Metabolic syndrome and risks of carotid atherosclerosis and cardiovascular events in community-based older adults in China

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ABSTRACT

Background and Objectives: Previous studies on the importance of metabolic syndrome (MS) as a cardiovascular risk factor had not focused on older Chinese adults. The present study analyzed the association of MS with carotid atherosclerosis and the risk of cardiovascular events in Chinese adults. **Methods and Study Design:** Data of a representative cohort study with 5-year follow-up were used. Community-dwelling people (n=1257) aged ≥55 years without cardiovascular disease (CVD) at baseline were followed up from 2009 to 2014. MS was defined based on the Chinese Diabetes Society criteria under the Chinese Medical Association. Multiple regression analyses were performed to examine the associations of MS with atherosclerosis and CVD events, with adjustment for confounding factors. **Results:** In a multivariate logistic regression model with adjustment, MS was closely related to common carotid artery intima–media thickness (CCA-IMT) (1.62; 95% CI: 1.19–2.21) and carotid plaque presence (1.38; 95% CI: 1.01–1.89), but not with carotid artery stenosis. At the end of the 5-year follow-up, compared with subjects without MS, hazard ratios and 95% confidence intervals for the different risks in subjects with MS were 1.86 (1.02–3.29) for myocardial infarction (MI), 1.39 (1.01–2.05) for stroke, 1.52 (1.02–2.37) for CVD death, and 1.13 (0.62–2.58) for total death, after adjusting for age, gender, smoking, drinking, physical activity, uric acid, high-sensitivity C-reactive protein, dietary factors and carotid atherosclerosis status. **Conclusions:** MS was significantly associated with IMT and the presence of carotid plaque and with positively increased risks of MI, stroke, and CVD mortality independent of CVD risk factors in older Chinese adults.

Key Words: metabolic syndrome, cohort study, food patterns, carotid atherosclerosis, myocardial infarction

INTRODUCTION

Metabolic syndrome (MS) is defined as the clustering of cardiovascular risk factors, including obesity, insulin resistance or glucose intolerance, atherogenic dyslipidemia (elevated triglyceride [TG] and lower high-density lipoprotein cholesterol [HDL-C]), and raised blood pressure. The prevalence of MS is increasing worldwide, affecting 24% of adults in the United States, 23% in seven European countries,[1,2] and 12%–22% in the Asian region.[3] Different countries exhibit different clusters of epidemic risk factors. Each component of MS is a known risk factor for the development of atherosclerosis, coronary artery disease (CAD), and stroke.[4,5] Substantial increases in the prevalence of MS has raised major concerns

regarding CAD development as well as cerebrovascular consequences for the Asian population in recent years.[4,6] Notably, MS and being overweight are becoming increasingly common in China. From 1992 to 2002, the prevalence of being overweight, obesity, and obesity-related chronic diseases has increased considerably in China.[7,8] According to a 2005 report, the prevalence rate of MS was 13.7% (95% confidence interval [CI]: 12.9%–14.5%) in Chinese adults aged >35 years.[9] Chinese people who have MS are 3–10 times more likely to develop CVD commensurate with high risks of morbidity and mortality.[3,10]

CVD is therefore becoming more prevalent and has become a leading cause of death. Researchers predict that cardiovascular morbidity and mortality will increase in China by 2030 owing to the increasing incidence of MS with lifestyle changes.

Carotid intima–media thickness (CIMT) and carotid plaque presence assessed using noninvasive high-resolution B-mode ultrasound are useful surrogate markers of CVD and powerful predictors of vascular outcomes (e.g., stroke and coronary heart disease [CHD]).[11-13] To date, the relationship between MS and subclinical carotid atherosclerosis and CVD in older Chinese adults has not been well characterized.[14] The aim of the current study was to assess the prevalence of MS and its association with subclinical carotid atherosclerosis and cardiovascular morbidity and mortality in a representative elderly Chinese population by applying the Chinese Diabetes Society (CDS) definition.

MATERIALS AND METHODS

Study population and data collection

Data for this study were obtained from the Beijing Longitudinal Study of Aging (BLSA), a population-based representative cohort study of community-dwelling Chinese people aged ≥55 years at baseline (response rate: 91.2%), as described elsewhere.[15-17] Residents from three districts, namely Xuanwu, Daxing, and Huairou, in the greater Beijing municipality area were selected randomly. Distributions of gender, age group, and educational level of the study sample were obtained from the Fourth National Census Data, which represent the older population of Beijing. The details of the study design, setting, sampling technique, and quality control of the survey are provided in previous studies.[15-17] All neighborhoods, such as towns, villages, and streets of the districts were included. The sampling process followed the three-stage stratification random clustering procedure to ensure the representativeness of older adults in this region. The cohort was assembled in 1992 and was followed up every 2–3 years. The present study is based on the survey conducted in 2009. A total of 2468 people aged ≥55

years were enrolled, and all subjects who completed the survey in 2009 were followed up until the end of 2014.

