

ORIGINAL

The Tottori-Ken Seibu earthquake and exacerbation of asthma in adults

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Abstract : The aim of the study was to characterize patients at risk for exacerbations of their asthma as a result of the Tottori-Ken Seibu earthquake and to identify factors that predict exacerbation of asthma after an earthquake. A retrospective cohort study-analysis was conducted of 156 asthmatic patients, aged 18 to 89 years, who were out-patients of Tottori University Hospital and who had completely recorded their asthmatic symptoms and measured their peak expiratory flow (PEF) rates for more than one year prior to the earthquake. Seventeen (11%) patients who experienced the earthquake were identified as having an exacerbation within one month after the earthquake. Diurnal variability of PEF during the month after the earthquake was compared to values during a matched month one year previously. When factors associated with exacerbation were identified by a review of the medical case notes and the contribution of these factors to the exacerbation was determined using multivariate analysis, airflow limitation was shown to be independently associated with exacerbation after the earthquake. Acute asthma attacks are more likely to occur within the first week after the earthquake event without diurnal PEF variability. Asthma is likely to worsen after an earthquake. *J. Med. Invest.* 52 : 80-84, February, 2005

Keywords : asthma, earthquake, exacerbation, stress

INTRODUCTION

Psychosocial stress is a major contributor to exacerbation of asthma. Psychosocial stress increases the risk of asthma attacks in children for several weeks (1). Posttraumatic psychological stress with the September 11, 2001 terrorist attacks on the New York City was contributed to moderate-to-severe asthma symptoms and unscheduled physician visits for asthma (2). Stress associated with final examination in college

students could act as a cofactor to increase eosinophilic airway inflammation to antigen challenge (3). An event such as a major earthquake has been identified as one of the factors that exacerbate asthma. However, it was reported that the number of asthma attacks seemed to decrease just after the Hanshin-Awaji earthquake (4). This decrease turned out to be factitious. The earthquake severely disrupted medical services, so reliable data for the 10-week period following the earthquake do not exist (5).

The Tottori-Ken Seibu earthquake in western Tottori prefecture in Japan occurred on October 6, 2000 and was graded with 7.3, on the Richter scale comparable to the Hanshin-Awaji earthquake. There were more than 100 people injured, but no fatalities were reported.

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Therefore the fact of an earthquake on the exacerbation of asthma can be assessed without the confounding influences of secondary factors associated with catastrophic disruption of the social fabric.

Measurement of the peak expiratory flow rate (PEFR) provides valuable information about the diurnal variation in airway caliber. Psychosocial stress affects the diurnal changes in PEFR and produce symptoms (6). It has been reported that the pattern of diurnal PEFR variability might be useful as a way to identify causes of exacerbation, such as allergen exposure, viral infection, and psychosocial stress (7-9).

The objective of this study was to examine whether the earthquake increases the risk of acute exacerbation of asthma in adults. We also investigated the pattern of diurnal PEFR variability to identify the causes of exacerbation.

MATERIALS AND METHODS

Patients

A retrospective analysis was performed on 156 outpatients in whom complete data on symptoms and PEFR during the year prior to and the month after the earthquake were available. All patients had a diagnosis of bronchial asthma as defined by American Thoracic Society (ATS) criteria (10).

Respiratory Questionnaire and Recording

All patients were questioned in regard to breathlessness, wheezing, cough, sputum production, chest tightness, and nocturnal awakening. The incidence of exacerbations was determined for the year prior to and the month after the earthquake. The determination of exacerbation prior to the earthquake was based on data from the patients' diaries; day-time and night-time symptom scores, use of rescue short acting β_2 -agonists, morning and evening peak expiratory flow (PEF) (am and pm PEF, respectively) and from case record forms (exacerbations). PEF diurnal variation was measured with a mini-Wright Peak Flow meter (Clement Clark International, London, UK) and calculated as $(\text{pm PEF} - \text{am PEF}) / (\text{am PEF} + \text{pm PEF}) / 2$. Post-earthquake exacerbations were determined clinically. As an exacerbation was defined as daily nocturnal symptoms, wheezing, and the use of β_2 -agonists (at least 2 puffs/day) or a mean decrease in the measured PEF of $>20\%$ in the am PEF or an increase in diurnal variation $>20\%$ during the month after the earthquake.

