GCS), Hunt-Hess (H-H) grade, Modified Fisher grade, total cholesterol (TC) , triglyceride (TG) , high-density cholesterol lipoprotein (HDL-C) , low-density cholesterol lipoprotein (LDL-C) , blood glucose (BG) , responsible aneurysm diameter and location were recorded too. Correlations between blood lipid and glucose levels and Modified Fisher grade were assessed by the Spearman correlation analysis. The receiver operating characteristic (ROC) curve was utilized to evaluate the diagnostic efficacy. The effect of blood lipid and glucose levels on adverse prognosis was analyzed by Logistic regression models.

Result: A total of 259 patients with aSAH were enrolled. The average age of all patients is (56.54 $\pm$ 10.52) years, including 96 males and 163 females. They were divided into Group A (n = 146) and Group B (n = 113). Univariate analysis results show that age, the levels of TC, TG, LDL-C, and BG were higher in Group B ($P < 0.05$). Besides, Group B had more severe GCS, H-H grade, and Modified Fisher grade than Group A, and a higher proportion of intracranial aneurysms with larger diameter ($P < 0.05$). Correlation analysis showed that TC, TG, LDL-C, and BG levels were positively correlated with Modified Fisher grade ($P < 0.05$) and H-H grade ($P < 0.05$). Multivariate logistic regression model analysis showed that high level of Modified Fisher grade (OR = 0.079, 95%CI: 0.027–0.230) , high level of H-H grade (OR = 0.204, 95%CI: 0.067–0.622) , TC (OR = 10.711, 95%CI: 2.457–46.700) , LDL-C (OR = 0.178, 95%CI: 0.039–0.823) and BG (OR = 1.273, 95%CI: 1.012–1.602) increased the risk of adverse prognosis. The AUC of "H-H grade", "Modified Fisher grade", "TC level", "LDL-C level" and "BG level" was 0.822, 0.885, 0.860, 0.772, and 0.721, respectively, in the ROC curve.

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Conclusion: Modified Fisher grade, H-H grade, TC, LDL-C, and BG levels at admission were independent predictors of adverse prognosis of aSAH. Besides, TC, LDL-C, and BG levels were positively correlated with Modified Fisher grade and Hunt-Hess grade. What's more, high levels of TC, LDL-C, and BG combined with Modified Fisher grade and H-H grade can identify high-risk groups with adverse prognoses in aSAH patients.

1. Introduction

Subarachnoid hemorrhage (SAH) is a serious subtype of stroke, in which the most important reason is the rupture of intracranial aneurysms, accounting for 85 % [1] of all cases with spontaneous SAH. aSAH has an acute onset, high risk, high disability, and mortality rate [2–4]. Many patients may be complicated with neurological dysfunction in the long term after treatment, resulting in an adverse prognosis. Gerner et al. [5] reported that after 12 months of treatment, nearly 50 % of 405 patients with aSAH had adverse prognosis and were unable to resume normal work. Therefore, looking for biomarkers that can predict the prognosis of aSAH patients is conducive to the early formulation of reasonable treatment programs to improve the prognosis and reduce the mortality of patients.

As we know, the detection of various biomarkers in the blood (such as inflammatory markers, blood glucose, blood lipids, etc.) is simple and efficient, which is the most easily obtained test result for aSAH patients. At present, the determination of these biomarkers has been paid more and more attention by neurosurgeons. Many studies [6–11] have shown that inflammatory markers, blood glucose markers, and blood lipid markers have high clinical reference value in predicting the clinical prognosis of patients with aSAH. Among them, the role of inflammatory markers in the pathogenesis of aSAH has been accepted. Although there have been some studies on the relationship between lipid and glucose levels and the onset, progression, and prognosis of aSAH, there are no rigorous randomized controlled trials to confirm this. Recently, some studies [12,13] have shown that blood lipids are involved in the pathogenesis of SAH. Lindbohm et al. [14] found that an increase of 1.28 mmol/L in TC is associated with an increased risk of aSAH in patients. However, the research results on the correlation between blood lipid levels and the prognosis of aSAH are controversial, especially the predictive value of high-level TC [15–17] and low-level TC [10,18] on the prognosis of SAH. In addition, few studies have focused on the impact of both lipid and glucose levels on patient prognosis. Integrated management of blood lipid and glucose levels is more in line with the current philosophy of integrative treatment by neurosurgeons.