Individuals were directly interviewed unless they were in poor health or were temporarily absent, in which case a shorter questionnaire was administered to a proxy. This study included only participants who were directly interviewed and were aged ≥55 years. The inclusion criteria were completing the procedures of the study and the presence of the following parameters: TG, HDL, fasting blood glucose (FBG) level, blood pressure, and body mass index (BMI). Exclusion criteria were having difficulty in completing the procedures of the study and history of CVDs (e.g., stroke, myocardial infarction (MI), angina, and heart failure). Face-to-face interview, comprehensive physical examinations, and blood drawing were conducted for all participants. Interviews were conducted to collect self-report data on demographic characteristics, physical and cognitive health, medical condition and functionality, and psychological health. Individual food consumption data were collected through one 24-h recalls combined with a food inventory. Among 2468 subjects, 1047 refused to undergo blood sampling or physical examinations. In addition, 164 subjects with a history of CVD were excluded. Thus, a total of 1257 subjects were analyzed.

The study protocol was approved by the Ethics Committees of Xuanwu Hospital, Capital Medical University, Beijing, China. Written informed consent for the procedure was obtained from each individual.

Physical examination and laboratory measurements

Seated blood pressure was measured on the right arm using a standard mercury sphygmomanometer after 5-min rest, and no food, smoking, and strenuous activity were allowed15min prior to the measurement. The second measurement was taken after at least a 1-min rest period, and both measurements were used for analyses.

With participants wearing light clothing and no shoes, height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, by trained staff using stadiometers and beam balance scales of government approved quality.

Morning blood or serum samples were collected after an overnight fast and were analyzed for fasting plasma glucose (FPG), total cholesterol(TC), TG, HDL-C, and low-density lipoprotein cholesterol (LDL-C).

All blood samples were obtained after 8 hours of fasting and were analyzed for glucose, TG, HDL-C, and LDL-C. The glucose oxidase-peroxidase method was used to determine fasting glucose levels. The direct assay method was used to measure HDL-C and LDL-C,

whereas TC and TG were measured using the standard enzymatic method. All biochemical analyses were performed on a Hitachi 7600 automatic analyzer (Hitachi High-Technologies Corporation, Tokyo, Japan).

Carotid ultrasonography

Carotid atherosclerotic lesions were examined using a high-resolution color Doppler ultrasound system (8.0 MHz, Logic E; GE Healthcare, USA) according to the guidelines established by the European Stroke Conferences.[18] As described in previous studies,[15-17] CCA-IMT was measured on both the left and the right sides of CCA at least 5 mm below its end. CCA-IMT was defined as the distance between the lumen–intima interface and the media–adventitia interface in areas free of plaque.[18,19] Measurements were repeated three times, and the averaged results were analyzed. Increased CCA-IMT was defined as mean CCA-IMT ≥1.0 mm. Plaque was defined as focal structures being 50% thicker than the surrounding wall or the structures manifesting a thickness of >1.5 mm, as measured from the intima-lumen interface to the media-adventitia interface.[18,19] According to the percentile method, low plaque score (PS) was defined as a thickness of >0 mm and <4.2mm, and high PS was defined as a thickness of ≥4.2 mm. Plaque characteristics were defined based on plaque localization, surface morphology, and echogenicity; accordingly, the plaque was categorized as unilateral or bilateral, regular or irregular, and heterogeneous or homogeneous.[20] Carotid stenosis was examined in the common or internal carotid artery according to the guidelines of the Society of Radiologists in Ultrasound Consensus Conference.[21] In this study, two sonographers performed repeated ultrasonographic examinations of 15% of participants to ensure reproducibility of measurements. The average intraclass correlation coefficient for interobserver reliability was 0.97 (95% CI: 0.96–0.98, p<0.001), and intraobserver test–retest reliability testing revealed an intraclass correlation coefficient of 0.93 (95% CI: 0.91–0.94, p<0.001).

Definition of MS

Participants were diagnosed with MS if they had three or more of the following criteria set by the CDS under the Chinese Medical Association in 2004:[22]

1. Overweight or obesity defined as BMI ≥ 25.0 kg/m^2.
2. High blood pressure defined as systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg.

