Structural and Functional Modification of Hollow Organs (Urinary Bladder and Stomach) in Vibration Syndrome

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Exposure to total and local vibration leads to the formation of specific forms of hollow organ diseases: vibration cystopathy and gastropathy. Their characteristic signs are organ dysfunction, thinned wall, atrophy of the mucosa, reduction of the capillary bed, and degenerative atrophic changes in the epithelium, associated with reduction of the protein-producing function and focal metaplasia. Vibration cysto- and gastropathies are systemic manifestations of microangio- and visceropathies of vibration origin.

Key Words: *vibration syndrome; urinary bladder; stomach; biopsy; ultrastructure*

Tumor diseases of various organs, including urinary bladder and stomach cancer, *etc.*, now attract the greatest attention of scientists [8-10,12,13]. We paid special attention to a professional disease associated with systemic pathological changes of the viscera in exposure to total and local industrial vibration [1,7,11]; the concept of vibration visceropathies has been formulated [5]. Systemic involvement of the capillary bed plays the major role in vibration sickness; vibration microangiopathy is the morphological base of structural changes in various organs [5,6].

We studied the structural and functional changes in the urinary bladder and stomach in vibration syndrome.

MATERIALS AND METHODS

A total of 217 cases of vibration syndrome (150 male and 67 female patients aged 33-60 years) caused by exposure to local and total vibration were analyzed; 108 of these were vibration cystopathies and 109 vibration gastropathies. Occupational exposure to vibration was 8-39 years.

Cysto- and gastroscopy with emphasis on the microcirculatory disorders were carried out in all patients. Biopsy specimens of the mucosa from the urinary bladder neck and right lateral wall and from the gastric fundal and antral compartments were collected. Light microscopy of paraffin and semithin sections and electron microscopy of ultrathin sections were carried out. Stereological analysis of the capillary bed of hollow organ mucosa in vibration syndrome was carried out on semithin sections by ocular multipurpose test system. The volume, surface area, and numerical density of capillaries were estimated.

The data were statistically processed using Student's t test; the differences were considered significant at $p<0.05$.

RESULTS

Circulatory disorders of the peripheral angiodystonic type (49%) and autonomic sensory polyneuro-

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pathy (20%) predominated in first-degree vibration sickness (80% cases). In patients with second-degree vibration sickness the changes in the peripheral innervation and hemodynamics were combined with locomotor dysfunction.

Urinary bladder dysfunction in vibration cystopathy was paralleled by urination disturbances, such as oliguria/anuria and hypotension, decreased muscle tone, urethral sphincter incompetence, increased capacity of the urinary bladder, and presence of residual urine. Cystoscopy showed diffuse atrophic changes in the urinary bladder mucosa (plane relief, poor vascular pattern, and high fragility of the vascular wall), the most severe shifts being observed in patients exposed to total vibration. Local hyperemia sometimes emerged in the urinary bladder triangle and neck mucosa.

Microscopic study showed degenerative and atrophic changes in the urinary bladder mucosa in all cases (Fig. 1, *a*, *b*). These changes were paralleled by significant restructuring of the subepithelial microcirculatory bed: reduction of capillaries, the greater part of which underwent aneurysm-like transformation, with degenerative changes in the endothelium and focal perivascular edema.

Transitional urothelium was severely thinned in the majority of cases, often consisting of several layers of cubical epitheliocytes. Pronounced desquamation with denudation of unevenly thickened basal layer was seen at some sites, sometimes with solitary flat basal cells, which indicated significant degenerative changes in urotheliocytes and weakening of cell-cell contacts, promoting rapid desquamation.

Foci of squamous-cell metaplasia apeared in diffuse atrophic urothelium in 32% cases (Fig. 1, *c*), glandular metaplasia with the formation of solitary Brunn's nests was observed in 16% cases. Involvement of the mitochondrial compartment with destruction of the cristae and vacuolation of cytoplasmic reticulum tubules predominated among ultrastructural changes in the atrophic zones of the urothelium. Epitheliocytes in the zone of squamous-cell metaplasia were presented by cells typical of this form of restructuring (Fig. 1, *d*).

The lamina propria and muscle plate were thinned and fibrosed in all cases. Fibroblasts and lymphocytes were seen among thickened collagen fibers. Endothelial lining of the majority of capillaries was thinned, mainly with signs of poor functional activity. Numerous processes often formed on the luminal surface of endotheliocytes, presumably reflecting the compensatory adaptive processes (Fig. 1, *e*).