Spirometry

Forced expiratory volume in one sec (FEV₁) was calculated from standardized maximal expiratory flow/volume curves using a calibrated Masterlab pneumotachograph (Jaeger, Wurzburg, Germany) during a symptom-free interval a few months prior to the earthquake. We selected the patient's best ever value as the FEV₁ % predicted.

Statistical Analysis

Data were analyzed using StatView version 5.0 for Macintosh (Chicago, IL). Within-group changes and between-group differences in parameters were tested by the Mann-Whitney and Wilcoxon tests, respectively. A probability value of $<5\%$ was considered statistically significant. Multivariate analysis was used to identify independent and logistic regression analysis was used to identify predictors of exacerbation. Results of multivariate analysis are reported as the odds ratios (OR) with 95% confidence intervals.

RESULTS

Patient's Clinical Characteristics

All 156 patients entered into the study (75 men and 81 women), completed the study, and provided complete data sets (Table 1). Their age was 62.2 ± 13.6 years and the FEV₁ % predicted was 81.2 ± 14.3 . Ten patients used an inhalation short-acting β_2 -agonists alone; 67 need regularly inhalation steroids plus theophylline; 58 regularly used inhalation steroids plus theophylline plus a leukotriene receptor antagonist; eight patients took theophylline plus inhalation short-acting β_2 -agonists; and 13 patients required all four medications plus oral steroids.

Exacerbations during One Month after the Earthquake

Seventeen patients (11%) developed an exacerbation during the month after the earthquake, fourteen (82%) of whom did so within one week of the earthquake. Only four patients (3%) had a matched-month exacerbation one-year prior to the earthquake. Three patients (27%) with an exacerbation had associated cold symptoms. No patients visited the emergency room or required extra out-patient consultation and had experience to live at temporary shelter the month after the earthquake.

PEF Variation during One Month after the Earthquake

A representative peak-flow chart generated during an exacerbation in the month period immediately after

Table 1. Demographics and Patient Characteristics

	No exacerbation (n=139)	Exacerbation (n=17)	p-value
Age, years	61+/-14	65+/-11	N.D.
Gender, F/M	67/72	8/9	N.D.
FEV ₁ %pred.	81.0+/-14.1	64.7+/-16.9	<i>P</i> < 0.01
Atopy	68/139	8/17	N.D.
Mean am PEF prior to earthquake (L/min)	393+/-57	316+/-48	<i>P</i> < 0.01
Mean pm PEF prior to earthquake (L/min)	402+/-46	324+/-46	<i>P</i> < 0.01
Coefficient of variance of PEF prior to earthquake	0.01+/-0.01	0.02+/-0.02	N.D.
Mean am PEF after earthquake (L/min)	385+/-63	247+/-38*	<i>P</i> < 0.01
Mean pm PEF after earthquake (L/min)	391+/-64	259+/-44*	<i>P</i> < 0.01
Coefficient of variance of PEF after earthquake	0.02+/-0.01	0.02+/-0.02	N.D.

Definition of abbreviations : FEV₁ %pred., % predicted forced expiratory volume in one sec ; PEF, peak expiratory flow. Data are expressed as mean+/-SD. N.D. = no difference.

*, significantly different from that prior to earthquake at *P* < 0.05.