Therefore, we hypothesize that elevated blood lipid and glucose levels upon admission of aSAH patients could result in an adverse prognosis. Patients should closely monitor changes in these levels during treatment and promptly adjust their treatment plan accordingly. This study collected and analyzed the clinical data (involved age, gender, past history, blood glucose, blood lipid, aneurysm size, location, imaging score, neurological score, etc.) of aSAH patients in the author's Hospital, which aimed to investigate the association between the blood lipid and glucose levels and the prognosis of aSAH.

2. Material and methods

Ethical approval

This study was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University (K2023-315) on August 3, 2023.

2.1. Case data collection

The clinical data of 259 patients with aSAH hospitalized in the neurosurgery department of the authors' hospital were retrospectively studied as the case group from January 2019 to May 2023. General data of age, gender, accompanying chronic diseases (hypertension, diabetes) , smoking, drinking, GCS, H-H grade, Modified Fisher grade, TC, TG, HDL-C, LDL-C, BG, responsible aneurysm diameter, and location of all patients were collected by viewing patient inpatient medical records and outpatient follow-up medical records. The disease progression of 259 aSAH patients was surveyed 3 months after the treatment, and the Modified Rankin Scale (mRS) was applied to evaluate the prognosis. According to mRS, the 259 patients were divided into two groups: the good prognosis group (Group A, mRS $<$ 3, n $=$ 146) and Group B (Group B,mRS $\geq$3, n $=$ 113).

Inclusion criteria were as follows: 1) diagnosed as aSAH through CTA and DSA; 2) admitted to the hospital and venous blood collection within 72h after onset; 3) 18–75 years old; 4) no anticoagulant medication history in recent 1 month; 5) underwent endovascular intervention for intracranial aneurysms.

Exclusion criteria were as follows: 1) Spontaneous SAH; 2) secondary SAH caused by other diseases such as trauma, cerebrovascular malformation, brain tumor, etc.; 3) dysfunction of vital organs such as pulmonary insufficiency, heart failure, decompensated renal failure, decompensated liver cirrhosis, etc.; 4) blood system disease or coagulation dysfunction; 5) Incomplete clinical data.

2.2. Statistical analysis

SPSS 26.0 software and GraphPad Prism 8.0 software were used for statistical analyses and plotting. Measurement data were shown as mean $\pm$ standard deviation (SD), and the comparison between the two groups was performed by *t*-test. The comparison of enumeration data and classification data was examined with the chi-square test. Then, correlations between the blood lipid and glucose levels and Modified Fisher grade were assessed by the Spearman test. The outcome was dichotomized as a dependent variable of logistic regression analysis, and logistic regression was conducted to analyze the risk factors of aSAH prognosis. To assess the predictive value of the blood lipid and glucose levels on functional outcome after aSAH, logistic regression models were developed taking 3-month adverse prognosis (mRS $\geq$3) as dependent variables. The receiver operating characteristic curve (ROC) was established to determine the AUC, sensitivity, specificity, and cutoff values of the final prognostic indicators. Differences were considered statistically significant at $p < 0.05$.

