Original

GLUCOSE INTOLERANCE AND CORONARY ARTERY DISEASE IN INDIVIDUALS WITH LONG-TERM SPINAL CORD INJURY

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Abstract

We investigated risk factors related to coronary artery disease (CAD) among individuals with long-term spinal cord injury (SCI). Some researchers point out visceral fat obesity plays an important role in developing CAD due to broad paralysis, extensive muscular atrophy and reduction in level of activity. We chose 22 males aged 61.8 ± 10.4 years with SCI from two rehabilitation centers and conducted such examination as Holter electrocardiogram (ECG), exercise tolerance tests and glucose tolerance tests, and biochemical tests to clarify the risk of CAD. Although the average percent body fat was 21.4 ± 2.9, the 75 g oral glucose tolerance tests revealed 12 of the 22 individuals (54.5%) had abnormal response. With exercise tolerance tests using an arm crank ergometer, 2 of them showed ischemic patterns on ECG and were diagnosed with CAD, and in 4 out of 22 (18.2%) CAD was suspected in the present study.

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—**Key words**—

spinal cord injury, coronary artery disease, glucose tolerance, multiple risk factors

Objective

Individuals with spinal cord injury (SCI) tend to become obese, namely visceral fat obesity, due to broad paralysis, extensive muscular atrophy and reduction in level of activity. Several researchers in Western countries have pointed out coronary artery disease (CAD) as well as urinary tract disease as the first or second cause of death among individuals with long-standing SCI[1) ~ 8)]. According to our previous study[9)] on individuals with SCI at Rosai rehabilitation centers in Japan, we reported high prevalence of fatty liver and obesity accompanied by the accumulation of visceral fat, and suggest that they have more risk factors than abled-man. Moreover, the prevalence of hypertension and diabetes among individuals with SCI exceeded two or three times greater than that among general population[10) 11)]. Although individuals with SCI are shown to be at a greater risk of developing CAD, no marked difference was reported in the incidence of heart disease between these individuals and the general population[11)]. In the present study, we visited two rehabilitation centers for SCI cases and conducted such tests as, exercise tolerance test and glucose tolerance tests, to examine the state of multiple risk factors of CAD.

Methods

Subjects were 22 men with SCI aged 61.8 ± 10.4 years at two Rosai rehabilitation centers. All subjects were informed the objectives and risks of the present study and consented to participate in this program. All individuals

were using wheelchairs to get around and had kept independent lives. At these two centers, every patient performed light duties for 4 to 7 hours a day, five days a week. Table 1 lists the spinal level of injury and table 2 shows the average age years after injury, and CAD-related test results. Three individuals who were diagnosed as having heart disease prior to the present study were excluded from the present study.

The percent body fat was measured by handgrip-type impedance meter HBF300 (OMRON). A glucose tolerance test was carried out according to the standard procedure for diagnosing of diabetes melitus (DM); each patient was given 75 g glucose orally and the blood glucose levels were monitored periodically after ingestion. Four out of 22 individuals had been diagnosed with DM prior to the present study, the rest 18 individuals received this screening. Test results were evaluated according to the 75 g OGTT criteria doccumented by the Japan Diabetes Society. Individuals were diagnosed as having insulin resistance when HOMA-IR (homeostasis model assessment-insulin resistance: FIRI [μ U/ml]× FPG [mM] /22.5)[12] indicated 1.6 or over.

Electrocardiograph (ECG) was monitored at rest and during exercise testing, and the Holter ECG was also applied to individuals.

Exercise tolerance tests were performed using an arm crank ergometer (ACE). The protocol of these tests was as follows. After asking each patient to relax in a wheelchair, the patient warmed up for 3 minutes at 0 watts, and

Table 1 Level of spinal cord injury in 22 persons with SCI

	subject (n = 22)	
	n	%
C–T5	3	13.6
T6–T10	6	27.3
T11–L1	11	50.0
L2–	2	9.1
Total	22	100