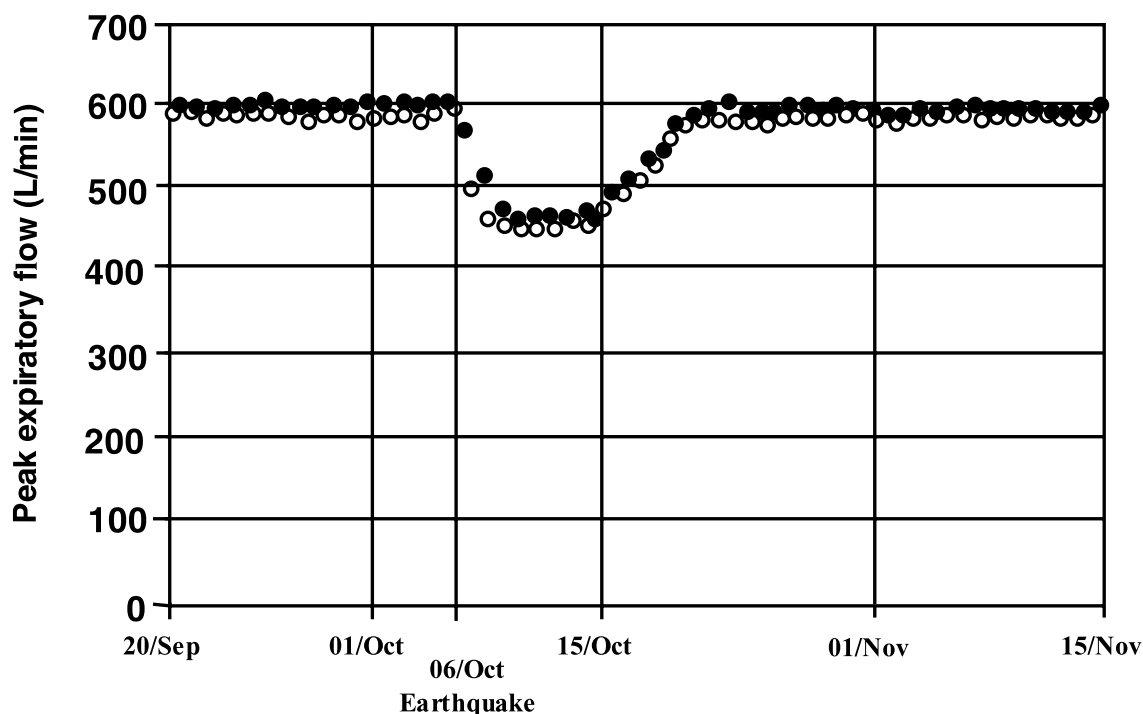


Figure 1. A representative peak-flow chart of a 36-year-old who generated during an exacerbation in the month period immediately after the earthquake. Morning (open circle) and evening (closed circle) peak expiratory flow (PEF) are indicated.

the earthquake, shows a distinctive pattern (Fig. 1). There was no difference in age, gender, and atopy situation between no-exacerbation group and exacerbation group (Table 1). Exacerbation group showed significantly lower value of % predicted FEV₁ during a symptom-free interval a few months prior to the earthquake than no-exacerbation group. Although the average fall in am PEF during the exacerbation was 23%, the diurnal variability was not higher during the exacerbation than during stable periods (Table 1). When we identified factors associated with exacerbation after the earthquake, age, gender duration time, and season-matched exacerbation were not predictors.

Table 2. Association of Clinical Variables with Exacerbation by Multivariate Analysis

Clinical features	OR	95% CI	p-value
FEV ₁ %pred. < 70%	13.2	1.1-24.6	0.01
Duration time > 10 years	4.8	0.7-11.6	0.07
Exacerbation at one-year earlier*	1.4	0.2-7.2	0.36
Age > 65 years	1.1	0.1-2.1	0.32

Definition of abbreviations : OR, odds ratio; FEV₁ % pred., % predicted forced expiratory volume in one sec ; CI, confidence interval.

*Occurrence of an exacerbation during the same season (Sep-Oct) one year previously.

Logistic regression analysis was performed to identify predictors of exacerbations after the earthquake, and only an FEV₁ % pred. <70% was identified as an independent predictor of exacerbation (Table 2).

DISCUSSION

We have shown that patients who live through an earthquake are vulnerable to exacerbation of asthma. When we retrospectively reviewed the charts 156 of adult patients with established asthma from outpatients in Tottori University, seventeen patients (11%) developed an exacerbation during the month after the earthquake. During these exacerbations, there is a linear decline and then a linear recovery in the PEF, with no change in diurnal variability.

