ULTRASTRUCTURAL CHANGES IN THE KIDNEY IN BURNS

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Severe thermal trauma is an urgent problem in modern medicine that attracts the attention of specialists of different profiles [9, 10,13]. The development of burn shock invariably involves the kidney, the function of which is severely disturbed [11]. The structure of the nephron in burns has been studied in sufficient detail only at the light-optical level [8] and no electron-microscopic investigations have been made.

The object of this investigation was to study the ultrastructure of the nephron in the toxemic period of burns.

EXPERIMENTAL METHOD

Burns were inflicted on 20 mongrel dogs by the method described previously [1]; 10 intact animals served as the control. Pieces of kidney were fixed in 1% osmium tetraxoide solution, and in certain cases they were fixed in 3% glutaraldehyde solution and postfixed in 1% osmium tetroxide solution. After dehydration, the material was embedded in a mixture of Epon and Araldite. Ultrathin sections, stained with uranyl acetate and lead citrate, were examined in the UÉMV-100K electron microscope. Semithin sections were cut from the same blocks and stained with toluidine blue for light-optical investigation.

EXPERIMENTAL RESULTS

Six days after burning irregular dilatation of the glomerular capillaries and congestion were observed under the light microscope (Fig. 1a). The urinary space was widened and contained disintegrated eipthelial cells.

Under the electron microscope considerable thickening of the basement membrane, with vacuolation and discrete focal swellings toward cells of the visceral epithelium were observed in the glomerular capillaries (Fig. 1b). The basement membrane was loose in texture, enlarged in cross section, and had become permeable to substances of high molecular weight. The pedicles of the podocytes had disappeared and the cells were spread out flat on the basement membrane (Fig. 1c). In the endothelium the nuclei were often enlarged and the electron density of the cytoplasm was increased on account of an increase in the number of free ribosomes, polysomal complexes, and mitochondria with a dense matrix. Mesangial cells were found more commonly and occupied a large area of surface because of the "migration" of their processes.

Changes in the glomeruli in the toxemic period of burns could thus be reduced to irregular thickening of the basement membrane, slight proliferation of the endothelium and mesangial cells, and loss of the pedicles of the podocytes. Ultrastructural changes of this type in the components of the glomerular filter lead to an increase in its permeability and to the passage of protein. Similar changes have been observed in cases of proteinuria of varied origin [12].

Light-optical investigations of the convoluted tubules also revealed sufficiently well-marked trophic disturbances and desquamation of the epithelium. Their lumen contained desquamated necortic cells (Fig. 2a). The intertubular spaces were considerably widened.

Electron-microscopically, the brush border of the epithelium of the proximal tubules was often reduced and in some places the microvilli had disappeared. Large vacuoles appeared in the cytoplasm, mainly in the apical part of the cell. Numerous cytoplasmic bodies with a matrix of high electron density also were seen in that region (Fig. 2b). These were autophagolysosomes (secondary lysosomes of autophagic type), described by the writers previously

