JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

Correlation between *Helicobacter pylori* infection and atherosclerosis in a physical examination population and its influencing factors

Lei Han[1], Ruijuan Gu[2], Hatira·Jingsihan[1], Yushan Wang[1], Alina·Abulaiti[3], Linnan Qu[1]

[1] Center of Health Management, The First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang 830054, China
[2] Data Statistics and Analysis Center,The First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang 830054, China
[3] Imaging center, The First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang 830054, China

Abstract

Objective: To investigate the influence of *Helicobacter pylori* (HP) infection on carotid atherosclerosis (AS) in the physical examination population.

Methods: This study included physical examination patients from the First Affiliated Hospital of Xinjiang Medical University (May 2021–May 2023). Participants underwent a carbon-13 urea breath test (13C-UBT), HP antibody detection, and carotid AS assessment via colour Doppler ultrasound. The patients were divided into the HP-infected group and the non-infected group based on 13C-UBT results, with the HP-infected group further subdivided into high-risk and low-risk groups based on antibody detection. General data, laboratory indexes and carotid AS indexes were compared between the groups. Multivariate logistic regression was used to analyse carotid plaque (CP) formation risk factors.

Results: The HP-infected group showed significantly higher body mass index levels, low-density lipoprotein cholesterol (LDL-C), and serum uric acid levels than the non-infected group ($p < 0.05$). The high-risk group demonstrated significant age differences, body mass index, hypertension, total cholesterol, LDL-C, and blood uric acid levels compared with the low-risk group ($p < 0.05$). Logistic regression identified age, smoking, systolic blood pressure and glycosylated haemoglobin as CP formation factors between the infected and non-infected groups ($p < 0.05$). Between the high-risk and low-risk groups, age, smoking, diabetes, systolic blood pressure and high-risk HP were identified as CP formation factors ($p < 0.05$).

Conclusions: *Helicobacter pylori* infection, particularly high-risk HP infection, advances carotid AS in the physical examination population, with high-risk HP infection serving as a risk factor for CP formation.

Key words: *Helicobacter pylori*; atherosclerosis; carotid plaque; risk factor.

J Infect Dev Ctries 2025; 19(1):28-33. doi:10.3855/jidc.0000

(Received 13 September 2023 – Accepted 23 February 2024)

Introduction

Helicobacter pylori (HP) is a gram-negative, spiral-shaped bacterium that can be transmitted from person to person [1]. It enters the human body through the oral cavity, specifically colonizes the gastric epithelium and is less likely to be spontaneously cleared by the body's immunity. If left untreated, HP can lead to long-lasting and even lifelong infections [2]. Available epidemiological data reveal that more than 50% of natural populations worldwide are infected with HP, with rates up to 80% in developing countries [3]. The data also show an HP infection rate of 44.2% in China, posing a significant economic and medical burden on the country [4]. For this reason, the factors contributing to HP infection should be analyzed to reduce its occurrence by controlling related risk factors.

Most HP infections cause active inflammation of the gastric mucosa, whereas some can lead to complications such as peptic ulcer and gastric cancer based on chronic active inflammation [5]. Additionally, immune and inflammatory reactions mediated by HP infection can directly contribute to the development of cardiovascular diseases such as stroke and coronary heart disease (CHD) [6]. It is widely recognized that there is a specific relationship between HP and gastrointestinal diseases. With a deeper understanding of HP, epidemiological studies suggest it has a close association not only with gastrointestinal diseases but also with cardiovascular conditions and may be involved in the development of atherosclerosis (AS) [7]. Carotid AS is a key predictor of systemic AS and cardiovascular diseases. Carotid artery color Doppler ultrasound is a non-invasive method for assessing carotid artery intima-media thickness and provides both qualitative and quantitative data for diagnosing carotid

plaque (CP). It is an effective tool for diagnosing AS and evaluating its severity.

In this study, we analyze the factors influencing HP infection in the physical examination population and further explore the relationship between HP infection and carotid AS in this population, aiming to provide a theoretical basis for the prevention and treatment of HP infection and cardiovascular diseases.