Note C : cervical vertebrae T : thoracic vertebrae L : lumbar vertebrae

Table 2 Average age, years after injury, and CAD related tests in the subject (22persons) and the remaining persons with SCI

items		subject (n=22)		
		n	mean	SD
years after injury		18	24.0	± 12.3
age		22	61.8	± 10.4
height	cm	22	160.1	± 6.9
weight	kg	22	55.6	± 10.2
BMI		22	21.4	± 2.9
abdominal circumference	cm	18	79.9	± 4.1
percent body fat	%	22	21.4	± 2.9
Abdominal fat index (AFI)		18	1.2	± 0.5
VS raito		10	1.0	± 0.6
1.5-anhydroglucitol	μg/dl	18	24.2	± 11.0
triglyceride	mg/dl	18	148.1	± 87.1
total cholesterol	mg/dl	18	198.1	± 35.4
HDL-cholestrol	mg/dl	18	49.6	± 13.9

Note 1) AFI : By the use of abdominal ultrasound, along the abdominal median line connecting the xiphoid process and the navel, the maximum thickness of preperitioneal fat (P) and the minimal thickness of the subcutaneous fat in the abdomial wall (S) were measured. Men with a P/S raito of 1 and adove are considered obese from the accumulation of visceral. fat.

Note 2) VS raito : Based on navel cross-section CT scan, the area of visceral fat (V) and subcutaneous fat (S) was determined to calculate a VS raito. Men with a VS raito of 0.4 and adove are considered obese from the accumulation of visceral fat.

the intensity of the exercise was then increased stepwise by 5 watts every 3 minutes. During the exercise test, the pace of ACE pedaling was set at 40 rotations per minute. The exercise was stopped when one of the following three conditions was observed. 1) The Borg index (rating of perceived exhaustion, RPE) reached at 16 (very strenuous), 2) onset of unpleasant subjective symptoms, or 3) abnormal ECG such as ST-segment deviation >3 mm or arrhythmia. Blood pressure was measured at rest, immediately after the end of the exercise test, and 10 minutes after the test.

In exercise testing, ECG with a chest CM5 lead was recorded. Then the state of CAD was assessed by analyzing the results of exercise ECG; abnormal Q wave, abnormal ST-segment (ST-segment depression: horizontal-type, descending-type and sagging descent-type) and abnormal T wave (crown T wave, flat T wave and negative T wave).

Results

The average BMI for 22 individuals was 21.4, which is lower normal value, but the average percent body fat was 21.4%, which is borderline obesity.

The results of 75 g oral glucose tolerance tests were as follows: the average fasting blood glucose level 90.1 ± 1.75 mg/dl (mean ± SD), the average 1-hour glucose level 155.9 ± 60.1 mg/dl and the average 2-hour glucose level 136.1 ± 74.1 mg/dl (Fig. 1). The results of these tests were normal in 10 individuals; borderline in 5 individuals and positive (diabetes) in 3 individuals. Since four individuals were diagnosed as having abnormal glucose tolerance prior to the present study, abnormal glucose tolerance was found in 12 of the 22 individuals (54.5%).

The results of exercise ECG showed ischemic patterns in 2 of the 22 individuals, and thus they were diagnosed as having CAD. In two individuals, although Holter ECG suggested CAD, the results of exercise ECG were negative, and two RBBB individuals were removed from the subsequent analyses. Since resting ECG showed an ST-segment depression in two individuals, they underwent echocardiography at a later date.

The background factors of the two individuals diagnosed as having CAD were as follows. One patient was a 62 year-old man who had had diabetes for the past 18 years. Although his BMI and percent body fat were 22.8 and 17.7, respectively, the accumulation of visceral fat was noticeable, and a health screening using CT showed a visceral subcutaneous ratio of 0.8. This patient was diagnosed as having CAD for the first time during the present study. The other patient was a 71 year-old man in whom resting ECG showed an ST-segment depression prior to the present study, and he should have been monitored by ECG. He was diagnosed as having CAD during the present study. Although his BMI and percent body fat were low at 19.1 kg/m^2 and 17.8%, respectively, and he did not have hyperlipidemia, he had untreated hypertension (pre-exercise blood pressure: 172/96, immediately after the exercise test: 172/99, 10 minutes after the exercise test: 163/96).

