Early Ultrastructural Adaptive Changes of Ileal Enterocytes After Proximal Small Bowel Resection as Determined Morphometrically

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Summary. The aim of the present study was to evaluate in terms of quantitative measurements whether the well-known histomorphological and functional adaptive changes in the intestinal mucosa after small bowel resection are accompanied by alterations on the ultrastructural level. Therefore, samples of the ileal remnants after a 60% proximal resection were processed for ultrastructural evaluation and analyzed employing point counting planimetry and direct measurements. Microvillus surface area increased from the bottom of the crypts to the villus tips in both resected and sham-operated animals. This increase in microvillus surface area from the crypt to the villus was significantly less pronounced after proximal resection, while there were no changes in the crypt compartment. No significant differences of the relative areas of the nuclei, mitochondria, and the rough endoplasmic reticulum were observed when comparing the different positions along the villus crypt axis in normal and hyperplastic mucosa. In agreement with functional and enzyme histochemical results, these ultrastructural findings provide further evidence for an altered pattern of enterocyte maturation after proximal resection, which is most probably due to an increase in the migration rate of the enterocytes.

Key words: Small bowel resection – Ultrastructure – Morphometry – Intestinal adaptation

Introduction

Following small bowel resection, adaptive changes occur in the intestinal remnants with development of mucosal hypertrophy [2, 3, 5, 12, 14, 16, 17]. This

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hypertrophy is characterized by an increase in mitotic activity and a parallel lengthening of villi and crypts. At the same time, enzyme activities are increased when related to unit intestinal length [1, 4, 8, 25, 27], and decreased when expressed per unit protein or DNA [6, 8, 15]. These latter findings may be explained in terms of an immature state of the individual enterocyte of the hyperplastic mucosa [16, 31]. Absorptive studies support this hypothesis: glucose absorption is increased when explored by perfusion techniques in vivo and when expressed in terms of unit intestinal length [5, 16], whereas tissue accumulation rates of sugar and amino acids are diminished in vitro [16, 31].

Only limited information exists as to how far these functional changes are accompanied by morphological alterations of the individual enterocytes on an ultrastructural level. To our knowledge, the only systematic morphometric studies on the ultrastructure of the absorptive cell in the intestinal remnants after small bowel resection are two investigations with conflicting results [7, 24]. In these studies, only the height of the microvilli has been measured. Morphometric data on the other subcellular organelles of the absorptive cells are completely lacking. However, a number of qualitative observations are available [7, 9, 23, 24, 32], but again with conflicting results.

The aim of the present study was to clarify by quantitative methods whether the above-mentioned functional impairments of the remnants after intestinal resection are accompanied by conceivable structural alterations of the brush border and of the other main cellular organelles, i.e. mitochondria, nuclei, and endoplasmic reticulum. To obtain a better insight into possible changes of enterocyte differentiation and maturation in the hyperplastic mucosa, the morphometric data were obtained of cells at different positions along the villus crypt axis. In view of the known time course of the gross morphological response in the ileal remnants after proximal resection [11, 19], the investigations were carried out 2, 6, and 12 days after the surgical manoeuvre.

Material and Methods

Animals

The experiments were performed with female Wistar rats, weighing 170–190 g. The animals were maintained under standard conditions in wire cages and nourished with Altromin standard pellet diet and tap water ad libitum until operation.

Surgical Procedure and Postoperative Care

Animals were anaesthetized with ether following a 12-h fast. A 60% proximal intestinal resection was performed, starting 2 cm distal from the ligament of Treitz, and the continuity was re-established by end-to-end anastomosis (n = 9). Sham operation was performed by opening the abdomen, handling the small intestine and reclosure of the abdominal cavity (n = 9). For the first 48 h post operation (p.o.), the animals received a sugared salt solution (equal parts of 150 mmol/l NaCl and 300 mmol/l glucose). Thereafter, standard pellet diet and tap water were again fed ad libitum. Three animals with a proximal resection and three sham-operated controls were killed on days 2, 6, and 12 p.o., respectively. Intestinal rings of about 0.5 cm length were dissected 3 cm distal from the anastomosis or equivalent region in sham-operated animals.