

Lipid accumulation product as useful predictors of stroke

A correlation analysis between lipid accumulation index/cerebral vascular hemodynamics indexes and risk factors of stroke in 3264 people undergoing physical examination in Xinjiang

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Abstract

Objective: To investigate the relationship between lipid accumulation index and cerebral hemodynamic integral value in 3264 people undergoing physical examination, so as to analyze the correlation between different lipid accumulation product index (LAP) levels and stroke risk factors.

Methods: This cross-sectional study was conducted from January to December 2019 on 3264 adults at the age of 19 to 85 living in Urumqi, Xinjiang. The stroke related risk factors were evaluated by the questionnaire survey. The enrolled subjects were divided into Q1 group (n = 817), Q2 group (n = 815), Q3 group (n = 816) and Q4 group (n = 816) according to the quartile site at a low-to-high-score manner.

Results: The proportion of males was significantly higher than that of females in Q2, Q3, and Q4 groups. The proportion of middle-aged people and the elderly in Q2, Q3, and Q4 groups was significantly higher than that of youths ($P < .05$). The proportion of patients with history of hypertension, hyperlipidemia, physical inactivity, and smoking, and the levels of systolic blood pressure, diastolic blood pressure, fasting blood glucose, total cholesterol, high-density cholesterol, low-density cholesterol, triglyceride, body mass index, waist circumference increased with the increase of LAP level in different groups ($P < .05$). On both sides of the cerebral hemodynamic integral value (CVHI) index, Vmean, Vmax, Vmin showed a decreasing trend whereas peripheral resistance, pulse velocity, Zcv, dynamic resistance, critical pressure level, difference between diastolic and critical pressure showed an increase trend with the increase of LAP level. The normal rate of CVHI in 4 groups (>75 points) was 97.4%, 89.7%, 87.0, and 80.8%, respectively, showing a decreasing trend. Logistic regression results showed that the higher the LAP, the higher the abnormal risk of CVHI.

Conclusion: There is a positive correlation between LAP and CVHI, the higher the LAP, the higher the risk of CVHI abnormality, which should be concerned seriously.

Abbreviations: BMI = body mass index, BP = blood pressure, CP = critical pressure level, CVHI = cerebral hemodynamic integral value, DBP = diastolic blood pressure, DP = difference between diastolic and critical pressure, DR = dynamic resistance, LAP = lipid accumulation product index, Rv = peripheral resistance, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride, WC = waist circumference, Wv = pulse velocity.

Keywords: cerebral hemodynamics, lipid accumulation index, stroke

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BZ and XW contributed equally to this work.

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All procedures for the study subjects were approved by Medical Ethics committee of the First Affiliated Hospital of Xinjiang Medical University. All study subjects enrolled had signed the informed consent form after being well informed of the study contents.

All study subjects enrolled had signed the informed consent form of publication.

All data and material were available.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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1. Introduction

Lipid accumulation index, also termed as lipid accumulation product index (LAP), is a safe, novel and convenient biomarker based on fasting triglyceride (TG) and waist circumference (WC).^[1] Body mass index (BMI) has been the focus of many studies on cardiovascular diseases, which has been frequently used to determine overweight or obesity. However, BMI cannot distinguish excessive fat and excessive muscle or identify the anatomical location and function of fat. Relative to BMI, LAP has significant advantages.^[2] A large number of studies at home and abroad have demonstrated that there is a correlation between LAP and intracranial atherosclerosis,^[3] metabolic syndrome,^[4] diabetes^[5] and other diseases, and can strongly predict the occurrence and causes of death induced by cardiovascular events.^[1,6] This study enrolled 3264 people who voluntarily underwent cerebral hemodynamic integral value (CVHI) examination in a health center in The First Affiliated Hospital of Xinjiang Medical University in Urumqi from January to December 2019 as the study subjects, and analyzed the relationship between different LAP levels and CVHI with the stroke related risk factors in the physical examination population.

