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Original Article

Evaluation of Atherosclerostic Characteristics in Senior Citizens from the Ximen Community of Haishu District by Ultrasonography

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SUMMARY

Background: The carotid artery is one of the means used to predict cardiovascular and cerebrovascular disease risk in the elderly.

Methods: 1057 senior citizens older than 60 years from Ximen community of Haishu district, had their carotid arteries examined by ultrasound examination with parameters including intima-media thickness (IMT), presence of plaque, the plaque thickness, peal systolic velocity (PSV), resistance index (RI) and the level of narrowing of bilateral internal carotid arteries.

Results: Except for IMT_{LICA}, IMT_{RCCA}, IMT_{RICA}, PSV_{LCCA} and PSV_{RCCA}, all ultrasound parameters were significantly different among different age groups ($p < 0.05$). Comparing between sex within the same age group, except for IMT_{RCCA}, PSV_{LCCA}, RI_{LICA}, PSV_{RCCA}, PSV_{RICA} and RI_{RICA}, other ultrasound parameters were found to be significantly different in the 60-70 year-old group ($p < 0.05$); with the exception of PSV_{LICA}, RI_{LICA}, PSV_{RICA}, RI_{RICA}, the feature of the plaque on the left carotid arteries , other ultrasound parameters were significantly different in the ≥ 70-80 year-old group ($p < 0.05$); except for IMT_{RICA} and RI_{LCCA}, no other ultrasound parameters were significantly different in the ≥ 80 year-old group ($p > 0.05$).

Conclusion: Ultrasound screening has significant predictive and preventative value for cardiovascular and cerebrovascular diseases such as atherosclerosis. Early detection of these diseases will significantly improve patient outcomes in clinical practice.

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1. Introduction

Atherosclerosis has become one of the most common chronic illnesses in the world. It is a common cause of cardiovascular and cerebrovascular diseases in the elderly. The combination of disease pathology in major vessels and related complications have a major effect on the survival and quality of life for elderly people.

The carotid artery can be used as window into systemic atherosclerosis and is thus one of the means used to predict cardiovascular and cerebrovascular disease risk in the elderly.[1,2] However, there are few epidemiology studies on carotid atherosclerosis of the elderly in China. Therefore, we conducted ultrasound screening of carotid arteries those citizens 60 years and over in Ximen community of Haishu district, in order to provide an objective basis for further medical examination by the community physician and possible diagnosis of cardiovascular and cerebrovascular diseases.

2. Materials and methods

2.1. Patients

Between May and August 2017, we sampled a randomly selected group of residents who held household registration from Ximen Community, Haishu District, and were aged 60 years or over who were ambulant. A total of 1082 senior citizens were enrolled, among which 1,057 had complete general clinical date and ultrasound examination data. 438 males and 619 females, with an average age of (71.86 ± 5.27) years were divided into three groups: of 60–70 year-olds (440 citizens), ≥ 70–80 year-olds (509 citizens), and ≥ 80 year-olds (108 citizens).

The study protocol was approved by the Ethics Committees, and all participants provided written informed consent.

2.2. Medical examinations

Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2). Blood pressure was measured three times with a mercury sphygmomanometer after the participants had rested for no less than ten minutes in seat, and all measurements of the blood pressure were performed at the same time period in the morning by one well-trained investigator. The blood pressure of each participant was calculated as the average of the readings. Blood samples for fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-L) and low-density lipoprotein cholesterol (LDL-L) were collected in the morning and then analyzed by the enzyme method in auto-analyzing machine.