3. Results

3.1. General data

A total of 394 patients with SAH were collected, 135 patients were excluded, and 259 patients with aSAH were included in the study. The average age of all patients is (56.54 $\pm$ 10.52) years, including 96 males and 163 females. The percentages and quantity of H-H grades distributed across grades one through five are as follows: grade 1 (51, 19.7 %) , grade 2 (121, 46.7 %) , grade 3 (65, 25.1 %) , grade 4 (20, 7.7 %) , and grade 5 (2, 0.8 %). The distribution of Modified Fisher grades among grades 1 to 4 is as follows: grade 1 (68, 26.3 %) , grade 2 (72, 27.8 %) , grade 3 (58, 22.4 %) , and grade 4 (61, 23.6 %). The average hospital stay duration for all patients is (16.61 $\pm$ 11.42) days. In addition, 7 deaths among hospitalized patients, accounting for 2.7 %. 36 people have severe disabilities, accounting for 13.9 %. According to the mRS after 3 months of treatment, they were divided into Group A (n = 146) and Group B (n = 113). There were 88 females and 58 males in Group A, with an average age of (54.73 $\pm$ 11.16) years, and 75 females and 38 males in

Table 1
Univariate analysis results (Based on the good prognosis group and the adverse prognosis group).

characteristics	the good prognosis group (mRS < 3; n = 113)	the adverse prognosis group (mRS $\geq$3; n = 146)	P-value
age (years)	54.73 ± 11.16	58.88 ± 9.16	0.002
gender			0.19
Male	58 (54.1)	38 (41.9)	
Female	88 (91.9)	75 (71.1)	
hypertension history			0.899
yes	61 (60.3)	46 (46.7)	
no	85 (85.7)	67 (66.3)	
diabetes history			0.232
yes	8 (10.7)	11 (8.3)	
no	138 (135.3)	102 (104.7)	
drinking history			0.936
yes	24 (24.2)	19 (18.8)	
no	122 (121.8)	94 (94.2)	
smoking history			0.659
yes	29 (27.6)	20 (21.4)	
no	117 (118.4)	93 (91.6)	
TC (mmol/L)	4.10 ± 0.81	5.40 ± 0.88	< 0.001
TG (mmol/L)	1.16 ± 0.49	1.90 ± 1.10	< 0.001
HDL-C (mmol/L)	1.33 ± 0.35	1.36 ± 0.42	0.469
LDL-C (mmol/L)	2.49 ± 0.67	3.27 ± 0.84	< 0.001
BG (mmol/L)	6.72 ± 1.69	8.30 ± 2.41	< 0.001
responsible aneurysm diameter			0.048
R < 5 mm	75 (84.6)	75 (65.4)	
5 mm ≤ R < 15 mm	70 (60.3)	37 (46.7)	
R ≥ 15 mm	1 (1.1)	1 (0.9)	
responsible aneurysm location			0.164
PcoA	56 (60.3)	51 (46.7)	
AcoA	41 (42.3)	34 (32.7)	
MCA	29 (22.5)	11 (17.5)	
others	20 (20.9)	17 (16.1)	
GCS			< 0.001
13–15	1 (11.8)	20 (9.8)	
9–12	6 (36.1)	58 (27.9)	
3–8	139 (98.1)	35 (75.9)	
Hunt-Hess grade			< 0.001
1–2	138 (97)	34 (75)	
3–5	8 (49)	79 (38)	
Modified Fisher grade			< 0.001
I - II	128 (78.9)	12 (61.1)	
III - IV	18 (67.1)	101 (51.9)	

TC, total cholesterol; TG, triglyceride; HDL-C, high-density cholesterol lipoprotein; LDL-C, low-density cholesterol lipoprotein; PcoA, Posterior communicating artery; AcoA, Anterior communicating artery; MCA, middle cerebral artery; GCS, Glasgow Coma Scale.

Group B, with an average age of (58.88 ± 9.16) years. Furthermore, Group A exhibits a notable disparity in the number of patients with low H-H grade (H-H grade $<$ 3) compared to those with high grade (H-H grade ≥3). Specifically, there are 138 patients with low scores and only 8 patients with high scores. On the contrary, Group B has 34 patients with low H-H grade and 79 patients with high low H-H grade. Meanwhile, there were also differences in the Modified Fisher grade between the two groups. In Group A, there are 128 patients classified as low Modified Fisher grades and 18 as high. Meanwhile, Group B has 13 and 100 individuals respectively (Table .1).