In contrast to cystopathy, chronic cystitis [4] was characterized by predominance of pronounced proliferative reactions in the urothelium and inflammatory cell infiltration (Fig. 1, *f*).

Stereological study of the microcirculatory bed in the urinary bladder mucosa showed that the numerical, volume, and surface densities of capillaries in vibration sickness were reduced in comparison with chronic cystitis, which was due to reduction and aneurysm-like transformation and reflected the microcirculatory system insufficiency, most pronounced in case of total vibration.

The inert type of gastric secretion predominated in vibration sickness (71% cases); normal type was observed in 17% patients and stimulatory type in 12%. According to the HCl debit hour, gastric acid producing function and acid productivity were suppressed during the basal and stimulated secretion phase in the majority of patients. Endoscopic study showed that the main form of changes developing in the gastric wall in vibration sickness is diffuse atrophy, which was detected in 95 (87%) patients; cardial sphincter incompetence was detected in 67%, low tonus of the stomach in 77%, reflux esophagitis in 30%, and atonia in 11% patients.

Light microscopy of stomach biopsy specimens showed diffuse changes in the surface and deep layers of the fundal and antral compartments. The main structural changes were degeneration and atrophy of the epithelium (Fig. 2, *a*, *b*) and of the glands, with their compensatory rearrangement (formation of polyfunctional mixed cells with acid- and mucus-producing functions; Fig. 2, *c*). Disorders in epithelial differentiation by the intestinal metaplasia type were observed in the majority of cases: from emergence of solitary goblet cells to subtotal replacement of the gastric epithelium by intestinal one, up to the formation of gastric rolls and fossae similar to the intestinal villi and cryptae.

In contrast to non-vibration gastropathy [2], diffuse sclerosis of the stroma was more pronounced in the deep layers of the mucosa and was associated with reduction of the microcirculatory system, thinning of the capillary endothelial lining (Fig. 2, *d*), and a sharp reduction of the biosynthetic reactions of epitheliocytes (according to *in vitro* radioautography; Fig. 2, *e*). Inflammatory cell infiltration was found in just few biopsy specimens; it was facultative and its severity did not correlate with the dissemination of sclerosis and atrophy of both compartments of the gastric mucosa.

Helicobacter pylori were microscopically detected in 71% cases; the bacteria were located on the surface of the epithelial layer, along the apical membrane (Fig. 2, *f*); their presence did not depend on the stage and form of chronic process.