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2.3. Ultrasound examination

Ultrasound examination was performed using the Hitachi EUB-8500 ultrasound system with 13L6 transducer. First, the two-dimensional gray-scale ultrasound transection was performed starting from the subclavian artery to observe the beginning of the common carotid artery, and continuing upward until reaching the proximal portion of the submaxillary carotid artery. This examination route allowed evaluation of carotid artery intimal thickening, presence of plaque and the echogenicity of the plaque. At the same time, the intima-media thickness (IMT) of the common carotid artery and the proximal internal carotid artery at a relatively thick location and the thickness of relatively thick plaques were transversely measured. Then carotid atherosclerosis was evaluated along a longitudinal section. Any identified plaques were divided into four types according to the echo of ipsilateral sternocleidomastoid: hypoechoic, moderate echogenic, hyperechoic and mixed echogenic. Mixed echogenic plaque was defined as a strong echo in low or middle echogenic plaque. During color Doppler ultrasound examination, the blood flow rate scale was adjusted to appropriate portion (the minimum blood flow velocity in normal arterial lumen without aliasing), then a location with increased blood flow velocity was identified. CDFI-guided pulse Doppler (PW) ultrasonography, and PW evaluation were performed at this location with a same angle range of 45°–60°. Arterial hemodynamic parameters were measured simultaneously: peak systolic velocity (PSV) and resistance index (RI) of the common and internal carotid arteries. In order to ensure the reproducibility of the ultrasound data, all the technicians underwent rigorous screening and training prior to examination, and all ultrasound measurement and image were preserved according to the pre-established examination procedures and specifications. The criteria for this study were: 1) For IMT a cross-section of the thickest region of the carotid artery was measured. Normal IMT < 1.0 mm, and IMT thickening was defined as an IMT $\geq$ 1.0 and < 1.5 mm.[1] 2) Plaque measurement was taken at the thickest region of the carotid artery on cross section. A plaque was defined as a focal thickening of IMT with a $\geq$ 0.5 mm protrusion into the arterial lumen, or a 50% increase compared in thickening compared to nearby IMT, or an IMT > 1.5 mm.[3] 3) The level of the internal carotid artery diameter stenosis was determined according to hemodynamic parameters such as the PSV and EDV of the carotid artery and internal carotid arteries:[4] Mild stenosis (narrowing level < 50%): PSV_{ICA} < 125 cm/s, PSV_{ICA}/PSV_{CCA} < 2, EDV_{ICA} < 40 cm/s; Moderate stenosis (narrowing level 50–70%): 125 cm/s $\leq PSV_{ICA}$ < 230 cm/s, 2 $\leq PSV_{ICA}/PSV_{CCA}$ < 4, 40 cm/s $\leq EDV_{ICA}$ < 100 cm/s; severe stenosis (stenosis level $\geq$ 70%): $PSV_{ICA} \geq$ 230 cm/s, $PSV_{ICA}/PSV_{CCA} \geq 4$, $EDV_{ICA} \geq$ 100 cm/s; Occlusion was defined as no blood flow signal.

2.4. Statistical analysis

SPSS 19.0 software was used for statistical analysis. Continuous quantitative data were expressed as mean ± standard deviation. In the univariate analysis, unadjusted means were compared by student's t-tests if the means were from two groups or by one-way ANOVA if the means were from more than two groups. The Chi-square test was used to analyze qualitative data. The relationship between ultrasound data and age was analysed using multiple logsitic regression model, and adjusted means were compared by one-way ANOVA test. *P*-values < 0.05 was considered to be statistically significant.

3. Results

3.1. General clinical date

Excluding age and sex, systolic blood pressure (SBP), diastolic blood pressure (DBP), TC, TG, HDL-L, LDL-L, FBG and BMI were no significant statistical difference between carotid plaque group and non-plaque group (Table 1). Carotid plaque group was older than non-plaque group, and males were more likely to develop carotid plaque than females.

3.2. Comparison of ultrasound screening parameters among bilateral carotid and different age groups

Excluding IMT_{CCA}, PSV_{ICA}, all ultrasound parameters were significantly different among bilateral carotid (p < 0.05) (Table 2). Excluding IMT_{LICA}, IMT_{RCCA}, IMT_{RICA}, PSV_{LCCA} and PSV_{RCCA}, all ultrasound parameters were significantly different among different age groups ($p < 0.05$) (Table 3). The prevalence of carotid atherosclerosis increases with age. After adjusted for sex, blood pressure, body mass index, lipid level and fasting blood glucose, all ultrasound parame-

Table 1
Comparison of general clinical date in different groups.