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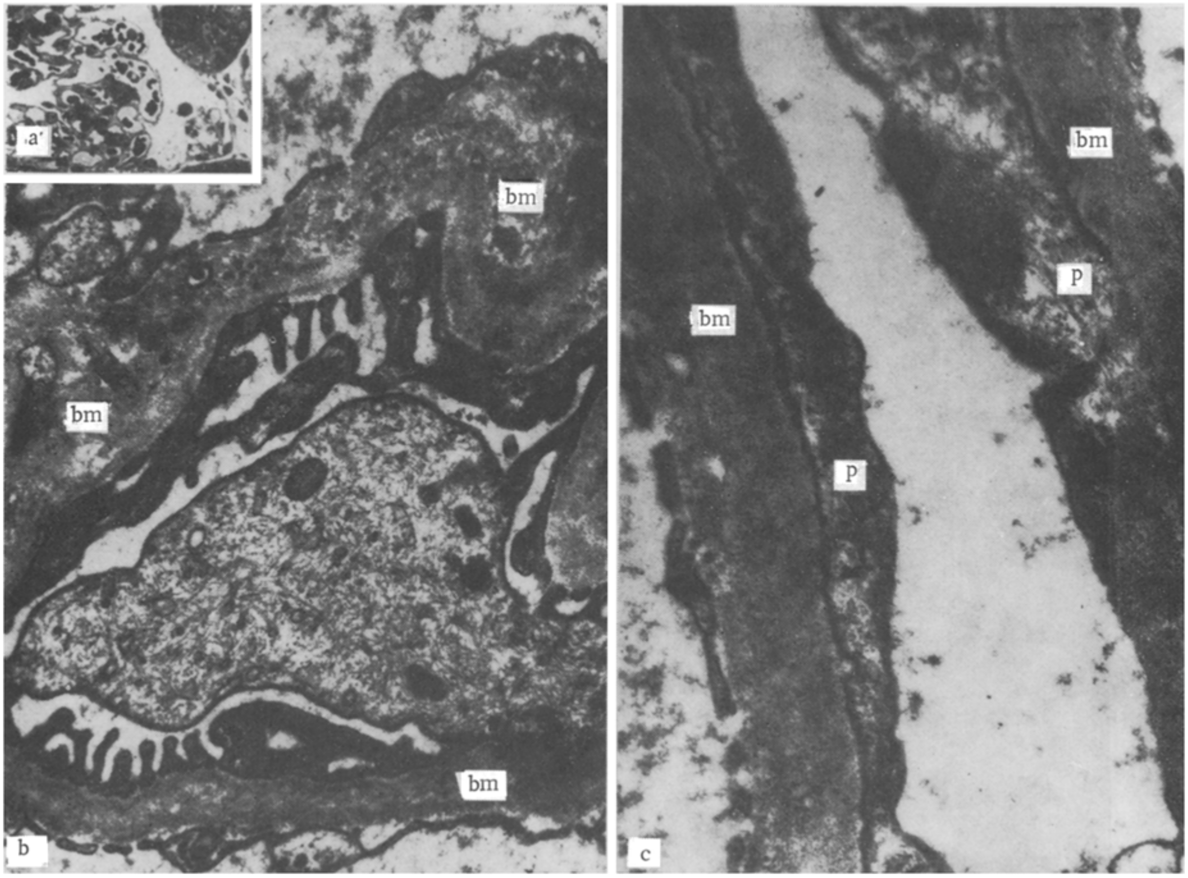

Fig. 1. Fragment of renal glomerulus in burns: a) dilatation of glomerular capillaries, congestion, and destruction of cells of the parietal layer, 280 ×; b) thickening of basement membrane (bm) and loosening of its texture, 15,000 ×: c) reduction of pedicles of podocytes (p) and their spreading out on basement membrane.

[4, 6]. The cristae of the mitochondria were distinguishable with difficulty or not at all. The membrane of these organelles was faintly outlined and the contents consisted of a homogeneous substance. Meanwhile small round bodies, evidently young mitochondria, formed *de novo* [1], were observed. True intranuclear inclusions, namely osmiophilic formations of irregular geometric shape, also were found fairly frequently (Fig. 2c, d).

Some epithelial cells of the proximal tubules were hydrated. The edematous cytoplasm in such cases compressed neighboring cells, which were converted into narrow bands. The lumen of the tubules was often occluded by desquamated epithelium, separate organelles, and fragments of cytoplasm, appearing there as a result of plasmatosis (Fig. 2b).

The most sensitive structure in the epithelial cells of the proximal tubules was thus the microvilli of the brush border, which was destroyed to expose the apical plasmalemma and thus bring about swelling of the cytoplasm in that zone. As a result plasmatosis or rupture of the plasmalemma took place, with the discharge of the contents of the cytoplasm into the lumen of the tubule. Meanwhile *de novo* formation of mitochondria was observed for the first time, indicating repair processes taking place parallel with disintegration.

The cytoplasm of most cells of the distal tubules was hydrated, the number of pinocytotic vesicles and vacuoles was sharply reduced, and the signs of transepithelial pinocytosis, which the writers described previously, disappeared [2, 5, 7]. Secondary lysosomes (autophagosomes), evidently taking part in the phagocytosis of protein, also were observed in the epithelium.

