

HYPERPRODUCTION OF EPITHELIUM AND ITS INTRAVITAL DESQUAMATION INTO THE LUMEN OF THE SMALL INTESTINE OUTSIDE THE "EXPULSION ZONE"

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Investigation of total and histologically treated biopsy material of the mucous membrane of the small intestine of dogs with a complete intestinal fistula and of dogs with a by-passed length of small intestine revealed intensive formation of superfluous epithelial structures (outgrowths, continuous sheets of cells) in the region of the crypts and the base of the villi. Desquamation of these structures into the lumen of the intestine takes place outside the "expulsion zone" without disturbance of the integrity of the covering villi. Less marked features of this process also were observed in control material. The results indicate the existence of yet another pathway of development whereby the crypt cell leaves the crypt-villus system as a component of branching and desquamated epithelial structures.

KEY WORDS: epithelium of small intestine; desquamation of epithelium; crypt-villus system.

According to the concept of cellular renewal in the crypt-villus system, the newly formed crypt cell either divides and remains in the crypt or, moving on to the villus, it differentiates into a specialized enterocyte and, having reached the "expulsion zone" on the apex of the villus, it is expelled into the lumen of the intestine [4,7-9].

The mechanisms of correlation between the formation of new cells and their desquamation, movement of the cell layer from the crypt to the villus, and the causes of desquamation of the cells have not yet been adequately explained [7,8,10].

Unlike the "wedging out" of the epithelial cells, which is an intravital process, most workers consider the rarely seen detachment of the covering villi and their complete desquamation to be an artefact. Attempts to interpret desquamation of sheets of epithelial cells as an expression of the functional morphology of the small intestine [3,5,6] have been criticized as methodologically and technically unsound [1,2,7].

This paper describes observations on the intravital desquamation of sheets of epithelium without disturbance of the continuity of the epithelial cover of the villi. This hitherto unknown fact was discovered during an investigation of the mucous membrane of the small intestine in dogs in which parts of the intestine were by-passed.

EXPERIMENTAL METHOD

The mucous membrane of the small intestine was studied in 428 biopsy specimens removed through intestinal fistulas from 26 dogs with a permanent and complete high fistula of the small intestine, and from nine dogs in which an extensive portion of the small intestine (up to two thirds of its length) was isolated from the gastro-intestinal tract, and also in 27 healthy dogs with fistulas (background). Control material was taken by biopsy (125 specimens) during operations to form fistulas in 40 healthy dogs. The pieces of biopsy material were oriented under a binocular microscope, fixed with 12% neutral formalin solution, and examined before histological treatment to determine any changes in the size, shape, or arrangement of the villi. During the examination of the region of the base of the villi near the mouth of the crypts, which is less accessible for ob-