3. Hypertriglyceridemia defined as serum TG level of ≥ 1.7 mmol/L or low HDL-C defined as serum HDL-C level of ≤0.9 mmol/L in men and <1.0 mmol/L in women.
4. Impaired FPG defined as FPG ≥6.1 mmol/L. Participants who received antihypertensive or antidiabetic medication met the criteria for high blood pressure or high fasting glucose.

BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Statistical analysis

Sample characteristics are presented as means and standard deviations for continuous data and percentages for categorical data, and their differences were tested using the independent sample t test and chi-square test, respectively. The multiple logistic regression model was used to evaluate the association of MS with artery atherosclerosis, where model I was adjusted for age and gender; model II was adjusted for age, gender, smoking, and drinking, physical activity, uric acid (UA) and C-reactive protein (CRP); and model III was adjusted for age, gender, smoking, drinking, physical activity, UA, CRP, intakes of red meat, intake of fruits and salty taste preference. The Cox proportional hazard model was applied to investigate the relationship between MS and the risk of cardiovascular events or mortality, where model I was adjusted for age and gender; model II was adjusted for age, gender, smoking, drinking, physical activity, UA, CRP, CCA-IMT and carotid plaque; and model III was adjusted for age, gender, smoking, drinking, physical activity, UA, CRP, CCA-IMT, carotid plaque, intakes of red meat, intake of fruits and salty taste preference. Cox proportional survival probability curves were drawn and were separately stratified for MS and nMS groups. A two-sided p value of <0.05 was considered significant. Data analysis was performed using SPSS version 22.0.

RESULTS

General characteristics and food consumption of the study population

Among the 1257 participants included in this study, the mean age was 69.2±8.1 years (range, 55±97 years), and 56.2% of the study participants were female. On the basis of the CDS criteria, 258 (20.5%) participants were diagnosed with MS (Figure 1). A total of 999 (79.5%) participants presented none of the four components of MS, whereas 84 (6.7%) participants presented one component of MS and 662 (52.7%) participants presented two components of MS. As expected, BMI, TG, TC, HDL-C, LDL-C, FBG, SBP and DBP, pulse pressure (PP), UA, and CRP were significantly higher in subjects with MS than in subjects without MS (all p<0.001). Participants with MS had a higher prevalence of obesity, hypertension (HT),

diabetes mellitus (DM), and dyslipidemia and a lower proportion of men, smokers, and drinkers (all $p<0.001$). Participants of the MS group and nMS group had similar age (Table 1). The type of food consumed by the participants of the MS and nMS groups is presented in Table 2. Participants with MS tended to have a higher intake of red meat, eggs, and bean products; having breakfast; and salty taste preference, whereas subjects without MS had a higher intake of fruits.

Carotid atherosclerosis according to the presence of MS

A total of 258 (20.5%) participants with MS had increased CIMT (1.02±0.15; $p=0.009$); similarly, a higher prevalence of CCA-IMT thickening (69.0%) was found in the MS group (Table 3). Participants with MS had a higher proportion of carotid plaque than the nMS group (68.6% vs 64.2%). However, no significant difference was observed in the prevalence of carotid artery stenosis between the MS group and nMS group. Moreover, no significant difference was observed in plaque localization, plaque surface morphology, and plaque echogenicity between these two groups.

Association of MS with carotid atherosclerosis

In the multivariable logistic regression analysis adjusted for age, gender, the presence of the MS was generally associated with CCA-IMT (odds ratio (OR)=1.62, 95% CI: 1.19–2.21) and carotid plaque presence (OR=1.38, 95% CI: 1.01–1.89) (model I, Table 4). Furthermore, after adjusting for age, gender, smoking, drinking, physical activity, UA, and CRP, the OR increased to 1.63 (95% CI: 1.20–2.23) and 1.40 (95% CI: 1.02–1.89) (model II, Table 4), respectively. Moreover, adding dietary variables (including intake of red meat, intake of fruits, and salty taste preference) to the model led to a slightly decrease in OR for CCA-IMT thickening (OR=1.60, 95% CI: 1.17–2.24). Additionally, the values of information criteria (Akaike information criterion: AIC and Bayesian information criterion: BIC) were significantly reduced ($p<0.001$). This result indicated that addition of all confounders to model III substantially improved the model fit. However, no significant associations were found between MS and the presence of carotid stenosis.