	Plaque group	Non-plaque group	t/χ^2	*p*
Age (year)	72.09 ± 5.69	70.92 ± 4.98	-3.259	0.001
Sex			32.461	0.000
Male	185 (53.94%)	253 (35.43%)		
Female	158 (46.06%)	461 (64.57%)		
SBP (mmHg)	136.19 ± 16.69	134.30 ± 16.82	-1.723	0.085
DBP (mmHg)	79.05 ± 8.15	78.71 ± 8.54	-0.622	0.534
TC (mmol/L)	4.64 ± 0.99	4.67 ± 1.02	0.492	0.623
TG (mmol/L)	1.65 ± 0.96	1.63 ± 1.01	-0.252	0.801
HDL-C (mmol/L)	1.56 ± 0.33	1.58 ± 0.40	0.851	0.395
LDL-C (mmol/L)	2.99 ± 0.94	2.99 ± 0.91	0.068	0.946
FBG (mmol/L)	6.17 ± 1.37	6.21 ± 1.52	0.458	0.647
BMI (kg/m^2)	25.49 ± 4.39	25.94 ± 4.34	1.547	0.122

SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglyceride; HDL-L, high-density lipoprotein cholesterol; LDL-L, low-density lipoprotein cholesterol; FBG, fasting blood glucose; BMI, body mass index.
P values are results from independent-samples *t-tests* comparing the mean scores in the plaque group *vs.* non-plaque group and of chi square tests comparing sample proportions.

Table 2
Comparison of ultrasound data in bilateral carotid.

	IMT_{CCA} (mm)	PSV_{CCA} (cm/s)	RI_{CCA}	IMT_{ICA} (mm)	PSV_{IMT} (cm/s)	RI_{ICA}
Left	0.90 ± 0.21	46.17 ± 21.50	0.73 ± 0.07	0.67 ± 0.16	39.61 ± 18.79	0.66 ± 0.08
Right	0.90 ± 0.22	44.39 ± 20.55	0.75 ± 0.06	0.68 ± 0.16	40.44 ± 21.03	0.67 ± 0.07
t	0.516	4.734	-6.246	-2.374	-1.555	-4.162
P	0.606	0.000	0.000	0.018	0.120	0.000

IMT, intima-media thickness; PSV, peak systolic velocity; RI, resistance index.
P values are results from paired-samples *t-tests* comparing the mean scores in bilateral carotid.

ters weren't changed significantly (Table 4). There were 1050 cases of mild carotid arterial narrowing, 7 cases of moderate carotid arterial narrowing (2 cases, 4 cases and 1 case in each respective age group), and the level of arterial narrowing was not significantly different among different age groups ($p > 0.05$).

3.3. *Comparison of ultrasound screening parameters between different sex in the same age group*

Excluding IMT_{RCCA}, PSV_{LCCA}, RI_{LICA}, PSV_{RCCA}, PSV_{RICA} and RI_{RICA}, all ultrasound parameters were significantly different in the 60–70 year-old group ($p < 0.05$). Excluding PSV_{LICA}, RI_{LICA}, PSV_{RICA}, RI_{RICA}, and the feature of the plaque on the left, all ultrasound parameters were significantly different in the ≥ 70–80 year-old group ($p < 0.05$). Excluding IMT_{RICA} and RI_{LCCA}, none of the ultrasound parameters were significantly different in the ≥ 80 year-old group ($p > 0.05$) (Fig. 1–3).

4. Discussion

With economic development, improvement in quality of life and changing lifestyles, risk factors for cardiovascular disease in China and around the globe have multiplied, leading to the increasing numbers of people who are affected by cardiovascular and

Table 3
Comparison of ultrasound data in different age groups.

