Impact of Psychological Stress caused by the Great East Japan Earthquake on Glycemic Control in Patients with Diabetes

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Key words
- psychological stress
- disaster
- glycemic control

Abstract

We examined the relationship between psychological stress and the worsening of glycemic control in diabetic patients at the time of the Great East Japan Earthquake. HbA1c levels in diabetic patients before and after the disaster were evaluated with the General Health Questionnaire (GHQ) and other questions including those on changes in diet, exercise, psychological stress and drug intake in 320 consecutive diabetic patients who had been followed in a diabetes clinic. Logistic regression analysis revealed that the total GHQ scores (odds ratio [OR] 1.03 [95% confidence interval 1.01–1.06]; $p<0.01$) and interruption of drug intake (OR 4.48 [1.57–12.7]; $p=0.01$) were independently associated with worsening of glycemic control defined as an increase in the HbA1c level equal to or greater than 0.5%. Among the scores on the GHQ, those for somatic symptoms (OR 1.18 [1.01–1.38]; $p=0.03$) and sleep disturbances or anxiety (OR 1.26 [1.08–1.46]; $p<0.01$) were independently associated with glycemic control. These results suggest that psychological stress during a disaster has independent effects on worsening of glycemic control.

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Introduction

Natural disasters have been shown to have a negative impact on glycemic control in patients with diabetes (Kirizuka et al., 1997; Ng et al., 2011; Fonseca et al., 2009; American Diabetes Association 2007; Sengul et al., 2004; Berggren and Curiel 2006; Cefalu et al., 2006). Although the worsening of glycemic control during disasters might be affected by many factors such as change in diet, reduction in exercise, interruption of drug intake and psychological stress, it has not been clarified whether and what kinds of psychological stress could have independent effects on glycemic control.

The Great East Japan Earthquake that occurred on March 11, 2011, with a magnitude of 9.0 on the Richter scale (Simons et al., 2011), was a huge blow to hundreds of thousands of people including patients with diabetes. The University of Tsukuba Mito Medical Center is located not very far from the earthquake center and is about 130 km from the Fukushima atomic power plant where the disastrous nuclear accident had a major influence worldwide (**Fig. 1**). Supplies of electricity and water were cut off in our city temporarily. Heavy damage to our hospital necessitated urgent evacuation of all admitted patients. Thus, because of our close proximity to the disaster, it might be expected that our patient population would undergo severe stress affecting glycemic control.

Therefore, we examined the relationships between changes in HbA1c levels and psychological stress and other factors that could affect glycemic control in diabetic patients during the Great East Japan Earthquake.

Materials and Methods

Study population

We initially examined data on 375 consecutive diabetic patients who had been followed at the outpatient department of the University of Mito Medical Center and whose blood pressure, body mass index, HbA1c values and serum levels of lipids had been measured within 3 months before and 3 months after the disaster. Of these 375 individuals, 55 patients who did not complete (n=22) or declined to fill out (busy, n=31; blind, n=2) questionnaires were excluded. There-

fore, data on 320 patients were available for analysis. A change in glycemic control was defined as the difference between the HbA1c value before and after the disaster. Worsening of glycemic control was defined as an increase in the HbA1c level of 0.5% or more. HbA1c values were converted from the Japanese Diabetes Society values into National Glycohemoglobin Standardization Program equivalent values [The Committee of Japan Diabetes Society: (Seino et al., 2010)]. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg or current use of antihypertensive agents.

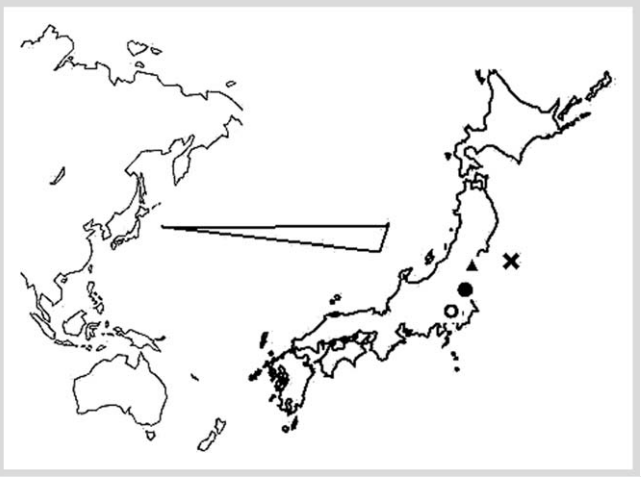

Fig. 1 Map showing the epicenter of the earthquake and our hospital. ×, epicenter; ●, our hospital; ○, Tokyo; ▲, Fukushima atomic power plant.