Univariate analysis results were as follows: There were no significant differences in Group A with Group B in gender, smoking history, drinking history, diabetes history, hypertension history, responsible aneurysm location, and the level of HDL-C ($P > 0.05$). Age, the levels of TC, TG, LDL-C, and BG, in Group B, were higher than those in Group A ($P < 0.05$). Besides, Group B had more severe GCS, H-H grade, and Modified Fisher grade than Group A, and a higher proportion of intracranial aneurysms with larger diameter ($P < 0.05$) (Table .1).

3.2. Correlation of biomarkers and H-H grade, Modified Fisher grade

In previous studies, H-H and Modified Fisher grades have been identified as reliable tools for assessing the severity of aSAH. Moreover, the univariate analysis showed that levels of TC, TG, LDL-C, and BG were significantly different between the good prognosis and adverse prognosis groups. Therefore, we further analyzed the correlation between TC, TG, LDL-C, and BG levels and H-H and Modified Fisher grade. It was discovered that TC (rs = 0.6044, Fig. 1A) , TG (rs = 0.3551, Fig. 1B) , LDL-C (rs = 0.4909, Fig. 1C) , and BG (rs = 0.3741, Fig. 1D) levels were positively correlated with Modified Fisher grade ($P < 0.05$). It also showed that they were positively correlated with H-H grade (Fig. 2). The relative coefficient (rs) was 0.5200(Fig. 2A), 0.2856(Fig. 2B), 0.3941(Fig. 2C), and 0.3614(Fig. 2D), respectively ($P < 0.05$).

3.3. Correlation of biomarkers and outcome

According to the results of univariate analysis, the occurrence of adverse prognosis (mRS ≥3) was taken as the dependent variable. Age, H-H grade, Modified Fisher grade, GCS, responsible aneurysm diameter, TC, TG, LDL-C, and BG levels were used as independent variables. Logistic regression model analysis showed that "Modified Fisher grade was high" (OR = 0.059, 95%CI: 0.020–0.168) , "High levels of TC" (OR = 10.711, 95%CI: 2.457–46.700) , "High levels of LDL-C" (OR = 0.178, 95%CI: 0.039–0.823) and "High levels of BG" (OR = 1.273, 95%CI: 1.012–1.602) increased the risk of adverse prognosis (Table .2).