	60–70 (years)	≥ 70–80 (years)	≥ 80 (years)	F/χ^2	p
IMT_{LCCA} (mm)	0.88 ± 0.21	0.91 ± 0.22*	0.96 ± 0.22*$^{\Delta}$	7.565	0.001
IMT_{LICA} (mm)	0.66 ± 0.17	0.67 ± 0.15	0.69 ± 0.17$^{\Delta}$	1.469	0.231
IMT_{RCCA} (mm)	0.88 ± 0.22	0.91 ± 0.22	0.93 ± 0.24	2.694	0.068
IMT_{RCIA} (mm)	0.67 ± 0.17	0.68 ± 0.16	0.71 ± 0.17$^{\Delta}$	2.742	0.065
PSV_{LCCA} (cm/s)	45.17 ± 20.88	46.11 ± 26.84	50.46 ± 22.05$^{\Delta}$	2.611	0.074
RI_{LCCA}	0.72 ± 0.06	0.74 ± 0.07*	0.77 ± 0.06*$^{\Delta}$	25.721	0.000
PSV_{LICA} (cm/s)	38.60 ± 16.93	39.48 ± 19.51	44.32 ± 21.81$^{\Delta}$	4.063	0.017
RI_{LICA}	0.64 ± 0.08	0.66 ± 0.08*	0.69 ± 0.07*$^{\Delta}$	17.098	0.000
PSV_{RCCA} (cm/s)	44.54 ± 20.63	43.55 ± 20.31	47.70 ± 21.22	1.842	0.159
RI_{RCCA}	0.73 ± 0.06	0.75 ± 0.06*	0.78 ± 0.05*$^{\Delta}$	22.522	0.000
PSV_{RICA} (cm/s)	39.01 ± 15.48	40.65 ± 23.48	45.27 ± 27.04$^{\Delta}$	3.915	0.020
RI_{RICA}	0.65 ± 0.07	0.67 ± 0.07*	0.70 ± 0.07*$^{\Delta}$	24.660	0.000
Plaque				27.542	0.000
No	210 (47.73%)	182 (35.76%)	25 (23.15%)		
Yes	230 (52.27%)	327 (62.24%)	83 (76.85%)		
Bilateral carotid plaque				22.546	0.000
No	328 (74.55%)	329 (64.64%)	57 (52.78%)		
Yes	112 (25.45%)	180 (35.36%)	51 (47.22%)		
Left plaque echo				46.036	0.000
Hypoechoic	15 (9.49%)	23 (10.13%)	3 (4.48%)		
Isoechoic	61 (38.61%)	53 (23.35%)	12 (17.91%)		
Heterogeneous	62 (39.24%)	115 (50.66%)	42 (62.69%)		
Hyperechoic	20 (12.66%)	36 (15.86%)	10 (14.92%)		
Right plaque echo				33.180	0.000
Hypoechoic	20 (12.05%)	20 (7.91%)	6 (9.84%)		
Isoechoic	50 (30.12%)	56 (22.13%)	9 (14.75%)		
Heterogeneous	74 (44.58%)	142 (56.13%)	35 (57.38%)		
Hyperechoic	22 (13.25%)	35 (13.83%)	11 (18.03%)		

IMT, intima-media thickness; PSV, peak systolic velocity; RI, resistance index.
p values are compared among the three groups by one-way ANOVA or χ^2 tests.
* versus 60–70 years group, $p < 0.05$; $^{\Delta}$ versus ≥ 70–80 years group, $p < 0.05$.

Table 4
Comparisons of ultrasound data in different age groups after adjusted for sex, blood pressure, body mass index, lipid level and fasting blood glucose.

	60–70 (years)	≥ 70–80 (years)	≥ 80 (years)	F	p
IMT_{LCCA} (mm)	0.87 ± 0.22	0.90 ± 0.22*	0.96 ± 0.21*$^{\Delta}$	7.532	0.002
IMT_{LICA} (mm)	0.65 ± 0.17	0.67 ± 0.14	0.68 ± 0.17$^{\Delta}$	1.463	0.234
IMT_{RCCA} (mm)	0.88 ± 0.22	0.90 ± 0.22	0.93 ± 0.23	2.687	0.068
IMT_{RCIA} (mm)	0.66 ± 0.17	0.68 ± 0.16	0.71 ± 0.16$^{\Delta}$	2.741	0.065
PSV_{LCCA} (cm/s)	45.09 ± 20.88	46.10 ± 26.82	50.50 ± 22.12$^{\Delta}$	2.651	0.072
RI_{LCCA}	0.71 ± 0.06	0.74 ± 0.06*	0.78 ± 0.07*$^{\Delta}$	25.625	0.000
PSV_{LICA} (cm/s)	38.58 ± 16.87	39.43 ± 19.53	44.52 ± 21.05$^{\Delta}$	4.425	0.013
RI_{LICA}	0.64 ± 0.08	0.65 ± 0.08*	0.68 ± 0.07*$^{\Delta}$	17.120	0.000
PSV_{RCCA} (cm/s)	44.53 ± 20.58	43.54 ± 20.28	47.69 ± 21.25	1.856	0.156
RI_{RCCA}	0.72 ± 0.06	0.75 ± 0.05*	0.77 ± 0.05*$^{\Delta}$	22.253	0.000
PSV_{RICA} (cm/s)	39.02 ± 15.50	40.63 ± 23.36	45.28 ± 26.98$^{\Delta}$	3.926	0.019
RI_{RICA}	0.66 ± 0.07	0.67 ± 0.06*	0.70 ± 0.07*$^{\Delta}$	24.659	0.000