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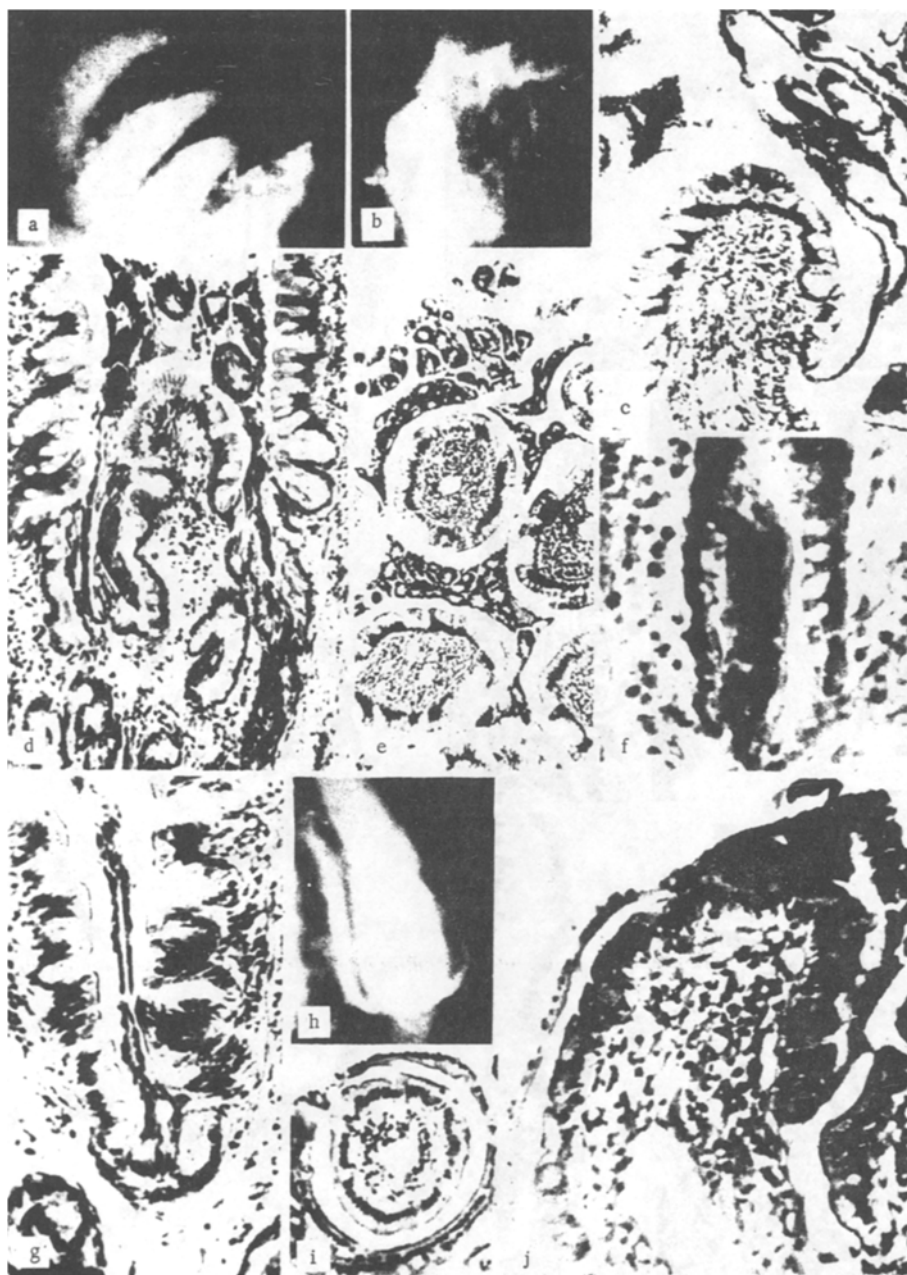


Fig. 1. Features of superfluous development of epithelium in mucous membrane of parts of small intestine isolated from digestion: a, b) whole villi; c, d, g) longitudinal sections through villus; e) transverse section; f) longitudinal section through crypt; epithelial "cuff" around whole villus (h) and in transverse (i) and longitudinal (j) sections through villi. Biopsy. Stained with hematoxylin-eosin (f, h, i, j, k), by Van Gieson's method (c-e, g, j), and by PAS reaction and hematoxylin-eosin (i). Magnification between $20\times$ (a, b) and $400\times$ (f).

servation, a method of atraumatic microdissection was used. Paraffin sections of biopsy material, 5-10 μ in thickness, were stained by the ordinary histological methods and by the PAS reaction with counterstaining with hematoxylin and eosin.

EXPERIMENTAL RESULTS

Investigation of whole biopsy specimens from the intestine excluded from digestion by isolation or by means of a complete fistula revealed that the thick, stringy mass frequently found to surround or cover the