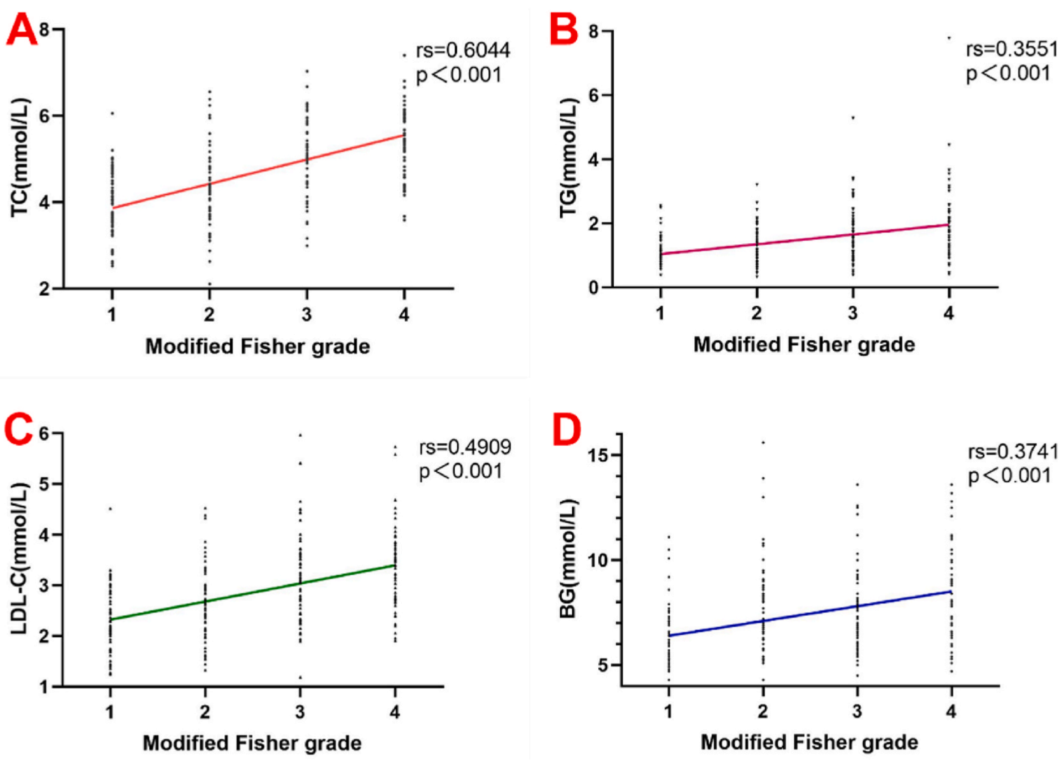

Fig. 1. Correlation analysis of Modified Fisher grade with TC, TG, LDL-C, and BG levels were analyzed using the Spearman's method. (A) TC level was positively correlated with Modified Fisher grade (rs = 0.6044, p $<$ 0.001) ; (B) TG level was positively correlated with Modified Fisher grade (rs = 0.3551, p $<$ 0.001) ; (C) LDL-C level was positively correlated with Modified Fisher grade (rs = 0.4909, p $<$ 0.001) ; (D) TG level was positively correlated with Modified Fisher grade (rs = 0.3741, p $<$ 0.001).