Effect of the presence of MS on CVD events and mortality

A multivariable Cox regression analysis for survival probability revealed that the presence of MS significantly contributed to the risks of MI and CVD death ($p<0.05$). Compared with the nMS group, the MS group had a 1.9-fold increased risk of MI (hazard ratio [HR]=1.87, 95%

CI: 1.04–3.36), 1.4-fold increased risk of stroke (HR=1.39, 95% CI:1.01–2.03), and 1.5-fold increased risk of CVD death (HR=1.52, 95% CI: 1.03–2.25), after adjusting for age, gender, smoking, drinking, physical activity, UA, CRP, CCA-IMT, and carotid plaque presence (model II, Table 5). When the model was additionally adjusted for dietary variables, the HR of MS was statistically significant for MI but was slightly attenuated after the addition of intake of red meat, intake of fruits, and salty taste preference (HR=1.86, 95% CI: 1.02–3.29), indicating that a higher intake of red meat, lower intake of fruits, and salty taste preference had a modest impact on MI. However, the presence of MS was not significantly associated with total death. Similarly, the survival curve indicated that older adults with MS generally had higher risks of MI, stroke, and CVD death, whereas the risk of total death showed statistically nonsignificant increases in older adults with MS (Figure 2).

DISCUSSION

This study examined the association between MS and subclinical carotid atherosclerosis and different health outcomes (e.g., MI, stroke, CVD death, and total death). The findings indicated that MS was correlated with subclinical atherosclerosis, as measured by CIMT and carotid plaque presence. Notably, these relationships were independent of age, gender, smoking, drinking, and other conventional risk factors. However, we did not observe any significant association between the MS and carotid stenosis, which is consistent with the results of previous studies.[23] Additionally, the smaller sample size of participants with carotid stenosis in this study is a potential reason for our negative result.

Previous studies that investigated the association between MS and carotid atherosclerosis presented in consistent results.[5,12,23-27] In BLSA, a population-based study, MS was significantly associated with greater carotid IMT and stiffness. Another study demonstrated that MS was closely related to the risk of increased aortic pulse wave velocity in middle-aged Japanese men.[5] A study in multiethnic middle-aged individuals revealed an independent association between MS and plaque presence and maximum carotid plaquethickness.[13] Additionally, the Atherosclerosis Risk in Communities (ARIC) cohort study and the Second Manifestations of Arterial Disease (SMART) study reported a positive association between MS and CIMT.[25,26] Studies in Swedish and Hong Kong populations revealed an association of CIMT with MS, but not with plaque.[23,27] However, consistent with the findings of the current study, the Bruneck study presented a significant association of carotid plaque progression with MS and with an increased risk of coronary heart disease (CHD) in a cohort of 888 Italian subjects.[28] These data provide evidence for the significant association of MS with

atherosclerosis. The discrepancy in these findings may be due to the difference in the diagnostic criteria of MS (i.e., although the major components of the MS definitions were similar, the diagnostic threshold for the components of MS varied among different definitions; thus, the determined high-risk population was different across the MS definitions), difference in study populations (e.g., population- or patient-based study), diverse sample sizes, varying effects of potential confounders, and the possible lack of statistical power.

To date, limited studies have investigated the relationship between MS and imaging markers of carotid atherosclerosis and CVD in a large elderly population. To the best of our knowledge, our study is the first to present the association of MS with carotid thickness and plaque formation in the community-based elderly Chinese population. In this analysis, we also demonstrated that MS was an independent predictor of MI, stroke, and CVD death in older adults without cardiovascular events at baseline, after adjustment for conventional risk factors and carotid atherosclerosis status. However, no significant association of MS with the risks of total mortality was observed in multivariable adjusted models. Our findings are in accordance with those of a population-based study that identified MS as an independent predictor of incident heart failure in middle-aged men without CVD events.[29] Moreover, previous epidemiological studies in Chinese individuals with diabetes presented that MS was associated with an increased risk of adverse cardiovascular events, such as CHD and CVD mortality with Ors of 3 and 1.8, respectively.[30,31] The largest meta-analysis, which covered 37 prospective studies and was based on diverse populations, revealed that MS was associated with cardiovascular events and CVD death (OR=1.78, 95% CI: 1.58–2.00). The association remained after adjusting for traditional cardiovascular risk factors (OR=1.54, 95% CI: 1.32–1.79).[32] Notably, as previously suggested, MS has been determined as the common underlying preclinical condition and has been considered a useful tool for predicting future diabetes and CVD development.