Questionnaires

The General Health Questionnaire (GHQ) was used to evaluate psychological stress. The GHQ is a self-administered questionnaire containing 60 questions concerned with psychological distress or altered behavior (Goldberg and Blackwell 1970; Medina-Mora et al., 1983). Originally, answers to the items in this questionnaire consisted of 4 choices: "much less than usual", "less than usual", "same as usual" or "better than usual". However, to obtain numerical values, we used a GHQ scoring method: absent, 0; and present, 1. For example, answers were categorized as follows: "much less than usual" and "less than usual" were converted to 0 and "same as usual" and "better than usual" were converted to 1 (Goldberg and Blackwell 1970; Medina-Mora et al., 1983). The total score represented the numerical value of the responses. These data were further analyzed according to 4 factors addressed in the GHQ: stress-related somatic symptoms, sleep disturbances or anxiety, social dysfunction, and severe depression. We also devised a 4-item questionnaire consisting of the following questions to which the response was either yes or no: "After the earthquake, 1) Did your dietary con-

Table 1 Characteristics of patients before and after the disaster according to worsening of glycemic control.

	all	ΔHbA1c<0.5%		ΔHbA1c≥0.5%		*p*-value*	*p*-value**	*p*-value***	*p*-value****
	Before disaster n=320	Before disaster n=274	After disaster	Before disaster n=46	After disaster				
age (years)	65±13	65±12	–	65±14		0.99	–		
male/female	201/119	177/97	–	24/22		0.11	–		
hypertension, *n* (%)	208 (65)	173 (63)	–	35 (76)		0.09	–		
type 1 diabetes, *n* (%)	20 (6)	16 (6)	–	4 (9)		0.46	–		
insulin use, *n* (%)	127 (40)	104 (38)		23 (50)		0.12	–		
periods of HbA1c measurements	30±22	30±22	–	28±22		0.46	–		
before the disaster (days)							–		
periods of HbA1c measurements	–	–	47±19		41±17	–	0.052		
after the disaster (days)									
the duration between baseline values and the follow-up data (days)	–	–	77±28		69±26	–	0.06		
BMI (kg/m^2)	24.3±4.1	24.3±3.9	24.1±3.8	24.6±5.0	25.0±5.3	–		0.04	0.03
systolic blood pressure (mmHg)	131±16	131±16	131±17	135±18	135±20	–		0.58	0.66
diastolic blood pressure (mmHg)	75±11	75±11	74±11	75±12	73±13	–		0.37	0.28
HbA1c (%)	7.7±1.3	7.7±1.3	7.5±1.3	7.9±1.4	8.9±1.5	–		<0.01	<0.01
random plasma glucose (mmol/L)	9.5±4.3	9.3±3.8	9.8±3.3	10.9±6.3	11.4±5.4	–		0.96	0.59
total cholesterol (mmol/L)	4.97±0.91	4.97±0.91	5.02±0.88	4.91±0.96	5.02±0.88	–		0.36	0.12
LDL cholesterol (mmol/L)	2.90±0.75	2.90±0.72	2.90±0.72	2.81±0.80	2.90±0.72	–		0.39	0.81
HDL cholesterol (mmol/L)	1.40±0.41	1.40±0.41	1.40±0.41	1.44±0.36	1.40±0.41	–		0.09	0.07
triglycerides (mmol/L)	1.48±0.86	1.50±0.88	1.50±0.88	1.42±0.73	1.50±0.88	–		0.45	0.22

Data are means±SD or N (%). A χ^2-test was used for categorical variables. Student' t-test was used for continuous variables. Paired t-test was used for continuous variables in each categorized HbA1c group

*P-value was based on comparison between groups with increases in HbA1c<0.5% and HbA1c≥0.5% before the disaster

**P-value was based on comparison between the groups with increases in HbA1c<0.5% and HbA1c≥0.5% after the disaster

***P-value was based on the comparison before and after disaster in group with increase in HbA1c<0.5%

****P-value was based on the comparison before and after disaster in the group with increase in HbA1c≥0.5%

	All	ΔHbA1c<0.5%	ΔHbA1c≥0.5%	
	n=320	n=274	n=46	*p*-value
change in dietary intake, *n* (%)	205 (64)	175 (64)	30 (65)	0.86
reduction of execise, *n* (%)	18 (6)	13 (5)	5 (11)	0.10
interruption of drug uptake, *n* (%)	22 (7)	14 (5)	8 (17)	<0.01
staying at shelter, *n* (%)	23 (7)	22 (8)	1 (2)	0.16
total GHQ scores	14.3±0.7	13.3±0.7	19.9±2.1	<0.01
somatic symptoms	2.0±0.1	1.9±0.1	2.9±0.3	<0.01
sleep disturbance/anxiety	2.4±0.1	2.2±0.1	3.5±0.3	<0.01
social dysfunction	1.3±0.1	1.2±0.1	1.8±0.3	0.02
severe depression	0.7±0.1	0.7±0.1	1.0±0.2	0.02