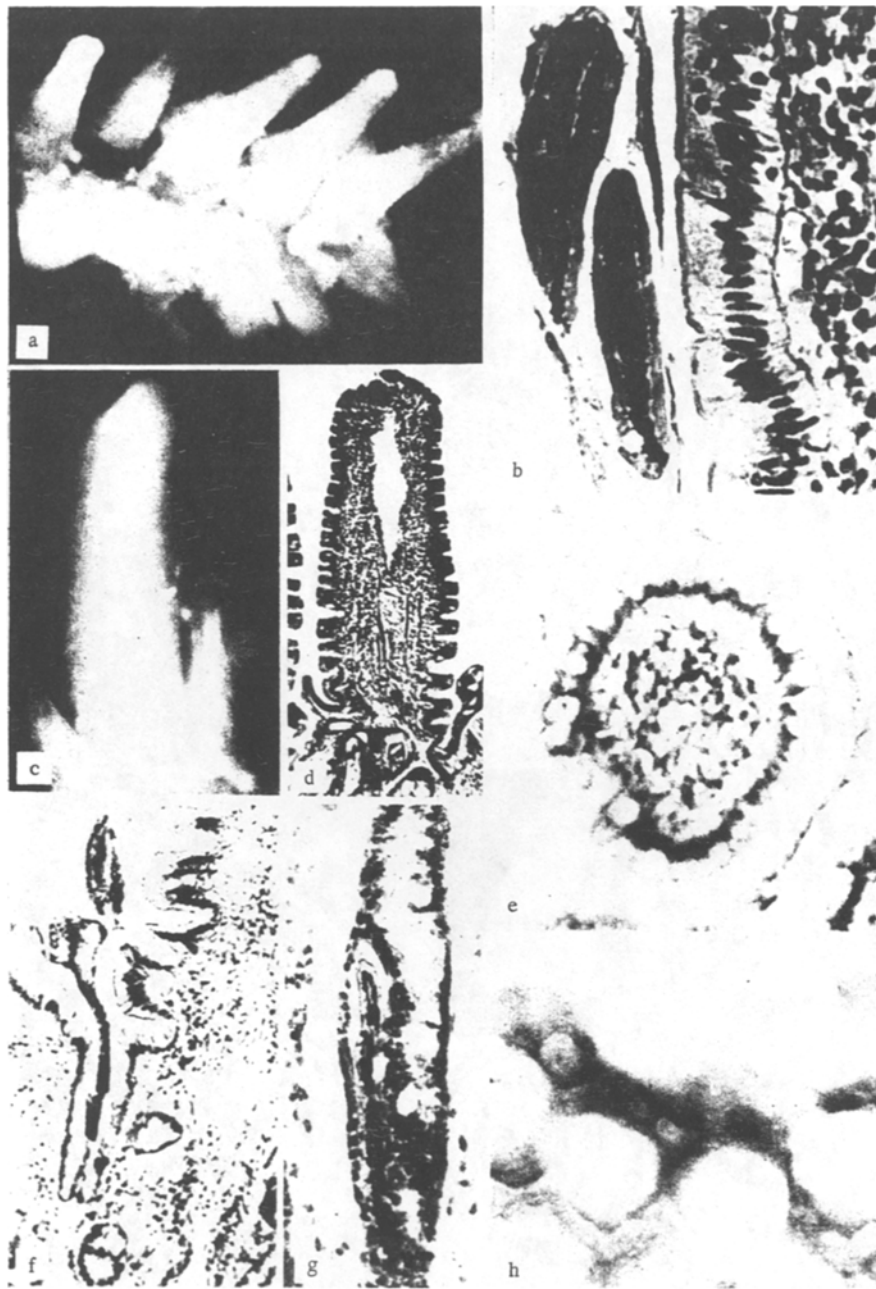


Fig. 2. Superfluous epithelial structures of small intestine of intact dogs: a, h) whole specimens of mucous membrane and f) longitudinal section; c) whole villus; b, d) longitudinal and e) transverse sections through villi; g) longitudinal section through crypt. Biopsy. Stained with hematoxylin-eosin (e) and by Van Gieson's method (b, d, f, g). Magnification between $20\times$ (a) and $400\times$ (b).

villi consisted mainly of mucus containing narrow coiled tubules, rod-shaped structures, and thin films in various states of preservation. Sometimes they were loosely attached to the surface of the villi and to the region of the mouth of the crypts (Fig. 1a, b). Projections of different lengths or a circular sheet of cells spread out from the base of many villi (Fig. 1h). Serial sections showed that these structures were epithelial in nature and arose as branches from the ordinary epithelium of the crypts and at the base of the villi (Fig. 1c, f, j). In photomicrographs they appeared as single or double bands and rings of flattened epithelium (Fig. 1d, e, g), distinguished by karyopycnosis and by absence of a basement membrane and of cell boundaries. In the narrow rod-shaped projections, covered by the same modified epithelium, the connective-tissue stroma was very poorly developed. In sections structures of this sort were located between the villi and in the lumen of

many crypts, from the mouth of which they emerged on to the surface of the mucous membrane (Fig. 1d-g). Mitotic figures of cell division could be seen in the crypts at all stages of the experiments.

Although in general the epithelial cover of the villi was intact, the mucous membrane of the intestine isolated from digestion was characterized by changes resulting from the development of the superfluous epithelial structures. Changes of this type included the appearance of villi surrounded by a cuff consisting of a sheet of modified epithelium which, growing out from their base, reached a considerable height.

Such a "cuff" could be clearly seen around whole villi or in longitudinal sections through them, but in transverse sections it appeared as a ring around the transversely divided villus (Fig. 1h, i, j). In some whole villi only the apical part was surrounded by the "cuff", which grew out of its lateral surface, at a point deprived of its epithelium, and not from its base. Correspondingly in photomicrographs some villi were seen with cavities, closed on the outside by modified epithelium, on their lateral surface or at their distal end. They attracted attention by the intense PAS reaction of the accumulated contents.

