

Original Article

Chinese water-pipe tobacco smoking acts as a risk factor for inflammation and endothelial dysfunction

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Abstract: The aim of this study was to compare the effects of Chinese water-pipe smoking with cigarette smoking on endothelial function and inflammation markers. This multicenter, cross-sectional study enrolled 356 individuals (≥ 18 years of age) from 6 towns in the Qujing area of the Yunnan Province, China. Plasma levels of hsCRP, IL-6, TNF- α , ET-1, MCP-1, sICAM-1, and sVCAM-1 were measured by enzyme-linked immunosorbent assay (ELISA) to evaluate endothelial function and inflammation. The results indicated that the levels of hsCRP, IL-6, TNF- α , ET-1, MCP-1, sICAM-1, and sVCAM-1 were significantly higher in the cigarette-smoking group and water-pipe smoking group compared to non-smokers, although there was no significant difference between the cigarette-smoking and water-pipe smoking groups. In conclusion, the exposure to Chinese water-pipe smoke is a comparable risk factor to cigarette smoking for endothelial dysfunction and inflammation.

Keywords: Chinese water-pipe smoking, cigarette smoking, inflammation, endothelial dysfunction

Introduction

Tobacco smoking through a water-pipe (also known as hookah, shisha, or nargile) is gaining popularity in China, Southeast Asia, the Middle East, and recently in the US and EU [1-3]. Chinese water-pipe smoking first became popular in the southeast of Yunnan in the beginning of 20th century and has become increasingly popular in Yunnan ever since. The pipes are one-half to one-meter long, while the diameter varies from five to ten centimeters, and most are made of bamboo. Tobacco smoke enters the pipe through the water.

Cigarette smoking is a major risk factor for cardiovascular disease [4-6]. Endothelial dysfunction [7-9] and inflammation [10, 11] are believed to play an important role in the initiation and progression of atherosclerosis; however, there are limited data and knowledge about the effects of Chinese water-pipe smoking on endothelial function and inflammation. It was traditionally believed that the use of a Chinese water-pipe is safer than cigarette smoking since the water filters the tobacco smoke. The present study compared the effect of Chinese

water-pipe smoking with direct cigarette smoking on endothelial function and inflammation.

Materials and methods

Patient selection and data extraction

A total of 356 subjects ≥ 18 years of age were enrolled in this cross-sectional study (June 1, 2015 to November 6, 2015), including 112 water-pipe smokers, 122 cigarette smokers, and 122 non-smokers, from 6 districts and counties (Qilin, Luliang, Zhanyi, Fuyuan, Huize and Malong) covering a wide geographic area in Qujing City, Yunnan Province, China. Since all of the water-pipe smokers were male, only male cigarette smokers and non-smokers were included in this study.

Exclusion criteria included evidence of malignant tumor, evidence of cardiovascular disease (CAD), cerebrovascular or peripheral vascular disease, acute or chronic inflammatory disease, pregnancy, recent surgery, anti-inflammatory drug intake, and hs-CRP levels >10 mg/L.

Resting venous blood samples were collected into EDTA tubes for the evaluation of plasma

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Table 1. Baseline characteristics of patients in water-pipe smoking group, cigarette smoking group and non-smokers group

	Water-pipe smoking group (N=112)	Cigarette smoking group (N=122)	Non-smokers group (N=122)	P
Age (years)	56.5±7.9	57.0±8.0	56.4±7.7	0.84
BMI (kg/m ²)	23.9±1.8	23.7±1.8	23.6±1.7	0.52
T-CHO (mmol/L)	4.84±1.43	4.72±1.52	4.92±1.38	0.81
TG (mmol/L)	2.23±1.63	2.38±1.48	2.14±1.52	0.45
LDL-C (mmol/L)	2.98±1.18	3.12±1.23	2.86±1.32	0.32
NHDL-C (mmol/L)	3.48±1.26	3.64±1.34	3.56±1.18	0.65
HDL-C (mmol/L)	1.08±0.34	1.05±0.29	1.14±0.38	0.76
apoA1 (mmol/L)	1.15±0.19	1.08±0.17	1.17±0.12	0.60
apoB (mmol/L)	1.04±0.22	1.09±0.26	1.06±0.31	0.57
Lp(a) (mg/L)	274.4±252.8	257.1±242.2	281.7±231.0	0.45
Cr (mmol/L)	57.5±23.6	65.1±21.3	61.2±23.2	0.46
History				
Hypertension	40 (35.7%)	45 (36.9%)	41 (33.6%)	0.86
DM	17 (15.2%)	16 (13.1%)	19 (15.6%)	0.84
Hypercholesterolemia	20 (17.9%)	21 (17.2%)	16 (13.1%)	0.56
Family history	9 (8.0%)	10 (8.2%)	8 (6.6%)	0.87

BMI: body mass index; T-CHO: total cholesterol; TG: triglyceride; LDL-C: low-density lipoprotein cholesterol; HDL-C: high-density lipoprotein cholesterol; Cr: creatine.