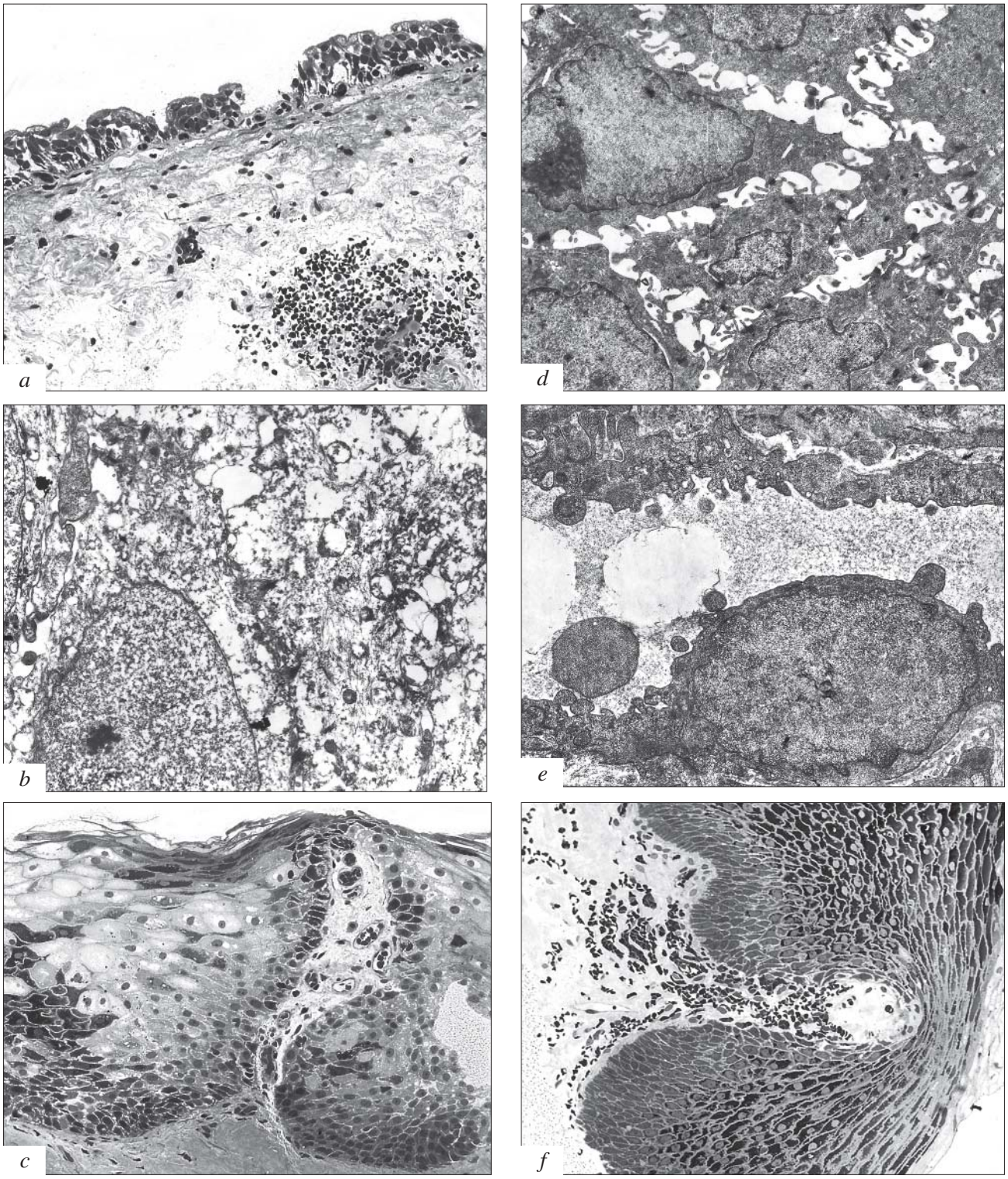

Fig. 1. Photo-optic and ultrastructural characteristics of the urinary bladder mucosa in vibration cystopathy. *a*) urothelial atrophy and desquamation; *b*) destruction of urotheliocyte mitochondria; *c*) squamous-cell urothelial metaplasia; *d*) polygonal urotheliocytes in a zone of squamous-cell metaplasia; *e*) microprocesses on the luminal plasmalemma of a capillary endotheliocyte; *f*) squamous-cell urothelial metaplasia in chronic cystitis: subepithelial inflammatory infiltration. *a*, *c*, *f*: semithin sections, staining by Schiff's reagent and Azur II, ×450; *b*, *d*, *e*: electronograms; *b*, *e*: ×5000; *d*: ×3000.