The study suggested that the participants with higher intakes of red meat, lower intake of fruits and salty taste preference had higher risks of Carotid atherosclerosis (e,g. CCA-IMT thickening and presence of carotid plaque) and MI, to some extent, these results illustrated the important effect of food intake patter on arterial disease, which was consistent with previous findings.[33-35]

The current study presented a strong association of MS with significantly higher risks of MI, stroke, and CVD death, but not with total death, in subjects aged >65 years. Our findings are consistent with those of the Health ABC study,[36] whereas a recent study among a middle-aged population presented contradictory results: MS was not only associated with a

significantly higher risk of cardiovascular outcomes, but also with total mortality.[37] The discrepancies in the associations of MS with total mortality between our study and the previous study may be attributed to the impact of weight loss on mortality risk among older adults. Particularly, weight-loss subjects without MS might exhibit an increased mortality risk. Furthermore, compared with the aforementioned study,[32] the present study featured competing risks of mortality and a shorter follow-up; thus, the presence of non-CVDs (e.g., cancer) and long-term follow-up might be reasons for the increased mortality. Future studies are needed to further elucidate the relationship of MS with all-cause mortality in older adults.

The strengths of the present study are the inclusion of a well-representative population-based cohort for a prospective epidemiological study and the utilization of standardized and validated assessment methods for MS and carotid atherosclerosis. However, there are several potential limitations to this study. First, a cross-sectional association between MS and carotid atherosclerosis was observed in the current study; therefore, the effects of MS on plaque progression could not be evaluated. Second, the baseline laboratory and ultrasonographic data of all participants in our cohort were not available for analyses, which might have biased our results and conclusions. However, we compared the characteristics of the entire cohort and the samples analyzed in this study, and no significant difference was found, except that those who did not allow such measurements to be conducted tended to be older (data not shown). Third, the effects of substantial residual confounding might have remained because detailed information concerning some potential confounding factors (e.g., medication for CVD or stroke) was unavailable for analyses in the current study. In particular, lipid-lowering medication was not included in the dyslipidemia definition because the effects of drugs on HDL and TG may differ. In the ARIC study, lipid-lowering treatment was not incorporated into the dyslipidemia definition for the same reason[24] consequently, the presence of dyslipidemia and the prevalence of the MS might have been slightly underestimated. Fourth, complete information regarding smoking duration and intensity was not available in this study. As smoking was used as a dichotomous variable in the multivariable analysis model, its effect may not be entirely adjusted when evaluating the risk of CVD events in this study. Additional studies are needed for the better assessment of effects of smoking and drinking (e.g., duration and quantity of smoking and drinking), which are probably strong influencing factors of CVD events. Finally, we used a baseline food frequency questionnaire to collect dietary intake data, and such variables can change over time. A future study with more detailed time-series analyses and multiple survey data can facilitate the assessment of the association between the outcome and dynamic changes.

In conclusion, older adults with MS (as defined by CDS criteria) are at significantly higher risks of subclinical carotid atherosclerosis, MI, stroke, and CVD death than those without MS. Identification of MS can play an important role in the risk assessment and treatment of patients because many of them are most likely to benefit from the prevention of cardiovascular events. Additional studies are required to assess the feasibility of modification of individual components of MS.

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AUTHOR DISCLOSURE

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Table 1. Baseline characteristics of participants with and without MS

Variables	nMS	MS	*p*
n	999	258	
Age (yrs, $\bar{x} \pm SD$)	69.5±8.3	68.9±7.3	0.272
Male, n (%)	472 (47.2%)	78 (30.2%)	<0.001
BMI, (kg/m^2, $\bar{x} \pm SD$)	23.2±3.7	27.4±3.6	<0.001
Obesity, n (%)	83 (8.3%)	101 (39.1%)	<0.001
HT, n (%)	514 (51.5%)	248 (96.1%)	<0.001
DM, n (%)	83 (8.3%)	114 (44.2%)	<0.001
Dyslipidemia, n (%)	525 (52.6%)	212 (82.3%)	<0.001
FBG (mmol/L)	5.4±1.3	6.9±2.3	<0.001
UA (mmol/L)	342.6±94.0	377.9±100.1	<0.001
TC (mmol/L)	5.8±1.1	6.2±1.3	<0.001
TG (mmol/L)	1.4±0.9	2.5±1.7	<0.001
HDL-C(mmol/L)	1.3±0.3	1.1±0.2	<0.001
LDL-C(mmol/L)	2.9±0.7	3.2±0.8	<0.001
CRP (mmol/L)	0.2±0.5	0.3±0.6	<0.001
SBP (mmHg)	136.9±20.0	146.7±19.7	<0.001
DBP (mmHg)	76.2±11.0	78.8±10.7	<0.001
PP (mmHg)	60.7±16.8	67.9±17.5	<0.001
Smoking, n (%)	320 (32.0%)	66 (25.6%)	0.049
Drinking, n (%)	329 (32.9%)	57 (22.1%)	<0.001