IMT, intima-media thickness; PSV, peak systolic velocity; RI, resistance index.
p values are compared among the three groups by one-way ANOVA tests.
* versus 60–70 years group, $p < 0.05$; $^{\Delta}$ versus ≥ 70–80 years group, $p < 0.05$.

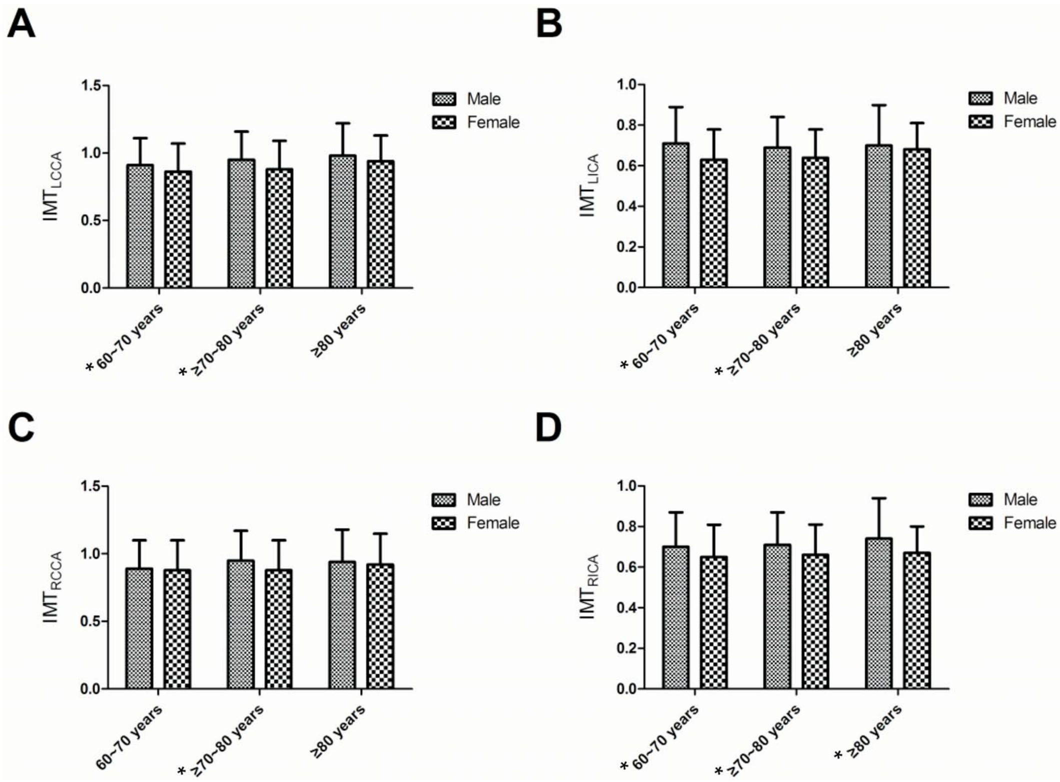

Fig. 1. Distribution of IMT_{LCCA}, IMT_{LICA}, IMT_{RCCA}, IMT_{RICA} in different age groups.

cerebrovascular diseases. The “China Cardiovascular Disease Report 2016" summary[5] explains: ”Cardiovascular death accounts for the highest proportion of total death of urban and rural residents, with 45.01% in rural areas and 42.61% in urban areas." The growing burden of cardiovascular disease has become a major public health issue.