2. Methods

2.1. Research design and study subjects

A cross-sectional study was performed in 3264 people (regardless of gender) in a health center in The First Affiliated Hospital of Xinjiang Medical University in Urumqi, Xinjiang, China. This study had been approved by the president of the hospital prior to the randomization of study subjects. The samples were collected by a simple random sampling method. Inclusion criteria: People with age ≥ 18 years old; long-term residents in Urumqi, Xinjiang (≥ 6 months); people who participated in the questionnaire screening voluntarily for highly risky stroke groups and WC/TG/CVHI without notable speech communication disorders. Exclusion criteria: People with incomplete clinical and laboratory data; pregnant or lactating women; study subjects with liver dysfunction, inflammatory diseases, neoplasms, adrenal or thyroid dysfunction, and mental disorders. Finally, 3264 adults were selected, among whom there were 1198 males and 2022 females with mean age of (45.92 ± 10.76) years.

2.2. Ethical approval

The study was conducted abiding by the Declaration of Helsinki. All procedures for the study subjects were approved by Medical Ethics committee of the First Affiliated Hospital of Xinjiang Medical University (Ethical NO.: 20160317-02), Urumqi, Xinjiang, China. All study subjects enrolled had signed the informed consent form after being well informed of the study contents.

2.3. Demographic data

The demographic data were acquired with a structured and standard questionnaire by the proficient medical staff in the primary healthcare center. The primary information was acquired, including age, gender, marital status, education status, smoking status, medical history (mainly containing the underlying diseases like hypertension, diabetes mellitus, stroke, dyslipidemia or cancer), and physical activity levels.

2.4. Anthropometry measurements and body composition

Measure the body weight in an electronic digital scale (TANITA model Ironman BC-554, Tokyo, Japan) certified by the Inmetro, with capacity of 150 kg and precision of 100 g. Measure the body height with a wall-mounted stadiometer (without footboard), with 2.5 m of height and 0.1 cm of resolution (WELMY, Santa Bárbara D'Oeste, Brazil). When measuring the height, tell the examinee to take off the shoes and then stand on his back the instrument for measuring height and weight when measuring height, with head, buttocks, heel, and 3 points close to the column of measuring instrument, so as to improve the measurement accuracy. When measuring the weight, tell the examinee to take off the shoes, coat and cap, and stand firmly in the center of the scale, and not to shake before steady reading. When measuring the WC, tell the examinee to separate the feet by a distance of 25 to 30 cm, stand erect. The WC is around the abdomen along the midpoint of the line between the highest point of iliac crest and the 12th costal margin. Measure all anthropometric variables twice, with mean values obtained for final analyses.

2.5. Blood pressure (BP) measurement

Measure the systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate. To evaluate the patient's BP, tell the subjects to sit on a chair and keep still without physical activity for 10 minute. Measure the BP of the right arm with the standard table mercury sphygmomanometer (Yu Yue brand, China) in the subjects at sitting position. Calculate the mean arterial pressure (MAP) by $MAP = (2DBP + SBP)/3$.

2.6. Laboratory tests

Collect the blood samples (5 mL) in the 12-hour fasting status. Centrifuge the blood samples at 3000 r.p.m. for 10 minute, evaluate the lipid profile and store the remnants at -80°C for later assessment. Detect the concentrations of serum total cholesterol (TC), TG, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol with an auto-analyzer (Hitachi 7600, Japan).

2.7. Cerebral hemodynamics

Use the Cerebrovascular Function Detector (Type GT-300, Shanghai Shenzhou Gaote Medical Equipment, the probe frequency MHz.5) to detect the $Q_{\text{mean}}/(\text{cm}/\text{m}^3)$, peripheral resistance (Rv), $V_{\text{max}}/(\text{cm}/\text{s})$, dynamic resistance (DR), $V_{\text{min}}/(\text{cm}/\text{s})$, $V_{\text{mean}}/(\text{cm}/\text{s})$, pulse velocity (Wv), critical pressure level (CP), characteristic impedance, and the difference between diastolic and critical pressure (DP).