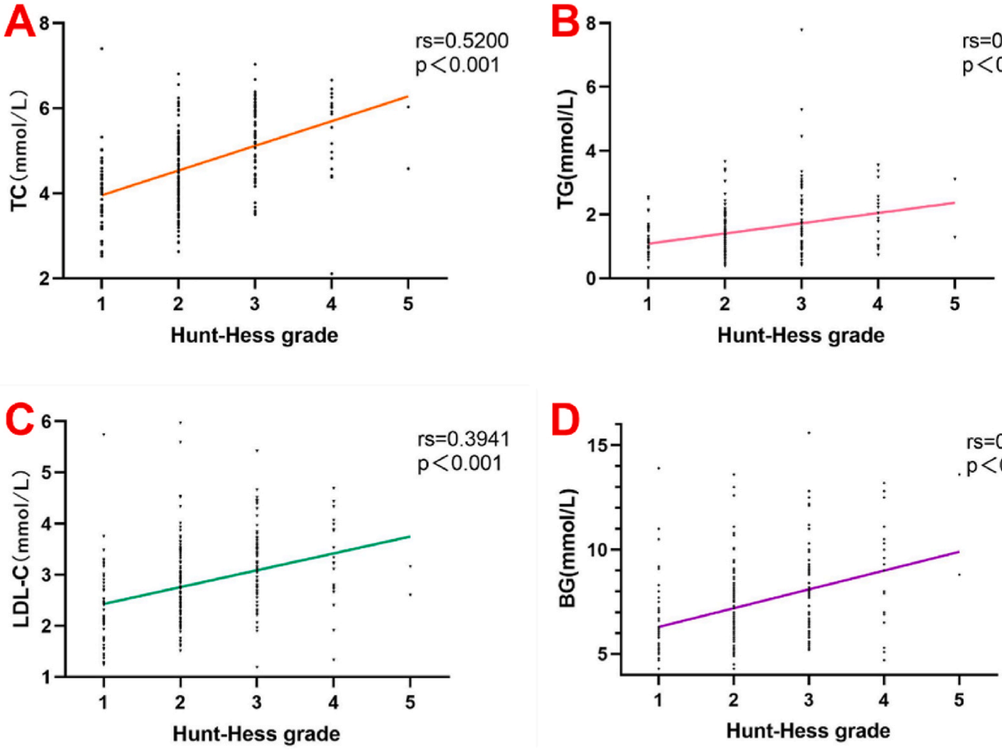

Fig. 2. Correlation analysis of Hunt-Hess grade with TC, TG, LDL-C, and BG levels were analyzed using the Spearman's method. (A) TC level was positively correlated with Hunt-Hess grade (rs = 0.5200, p < 0.001) ; (B) TG level was positively correlated with Hunt-Hess grade (rs = 0.2856, p < 0.001) ; (C) LDL-C level was positively correlated with Hunt-Hess grade (rs = 0.3941, p < 0.001) ; (D) TG level was positively correlated with Hunt-Hess grade (rs = 0.3614, p < 0.001).

ROC curves of H-H grade, Modified Fisher grade, TC, LDL-C, and BG levels are analyzed, and the results are as follows: The AUC of "H-H grade ", "Modified Fisher grade ", "TC level ", "LDL-C level" and "BG level" was 0.822, 0.885, 0.860, 0.772 and 0.721, respectively. The optimal cut-off values of them were 1.500, 1.500, 5.035, 3.035, and 7.750, respectively, in predicting the adverse prognosis of aSAH. The sensitivities were 69.90 %, 89.40 %, 70.80 %, 61.90 %, and 55.80 %, respectively. The specificities were 94.50 %, 84.70 %, 89.00 %, 82.90 %, and 80.10 %, respectively (Table .3, Fig. 3).

4. Discussion

In this study, multivariate logistic regression demonstrates that higher admission TC, LDL-C and BG levels are independently associated with an increased risk of adverse prognosis following aSAH. However, we showed that higher TG was associated with increased risk of adverse prognosis in univariate analysis, but failed to maintain significance in multivariate analysis. These results reveal the potential value of blood lipid and glucose levels at admission in evaluating the prognosis of patients with aSAH. Therefore, promptly attending to and regulating high blood lipid and glucose levels in patients upon admission may be beneficial in enhancing patient outcomes.

Firstly, for a long time, there has been research on predicting the prognosis of patients by detecting TC levels. Among them, studies

Table 2
Multivariable logistic analysis (Based on the good prognosis group and the adverse prognosis group).

Characteristics	OR	95 % CI	P-value
TC	10.711	2.457–46.700	0.002
LDL-C	0.178	0.039–0.823	0.027
BG	1.273	1.012–1.602	0.039
Modified Fisher grade	0.059	0.020–0.168	< 0.001
Hunt-Hess grade	0.204	0.067–0.622	0.005
responsible aneurysm diameter			0.813
age			0.836
TG			0.369

OR, odds ratio; CI, confidence interval.

Table 3
The AUC, cut-off value, sensitivity, and specificity from the ROC curve (Based on the good prognosis group and the adverse prognosis group).

Characteristics	AUC	95 % CI	Cut-off	Sensitivity (%)	Specificity (%)
TC	0.86	0.814–0.905	5.035	70.80	89.00
LDL-C	0.772	0.714–0.830	3.035	61.90	82.90
BG	0.721	0.658–0.783	7.750	55.80	80.10
Hunt-Hess grade	0.822	0.766–0.878	1.500	69.90	94.50
Modified Fisher grade	0.885	0.840–0.930	1.500	89.40	87.70

