Seasonal Effect on Association between Atmospheric Pollutants and Hospital Emergency Room Visit for Stroke

Hua Zhong, MD,*,[1] Zhihao Shu, MD,†,‡,[1] Yuqing Zhou, MD,†,‡ Yao Lu, PhD,† Bin Yi, MD,§ Xiaohong Tang, MD,†,‡ Chan Liu, MD,† Qihong Deng, PhD,§ Hong Yuan, MD,†,‡,§ and Zhijun Huang, PhD†,§

Background: The relationship between air pollution and stroke is conflicting. This study was conducted to document the relationship between daily changes in atmospheric pollutants and hospital emergency room visits (ERVs) for stroke. *Methods:* Data of daily hospital ERVs for stroke and atmospheric pollutants in Changsha city between 2008 and 2009 were collected. Using a time-stratified bidirectional case-crossover design, we analyzed the association between atmospheric pollutants and stroke incidence in 4 seasons. *Results:* In the single-pollutant model, we found changes in sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matters (PM_{10}) were significantly associated with cerebral hemorrhage and cerebral infarction ($P < .05$) in lags of 0-2 days in autumn. A 10-μg/m^3 increase in SO_2 in autumn was significantly associated with ERVs for both cerebral hemorrhage (odds ratio [OR], 1.166; 95% confidence interval [CI], 1.012-1.343) and cerebral infarction (OR, 1.214; 95% CI, 1.018-1.448). NO_2 in autumn was significantly associated with ERVs for cerebral hemorrhage and infarction with OR = 1.162 (95% CI, 1.005-1.344) and OR = 1.137 (95% CI, 1.011-1.279), respectively. PM_{10} in autumn was significantly associated with ERVs for cerebral hemorrhage and infarction with OR = 1.147 (95% CI, 1.045-1.259) and OR = 1.091 (95% CI, 1.019-1.168), respectively. Results of the multipollutant model showed that in autumn after PM_{10} and NO_2 adjustment, only a 10-μg/m^3 increase in SO_2 was significantly associated with ERVs for cerebral infarction (OR, 1.158; 95% CI, 1.006-1.333; $P < .05$). SO_2, NO_2, and PM_{10} were not associated with ERVs for cerebral hemorrhage ($P > .05$). *Conclusions:* This study demonstrates that the change in atmospheric SO_2 levels in Changsha is significantly associated with the stroke incidence in autumn. **Key Words:** Stroke—hospital emergency room visit—atmospheric pollution—sulfate dioxide.

From the *Department of Cardiology, Xiangya Hospital; †Center of Clinical Pharmacology, The Third Xiangya Hospital; ‡Department of Cardiology, The Third Xiangya Hospital; and §Institute of Environmental Health, Central South University, Changsha, China.

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Address correspondence to Zhijun Huang, PhD, Center of Clinical Pharmacology, the Third Xiangya Hospital, Central South University, Changsha 410013, China. E-mail: huangzj@csu.edu.cn.

[1] Contributed equally.

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Introduction

According to the World Health Organization statistical database, stroke mortality risk and disease burden in the Chinese population are at a very high level in the world.[1,2] In the middle- and low-income countries, losses due to stroke-caused disability-adjusted life years are 7 times higher than those in high-income countries.[3] Although high stroke mortality may be related to large population with hypertension in China, environmental factors represented by atmospheric pollutants are also considered to be an important trigger of stroke. However, the severity of the atmospheric pollution and the incidence of cerebrovascular diseases are not always correlated with each other. Meanwhile, studies have found that air pollution–caused damage to the human body varied with seasons.[4-6] Previous research on the association between air pollution and stroke usually used total hospitalization or death as an end point.[7-9] Little study has been focused on different types of stroke caused by air pollution.

In our study area, air pollution displayed a seasonal variation that is subject to energy consumption, solar radiation, and precipitation.[10,11] The seasonal effect of air pollution on hospital emergency room visits (ERVs) for stroke is still unclear. Therefore, we performed this time-stratified study to analyze the association between sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and atmospheric inhalable particulate matters (PM_{10}) and ERVs for cerebral hemorrhage and cerebral infarction.

Materials and Method

Hospital ERV Record

The medical record of hospital ERVs for cerebral hemorrhage and infarction between January 1, 2008, and December 31, 2009, was collected from the medical database of The Third Xiangya Hospital of Central South University, which is the largest general hospital located in the Yuelu district of Changsha City (2009 population, 801,800; the sixth census bulletins, Changsha, Hunan Province, China). The ERV medical record includes the patient's name code, age, sex, admission department, inpatient department, diagnosis, and address. Cerebrovascular diseases were classified and coded according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10: I60-70). The information of patients with the first stroke attack, which was confirmed with computed tomography or magnetic resonance imaging, was collected. Subjects in this study included local residents and the migrant population with permanent residents.

The Ethics Committee at the Third Xiangya Hospital, Central South University, approved the study protocol (NO. 2007-S050). Health information was released to us at an aggregate level without any potential of identifying individual patients. There was no contact with patients for this study.

Meteorological and Air Pollution Data

Daily data of gaseous air pollutants including NO_2, SO_2, and PM_{10} in Changsha City were obtained from the Changsha Municipal Public Weather Information Service Website (http://www.cma.gov.cn/2011qxfw/2011qsjgx/) for the period between December 1, 2007, and January 31, 2010. Meteorological data (temperature and relative humidity) at the monitoring site Changsha Huanghua Airport were obtained from the international meteorological site (http://www.wunderground.com/). The division of seasons was as follows: spring, March-May; summer, June-August; autumn, September-November; winter, December-February.

Experimental Design

A case-crossover design is often used to compare the exposure in the case period with the exposure in the nearby control period. The differences in exposure may explain the different occurrences of case. Therefore, the case-crossover design may inherently control the individual characteristic-related confounders and is often used in the study of environmental influence on the acute effect of disease.[12,13] In this time-stratified bidirectional case-crossover study, the case day was defined as the day of an emergency. The control day was defined as the same day of the same stratum as the case day. Study time was stratified by season. Recent studies have shown that this approach gives unbiased estimates in the presence of strong seasonal confounding.[14]

Statistical Analysis

The analyses were performed using SPSS 22.0 software (SPSS, Inc., Chicago, IL, USA). Conditional logistic regression was performed to estimate the association between the short-term effects of each air pollutant measured and stroke onset. The odds ratio (OR) in the study phase over the control phase was analyzed with the daily number of ERVs as weights adjusted for temperature and humidity. A stratification of time into seasons was made to select control days as the days falling on the same day of the week within the same season as the case day. Air pollution levels during the case period were compared with exposures occurring on control days both before and after the case day. For each ERV, an individual's exposure at the case day was compared with his or her exposure at control days both before and after the case day.[15] Considering the influence of other meteorological factors, single-pollutant and multiple-pollutants models were established using daily temperature and relative humidity as covariates. Considering a possible delay may occur between the exposure to pollution and the onset of cerebrovascular diseases, we evaluated the hazard period defined as the same day as the ERV to up to 3 days prior. The optimal lag phase for each pollutant was defined as the day with a maximal OR value using the single pollutant model,