2.8. Calculation and stratification of lipid accumulation index fraction

LAP is a new index based on WC and TG.^[7]

The formula is as follows^[7]:

$$\begin{aligned} \text{LAP(M)} &= [\text{WC}(\text{cm}) - 65] \times \text{TG}(\text{mmol/L}) \\ \text{LAP(F)} &= [\text{WC}(\text{cm}) - 58] \times \text{TG}(\text{mmol/L}) \end{aligned}$$

Calculate the male and female quartiles respectively, and set the cut points of the male quartile as 27.83, 47.20, and 78.51, respectively. Divide all subjects into Q1, Q2, Q3, and Q4 groups according to the quartile site at a low-to-high-score manner.

2.9. Calculation of cerebrovascular function score

The optimal cut-off point of CVHI is 75 points. Subjects with a score <75 points are considered to be highly risky in stroke, among whom subjects with CVHI score of 50 to 74 points are considered as lowly risky in stroke, those with CVHI score of 25 to 49 points as moderately risky in stroke, and those with CVHI score of 0 to 24 points as highly risky in stroke.^[8]

2.10. Experimental grouping

Firstly, all study subject's basic information and medical history were acquired through on-site questionnaires, including height, weight, and WC. Meanwhile, related laboratory tests and cerebral hemodynamic monitoring were completed, and BMI and LAP were calculated. The study subjects were divided into normal cerebrovascular function group (cerebral hemodynamic indicator ≥ 75 points) and abnormal normal cerebrovascular function group (cerebral hemodynamic indicator <75 points). Based on the LAP quartile calculation formulae LAP (males) = $[WC (cm) - 65] \times TG (mmol/L)$ and LAP (females) = $[WC (cm) - 58] \times TG (mmol/L)$, the quartiles of males and females were calculated. The LAP quartile cut-points were 27.83, 47.20, and 78.51 for males and 15.23, 29.38, and 52.17 for females. The enrolled subjects were divided into Q1 group (n=817), Q2 group (n=815), Q3 group (n=816) and Q4 group (n=816) according to the quartile site at a low-to-high-score manner.

2.11. Statistical data analysis

SPSS 21.0 (SPSS Inc, Chicago, IL) software was adopted for data analysis. Use Kolmogorov-Smirnov test to check the data normality. Use the chi-squared test, Student *t* test, ANOVA, and Fisher exact probability method were adopted to evaluate the differences among groups. $P < .05$ was considered as statistically significant. In Logistic regression model, set CVHI anomaly groups (<75 points) as dependent variables, and LAP and stroke risk factors as independent variables.

3. Results

3.1. General characteristics of study subjects

Of the 3264 subjects included in the final analyses, there were 2066 males (63.3%) and 1198 females (36.7%) with mean age of (45.92 ± 10.76) years. Q1 group enrolled 817 people (347 males and 470 females), including 286 youths (<35 years), 489 middle-aged people (of 35-60 years), and 42 elderly (>60 years); Q2 group intake 815 people (521 males and 294 females), including 161 youths (<35 years), 571 middle-aged people (of 35-60 years)

and 83 elderly (>60 years); Q3 group enrolled 816 people (561 males and 255 females), including 135 youths (<35 years), 574 middle-aged people (of 35-60 years), and 107 elderly (>60 years); Q4 group enrolled 816 people (637 males and 179 females), including 152 youths (<35 years), 586 middle-aged people (of 35-60 years), and 78 elderly (>60 years). In different LAP groups, there were statistically significant differences in gender and age ($P < .05$). The proportions of males in Q2, Q3, and Q4 groups were significantly higher than those of females; the proportions of the middle-aged people (of 35-60 years) and the elderly (>60 years) were significantly higher than the proportions of the youths (<35 years) in Q2 and Q3 groups. As shown in Table 1.

3.2. Comparison of clinical and laboratory data among different LAP groups

The proportion of study subjects with history of hypertension, hyperlipidemia, physical inactivity, and smoking as well as the levels of SBP, DBP, FBG, TC, HDC, LDL, TG, BMI, and WC increased with the increase of LAP level in different groups ($P < .05$). However, there was no statistical significance in the proportion of study subjects with history of atrial fibrillation/valvular heart disease diabetes and the family history of stroke ($P > .05$). As shown in Table 2.