SD: standard deviation; MS: metabolic syndrome; BMI: body mass index; TC: total cholesterol; TG: triglyceride; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; UA: uric acid; CRP: C-reactive protein; FBG: fasting blood glucose; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; HT: hypertension; DM: diabetes mellitus.
Data are presented as mean±standard deviation, otherwise as indicated.

Table 2. Type of food consumption by participants with and without MS

Variables	nMS	MS	*p*
n	999	258	
Red meat (≥once a week)	541 (54.2%)	157 (60.8%)	0.042
Chicken/Duck meat (≥once a week)	323 (32.3%)	88 (34.0%)	0.592
Fish/shrimp (≥twice a month)	217 (21.7%)	55 (21.3%)	0.893
Egg (≥one egg/per day)	515 (51.6%)	152 (59.0%)	0.024
Milk (≥once per day)	222 (22.2%)	61 (23.8%)	0.579
Bean products (≥once a week)	493 (49.3%)	147 (56.8%)	0.023
Vegetables (≥once per day)	979 (98.0%)	251 (97.2%)	0.427
Fruits (≥once per day)	589 (59.0%)	134 (51.9%)	0.048
Tea (≥once per day)	419 (41.9%)	107 (41.4%)	0.868
Having Breakfast (always)	941 (94.2%)	253 (98.1%)	0.004
Staple food (≥300 g/per day)	469 (46.9%)	120 (46.6%)	0.937
Taste (salty taste preference)	351(35.1%)	108 (42.0%)	0.030

MS: metabolic syndrome; nMS: without metabolic syndrome.
Data are presented as mean±standard deviation, otherwise as indicated.

Table 3. Comparison of presence of carotid atherosclerotic lesions and CCA-IMT between MS and nMS groups

Variable	nMS	MS	t/X^2	*p*
n	999	258		
CCA-IMT(mm, $\bar{x}$±SD)	0.99±0.15	1.02±0.15	6.93	0.009
CCA-IMT thickening, n (%)	622 (62.3%)	178 (69.0%)	4.01	0.045
Carotid plaque, n (%)	641 (64.2%)	177 (68.6%)	1.78	0.183
Plaque localization, n (%)			3.03	0.227
Unilateral	261 (26.1%)	64 (24.8%)		
Bilateral	380 (38.0%)	113 (11.3%)		
Plaque surfacemorphology, n (%)			1.31	0.255
Regular	543 (54.4%)	156 (60.5%)		
Irregular	98 (9.8%)	21 (8.1%)		
Plaque echogenicity, n (%)			0.78	0.381
Homogeneous	339 (33.9%)	87 (33.7%)		
Heterogeneous	302 (30.2%)	90 (34.9%)		
Carotid artery stenosis, n (%)	51 (5.1%)	15 (5.8%)	0.21	0.653

CCA-IMT: common carotid artery intima–media thickness; MS: metabolic syndrome; nMS: without metabolic syndrome; SD: standard deviation.

Table 4. Odds ratios for artery atherosclerosis for MS and nMS groups

	nMS	MS
n	999	258
Increased CCA-IMT		
Model I†	1	1.62 (1.19-2.21)*
Model II‡	1	1.63 (1.20-2.23)*
Model III§	1	1.60 (1.17-2.24)*
Plaque		
Model I†	1	1.38 (1.01-1.89)*
Model II‡	1	1.40 (1.02-1.89)*
Model III§	1	1.38 (1.00-1.87)*
Carotid artery stenosis		
Model I†	1	1.42 (0.77-2.61)
Model II‡	1	1.41 (0.76-2.59)
Model III§	1	1.44 (0.77-2.65)

CCA-IMT: common carotid artery intima–media thickness; CRP: C-reactive protein; MS: Metabolic Syndrome; nMS: without Metabolic Syndrome.

*Indicates statistically significant estimates ($p<0.05$).