Materials and Methods

General data

A retrospective analysis was conducted on the clinical data of 336 individuals who underwent physical examination at our hospital between May 2021 and May 2023. All participants received carbon-13 urea breath tests (13C-UBT) and HP antibody detection tests. The inclusion criteria were as follows: i) individuals meeting the diagnostic criteria of the *Guideline for Primary Care of Helicobacter pylori Infection* (2019) [8] and ii) those with complete clinical data. The exclusion criteria were as follows: i) individuals with a history of HP infection or gastropathy; ii) those who used proton pump inhibitors, bismuth or antibacterial drugs in the past 3 months; iii) those with diabetes, hypertension, CHD, stroke or other metabolic or cardiovascular diseases; iv) those with severe functional impairment of the heart, liver, kidneys or other vital organs; v) those with hematopoietic, immune or nervous system damage; vi) those with acute or chronic infection in the past 2 weeks; and vii) those with thyroid diseases, neck injuries or other conditions affecting carotid ultrasound examination. This study was approved by the ethics committee of our hospital (approval number: K202312-07).

Study methods

Carbon-13 urea breath test

All enrolled patients underwent 13C-UBTs after admission. First, they held their breath for 5 seconds, then blew into a breath bag to collect the first sample. They subsequently took the 13C urea reagent orally, sat still for 30 minutes and blew again to collect the second sample. The collected samples were tested for abundance using a carbon-13 breath analyzer (Guangzhou Richen-Frinse Optical & Electronic Co., Ltd., model HY-IREXB), and the delta over baseline (DOB) value was calculated. Infection grouping was performed according to the breath test value: samples with a DOB value of < 4 were classified as the HP non-infected group, whereas those with a DOB value of ≥ 4 were classified as the HP-infected group [8].

Detection of Helicobacter pylori antibodies

Patients who were 13C-UBT positive were tested for antibodies against HP in the outpatient department of our hospital. A 2 mL sample of venous blood was collected, and the HP antibodies in the patient's serum were detected by immunoblotting using an HP immunoblotting kit (Shenzhen Blot Biotech Co., Ltd.), which included cytotoxin antibody, vacuolating toxin antibody, urease A antibody and urease B antibody. In the HP-infected group, those who were positive for cytotoxin antibody and/or vacuolating toxin antibody were classified as the high-risk group, whereas those who were only positive for urease A antibody and/or urease B antibody were classified as the low-risk group [9].

Carotid artery color Doppler ultrasound

GE's E9 series color Doppler ultrasound diagnostic system was used to evaluate the carotid arteries of the patients. The patient was positioned supine with the neck exposed. Observations were made in grey-scale imaging mode, starting with a transverse scan followed by a longitudinal scan from the bifurcation of the innominate artery on the right side to the origin of the aortic arch on the left side. Subsequently, continuous observations were made on the common carotid artery (proximal, middle and distal segments), the bifurcation of the internal and external carotid arteries, the internal carotid artery (proximal, middle and distal segments) and the trunk and branches of the external carotid artery. Finally, the carotid intima-media thickness (CIMT) of the distal and bulbous parts of the common carotid artery was measured on the long-axis section of the carotid artery. The presence or absence of plaque was observed, and its size was recorded. According to the *Guidelines for Examination of Blood Vessels and Superficial Organs* compiled by the Chinese Ultrasound Doctors Association and the Chinese Medical Doctor Association [10], CIMT $\geq$ 1.0 mm is defined as CIMT thickening, whereas limited CIMT $\geq$ 1.5 mm is defined as CP formation.

Risk factors

According to the *China Guidelines for Prevention of Cardiovascular Diseases* (2017) [11], the related risk factors for carotid AS include age, body mass index, smoking, hypertension, diabetes, serum uric acid, total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), high-sensitivity C-reactive protein and plasma homocysteine. Smoking is defined as smoking at least one cigarette a day for more than 1

Table 1. Carotid artery AS.