3.3. Comparison of cerebral hemodynamic indexes among different groups

The Q_{mean} differences between different groups were statistically significant on the left side. In the right side, there was no statistical difference in Q_{mean} value among the 4 groups ($P > .05$). On both sides of the CVHI index, V_{mean} , V_{max} , V_{min} showed a decrease trend with the increase of LAP level, but R_v , W_v , Z_{cv} , DR, CP, DP showed an increase trend with the increase of LAP level, as showed in Table 3.

3.4. Comparison of LAP/CVHI anomaly rates among different groups

The mean CVHI score was (94.55 ± 8.98) , (90.35 ± 14.05) , (87.95 ± 16.46) , and (85.00 ± 17.36) points in Q1, Q2, Q3, and Q4 groups, respectively, which showed a decrease trend along with the increase of CVHI score. The proportion of subjects with normal CVHI score (>75 points) was 97.4%, 89.7%, 87.0, and 80.8% in Q1, Q2, Q3, and Q4 groups, respectively, which revealed a decrease trend along with the increase of CVHI scores, with a total proportion of subjects with normal CVHI (>75 points) of 88.7%. The CVHI scores in Q3 group and Q4 group were significantly lower than the mean proportion of subjects

Table 1
Comparison of general information/case (%) among different LAP groups.

Variables	Group	Q1 group	Q2 group	Q3 group	Q4 group	χ^2	P
Gender	Males	347 (16.8)	521 (25.2)	561 (27.2)	637 (30.8)	239.67	.00
	females	470 (39.2)	294 (24.5)	255 (21.3)	179 (14.9)		
Age/ yrs	<35	286 (39.0)	161 (21.9)	135 (18.4)	152 (20.7)	116.71	.00
	35-60	489 (22.0)	571 (25.7)	574 (25.9)	586 (26.4)		
	>60	42 (13.5)	83 (26.8)	107 (34.5)	78 (25.2)		
Nationality	Han	716 (25.4)	702 (24.9)	719 (25.5)	686 (24.3)	6.94	.07
	Other	101 (22.9)	113 (25.6)	97 (22.0)	130 (15.9)		

Presented in mean \pm SE (standard error of mean) for continuous data; N(%) for categorical data.

Table 2
Comparison of clinical and laboratory data among different LAP groups.

Variables	Q1 group	Q2 group	Q3 group	Q4 group	χ^2/F	P
History of hypertension	315 (28.0)	298 (26.5)	248 (22.1)	262 (23.3)	15.65	.01
History of hyperlipidemia	5 (0.5)	19 (2.0)	205 (21.8)	711 (75.6)	1954.50	.00
Lack of movement	285 (19.2)	373 (25.1)	408 (27.5)	420 (28.3)	55.71	.00
AF/cardiac valve disease	59 (29.1)	45 (22.2)	59 (29.1)	40 (19.7)	5.94	.15
History of smoking	201 (19.3)	270 (26.0)	248 (23.8)	321 (30.9)	42.25	.00
History of drinking	321 (21.6)	387 (26.0)	374 (25.1)	406 (27.3)	19.97	.00
History of diabetes	110 (24.0)	100 (21.8)	119 (26.0)	129 (28.2)	4.65	.19
Family history of stroke	4 (6.3)	19 (30.2)	22 (34.9)	18 (28.6)	12.5	.06
Predialysis SBP (mm Hg)	118.49±15.05	127.18±16.80	129.24±17.51	132.43±16.86	105.86	.00
Predialysis DBP (mm Hg)	73.44±10.67	78.60±11.24	80.51±12.04	83.46±12.11	108.96	.00
FBG (mmol/L)	4.77±0.79	5.08±1.38	5.28±1.40	6.50±4.50	75.25	.00
TC (mmol/L)	4.40±0.81	4.71±0.90	4.95±0.96	6.11±4.32	85.94	.00
HDL-c (mmol/L)	1.45±0.35	1.27±0.29	1.19±0.27	2.10±4.38	27.82	.00
LDL (mmol/L)	2.86±0.69	3.21±0.75	3.41±0.81	4.48±4.71	66.66	.00
TG (mmol/L)	0.89±0.32	1.33±0.39	1.93±0.51	4.83±4.71	450.96	.00
BMI (kg/m ²)	22.27±2.64	25.05±2.59	26.53±2.91	27.94±3.45	564.50	.00
WC (cm)	76.72±7.70	87.35±7.43	91.72±7.16	96.26±8.88	932.84	.00

Presented in mean ±SE (standard error of mean) for continuous data; N(%) for categorical data.