†Model Ⅰ: Adjusted for age and gender;

‡Model Ⅱ: Adjusted for age, gender, smoking and drinking, physical activity, uric acid and CRP;

§Model Ⅲ: Adjusted for age, gender, smoking, drinking, physical activity, uric acid and CRP, intakes of red meat, intake of fruits and salty taste preference

Table 5. Cox regression analysis for cardiovascular events and death stratified by MS

		HR (95% CI)			
		MI	Stroke	CVD Death	Total Death
n		50	113	62	155
Model I†					
MS					
No	999	1	1	1	1
Yes	258	1.87 (1.04-3.36)*	1.29 (0.93-2.02)	1.41 (0.95-2.08)	0.96 (0.48-1.90)
Model II‡					
MS					
No	999	1	1	1	1
Yes	258	1.88 (1.04-3.43)*	1.39 (1.01-2.03)	1.52 (1.03-2.25)	1.11 (0.57-2.23)
Model III§					
MS					
No	999	1	1	1	1
Yes	258	1.86 (1.02-3.29)*	1.39 (1.01-2.05)*	1.52 (1.02-2.37)*	1.13 (0.62-2.58)

CVD: cardiovascular disease; MS: metabolic syndrome. MI: myocardial infarction. HR: hazard ratio. CI: confidence interval.
*Indicates statistically significant estimates (p<0.05).
†Model Ⅰ: Adjusted for age and gender;
‡Model Ⅱ: Adjusted for age, gender, smoking and drinking, physical activity, uric acid, CRP, CCA-IMT and carotid plaque;
§Model Ⅲ: Adjusted for age, gender and smoking, drinking, physical activity, uric acid, CRP, CCA-IMT and carotid plaque, intakes of red meat, intake of fruits and salty taste preference

