STUDIES OF ULTRAMICROSTRUCTURE IN RELATION TO DISACCHARIDASE ACTIVITY IN THE JEJUNAL MUCOSA

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Summary

Ultramicrostructural changes of the mucosa of the small intestine were studied in relation to the alterations of the lactase activity, measuring the height of microvilli by electron microscopy and the enzyme activity by the method of Dahlqvist.

Studies with clinical cases revealed that the height of microvilli correlated with the lactase activity significantly (p < 0.01), and that patients with relatively higher microvilli had a correspondingly higher activity of lactase. In animal experiments an increase of lactase activity by lactose load feeding and low calorie feeding resulted in a raise in the height of microvilli.

It was concluded that lactase deficiency in adults and in various gastrointestinal diseases, where no histological abnormality was observed by light microscopy is perhaps due to shortening of the microvilli of the mucosa. It was speculated that the microvillous change and the sequential hypolactasia may be the initial ultramicrostructural and enzymatic alteration in the diffuse disease of the small intestine.

Key Words: Disaccharidase, Lactase, Microvilli, Jejunal mucosa, Ultramicrostructure

Introduction

There appeared numerous reports stating that disaccharidase deficiency, namely lactase deficiency, can exist without morphological changes or in the normal small-bowel mucosa. Also, there are papers reporting that in the secondary disaccharidase deficiency lactase activity is most severely affected and remains still deficient after the other enzymes have been restored with treatment. In our own experiences, lactase is the only desaccharidase that is lower in apparently normal Japanese adults than it is in American whites. Also, in various gastrointestinal diseases such as postgastrectomy, irritable colon syndrome, and ulcerative colitis, in which no histological abnormality was found in the jejunal mucosa, lactase was even lower.

With these papers and experiences in mind, we then carried out the present study to investigate the initial ultramicrostructural changes in relation to the changes in disaccharidase activity.

Materials and Methods

Except for the normal controls all patients
subjected to the study were in-patients of our
department in Hirosaki University hospital.
Patients with diarrhea or with malabsorption
of mono- or multi-nutrients, and those with
morphological abnormality in the mucosal
histology under the light microscopy were
excluded from the study. Animals used for
experiments were all Wistar rats, aged three to
four weeks, and weighing 200 to 250 grams.

Jejunal biopsies were obtained from a
standard site, approximately 20 cm distal to
the ligament of Treitz, using either the Tohoku
University biopsy capsule or Rubin's multi-
purpose biopsy tube. Immediately after
biopsy the specimens were divided for dif-
ferent purposes: one piece was frozen on dry
ice for disaccharidase assay and the other fixed
either for scanning electron microscopic study
or for transmission electron microscopic study.

The enzyme assays were performed accord-
ing to the method of Dahlqvist and
the activity was expressed as units (micromoles of
disaccharide hydrolysed per minute) per gram
protein. Protein concentration of the biopsied
materials was measured by the method of
Lowry et al.

Results
A. Studies with clinical cases
1. Light microscopic study
A comparative study of light microscopic
histology of nine normal controls with that of
44 patients with various gastroenterological
diseases and six patients with diabetes mellitus
confirmed that there was essentially no differ-
ence between the two groups both in the villi
and the lamina propria mucosa (Table 1).

2. Height of microvilli
Electronmicroscopically the height of micro-
villi was measured at the villous crest according
to Brown's criteria. A comparison of the
height of microvilli in the controls and various
diseases in relation to their lactase activity
revealed that in those with relatively higher
microvilli a correspondingly higher activity of
lactase was assayed (Fig. 1). The correlation
between the height and the lactase activity
was statistically significant (p < 0.01) as shown
in Fig. 2. The height was not correlated
with the activities of maltase and sucrase
(p > 0.05).

The electronmicroscopic picture compares
the microvilli of the gastrectomized patient on
the left (lactase 3.9 units) with that of the
normal control on the right (lactase 12.8
units). The microvilli on the left are definitely
lower in height (Fig. 3).

B. Studies with animal experiments
1. Lactose load feeding
A 25% lactose diet (4 g/day/rat) was given
for six weeks. The animals were then killed

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<th>Gastric resection</th>
<th>Gastric ulcer</th>
<th>Ulcerative colitis</th>
<th>Irritable colon</th>
<th>Hepatic disease</th>
<th>Diabetes mellitus</th>
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Table 1. Light microscopic histology (H.E. Stain)