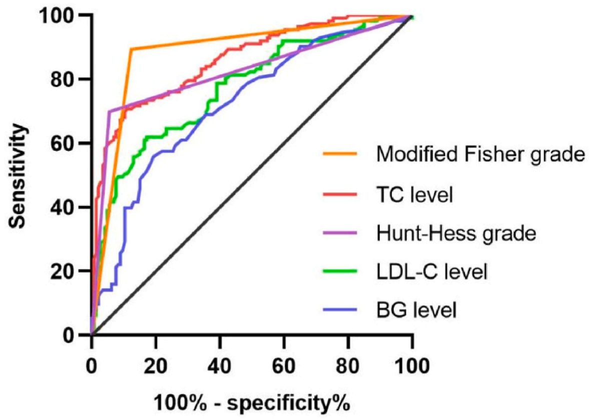

Fig. 3. ROC curve (Based on the good prognosis group and the adverse prognosis group). The AUC of "Modified Fisher grade" was 0.885, sensitivity was 89.4 %, specificity was 87.70 %. The AUC of "TC level" was 0.860, sensitivity was 70.80 %, specificity was 89.00 %. The AUC of "Hunt-Hess grade" was 0.822, sensitivity was 69.90 %, specificity was 94.50 %. The AUC of "LDL-C level" was 0.772, sensitivity was 61.90 %, specificity was 82.90 %. The AUC of "BG level" was 0.721, sensitivity was 55.80 %, specificity was 80.10 %.

have proved that high TC level is an important factor leading to adverse prognosis of patients with cardiovascular disease [9,19,20]. However, in many studies of stroke [9,14,15,21–23], because both high-level TC and low-level TC seem to affect the advers prognosis, researchers have been puzzled about the predictive value of TC level. Although there are few studies on the specific impact of TC levels on the onset and prognosis of SHA patients, opposite research results have also emerged. In a prospective cohort study [14], Joni Lin et al. found that an adverse lipid profile seemed to increase the risk of SAH, in which a high TC level increased the risk of men. Moreover, in the retrospective studies of Park JK et al. [24] and Inagawa T et al. [25], their findings suggest that elevated TC increases the risk of death in aSAH patients. Meanwhile, some studies [26–28] have different research results. Boyi et al. [10] found that low TC and HDL-C were independent predictors of adverse prognosis of aSAH. However, this study included fewer cases and had selection bias.

In our study, we found that there was a strong positive correlation between TC level and H-H grade, which indicated that high TC levels during admission may be an indicator of more severe illness in patients. At the same time, we also confirmed that TC levels above 5.035 mmol/L predicted adverse patient prognosis by logistic regression modeling analysis. Therefore, our research results are more consistent with the view of that high TC level is an independent risk factor for adverse prognosis of patients with aSAH.

Secondly, it is suggested that HDL-C level has a greater impact on the disease than LDL-C level among the numerous studies on stroke. Some studies have shown that low-level HDL-C is associated with aSAH and stroke risk [18,29,30]. However, our study has even excluded HDL-C as an independent risk factor for evaluating the prognosis of aSAH. Coincidentally, Sandvei et al. [31] conducted a follow-up study of aSAH patients for up to 11 years and found that there was no association between HDL-C and the risk of aSAH. Thus, a definitive correlation between HDL-C and disease advancement in patients with aSHA cannot be comprehensively clarified presently. However, it confirmed the predictive value of LDL-C for aSAH prognosis in our study. Lindbohm, J et al. [14] also obtained similar experimental results as ours. In addition, a recent study found that oxidized low-density lipoprotein (ox-LDL) and lectin-like ox-LDL receptor-1 (LOX-1) in basilar artery walls of SAH rabbits increased [32]. Moreover, the increase of ox-LDL and LOX-1 will affect the prognosis of aSAH patients [33], and LDL-C and ox-LDL can be mutually transformed [34]. Therefore, when assessing the prognosis of aSAH patients, it is important for neurosurgeons to consider not only TC levels, but also to take into account the role of LDL-C.