Discussion

In Western countries, CAD becomes leading cause of death among individuals with long-term SCI, with a de-

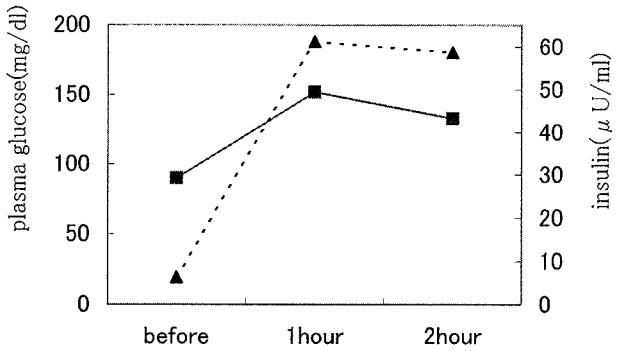

Fig. 1 Oral glucose tolerance results (75 g) Results are expressed as mean of 18 subjects. The continuous line and the broken line express plasma glucose and insulin concertrations, respectively.

crease in genitourinary sepsis[1)~7)]. Individuals with SCI often have glucose intolerance[13) 14)], and it has been reported that these individuals are at a greater risk for developing CAD[15)]. According to the study conducted by Maki[16)], the average BMI for individuals with SCI was 25.6, and since these individuals have paralysis-induced muscular atrophy of the legs, this number suggests that they tend to be obese. Bauman[17)] conducted GTTs and reported that 22% of individuals with SCI were diagnosed as having abnormal glucose tolerance according to WHO standards. Also, many cases have hyperinsulinemia, so insulin resistance could lead to the onset of dyslipidemia and hypertension[17) 18)], causing them to have CAD as multiple risk factors.

On the other hand, the percent body fat and BMI for our individuals were low, and thus they were not obese. Despite low BMI and percent body fat, the rates of abnormal glucose metabolism (54.5%) and visceral fat accumulation [abdominal fat index (AFI) of 1 or above] were high.

In the present study, 2 out of the 22 individuals (9%) were diagnosed as having CAD, and a total of 6 individuals (27.3%) were either diagnosed with CAD or having suspected CAD. The prevalence of CAD is increasing among individuals with SCI in Japan, but the pattern of multiple risk factors in Japan is different from that in other countries. In other words, although BMI is low, the prevalence of abnormal glucose tolerance and visceral fat accumulation is high. Furthermore, the prevalence of insulin resistance is relatively low, and the prevalence of complications such as diabetes and hypertension is also low. Ploug[19)] reported that exercise-induced muscular contraction itself contributes to glucose uptake. As a result, a lack of exercise has a negative impact on glucose tolerance. Also, a lack of exercise could induce abnormal lipid and glucose metabolism, thus resulting in the accumulation of visceral fat. Nakamura[20)] found that, even in the absence of obesity, accumulation of visceral fat has an important role in the onset of CAD.

Since the fasting glucose level of many individuals with SCI is normal, it is difficult to detect abnormal glucose tolerance by a health screening. As a result, including GTT and visceral fat measurement in health screenings could be important for preventing CAD, a condition that is expected to be more common among individuals with SCI.

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長期脊髄損傷者における耐糖能と虚血性心疾患

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―キーワード―
脊髄損傷，虚血性心疾患，耐糖能，マルチプル・リスク・ファクター

長期脊髄損傷者（脊損者）における虚血性心疾患（CAD）に関連した危険要因の検討を行った．脊損者の場合，広範囲にわたる麻痺と筋萎縮，身体活動性の低下によって生じた内臓脂肪蓄積型肥満が，CADの発症に重要な影響を与えていることが示唆される．調査対象者は2カ所のリハビリテーション作業所に在所している脊損者男性22名（平均年齢は61.8 ± 10.4）とした．CADと危険因子の診断に関して，ホルター心電図，運動負荷試験，ブドウ糖負荷試験，血液生化学試験を行った．体脂肪率は平均21.4 ± 2.9であるにも関らず，22名中12名（54.5％）は耐糖能（75gOGTT）において異常が認められた．アームクランクエルゴメーターを用いた運動負荷試験では，2名が虚血性のパターンを示し，CADと認められた．今回，ホルター心電図の結果も合わせてCADあるいはその疑いありと認められた者は22名中4名（18.2％）であった．