BMI=body mass index, FBG=fasting blood-glucose, HDL-C=high-density lipoprotein cholesterol, LDL-C=low density lipoprotein cholesterol, TC=total cholesterol, TG=triglycerides, WC=waist circumference.

with normal CVHI. There were significant statistical differences among the 4 groups ($P < .05$), as specified in Table 4.

3.5. Logistic regression analysis of influencing factors of cerebral hemodynamics

According to Table 3, CVHI abnormality served as dependent variable, and BMI, SBP, DBP, TC, HDC, LDL, FBG, age, sedentary, smoking, drinking, and LAP level were used as independent variables to fit Logistic regression equations. The results showed that there was a positive correlation between LAP and CVHI abnormal. Compared with Q1 group, Q2, Q3, and Q4 groups had statistical significance ($P < .05$), and the OR value of the Q4 group was the largest (ORP=2.27). As shown in Table 5.

4. Discussion

Stroke is one of the serious threats to human health, and it is also the primary cause of morbidity and mortality in China. Obesity is a recognized risk factor for stroke and other cardiovascular diseases. Therefore, it is of great significance to continue to explore the effective screening indicators related to obesity for

screening, preventing, and treating highly risky populations with cardiovascular and cerebrovascular diseases. LAP is a new index based on WC and TG, which is used as a marker of abdominal obesity in the United States. This study subjects were divided into 4 groups according to the LAP quartile sites. The results showed that the proportions of males in Q2, Q3, and Q4 groups were significantly higher than those of females.^[9] It may be because males have more exposure to stroke risk factors than females, which is related to smoking, drinking, staying up late, poor dietary habits, and more social responsibility and psychological stress. The proportions of the middle aged and the elderly in Q2, Q3, and Q4 groups were significantly higher than those of the youth. Some studies^[10,11] have proven that both WC and TG concentrations increase along with age, so their LAP also increases with age, which is consistent with the results of this study.

Obesity, as an independent risk factor for stroke, has received more and more attentions from the scholars at home and abroad. Currently, common indicators for obesity assessment include BMI, WC, hip circumference and waist-to-hip ratio and so on. Relative to the above traditional indicators, LAP can comprehensively predict the occurrence of cardiovascular and cerebrovascular diseases by integrating WC and TG. This study showed

Table 3
Comparison of cerebral hemodynamic indexes among different groups.

Index	Left side					Right side						
	Q1 group	Q2 group	Q3 group	Q4 group	F	P	Q1 group	Q2 group	Q3 group	Q4 group	F	P
Qmean (cm/s)	9.90±1.43	10.23±1.57	10.14±1.60	10.34±1.51	11.787	<.001	9.64±1.51	9.87±1.60	9.73±1.65	9.86±1.56	3.846	>.050
Vmean (cm/s)	22.74±3.62	20.77±3.68	20.00±3.63	19.64±3.42	121.786	<.001	21.73±3.68	19.70±3.71	18.84±3.65	18.41±3.48	134.334	<.001
Vmax (cm/s)	46.17±7.19	42.42±7.10	41.31±7.00	40.73±6.85	98.256	<.001	44.79±7.36	41.26±7.38	40.23±7.14	39.57±7.01	84.278	<.001
Vmin (cm/s)	11.15±2.23	10.21±2.15	9.88±2.00	9.86±1.97	67.934	<.001	10.75±2.19	9.89±2.12	9.47±2.07	9.37±2.06	71.547	<.001
Rv (kpa-s/m)	55.14±13.76	65.21±17.81	69.92±23.52	72.84±20.40	133.160	<.001	58.01±15.32	69.44±21.06	74.39±23.28	78.23±22.72	144.874	<.001
Vw (m/s)	12.40±4.57	14.67±6.25	15.25±6.22	15.59±6.05	49.589	<.001	12.73±4.80	15.06±6.12	15.37±6.13	15.95±6.49	46.413	<.001
Zcv (kpa-s/m)	13.02±4.80	15.40±6.57	16.02±6.53	16.36±6.35	49.600	<.001	13.37±5.04	15.81±6.43	16.14±6.44	16.75±6.81	46.419	<.001
DR (kpa-s/m)	28.48±10.01	34.31±13.49	36.51±16.05	37.81±15.24	72.050	<.001	30.34±11.53	37.95±16.96	39.69±15.90	41.21±15.77	82.600	<.001
CP (kpa)	6.05±1.82	6.39±1.92	6.60±1.94	6.80±2.01	22.612	<.001	5.97±1.85	6.14±2.04	6.38±2.03	6.66±2.07	17.922	<.001
DP (kpa)	3.10±1.03	3.37±1.18	3.42±1.13	3.58±1.24	25.377	<.001	3.16±1.06	3.58±1.28	3.60±1.22	3.70±1.26	32.406	<.001