The Hanshin-Awaji earthquake on January 17, 1995 was a so-called, "directly under a region" earthquake that occurred in an inland area. It shook the ground powerfully in the area around the fault line, and caused tremendous damage. That earthquake measured 7.2 on the Richter scale directly under the cities, and 6,433 people died. Over 40,000 people were injured, and approximately 240,000 buildings and houses damaged. The earthquake provided a shelter to over 300,000 people who lost their homes in the disaster. So a variety of secondary factors, such as poor facilities in temporary shelters, psychosocial stress from disruption of normal routines, and epidemic viral respiratory infections, were associated with a belated rise in earthquake-induced hospitalizations for asthma (5). On the other hand, although the magnitude of the 2000 Tottori-Ken Seibu earthquake was as almost same as that of the Hanshin-Awaji earthquake, only 141 people were injured and there were no fatalities. Approximately 1,300 damaged buildings and houses had been estimated. Less than 3,700 people had lived at poor facilities in temporary shelter. This study attempts to isolate the influence of major earthquakes on asthma. We demonstrated that psychological stress such as earthquake might lead to asthma exacerbations even in some patients, who had no experience to live at temporary shelter.

Previous studies have reported that there are two patterns of diurnal PEF variability depending on the cause of the exacerbation of asthma. Exacerbations that are due to a reduction in the dosage of inhaled corticosteroid (11,12) or acute allergen exposure (7) show a reduction of in the PEF with wide diurnal vari-

ability. The mean daily PEF decreases during asthma exacerbations without any increase in diurnal variability (8, 9, 13, 14). In viral-induced exacerbations (13, 14) and exacerbations caused by mood change (9), diurnal variability is decreased. In this paper, asthmatic patients who suffered an exacerbation showed a decline in the PEF without diurnal PEF variability after the earthquake. One possible explanation for this phenomenon is vagal hyperreactivity secondary to mood change. Another possible explanation is viral infection. Tarlo *et al.* (15) reported that approximately 50% of exacerbations are associated with cold symptoms. Negative life events may influence susceptibility to and severity of exacerbations of asthma by increasing susceptibility to respiratory viral infection (16). However, we found that few patients (27%) with an exacerbation had cold symptoms after the earthquake.

The exact relationship between stress and exacerbation of asthma is unclear. An earthquake is an acute psychological stressor, but it can become a chronic stress if seismic activity persists for several months. Thus, earthquake may affect not only sympathetic and parasympathetic tone but hormonal responses as well. Acceleration stress, although of very short duration, is very potent in eliciting glucocorticoid and androgenic responses (17, 18). When exposed to acceleration stress with the vector in the head-foot direction, the serum epinephrine increases 7-fold and the serum cortisol level decreases (17). When stress is ongoing, plasma epinephrine, norepinephrine, and cortisol levels declined (17). Acute stress induces significant neuroendocrine and immune changes that can affect pulmonary function (19). These neurohormones might regulate the tone of airway smooth muscle and affect eosinophilic inflammation in the airway.

The findings of this study have implications on what parameters should be used to predict exacerbations during and after an earthquake. Restriction of airflow, expressed as the FEV₁ % predicted, is a valuable predictor. Pulmonary function tests measured during intervals of clinical stability may be of some use in predicting emergency department visits (20). Older adults have been shown to have less emotional distress after natural disasters, and older adults are less reactive to stressful events, such as an earthquake (21). However, in our study, age did not predict post-earthquake exacerbation.

In conclusion, this study demonstrates that asthma is exacerbated after an earthquake, as shown by month-

matched historical controls. Earthquake-induced asthma shows no diurnal PEF variability, and airflow restriction is a predictor of exacerbation.