The main changes in the collecting tubule cells followed a course resembling those in the distal tubules. Slight translucency of the cytoplasm remained in the pale cells and the basal part of the dark cells. The mitochondria were practically indistinghishable from normal, except that in a few of them the matrix was a little paler. Moderate dilatation of the tubules of the endoplasmic reticulum also was observed. Despite considerable repair processes, a few cells, mainly pale, underwent destruction. Just as in more proximal fragments of the nephron,

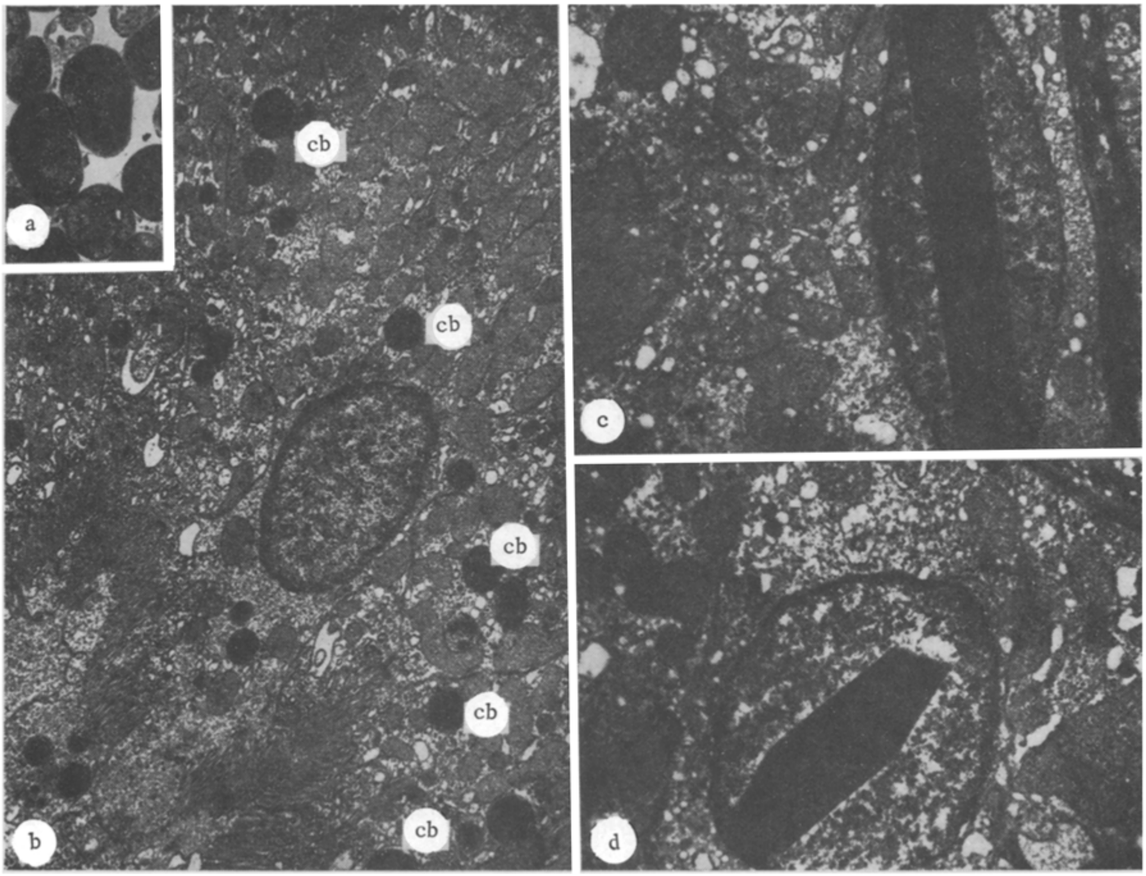

Fig. 2. Tubular portion of renal nephron in burns: a) desquamation of epithelium and trophic disturbances, 280 ×; b) absence of brush border (arrows) and appearance of numerous cytoplasmic bodies (cb), 4000 ×; c, d) intranuclear inclusions, 700 ×.

especially the proximal tubules, the apical plasmalemma was destroyed and contents of the cytoplasm could be seen in the lumen of the collecting tubules. Consequently, in established burns two opposite processes take place simultaneously: integration and disintegration of macromolecular cell complexes, and restoration of function will depend on which of the two predominates.

In the toxemic period of burns primarily the filtration barrier of the kidney — the podocytes and basement membrane — is affected. Changes in the membrane of the glomerular filter are the main cause of the high proteinuria frequently observed after severe burns. The proteinuria is also accompanied by some degree of resorption insufficiency of the tubules, reflected morphologically as hyaline-droplet or vacuolar degeneration.

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