Data are mean±SD. GHQ, General Health Questionnaire

P-value was based on the comparison between groups with increases in HbA1c<0.5% and HbA1c≥0.5% using the t-test or Mann-Whitney *U*-tests

Table 2 Characteristics of the patients after the disaster according to the worsening of glycemic control.

tent change? 2) Did you continue to exercise? 3) Did you continue to take your medicines? and 4) Did you stay at the shelter?". This study was approved by the Ethics Committee of the University of Tsukuba Mito Medical Center, and we obtained informed consent from all patients.

Statistical analysis

Categorical variables were expressed as numerals and percentages and were compared with the χ^2 test. Continuous variables were expressed as mean±SD or SE. Based on distribution, continuous variables were compared using unpaired Student *t*-tests or Mann-Whitney *U*-tests for 2-group comparisons before and after the disaster with regard to groups categorized according to an increase in the HbA1c level≥0.5% or <0.5%. Paired t-test was used for comparison of variables before and after the disaster in each group categorized as described above. Logistic regression analyses identified variables related to worsening of glycemic control. Each model contained 1 GHQ measurement as a predictor and the other confounding factors. All statistical analyses were performed by SPSS (version 15.0, Chicago, IL), and statistical significance was considered for $p<0.05$.

Results

The mean periods of visiting the hospital before and after the disaster and the duration between acquisition of baseline values and follow-up data were 29±22, 46±19, and 76±28 days, respectively. The mean level of HbA1c did not significantly change during the period before (7.7±1.3%) and after (7.7±1.4%) the disaster ($p=0.10$). Characteristics of study subjects at baseline are shown in **Table 1**. In addition, **Table 1** shows clinical values before and after the disaster in the 2 groups categorized according to whether the HbA1c value increased <0.5 or ≥0.5. The numbers of patients who answered affirmatively to experiencing a change in dietary intake, reduction in exercise, interruption of drug intake, and staying at a shelter were 205 (64%), 18 (6%), 22 (7%), and 23 (7%), respectively (**Table 2**).

The scores for the total GHQ and those for somatic symptoms, sleep disturbances and anxiety, social dysfunction, and severe depression were 14.3±0.7, 2.0±0.1, 2.4±0.1, 1.3±0.1, and 0.7±0.1, respectively (**Table 2**). The group with worsening glycemic control had significantly higher GHQ-related scores than those whose glycemic control had not worsened. Logistic regression analyses showed that the total GHQ scores (odds ratio [OR] 1.03 [95% confidence interval 1.01–1.06]; $p<0.01$) was independently associated with the worsening of glycemic control (**Table 3**). After further adjustment for interruption of drug intake, the total GHQ scores (OR 1.03 [1.01–1.06]; $p<0.01$) remained independent predictors. Stress-related somatic symptoms and sleep disturbances or anxiety were independently associated with the worsening of glycemic control when values for these factors were used instead of the total GHQ scores. Social dysfunction had borderline significance in association with the worsening of glycemic control.

Discussion

As far as we know, this is the first study that showed that psychological stress during a disaster could independently affect the worsening of glycemic control in patients with diabetes, although one study also implicated the effect of psychological stress on glycemic control; however, those investigators did not adjust their results with other factors that could also worsen glycemic control (Inui et al., 1998). Our results revealed that among psychological stresses, stress-related somatic symptoms, sleep disturbances or anxiety, and social dysfunction were significantly associated with the worsening of glycemic control. These results did not change even after adjustment for confounding factors. The psychological consequences of earthquake exposure are long lasting (Bland et al., 1996). Therefore, in an effort to identify patients with psychological stress during a disaster, especially stress-related somatic symptoms, sleep disturbances and anxiety or social dysfunction might be important in recognizing those who need special care to prevent the worsening of glycemic control.

Our study showed the mean HbA1c level did not change significantly after the disaster as values before and after the disaster remained the same in many patients. However, the group with worsening of glycemic control had a large increase in HbA1c in a relatively short period, suggesting the effect of psychological stress on glycemic control. Nevertheless, since we performed the GHQ only after the disaster, we could not explain a cause-effect relationship.