During investigation of whole villi a frequent discovery was their fusion in certain parts of the surface. An equally frequent finding in the photomicrographs was of epithelized bridges connecting the surface of neighboring villi at different levels. Finally, in the case of more superficial biopsy material from the mucous membrane, villi surrounded by structures connected with their surface and desquamated from the cryptal portion, were constantly observed (Fig. 1b).

The patterns described suggest that surplus formation and desquamation of epithelial structures can take place not only in the region of the crypts and at the base of the villi, but in any other part of the surface of the villi. This is evidently a matter for further clarification.

By contrast with parts of the small intestine isolated from digestion by various methods, where hyperproduction and intensive desquamation of the surplus epithelium were clearly identified, in the duodenum of the same dogs, which was in contact with the food masses, and also in healthy dogs with fistulas, signs of formation of similar structures were observed only in part of the biopsy material. In control dogs this phenomenon was even less conspicuous: Overgrowth of epithelium on the surface of the villi was absent and only in some parts of the biopsy fragments could tubules, rod-shaped projections and continuous sheets be found in the region of the base of the villi and the mouth of the crypts (Fig. 2a, c, h). In photomicrographs of the mucous membrane of the small intestine of the control dogs, modified epithelium was observed in some of the crypts and in places between the villi (Fig. 2b, d-g).

The results of this investigation provide evidence that superfluous epithelial structures can appear in the small intestine. Branching from the epithelial layer, they lose their connection with the connective tissue stroma but do not break up into individual cells; instead they continue to grow and remain an integral part of the tissue. Ultimately they are broken off the epithelium of the mucous membrane and desquamated to the lumen of the intestine. This process, although relatively poorly developed under physiological conditions, is sharply intensified when the intestine is isolated from the digestive tract, and this leads to intensive formation and desquamation of the epithelium without any significant disturbance of the cover of the villi. Hyperproduction of epithelium under these conditions may be connected to some degree with the delayed "wedging out" of the epithelial cells on the apices of the villi in the absence of the mechanical effect of the food on them.

On the basis of these results yet another course which can be followed by the enterocytes can be postulated, outside of the crypt-villus system, as components of branching and desquamated epithelial structures. The ability of the intestinal epithelium of dogs to develop superfluous structures and to reject them into the lumen of the small intestine outside the "expulsion zone" may play a role in the correlation between the formation of new epithelial cells and their desquamation in the crypt-villus system and may also serve as an additional source of endogenous substances appearing in the lumen of the intestine.

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STATE OF THE NERVOUS APPARATUS OF THE MENINGES AFTER BILATERAL LIGATION OF THE COMMON CAROTID ARTERIES

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Bilateral ligation of the common carotid arteries was followed by marked changes in the nervous apparatus of the meninges, leading in some places to the reorganization of neurovasal relations.

KEY WORDS: meninges; carotid arteries; peripheral nervous system.

The nature of the collateral circulation of the brain and its meninges after extracranial occlusion of the main vessels of the head is at present a matter for special attention of both clinicians and theoreticians [2,7,15,16]. However, no mention could be found in the accessible literature of the state of the nervous apparatus of the blood vessels of the brain and its meninges in disturbances of this type or, in particular, in extracranial lesions of the carotid arteries, the frequent cause of softening of the cerebral hemispheres [7,15]. Nevertheless, such information is particularly relevant to the deeper analysis of these processes for the responses of blood vessels are largely dependent on the state of their innervation [3-5,11].

The object of this investigation was to study the state of the nervous apparatus of the meninges after bilateral ligation of the common carotid arteries.

EXPERIMENTAL METHOD

The meninges from the brains of 32 healthy, sexually mature dogs (24 experimental and eight control animals) were used as the test object. The experiments were carried out on dogs because the principle of construction of the vascular system of the brain and the innervation of the meninges in these animals are similar in many respects to those observed in man [6,8,14].

Under sterile conditions the middle part of the common carotid arteries of the experimental dogs was exposed and completely ligated with a Kapron thread (each vessel at two places). The animals were killed at different times after the operation: 1, 3, 7, 30, 90, and 120 days (four dogs in each group).

The meninges were investigated in total preparations. Nerve cells were detected by impregnation with silver nitrate by the Bielschowsky-Gros, Rasskazova, and Campos methods, by means of which the vascular network could be demonstrated at the same time. After impregnation with silver, the preparations were gilded and stained with hematoxylin-eosin, azure II-eosin, or picrofuchsin so as to detect the other tissue elements. The myelin sheath of the nerve fibers was stained with hematoxylin lake by Spielmeyer's method or with osmic acid by Schultze's method.

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