Atherosclerosis is a systemic pathological condition that can simultaneously involve the coronary arteries and carotid arteries. It is the pathological basis for diseases such as coronary heart disease and cerebral stroke. Most patients with cardiovascular disease have obvious atherosclerosis in their carotid arteries even before the onset of clinical symptoms and changes in IMT precede the plaque formation.[6] A study[7] found that, for each additional standard deviation of carotid IMT, the incidence of myocardial infarction and cerebral stroke increased by 1.36 times. Another study[8] reported that with every additional 0.15 mm increase in IMT, the incidence of cerebral infarction increased by 1.82 times.

Ultrasound examination is the gold standard for monitoring and screening for atherosclerosis. It is important for the detection of early atherosclerosis lesions, the selection of preventive measures, and the evaluation of the effects of clinical interventions.[9] Because this technology is simple, economically friendly, noninvasive, widely used and results are reproducible, ultrasound has become a key parameter in the examination of subclinical vascular disease in large populations. However, there is a certain level of human error in ultrasound results, and in order to ensure the reliability of the test results with a high degree of reproducibility, doctors performing ultrasound must be appropriately and uniformly trained.

There are many factors that can affect the risk of vascular structural changes, such as age, high blood pressure, high blood sugar and weight. As the current community’s emphasis on their health in the elderly, most of the person’s blood pressure, blood lipid and blood sugar can be effectively controlled, just like our studies. Some scholars believe that age is a risk factor for atherosclerosis, and even some studies suggest that atherosclerosis is a part of the age process.[10]

Age is an important factor in the formation of carotid atherosclerosis plaques. The prevalence of carotid atherosclerosis increases with age.[11] Zureik et al. (2000) demonstrated that age is the strongest risk factor for carotid atherosclerosis in people older than 65 years.[12] Similar to our results, other study[13] in China have also shown that there is a high incidence of carotid atherosclerotic plaques in people over the age 60. The incidence of carotid plaques and incidence of bilateral carotid atherosclerosis increases with further aging beyond age 60. The plaque’s echo on ultrasound gradually turns from mainly low or moderate echogenic plaque, to a mixed echogenic plaque. However IMT in people over the age of 60 was not positive correlated with age, which may be related to the fact that plaque thickness was not included in IMT for this study. These results still indicate that carotid atherosclerosis is mainly due to the increase of IMT prior the age 60, and that plaque echo and formation change after the age of 60. IMT is significantly associated with age and reflects the thickening of the intima and medial membrane. A large number of studies have confirmed that carotid IMT is an independent risk factor for cardiovascular ischemic disease.[14,15] These results support the recommendation that community physicians should make necessary interventions for atherosclerosis in high-risk populations, and that carotid ultrasound can evaluate the effectiveness of these interventions.

This study also analyzed differences in ultrasound screening data between different sexes within the same age group. We found an increasingly severe carotid atherosclerosis in men before age 80. There was no significant difference in the severity of carotid atherosclerosis between men and women after age 80, indicating that the onset age of carotid atherosclerosis in women was later than that of men. It is possible that men may have more risk factors for