Group	Number of cases	AS detection rate [n (%)]	CP detection rate [n(%)]	Mean CIMT (mm, $\bar{x} \pm s$)
Hp infected group	102	61 (59.80)	39 (38.24)	1.69 ± 0.74
Non-infected group	234	74 (31.62)	42 (17.95)	1.54 ± 0.61
P value		0.029	0.037	0.041
High-risk group	43	31 (72.09)	23 (53.49)	1.84 ± 0.75
Low-risk group	59	24 (40.68)	19 (32.20)	1.39 ± 0.74
p		0.085	0.031	0.016

AS: atherosclerosis; CP: carotid plaque; CIMT: carotid intima-media thickness; HP: *Helicobacter pylori*

year. The diagnostic criteria for hypertension include a history of hypertension, systolic blood pressure of ≥ 130 mmHg and/or diastolic blood pressure of ≥ 85 mmHg [12].

Statistical analysis

All data in this study were statistically analyzed using SPSS 26.0 statistical software. Measurement data that conformed to a normal distribution were expressed as mean ± standard deviation (x ± s), and the *t*-test was used for comparisons between groups. Non-normally distributed measurement data were represented as median [M (P_{25}, P_{75})], with comparisons between groups made using non-parametric tests. Moreover, counting data were expressed as the number of cases and percentages and tested using the chi-squared (χ^2) test. Logistic regression analysis was performed to examine the relationship between influencing factors and CP. For all tests, p values of < 0.05 were considered to denote statistical significance.

Results

Helicobacter pylori infection

A total of 336 healthy individuals were enrolled in this study, with 102 in the HP-infected group and 234 in the non-infected group. The incidence of HP infection was 30.36%. In the HP-infected group, there were 43 cases in the high-risk group, resulting in an incidence rate of 42.16%, and 59 cases in the low-risk group, resulting in an incidence rate of 57.84%.

Comparison of carotid atherosclerosis-related indexes

The comparison of carotid artery AS indicators between the HP-infected group and the non-infected group revealed significant differences. Specifically, the HP-infected group had a higher AS detection rate (59.80% vs 31.62%, $p = 0.029$), a higher CP detection rate (38.24% vs 17.95%, $p = 0.037$) and a greater mean CIMT of 1.69 ± 0.74 mm compared with 1.54 ± 0.61 mm in the non-infected group ($p = 0.041$). These findings are statistically significant ($p < 0.05$) and are detailed in Table 1. No statistically significant difference was observed in the carotid AS detection rate (72.09% vs 40.68%, $p = 0.085$) between the high-risk group and the low-risk group ($p > 0.05$). However, the CP detection rate (53.49% vs 32.20%, $p = 0.031$) and mean CIMT (1.84 ± 0.75 mm vs 1.39 ± 0.74 mm, $p = 0.016$) in the high-risk group were significantly higher than those in the low-risk group, with statistically significant differences ($p < 0.05$). See Table 1 for details.

Analysis of related risk factors of carotid atherosclerosis caused by Helicobacter pylori infection

Body mass index (25.23 ± 3.65 vs 23.29 ± 3.32, $p = 0.047$), LDL-C (2.97 ± 0.66 vs 2.75 ± 0.83, $p = 0.037$) and serum uric acid level (353.11 ± 82.77 vs 330.37 ± 77.05, $p = 0.038$) in the HP-infected group were significantly higher than those in the non-infected group, with statistically significant differences ($p < 0.05$). See Table 2 for details.

Table 2. Analysis of related risk factors of carotid AS caused by HP infection.

