High Incidence of Impaired Glucose Tolerance in Spinal Cord Injuries

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Abstract. Glucose intolerance occurs frequently in patients with spinal cord injury (SCI). To clarify this better, 24 patients with spinal cord injuries received an oral glucose tolerance test (OGTT) and the causal relationships between glucose tolerance and body fat composition were analyzed. More than 50% of SCI patients had elevated plasma insulin levels, although the subjects were not obese, suggesting adipose tissue resistance to endogenous insulin.

Key words: Glucose intolerance, Spinal cord injury, Insulin resistance. (This article was submitted Feb. 26, 1998, and was accepted May 20, 1998)

INTRODUCTION

Physicians who care for patients with spinal cord injuries (SCI) have long had the clinical impression that some of them had high percentage of body fat, despite lack obesity, due to paraplegia or quadriplegia. Studies on this question, however, have been insufficient, and few investigators have reported the factors that potentiate the development of glucose intolerance in patients with a stable, established SCI.

In the present study we investigated the responses to oral glucose load in patients with SCI and found the existence of a high frequency of glucose intolerance and the causal relationships between glucose intolerance and insulin resistance in adipose tissues.

MATERIALS AND METHODS

1) Subjects

We studied twenty-four patients with SCI not previously diagnosed with diabetes mellitus (18 male and 6 female, mean age of 28.6 ± 8.1 years, mean periods after injury 44.4 ± 15.9 months). The level of the spinal cord lesions varied from C5 to Th12 with most lesions being located in the cervical cord. Their physical activities were varied widely, almost free although restricted to wheelchairs. The control was 6 healthy volunteers from our laboratories. We obtained informed consent from all subjects.

2) Procedure

The 75 g oral glucose tolerance test (OGTT) was performed according to WHO guidelines. After overnight fasting and an oral glucose load, blood samples were collected at 0 (before load), 30, 60, 120 and 180 minutes after load to determine glucose and insulin levels. Plasma glucose was assayed by the glucose oxidase methods and insulin by double antibody radioimmunoassay. The plasma glucose and insulin area was determined by calculating the area under the concentration curve; i.e., by multiplying the level at 30 minutes by the sum of half the fasting level, and by multi-
plying the levels at 30, 60 and 180 minutes by 1.5 times the level at 120 minutes. After an overnight fast, above mentioned, blood was drawn and serum total-cholesterol, HDL-cholesterol and triglyceride level were determined by enzymatic methods, and the hemoglobin A1C level was measured by radio-immunoassay. Percentage body fat (% body fat) was measured7) with an impedance fat meter (Selco, SIF-891, Japan).

3) Statistics
The results were expressed as mean ± SD and the significance of differences between means of measurement for SCI patients and control were determined by Student’s t test for unpaired data after analysis of variance.

RESULTS
As shown in the Table 1, the SCI and control groups were matched for age (28.6 ± 8.1 vs 30.5 ± 7.7 years) and body mass index (20.9 ± 3.5 vs 21.2 ± 1.4 kg/m²). Fasting plasma glucose in SCI group was not significantly different from the control group (89.2 ± 7.2 vs 87.8 ± 5.7 mg/dl). Percentage body fat and fasting plasma insulin in the SCI group were higher than the control, although they were not significantly different (% body fat: 27.9 ± 7.9 vs 23.6 ± 5.7%; fasting plasma insulin: 9.2 ± 5.7 vs 5.7 ± 3.5 µU/ml). Plasma glucose area and plasma insulin area were significantly increased in the SCI group compared with those of the control group (plasma glucose area: 152.7 ± 34.1 vs 125.7 ± 19.1 mg min/dl × 10² [p<0.05]; plasma insulin area: 103.5 ± 26.8 vs 43.8 ± 15.0 µU min/ml × 10² [p<0.01]).

Serum total-cholesterol, HDL-cholesterol and triglyceride levels of the SCI group were not significantly different from those of the control group.

DISCUSSION
In the present study 12 (50%) of the 24 patients with SCI had some evidence of glucose intolerance, although they were not obese. There are at least 2 important factors8–10) in the development of glucose intolerance: (1) insulin resistance and (2) decrease of glucose uptake and utilization in peripheral tissues due to para- or quadriplegia. In this study almost SCI patients with glucose intolerance were shown to have excessive insulin responses after receiving glucose orally, suggesting resistance to endogenous insulin. Although they were not obese, they did have adequate body fat. Glucose intolerance is a frequent occurrence in patients with neuromuscular disease such as myotonic dystrophy11).

Although the mechanisms of the insulin resistance in these patients is most likely multifactorial, the basic defect may well be in abnormalities secondary to the denervated and waste muscles10). The evidence suggest that insulin resistance can be due to nongenetic processes, but the mechanisms producing this are not clear. Additional studies will be required to evaluate the relative contribution of specific factors to glucose intolerance and insulin resistance in SCI patients.

Table 1. Metabolic features of the spinal cord injury patients with oral glucose tolerance test

<table>
<thead>
<tr>
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<th>Control group (n=5)</th>
<th>Spinal cord injury group (n=24)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>30.5 ± 7.7</td>
<td>28.6 ± 8.1</td>
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<tr>
<td>Body mass index (kg/m²)</td>
<td>21.2 ± 1.4</td>
<td>20.9 ± 3.5</td>
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<tr>
<td>Percentage body fat (%)</td>
<td>23.6 ± 5.7</td>
<td>27.9 ± 7.9</td>
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<tr>
<td>Fasting plasma glucose (mg/dL)</td>
<td>87.8 ± 5.7</td>
<td>89.2 ± 7.2</td>
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<tr>
<td>Fasting plasma insulin (µU/ml)</td>
<td>5.7 ± 3.5</td>
<td>9.2 ± 5.7</td>
</tr>
<tr>
<td>Plasma glucose area (mg min/dL) × 10²</td>
<td>125.7 ± 19.1</td>
<td>152.7 ± 34.1*</td>
</tr>
<tr>
<td>Plasma insulin area (µU min/ml) × 10²</td>
<td>43.8 ± 15.0</td>
<td>103.5 ± 26.8**</td>
</tr>
<tr>
<td>Plasma insulin/plasma glucose (30 min)</td>
<td>2.3 ± 0.4</td>
<td>2.2 ± 0.3</td>
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<tr>
<td>Glycohemoglobin A1C (%)</td>
<td>4.6 ± 0.4</td>
<td>4.6 ± 0.4</td>
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<tr>
<td>Total-cholesterol (mg/dl)</td>
<td>173.5 ± 17.7</td>
<td>164.8 ± 25.6</td>
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<tr>
<td>HDL-cholesterol (mg/dl)</td>
<td>42.0 ± 10.8</td>
<td>40.4 ± 11.1</td>
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<tr>
<td>Triglyceride (mg/dl)</td>
<td>98.3 ± 17.3</td>
<td>116.2 ± 48.9</td>
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Data are means ± SD. *p<0.05 vs control, **p<0.01 vs control.
REFERENCES