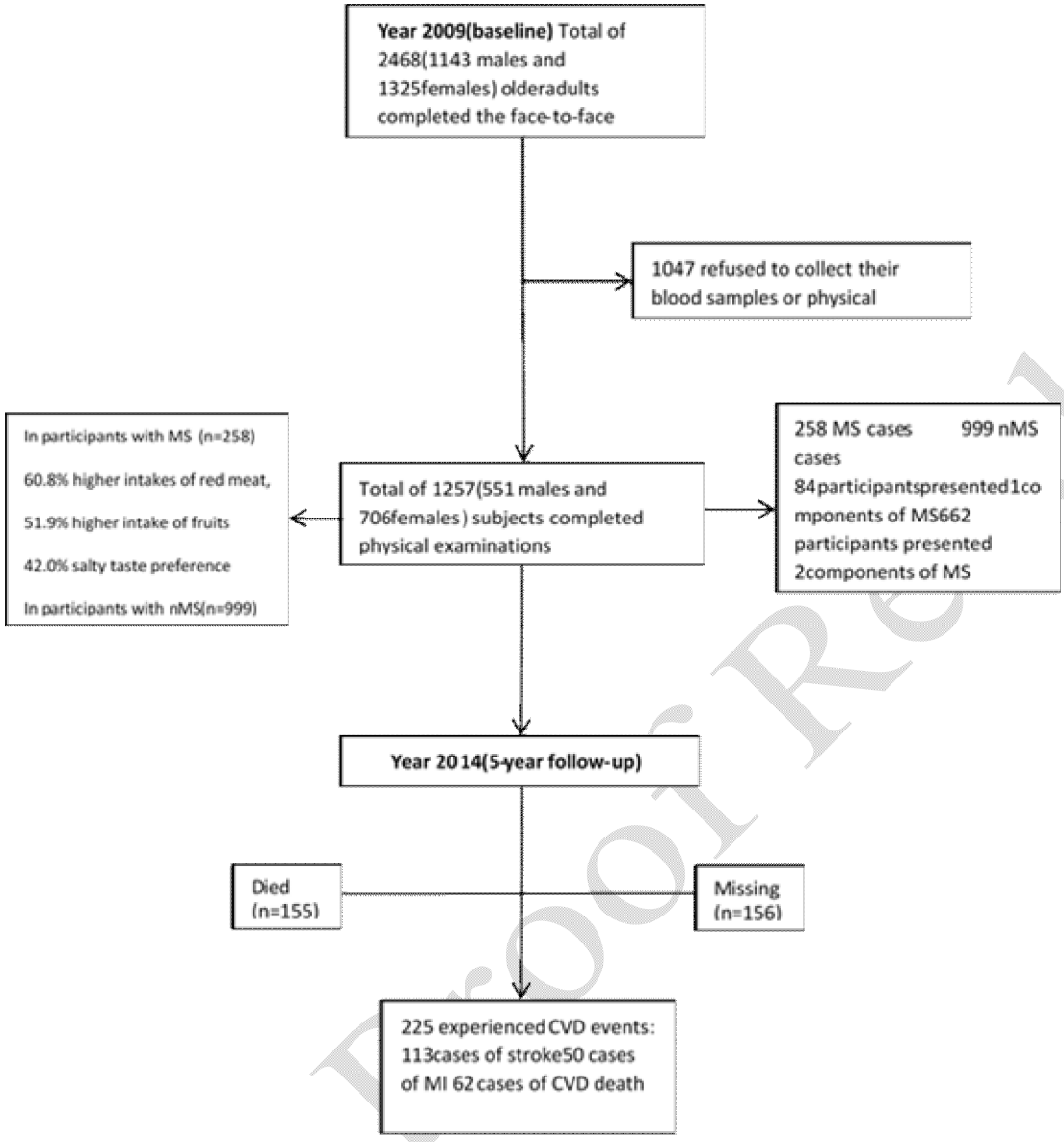

Figure 1. Flowchart on the cohort of the Beijing Longitudinal Study of Aging.

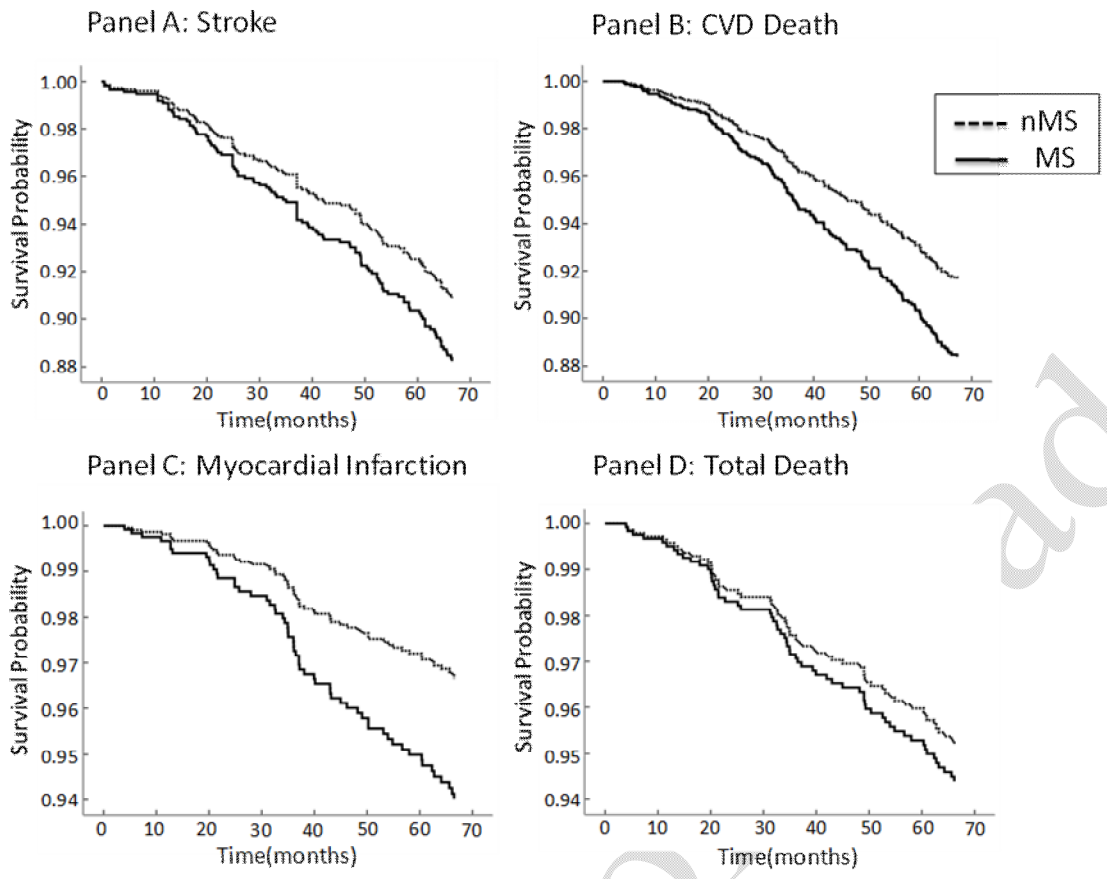

Figure 2. Multivariable Cox proportional survival probability curves for older adults with MS or without MS, adjusted for age, gender, smoking, drinking, physical activity, UA, hsCRP, diabetes, CCA-IMT, and carotid plaque.