Table 2. Biomarkers of endothelial function and inflammation in water-pipe group, cigarette smoking group and non-smokers group

	Water-pipe group (N=112)	Cigarette smoking group (N=122)	Non-smokers group (N=122)	P
hsCRP (mg/L)	2.76±1.11	2.94±1.51	1.34±0.89	<0.001
IL-6 (pg/ml)	1.65±1.00	1.86±1.09	1.31±0.91	<0.001
TNF- α (pg/ml)	8.21±2.05	8.58±2.36	7.33±3.21	0.001
ET-1 (pg/ml)	1.65±0.72	1.77±1.30	1.40±0.91	0.015
MCP-1 (pg/ml)	97.5±32.0	104.8±42.1	80.9±37.6	<0.001
sICAM-1 (ng/ml)	182.7±60.5	195.2±74.7	158.4±84.3	0.001
sVCAM-1 (ng/ml)	615.4±170.3	645.6±165.7	567.7±180.0	0.002

hsCRP: high sensitivity C-reactive protein; IL-6: interleukine 6; TNF- α : tumor necrosis factor α ; ET-1: endothelin 1; MCP-1: monocyte chemoattractant protein 1; sICAM-1: soluble Intercellular adhesion molecule 1; sVCAM-1: soluble vascular cell adhesion molecule 1.

levels of hsCRP, IL-6, TNF- α , ET-1, MCP-1, sICAM-1, and sVCAM-1. These biomarkers were measured by enzyme linked immunosorbent assay (ELISA).

History of hypertension, hyperlipidemia, diabetes mellitus, and family history were obtained and recorded. A positive family history for coronary artery disease was defined as evidence of coronary artery disease in a parent or sibling before 60 years of age, such as a history of myocardial infarction, coronary artery bypass surgery, angina pectoris, or pathological exercise tolerance test diagnostic of ischemia.

Statistical analysis

Statistical analysis was performed using JMP 9.0 (SAS Institute, Inc., Cary, NC, USA) and SPSS 18.0 (SPSS Inc., Chicago, IL, USA). Continuous variables and categorical variables are expressed as mean \pm standard deviation and percentages (%), respectively.

Student's t-test was used to compare continuous variables, and the chi-square test or Fisher's exact test was used to compare categorical variables. $P < 0.05$ was considered to indicate a statistically significant difference.

Results

Patient characteristics

Table 1 shows the main characteristics and lipid results across the three groups. All of the included subjects were males. There were no differences in age, BMI, T-CHO, TG, LDL-C, NHDL-C, HDL-C, apoA1, apoB, Lp(a), Cr, history

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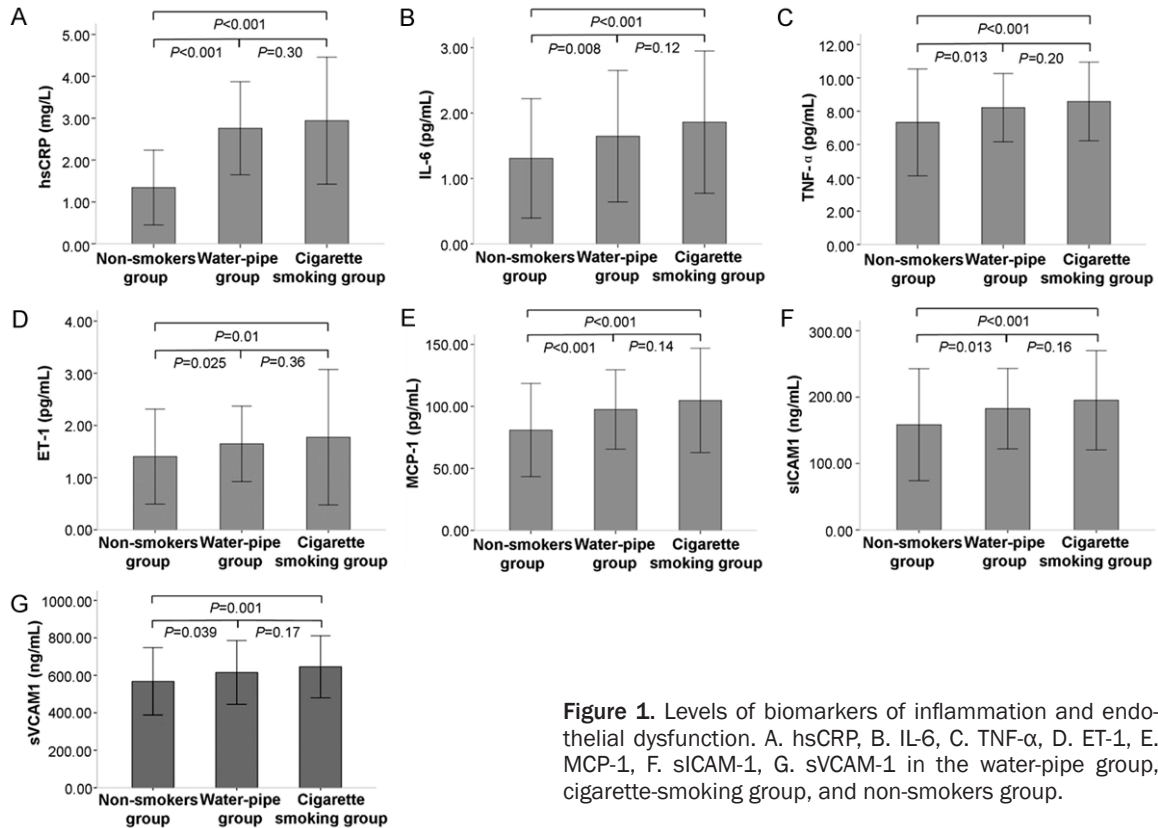