BMI=body mass index, CP=the critical pressure level, DP=the difference between diastolic pressure and critical pressure, DR=dynamic resistance, Qmean=mean blood flow, Rv=peripheral resistance, Vmax=the maximum flow rate, Vmean=mean flow rate, Vmin=the minimum flow rate, Vw=the pulse wave velocity, Zcv=characteristic impedance.

Table 4
Comparison of LAP/CVHI anomaly rates among different groups.

Groups	N	CVHI integral (251658240 $\bar{X} \pm s$)	0-24 points	25-49 points	50-74 points	>75 points
Q1 group	817	94.55 ± 8.98	0 (0)	9 (1.1)	12 (1.5)	796 (97.4)
Q2 group	815	90.35 ± 14.05	6 (0.7)	23 (2.8)	55 (6.7)	731 (89.7)
Q3 group	816	87.95 ± 16.46	14 (1.7)	22 (2.7)	70 (8.6)	710 (87.0)
Q4 group	816	85.00 ± 17.36	9 (1.1)	44 (5.4)	104 (12.7)	659 (80.8)
Mean		89.46 ± 14.98	29 (0.9)	98 (3.0)	241 (7.4)	2896 (88.7)
F/ χ^2		62.64	125.54			
P		.00	.00			

The population was divided into 4 groups according to CVHI score. People with CVHI score of 0 to 24 points served as high-risk group, those with 25 to 49 points as medium-risk group, and those with 50 to 74 points as low-risk group. People with CVHI score 75 points served as normal group.

Rank sum test for intergroup comparison in anomaly rate; Chi-square test for comparison of population composition.

CVHI = cerebral hemodynamic integral value, LAP = lipid accumulation product index.

that the proportion of study subjects without smoking history and the levels of SBP, SDP, FBP, TC, LDL, TG, BMI, and WC all revealed an increase trend along with the increase of LAP level, and there were significant differences ($P < .05$), which were consistent with the study results of Rui Li et al^[12] However, lacking of exercise, high levels of BP, blood sugar, TC, LDL, and TG as well as smoking and alcohol consumption all increase the risk of stroke. LAP is an intermediary factor that can indirectly increase the risk of stroke. As a result, maintaining normal LAP level is also important to prevent and cure hyperlipidemia, hypertension, hyperglycemia, and other stroke risk factors.