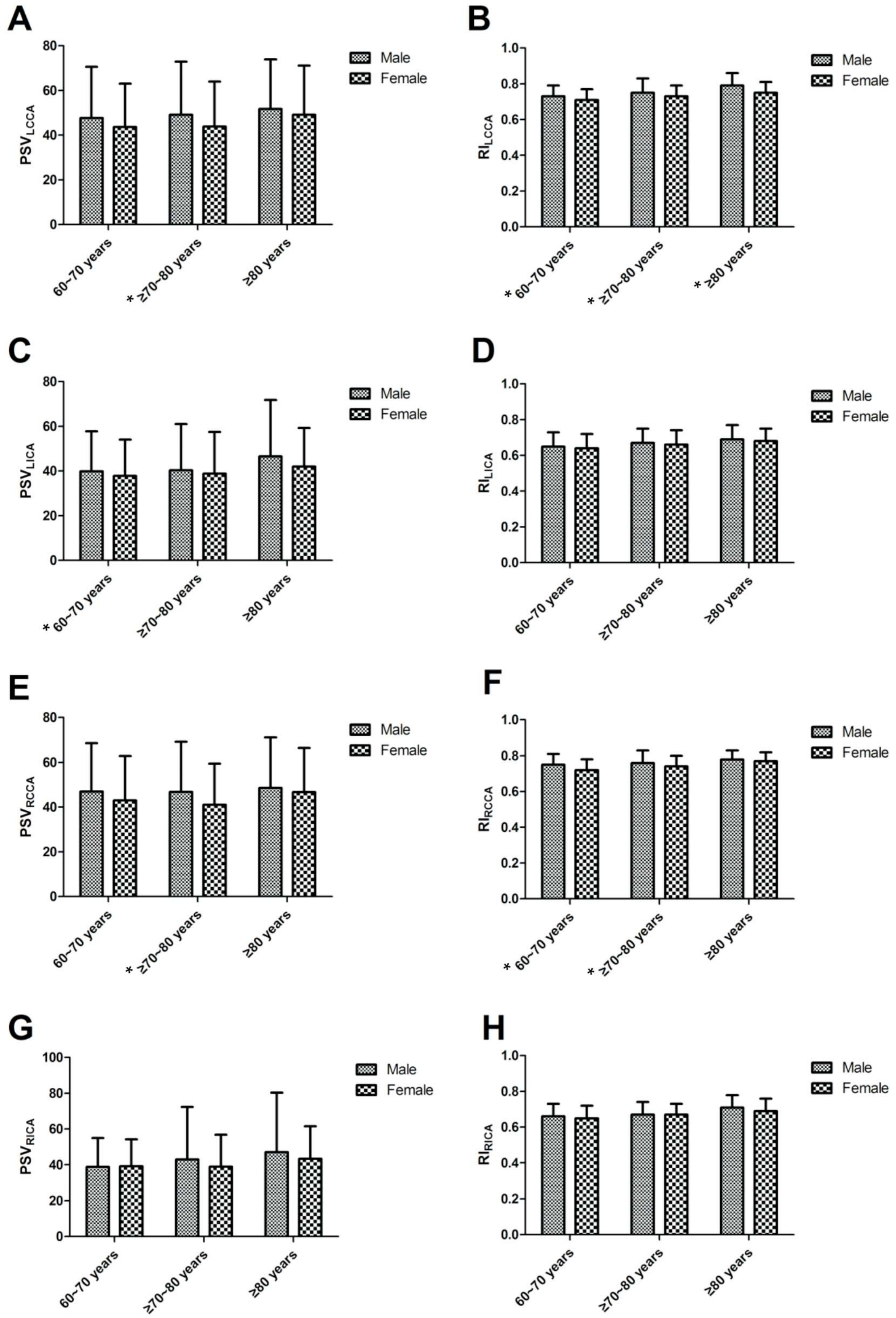

Fig. 2. Distribution of carotid artery blood flow in different age groups.

the disease such as alcoholism, smoking, hypertension, hyperlipidemia among other risk factors, in addition to the fact that women in different ages have different estrogen levels. According to the results of this study, community physicians should make both preventive and clinical interventions for men over the age of 60, while the physician should focus on preventative education for the elderly female population, and using clinical intervention as a supplement to treatment.

The primary results of this study analyzed the prevalence of carotid atherosclerosis among residents in a community in Ningbo, China, and found that the prevention of carotid atherosclerosis should start in middle-age, and the IMT of carotid arteries could also be changed after 60 years of age. The carotid atherosclerotic plaques were detected in younger ages for males in comparison to females, therefore preventative examination in middle-aged men is of particular importance.