REFERENCES

- Sandberg S, Paton JY, Ahola S, McCann DC, McGuinness D, Hillary CR, Oja H: The role of acute and chronic stress in asthma attacks in children. *Lancet* 356 : 982-987, 2000
- Fagan J, Galea S, Ahern J, Bonner S, Vlahov D: Relationship of self-reported asthma severity and urgent health care utilization to psychological sequelae of the September 11, 2001 terrorist attacks on the World Trade Center among New York City area residents. *Psychosom Med* 65 : 993-996, 2003
- Liu LY, Coe CL, Swenson CA, Kelley EA, Kita H, Busse WW: School examination enhance airway inflammation to antigen challenge. *Am J Respir Crit Care Med* 165 : 1062-1067, 2002
- Takakura R, Himeno S, Kanayama Y, Sonoda T, Kiriyama K, Furubayashi T, Yabu M, Yoshida S, Nagasawa Y, Inoue S, Iwano N: Follow-up after the Hanshin-Awaji earthquake: diverse influences on pneumonia, bronchial asthma, peptic ulcer and diabetes mellitus. *Intern Med* 36 : 87-91, 1997
- Maeda H, Nakagawa M, Yokoyama M: Hospital admissions for respiratory diseases in the aftermath of the great Hanshin earthquake. *Nihon Kyobu Shikkan Gakkai Zasshi* 34 (in Japanese): 164-173, 1996
- Smyth JM, Soefer MH, Hurewitz A, Kliment A, Stone AA: Daily psychosocial factors predict levels and diurnal cycles of asthma symptomatology and peak flow. *J Behav Med* 22 : 179-193, 1999
- Meijer GG, Postma DS, van der Heide S, de Reus DM, Roorda RJ, Koeter GH, van Aalderen WM: Exogenous stimuli and circadian peak flow variation in allergic asthmatic children. *Am J Respir Crit Care Med* 153 : 237-242, 1996
- Reddel H, Ware S, Marks G., Salome C, Jenkins C, Woolcock A: Differences between asthma exacerbations and poor asthma control. *Lancet* 353 : 364-369, 1999
- Browne S, Hyland ME: Mood and peak flow in asthma. *Lancet* 339 : 118-119, 1992
- American Thoracic Society: Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease (COPD) and asthma. *Am Rev Respir Dis* 136 : 225-244, 1987
- Gibson PG, Wong BJ, Hepperle MJ, Kline PA, Girgis-Gabardo A, Guyatt G, Dolovich J, Denburg JA, Ramsdale E, Hargreave FE: A research method to induce and examine a mild exacerbation of asthma by withdrawal of inhaled corticosteroid. *Clin Exp Allergy* 22 : 525-532, 1992
- van Aalderen WM, Postma DS, Koeter GH, Knol K: The effect of reduction of maintenance treatment on circadian variation in peak expiratory flow rates in asthmatic children. *Acta Paediatr Scand* 77 : 269-274, 1988
- Nicholson KG, Kent J, Ireland DC: Respiratory viruses and exacerbations of asthma in adults. *BMJ* 307 : 982-986, 1993
- Beasley R, Coleman ED, Hermon Y, Holst PE, O'Donnell TV, Tobias M: Viral respiratory tract infection and exacerbations of asthma in adult patients. *Thorax* 43 : 679-683, 1988
- Tarlo SM, Easty A, Eubanks K, Parsons CR, Min F, Juvet S, Liss GM: The role of symptomatic colds in asthma exacerbations: Influence of outdoor allergens and air pollutants. *J Allergy Clin Immunol* 108 : 52-58, 2001
- Smith A, Nicholson K: Psychosocial factors, respiratory viruses and exacerbation of asthma. *Psychoneuroendocrinology* 26 : 411-420, 2001
- Miyamoto Y, Shimazu H, Nakamura A: Plasma catecholamine and cortisol concentrations during acceleration stress. *Eur J Appl Physiol Occup Physiol* 70 : 407-412, 1995
- Obminski Z, Wojtkowiak M, Stupnicki R, Golec L, Hackney AC: Effect of acceleration stress on salivary cortisol and plasma cortisol and testosterone levels in cadet pilots. *J Physiol Pharmacol* 48 : 193-200, 1997
- Kang DH, Fox C: Neuroendocrine and leukocyte responses and pulmonary function to acute stressors. *Ann Behav Med* 22 : 276-285, 2000
- Lucera CM, Greenberger PA, Yarnold PR, Choy AC, Levenson T: An attempted prospective testing of an asthma severity index and a quality of life survey for 1 year in ambulatory patients with asthma. *Allergy Asthma Proc* 20 : 29-38, 1999
- Knight BG, Gatz M, Heller K, Bengtson VL: Age and emotional response to the Northridge earthquake: a longitudinal analysis. *Psychol Aging* 15 : 627-634, 2000