CVHI changes can not only reflect the changes of CVHI indicators, but also objectively reflect the risk of stroke. The sensitivity of early warning stroke can reach 80% while the specificity is 68%.^[13] Our study demonstrated that LAP was negatively correlated with Vmean, Vmax, Vmin, and positively associated with Rv, Wv, Zcv, DR, CP, DP. These results indicated that elevated LAP could lead to changes in cerebral hemodynamic parameters, which might be related to the abnormal microvascular pattern, the decreased inflammatory endothelial function and the impaired vascular reactivity caused by high LAP level.^[14] In addition, excessively high LAP level revealed different degrees of abnormalities in the neuroendocrine system, such as insulin resistance, sympathetic activity enhancement, which could also affect the abnormalities of intravascular dynamics to different extents. This study further illustrated that the CVHI mean and

normal rate decreased with the increase of LAP level, and the CVHI normal rates were significantly lower than the overall normal rate in Q3 and Q4 groups. The higher the LAP, the lower the normal rate. The main reason may be that with the increase of LAP, excessive adipose tissue-generated angiotensin sources are release into the blood, which can not only raise BP, but also increase TG ectopic deposition, so that more and more lipid substances deposited on nonfat ectopic tissue (blood vessels), consequently causing various adverse effects on the metabolism of cardiovascular cells and resulting in abnormal CVHI integral values.^[15]

The occurrence of stroke is the result of the synergistic effect of many factors. The Logistic regression analysis in this study indicated that age, alcohol consumption, BMI, SBP, and LAP were influencing factors of CVHI. The risks of CVHI abnormalities in Q2, Q3, and Q4 groups was 1.92 folds, 1.81 folds, and 2.27 folds higher than that in Q1 group. With the increase of LAP level, CVHI could be affected to different degrees, thus increasing the risk of stroke. Therefore, reasonable diet and active exercise and correcting bad behaviors and habits such as excessive eating or prolonged sitting, can maintain normal WC and TG levels. Moreover, controlling LAP within reasonable limits can effectively reduce the risk of stroke. LAP develops to reflect the anatomical and physiological indicators related to fat accumulation. Using LAP to evaluate stroke risk populations can significantly reduce the time required for

Table 5
Logistic regression analysis of influencing factors of cerebral hemodynamics.

Independent variable	Comparable group	Control group	B	SE	Wald	P	OR	95% C L
BMI	Yes	None	0.15	0.02	47.25	.00	1.16	1.12-1.22
SBP (mm Hg)	Yes	None	0.06	0.01	116.63	.00	1.06	1.05-1.07
DBP (mm Hg)	Yes	None	0.00	0.08	0.02	.89	1.00	0.99-1.02
TC (mmol/L)	Yes	None	0.030	0.96	0.10	.75	1.03	0.85-1.25
HDC (mmol/L)	Yes	None	0.04	0.08	0.28	.60	1.04	0.89-1.23
LDL (mmol/L)	Yes	None	-0.06	0.91	0.38	0.54	0.95	0.79-1.13
FBP mmol/L	Yes	None	-0.11	0.12	0.33	.57	0.89	0.61-1.32
Age			0.03	0.01	25.03	.00	1.03	1.02-1.05
Situated	Yes	None	0.17	0.14	1.58	.21	1.19	0.91-1.55
Smoking	Yes	None	-0.12	0.17	1.36	.24	0.82	0.59-1.15
Alcohol	Yes	None	-0.41	0.16	6.81	.01	0.67	0.49-0.90
LAP	Q2 group	Q1 group	0.63	0.28	5.54	.02	1.92	1.17-3.31
	Q 3 group		0.59	0.29	4.25	.04	1.81	1.03-3.19
	Q 4 group		0.98	0.35	17.99	.00	2.27	1.35-5.28

BMI = body mass index, DBP = diastolic blood pressure, LAP = lipid accumulation product index, LDL = low-density lipoprotein, SBP = systolic blood pressure, TC = total cholesterol.

evaluation and the need for complex diagnostic tests. Meanwhile, LAP is easier to be followed up than other indicators, which can provide a more convenient and accurate dynamic evaluation for patients. Hence, using LAP is an intermediate variable to assess the stroke risk factors and implement relevant interventions.

In conclusion, people with excessive LAP may have CVHI abnormalities and risk factors of stroke, which should be highly concerned. Regular cerebral vascular function examination and effective interventions should be conducted to further prevent the occurrence of stroke.

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Author contributions

Bing Zhang was responsible for data acquisition and paper writing; Xiao Wang was responsible for data management and statistical analysis; Li Zhong was responsible for data review and statistical analysis; Yu-Shan Wang was responsible for paper review

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