Group	Hp infected group (n = 102)	Non-infected group (n = 234)	*p*	High-risk group (n = 43)	Low-risk group (n = 59)	*p*
Age [years, M (P_{25}, P_{75})]	57 (50.61)	53 (49.60)	0.073	57 (51.62)	54 (48,61)	0.031
Body mass index (Kg/m^2)	25.23 ± 3.65	23.29 ± 3.32	0.047	25.84 ± 3.49	22.15 ± 2.93	0.027
Smoking [n (%)]	27 (26.47)	69 (29.49)	0.195	17 (39.53)	21 (35.59)	0.593
Hypertension [n (%)]	29 (28.43)	66 (28.21)	0.325	23 (53.49)	14 (23.73)	0.014
Diabetes [n (%)]	15 (14.71)	41 (17.52)	0.418	7 (16.28)	9 (15.25)	0.972
Total cholesterol (mmol/L)	5.21 ± 1.14	4.95 ± 0.84	0.059	5.48 ± 1.52	4.74 ± 0.95	0.017
LDL-C (mmol/L)	2.97 ± 0.663	2.75 ± 0.83	0.037	3.31 ± 0.84	2.94 ± 0.69	0.012
Serum uric acid (mmol/L)	353.11 ± 82.77	330.33 ± 79.54	0.038	358.85 ± 79.39	333.25 ± 85.30	0.010
Hcy (μmol/L)	13.50 ± 6.16	12.85 ± 6.29	0.810	13.17 ± 6.18	12.38 ± 6.74	0.476
hs-CRP (mg/L)	1.84 ± 3.47	1.59 ± 3.52	0.645	1.59 ± 2.27	1.77 ± 5.25	0.504
Fatty liver [n (%)]	32 (31.37)	71 (30.34)	0.352	15 (34.88)	19 (32.20)	0.264

AS: atherosclerosis; HP: *Helicobacter pylori*; LDL-C: low density lipoprotein cholesterol; Hcy: homocysteine; hs-CRP: high sensitive c reactive protein

Table 3. Logistic regression analysis of related risk factors of CP formation between the HP infected group and the non-infected group.

Variable	β value	Wald value	OR value	95% *CI*	*p*
Age	0.137	49.294	1.142	1.105~1.187	0.001
Smoking	0.782	7.562	2.031	1.249~3.842	0.007
Systolic blood pressure	0.013	5.458	1.023	1.0041.029	0.021
Glycated hemoglobin	0.421	7.623	1.503	1.131~2.149	0.004
Hp infection	0.445	3.549	1.530	0.979~2.631	0.057

CP: carotid plaque; HP: *Helicobacter pylori.*

Comparison of risk factors related to carotid AS between the high-risk group and the low-risk group revealed statistically significant differences ($p < 0.05$) in terms of age [57 (51, 62) vs 54 (48, 61), $p = 0.031$], body mass index (25.84 ± 3.49 vs 22.15 ± 2.93, $p = 0.027$), hypertension (53.49% vs 23.73%, $p = 0.014$), total cholesterol (5.48 ± 1.52 vs 4.74 ± 0.95, $p = 0.017$), LDL-C (3.31 ± 0.84 vs 2.94 ± 0.69, $p = 0.012$) and blood uric acid level (358.85 ± 79.39 vs 333.25 ± 85.30, $p = 0.010$). See Table 2 for details.

Logistic regression analysis of related risk factors of carotid plaque formation

Logistic regression analysis of related risk factors for CP formation in the HP-infected group and the non-infected group was performed, with CP as a dependent variable and related risk factors leading to CP formation as independent variables. The results showed that age (odds ratio [OR] = 1.142, 95% CI = 1.105–1.187, $p = 0.001$), smoking (OR = 2.031, 95% CI = 1.249–3.842, $p = 0.007$), systolic blood pressure (OR = 1.023, 95% CI = 1.004–1.029, $p = 0.021$) and glycated hemoglobin (OR = 1.503, 95% CI = 1.131–2.149, $p = 0.004$) were related factors for CP formation ($p < 0.05$). See Table 3 for details.

Logistic regression analysis of related risk factors for CP formation in the high-risk group and the low-risk group was also performed, with CP as the dependent variable and related risk factors leading to CP formation as independent variables. The results showed that age (OR = 1.149, 95% CI = 1.091–1.224, $p = 0.001$), smoking (OR = 3.459, 95% CI = 1.580–7.612, $p = 0.003$), systolic blood pressure (OR = 1.021, 95% CI = 1.006–1.052, $p = 0.018$), diabetes (OR = 3.630, 95% CI = 1.127–11.729, $p = 0.036$) and high-risk HP (OR = 1.610, 95% CI = 0.773–3.353, $p = 0.029$) were related factors for CP formation ($p < 0.05$). See Table 4 for details.