Most previous studies have investigated the relationship between elevated blood lipid levels and the occurrence of aSAH, suggesting that good blood lipid control may be a potential strategy for the prevention of aSAH. Building on these findings, we further explored the impact of high blood lipid levels on the adverse prognosis of aSAH patients. The reasons why elevated blood lipid levels can predict the adverse prognosis of SAH patients, we speculate that it is likely to be related to cerebrovascular atherosclerosis. Frösen, J et al. [35] pointed out that atherosclerotic changes in the vascular wall can often be found in the aneurysm wall. In the prospective studies [36–38] of myocardial infarction and stroke, the high levels of TC and LDL-C can be considered as key factors, especially TC. In addition, TG is also associated with vascular wall atherosclerosis, and studies have reported the impact of TG levels on the risk and prognosis of cardiovascular and cerebrovascular diseases [31,39–41]. However, our study found that TG was weakly positively correlated with the Modified Fisher grade and H-H grade, but the final multivariate analysis excluded TG. Therefore, it seems unable to determine the specific impact of TG level on the prognosis of SAH patients, which maybe need more and larger sample size studies.

Thirdly, as we all know, the rational management of BG has always been an important link in the treatment of stroke patients. Patients with high BG may bring serious consequences to them, even life-threatening ones. Moreover, some studies [7,42]believe that controlling the excessive BG level will improve the therapeutic effect of aSAH patients. Our study found that high BG levels ($\geq$7.75 mmol/L) on admission in patients with aSAH would increase the risk of adverse prognosis. Wang et al. [43] also found that patients with an average BG $\geq$ 152.25 mg/dl had significantly higher mortality during hospitalization and follow-up. In addition, the influence of BG level on the prognosis of aSAH patients has some theoretical basis. Lv, G et al. [22] speculated that high BG may lead to mitochondrial damage, affect energy metabolism, and ultimately lead to adverse prognosis of patients. In addition, another study explained that a hypoglycemic drug (metformin) alleviated EBI after SAH in rats through the AMPK-dependent signaling pathway [44]. Therefore, there is a certain correlation between high BG levels and poor prognosis. It may be important to pay more attention to aSAH patients with high BG at admission, which may prevent the occurrence of adverse prognosis.

In addition, Previous studies have focused on either lipids or glucose to determine disease severity, which is incomplete and inaccurate for predicting the prognosis of patients with aSAH. It is widely understood that lipid and glucose metabolism in the human body are interconnected and mutually transformative. Therefore, this study incorporated lipid and glucose levels in the examination of patients' prognoses to better comprehend their effects on disease development. Consequently, blood lipid and glucose levels must be regularly monitored during the management and treatment of aSAH patients, and adjustments to the treatment program should be made promptly.

Finally, this study also has some limitations. 1) The geographical area of the subjects was limited to southwest China, and the experimental results may partly represent the situation of all aSAH patients; 2) As a retrospective study with a small sample size, the evidence strength of our research results may not be as strong as those of larger research centers or other prospective studies. 3) The inclusion and exclusion criteria of patients can't be unified with other studies. So selection bias cannot be avoided in the study. 4) It is not known that decreased the levels of TC, LDL-C, and BG could improve the prognosis of aSAH, which is the further research of this study in the future.

5. Conclusions

In conclusion, Modified Fisher grade, H-H grade, TC, LDL-C and BG levels at admission were independent predictors of adverse prognosis of aSAH. Besides, TC, LDL-C, and BG levels were positively correlated with Modified Fisher and Hunt-Hess grades. What's more, high levels of TC, LDL-C, and BG combined with Modified Fisher grade and H-H grade can identify high-risk groups with adverse prognoses in aSAH patients.

Founding

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Data availability statement

The authors declare that the data for this study will be made available on request.

Ethics requirements

This study was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University (K2023-315) on August 3, 2023. In addition, this study is a retrospective study. All patients included in the study have discharged for a long period. Therefore, we are unable to sign informed consent forms for every patient, so we choose to undergo verbal informed consent.

CRediT authorship contribution statement

Zhu Yajun: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Ouyang Diqing:** Writing – review & editing, Formal analysis, Data curation. **Lei Xingwei:** Investigation. **Tang Liuyang:** Investigation. **Zhang Xiaofeng:** Investigation. **Li Xiaoguo:** Validation, Software. **Guo Zongduo:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Guo Zongduo reports financial support was provided by National Natural Science Foundation of China. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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