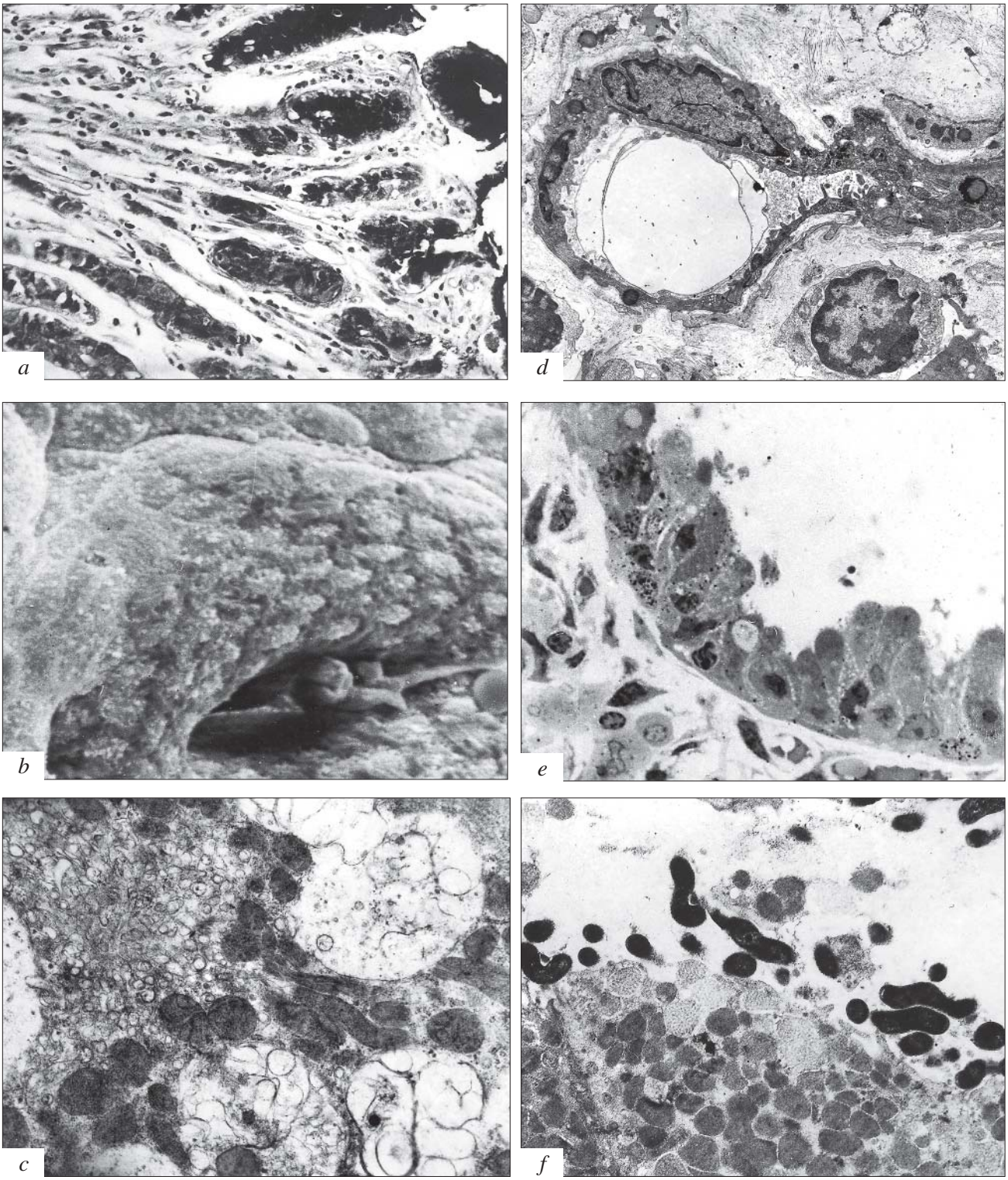

Fig. 2. Pathomorphological characteristics of the mucosa in the gastric fundal part in vibration gastropathy. *a*) glandular degeneration and atrophy. Van Gieson staining, ×350; *b*) mucosal atrophy, hyposecretion. Scanning electron microscopy, ×2000; *c*) mixed cell of the fundal gland, ×8000; *d*) blood capillary of the lamina propria, thinned endothelial lining, no signs of pinocytosis, ×3300; *e*) poor density of ^{3}H-uridine label in surface epitheliocytes. Incubation with ^{3}H-uridine, semithin section, staining by Azur II, ×600; *f*) osmiophilic *Helicobacter pylori* near the apical surface of the epithelium, ×8000. *c*, *d*, *f*: electronograms.

Stereological parameters of the volume and surface/volume capillaries/epithelial structures ratio were lower in the fundal compartment in comparison with the pyloric one, which, together with electron microscopy and radioautography findings, reflects the microcirculatory system insufficiency in the fundal compartment.

Changes in the urinary bladder and stomach in vibration syndrome tended to progress as the disease severity augmented and length of patient's service increased, and persisted after the exposure ceased, not correlating with the patient's age.

Hence, the studies showed a complex of structural and functional changes in the urinary bladder and stomach of patients exposed to vibration; these changes were called vibration cysto- and gastropathies. Their main structural signs are degenerative dystrophic and atrophic changes in the endothelial and epithelial compartments of the mucosa, reduction of the microcirculatory system, diffuse fibrosis, and absence of inflammatory cellular infiltration. The pathogenesis of vibration cysto- and gastropathies (manifestations of systemic visceropathies of vibration origin) is based on systemic microangiopathy and the resultant primary degenerative process, with development of regeneratory plastic insufficiency of cell populations in the walls of the urinary bladder and stomach [3].

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