Discussion

Atherosclerosis is the primary cause of cardiovascular and cerebrovascular diseases. Studies have shown that AS is a chronic inflammation of large and medium-sized arteries, characterized by a large number of activated immune cells. Inflammation may be the primary cause of plaque rupture, which directly leads to cardiovascular and cerebrovascular diseases. Due to the superficial location of the carotid artery, it is easy to detect the presence or absence of AS. Carotid intima-media thickness, obtained through color Doppler measurement, is recognized as an objective index reflecting the degree of early AS development in recent years, boasting satisfactory predictive value for cardiovascular and cerebrovascular diseases. Therefore, it is of great significance to explore the risk factors for carotid AS in the physical examination population for the early prevention and treatment of macroangiopathy.

In this work, the existence of HP infection can be determined using 13C-UBT, and high-risk and low-risk HP strain infections can be distinguished by the detection of HP antibodies. The results showed that the detection rate of CP and mean CIMT in the HP-infected group were higher than those in the non-infected group. The detection rate of CP and mean CIMT in the high-risk HP-infected group were higher than those in the low-risk group. This further suggests that HP infection, particularly high-risk HP infection, may participate in the occurrence and development of AS. The increase in LDL-C levels and the decrease in HDL-C levels were the most important risk factors for AS. It was found that the serum total cholesterol and LDL-C of the HP-infected group were higher, whereas HDL-C was lower. The results showed that HP infection was an independent risk factor for dyslipidemia and played a key role in AS. After successfully clearing HP infection, HDL-C and LDL-C levels increased and decreased significantly, respectively, and the follow-up

Table 4. Logistic regression analysis of risk factors related to CP formation in the high-risk group and the low-risk group.

Variable	β value	Wald value	OR value	95% *CI*	*p*
Age	0.152	25.348	1.149	1.091~1.224	0.001
Smoking	1.247	9.574	3.459	1.580~7.612	0.003
Systolic blood pressure	0.032	5.421	1.021	1.006~1.052	0.018
Diabetes	1.275	4.585	3.630	1.127~11.729	0.036
High-risk Hp infection	0.439	1.578	1.610	0.773~3.353	0.029

CP: carotid plaque.

effect could last for more than 3 years. According to this study, the level of LDL-C in the HP-infected group was significantly higher than that in the non-infected group. Compared with the low-risk group, the levels of total cholesterol and LDL-C in the high-risk group were significantly higher. It is speculated that HP infection, especially high-risk HP infection, is a susceptible factor promoting AS by adjusting lipid metabolism patterns.

In recent years, research on the relationship between hyperuricaemia and cardiovascular diseases has received extensive attention. A meta-analysis showed that the relative risk of CHD mortality in patients with hyperuricaemia increased. Furthermore, the overall risk and all-cause mortality of CHD increased by 20% and 9%, respectively, with each 1 mg/dL increase in serum uric acid level. In this study, the serum uric acid level in the HP-infected group was significantly higher than that in the non-infected group and the high-risk group, which indirectly suggests that HP infection, especially high-risk HP infection, is a susceptible factor promoting AS.

Carotid plaque formation is evidence of carotid AS, which is an objective index of AS and has a significant causal relationship with cardiovascular events. Many risk factors have been proven to affect CP formation, especially smoking, age, blood pressure, blood lipids and blood sugar, which have long been recognized in domestic and foreign studies. The role of HP infection in the occurrence and development of AS is significantly higher than that in people without HP infection; the proportion of carotid AS in HP-infected individuals is markedly increased, and HP infection is significantly related to the increase of carotid AS with CIMT. A meta-analysis showed that HP infection would increase the risk of CHD and increase its incidence by 1.1%. Another epidemiological study indicated that the proportion of HP infection in patients with CHD diagnosed by angiography increased, further proving that HP infection is related to CHD. Additionally, the presence of anti-cytotoxin-associated gene A-positive HP infection in patients with ST-segment elevation myocardial infarction indicates a significant increase in the risk of adverse cardiac events. However, HP infection has no significant effect on CP formation in 336 physical examination patients in this study. Further analysis of the HP-infected group shows that high-risk HP infection is one of the risk factors for CP compared with low-risk HP infection.

However, the limited number of cases in this study may affect the assessment of the influence of HP infection on CP formation in the physical examination population, which needs to be further confirmed by expanding the research sample. Nonetheless, our findings indicate that even with a limited sample size, high-risk HP infection has a significant impact on CP formation, further suggesting that it contributes to the occurrence and development of AS and increases the risk of cardiovascular diseases.