Our study has some limitations. First, since almost all patients who attended our clinic were disaster victims, it would have been difficult to form a control group comprised of persons who had not experienced the disaster from this same clinic. Second, we could not evaluate fasting plasma glucose. Third, we did not

Table 3 Logistic regression models for variables associated with the worsening of glycemic control.

	Total GHQ scores OR (95 % CI)	*p*-value	Total GHQ scores OR (95 % CI)	*p*-value	Somatic symptoms OR (95 % CI)	*p*-value	Sleep disturbance or anxiety OR (95 % CI)	*p*-value	Social dysfunction OR (95 % CI)	*p*-value	Severe depression OR (95 % CI)	*p*-value
age	0.99 (0.97–1.02)	0.64	1.00 (0.97–1.03)	0.88	1.00 (0.97–1.03)	0.97	1.00 (0.97–1.03)	0.86	1.00 (0.97–1.02)	0.70	1.00 (0.97–1.03)	0.83
male sex	0.62 (0.31–1.23)	0.17	0.60 (0.30–1.21)	0.16	0.61 (0.30–1.24)	0.17	0.61 (0.29–1.18)	0.14	0.61 (0.28–1.14)	0.11	0.61 (0.27–1.07)	0.08
hypertension	1.96 (0.87–4.44)	0.11	1.93 (0.85–4.37)	0.12	2.03 (0.89–4.62)	0.09	1.98 (0.86–4.51)	0.11	2.01 (0.89–4.54)	0.09	1.97 (0.87–4.46)	0.10
BMI	1.00 (0.92–1.10)	0.99	1.02 (0.93–1.11)	0.65	1.02 (0.94–1.11)	0.66	1.02 (0.93–1.11)	0.70	1.03 (0.94–1.12)	0.55	1.02 (0.94–1.12)	0.60
HbA1c before the earthquake	1.08 (0.85–1.38)	0.51	1.04 (0.81–1.13)	0.77	1.02 (0.80–1.30)	0.88	1.04 (0.81–1.33)	0.77	1.02 (0.80–1.31)	0.85	1.03 (0.80–1.31)	0.84
insulin use	1.34 (0.67–2.69)	0.42	1.43 (0.70–2.94)	0.33	1.41 (0.68–2.90)	0.35	1.51 (0.73–3.10)	0.26	1.49 (0.73–3.04)	0.27	1.49 (0.73–3.04)	0.27
change in dietary intake	1.43 (0.69–2.98)	0.33	1.48 (0.70–3.11)	0.30	1.36 (0.66–2.83)	0.41	1.51 (0.72–3.16)	0.28	1.37 (0.66–2.84)	0.39	1.26 (0.61–2.58)	0.53
reduction in exercise	2.63 (0.81–8.57)	0.11	2.45 (0.75–8.06)	0.14	2.36 (0.72–7.76)	0.16	2.46 (0.74–8.17)	0.14	2.47 (0.75–8.17)	0.14	2.23 (0.67–7.39)	0.19
interruption of drug uptake	NI		4.48 (1.57–12.7)	<0.01	4.16 (1.46–11.9)	<0.01	4.43 (1.55–12.7)	<0.01	5.01 (1.78–14.2)	<0.01	4.86 (1.73–13.7)	<0.01
staying at shelter	0.20 (0.03–1.61)	0.13	0.16 (0.02–1.37)	0.09	0.18 (0.02–1.48)	0.11	0.15 (0.02–1.32)	0.09	0.16 (0.02–1.37)	0.09	0.18 (0.02–1.44)	0.11
total GHQ scores	1.03 (1.01–1.06)	<0.01	1.03 (1.01–1.06)	0.01	NI		NI		NI		NI	
somatic symptoms	NI		NI		1.18 (1.01–1.38)	0.03	NI		NI		NI	
sleep disturbance/anxiety	NI		NI		NI		1.26 (1.08–1.46)	<0.01	NI		NI	
social dysfunction	NI		NI		NI		NI		1.19 (0.99–1.41)	0.06	NI	
severe depression	NI		NI		NI		NI		NI		1.08 (0.89–1.32)	0.43

BMI, body mass index; BW, body weight; GHQ, General Health Questionnaire; NI, not included in the model
Hypertension, SBP ≥ 140 and/or DBP ≥ 90 or treatment

have baseline measures for the GHQ. Therefore, it is difficult to know how the disaster impacted on psychological functioning, as some people may have had high GHQ scores from the start.

In conclusion, psychological stress during a disaster could independently affect glycemic control in patients with diabetes. These results suggested the necessity of stress care after disasters for preventing the worsening of glycemic control in diabetic patients.

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