Figure 1. Levels of biomarkers of inflammation and endothelial dysfunction. A. hsCRP, B. IL-6, C. TNF- α , D. ET-1, E. MCP-1, F. sICAM-1, G. sVCAM-1 in the water-pipe group, cigarette-smoking group, and non-smokers group.

of hypertension, DM, hypercholesterolemia, or family history.

Biomarkers of endothelial function and inflammation in water-pipe smokers, cigarette smokers, and non-smokers

The results for biomarkers of inflammation and endothelial dysfunction are shown in **Table 2**. Levels of hsCRP, IL-6, TNF- α , ET-1, MCP-1, sICAM-1, and sVCAM-1 were significantly higher in the cigarette-smoking group and water-pipe smoking group compared to non-smokers. There was no significant difference between the cigarette-smoking and water-pipe smoking groups (**Figure 1**).

Discussion

Water-pipe smoking is a traditional smoking method practiced across various cultures [2, 12, 13]. Water-pipes allow for the smoking of flavored tobacco bubbled through water. There has been a recent significant increase in water-pipe smoking over the past 20 years, particularly among young smokers since water-pipe smoking is seen as a more social, sophisticat-

ed, and fashionable way of smoking tobacco [12, 13].

The endothelium is an active, dynamic tissue that controls many important functions. It plays a vital role in vascular homeostasis, vascular tone regulation, thrombosis, angiogenesis, and inflammation [9]. In response to various stimuli, endothelial cells produce and release a large number of vasoactive substances, growth modulators, and other factors that mediate these functions [8, 14]. Endothelial dysfunction [15, 16] and chronic inflammation [10] caused by tobacco smoking is an early feature of atherosclerosis *in vitro* and can induce cardiovascular disease *in vivo*. Water-pipe smoking was believed to be a safer and less addictive version of smoking than cigarette smoking and other forms of tobacco consumption since, in water-pipe smoking, the smoke comes through a column of water, which was thought to filter the smoke [6, 17].

Recent studies have demonstrated that water-pipe smoking, like cigarette smoking, is a risk factor for nicotine/tobacco dependence and is

also significantly associated with cardiovascular disease, respiratory illness, and cancer [17-20]. In our study, we found that biomarkers of inflammation and endothelial dysfunction in water-pipe smoking and cigarette smoking were both significantly higher than in non-smokers, although there was no difference between water-pipe smoking and cigarette smoking, indicating that water-pipe smoking does not reduce the harm of tobacco to endothelial function. Water-pipe smokers are exposed to significant levels of carbon monoxide, nicotine, tobacco-specific nitrosamines (TSNA), carcinogenic polycyclic aromatic hydrocarbons, and volatile aldehydes over the duration of the smoking session [1, 21]. The water's filtering capacity in the water pipe is limited and nicotine dependence may also result from repeated inhalation of tobacco in water-pipe smoking [17, 22, 23]. Thus, water-pipe smokers may receive equal or even higher doses of this hazardous substance, producing harm to endothelial and cardiovascular system.

In conclusion, the current study has provided evidence demonstrating that Chinese water-pipe smoking has mistakenly considered to be less harmful than cigarette smoking. Exposure to Chinese water-pipe smoke is a comparable risk factor as cigarette smoking to endothelial dysfunction and cardiovascular disease. Public health agencies should directly address water-pipe smoking in their tobacco-control strategies since water-pipe smoking is gaining popular especially among young smokers.

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Disclosure of conflict of interest

None.

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