Conclusions

High-risk HP infection is closely associated with CP formation, contributing to the occurrence and development of AS and increasing the risk of cardiovascular diseases. Therefore, active screening for HP infection should be implemented, with high-risk HP strains identified through the detection of typing antibodies to enable more accurate eradication treatment and reduce the risk of cardiovascular diseases.

Authors' contributions

Conception and design of the work: Lei Han; Data collection: Ruijuan Gu, Hatira Jingsihan, Yushan Wang, Alina Abulaiti, Linnan Qu; Supervision: Lei Han; Analysis and interpretation of the data: Ruijuan Gu, Hatira Jingsihan, Yushan Wang, Alina Abulaiti, Linnan Qu; Statistical analysis: Lei Han, Linnan Qu, Alina Abulaiti; Drafting the manuscript: Lei Han; Critical revision of the manuscript: all authors; Approval of the final manuscript: all authors.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of The First Affiliated Hospital of Xinjiang Medical University (Approval number: K202312-07).

Corresponding authors

Linnan Qu
Center of Health Management,
The First Affiliated Hospital of Xinjiang Medical University
No.137 of Liyushan South Road, Xinshi District
Urumqi, Xinjiang 830054, China
Tel: +8609914360111
Email: qu_linnan2309@163.com

Alina·Abulaiti
Imaging center, The First Affiliated Hospital of Xinjiang Medical University
No. 137 of Liyushan South Road
Xinshi District, Urumqi
Xinjiang 830054, China.
Tel: +8609914360111
Email: alina_ablt@21cn.com

Conflict of interests

No conflict of interests is declared.