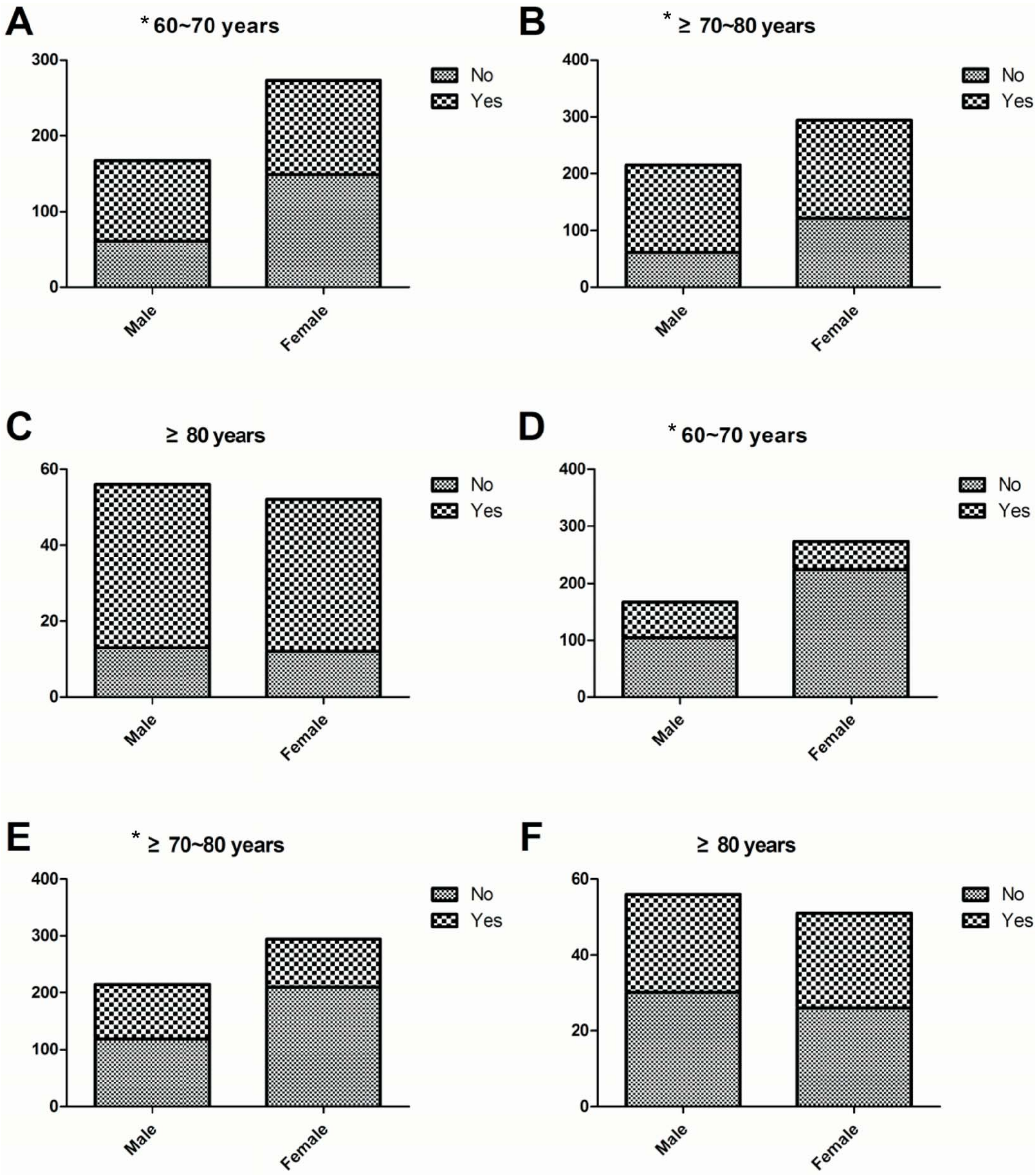

Fig. 3. (A–C) Distribution of carotid atherosclerotic plaques in different age groups; (D–F) Distribution of bilateral carotid atherosclerotic plaques in different age groups.

The sample size of this study is about one thousand cases. Due to the limited source of samples for this study, and the fact that all the patients enrolled in the study group have independent movement ability, our results must be verified with a larger sample size. In addition, this study did not analyze the impact of blood pressure, blood glucose, blood lipids, lifestyle and exercise among other factors on carotid atherosclerosis. These clinical variables should also be examined in future studies of carotid atherosclerosis in the elderly.

5. Conclusion

Ultrasound screening has significant predictive and preventative value for cardiovascular and cerebrovascular diseases such as atherosclerosis. Early detection of these diseases will significantly improve patient outcomes in clinical practice.

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