References

1. FitzGerald R, Smith SM (2021) An overview of *Helicobacter pylori* infection. Methods Mol Biol 2283: 1-14. doi: 10.1007/978-1-0716-1302-3_1.
2. de Brito BB, da Silva FAF, Soares AS, Pereira VA, Santos MLC, Sampaio MM, Neves PHM, de Melo FF (2019) Pathogenesis and clinical management of *Helicobacter pylori* gastric infection. World J Gastroenterol 25: 5578-5589. doi: 10.3748/wjg.v25.i37.5578.
3. Hu Y, Zhu Y, Lu NH (2022) The management of *Helicobacter pylori* infection and prevention and control of gastric cancer in China. Front Cell Infect Microbiol 12: 1049279. doi: 10.3389/fcimb.2022.1049279.
4. Ren S, Cai P, Liu Y, Wang T, Zhang Y, Li Q, Gu Y, Wei L, Yan C, Jin G (2022) Prevalence of Helicobacter pylori infection in China: A systematic review and meta-analysis. J Gastroenterol Hepatol 37: 464-470. doi: 10.1111/jgh.15751.
5. Su JY, Liu CT, Wang TS, Li WK, Yang Y, Wu SS, Li P, Wu J (2022) Correlation between serum Helicobacter pylori antibody typing and gastric mucosal lesions. Journal of Capital Medical University 43: 216-220. doi: 10.3969/j.issn.1006-7795.2022.02.009.
6. Crowe SE (2019) *Helicobacter pylori* infection. N Engl J Med 380: 1158-1165. doi: 10.1056/NEJMcp1710945.
7. Santos MLC, de Brito BB, da Silva FAF, Sampaio MM, Marques HS, Oliveira E Silva N, de Magalhães Queiroz DM, de Melo FF (2020) *Helicobacter pylori* infection: beyond gastric manifestations. World J Gastroenterol 26: 4076-4093. doi: 10.3748/wjg.v26.i28.4076.
8. Zhou L, Lu H, Song Z, Lyu B, Chen Y, Wang J, Xia J, Zhao Z, Helicobacter Pylori Study Group of Chinese Society of Gastroenterology (2022) Chinese national clinical practice guideline on *Helicobacter pylori* eradication treatment. Chin Med J (Engl) 135: 2899-2910. doi: 10.1097/CM9.0000000000002546.
9. Kishikawa H, Kimura K, Takarabe S, Kaida S, Nishida J (2015) *Helicobacter pylori* antibody titer and gastric cancer screening. Dis Markers 2015: 156719. doi: 10.1155/2015/156719.
10. Chinese Ultrasound Doctors Association, Chinese Medical Doctor Association (2011) Guidelines for examination of blood vessels and superficial organs. Beijing: People's Military Medical Press. 2011: 26.
11. Task Force on Chinese Guidelines for the Prevention of Cardiovascular Diseases(2017), Editorial Board of Chinese Journal of Cardiology (2018) Chinese guidelines for the prevention of cardiovascular diseases(2017). Zhonghua Xin Xue Guan Bing Za Zhi 46: 10-25. doi: 10.3760/cma.j.issn.0253-3758.2018.01.004. [Article in Chinese]
12. Revision Committee of the Guidelines for the Prevention and Treatment of Hypertension in China. (2019) Guidelines for prevention and treatment of hypertension in China (revised edition 2018). Prevention and Treatment of Cardio-Cerebral-Vascular Disease 19: 1-44. doi: 10.3969/j.issn.1009-816X.2019.01.001.
13. Engelen SE, Robinson AJB, Zurke YX, Monaco C (2022) Therapeutic strategies targeting inflammation and immunity in atherosclerosis: how to proceed? Nat Rev Cardiol 19: 522-542. doi: 10.1038/s41569-021-00668-4.
14. Thomas IC, Forbang NI, Criqui MH (2018) The evolving view of coronary artery calcium and cardiovascular disease risk. Clin Cardiol 41: 144-150. doi: 10.1002/clc.22842.
15. Scoutt LM, Gunabushanam G (2019) Carotid Ultrasound. Radiol Clin North Am 57: 501-518. doi: 10.1016/j.rcl.2019.01.008.
16. Lu J, Van Hoang D, Hayashi Y, Hashimoto M, Kubo S, Kajio H, Mizoue T (2022) Negative-High Titer of *Helicobacter pylori* antibody and lipid profiles. Biomed Res Int 2022: 9984255. doi: 10.1155/2022/9984255.
17. Fu L, Wang TT, Liu LL, Ma LL, Ding LL, Zhang YF, Li L (2022) Study on the relationship between carotid atherosclerosis and *Helicobacter pylori* infection in middle-aged and elderly people. Journal of Clinical and Experimental Medicine 21: 2429-2433.
18. Braga F, Pasqualetti S, Ferraro S, Panteghini M (2016) Hyperuricemia as risk factor for coronary heart disease incidence and mortality in the general population: a systematic review and meta-analysis. Clin Chem Lab Med 54: 7-15. doi: 10.1515/cclm-2015-0523.
19. Zuo T, Liu X, Jiang L, Mao S, Yin X, Guo L (2016) Hyperuricemia and coronary heart disease mortality: a meta-analysis of prospective cohort studies. BMC Cardiovasc Disord 16: 207. doi: 10.1186/s12872-016-0379-z.
20. Liang H, Lin S, Ji Y, Xiao Y, Zheng G (2021) *Helicobacter pylori* increases the risk of carotid plaque formation: a clinical evidence. Ann Med 53: 1448-1454. doi: 10.1080/07853890.2021.1927169.
21. Shan J, Bai X, Han L, Yuan Y, Yang J, Sun X (2018) Association between atherosclerosis and gastric biomarkers concerning *Helicobacter pylori* infection in a Chinese healthy population. Exp Gerontol 112: 97-102. doi: 10.1016/j.exger.2018.09.009.
22. Yu XJ, Yang X, Feng L, Wang LL, Dong QJ (2017) Association between *Helicobacter pylori* infection and angiographically demonstrated coronary artery disease: a meta-analysis. Exp Ther Med 13: 787-793. doi: 10.3892/etm.2017.4028.
23. Huang M, Zhu L, Jin Y, Fang Z, Chen Y, Yao Y (2021) Association between *Helicobacter Pylori* infection and systemic arterial hypertension: a meta-analysis. Arq Bras Cardiol 117: 626-636. doi: 10.36660/abc.20200186. [Article in Portuguese]