Short and Rapid

Fine Structure of the Sinusoidal Wall in the Liver of Fresh-Water Catfish (Parasilurus asotus), with Special Reference to the Smooth Muscle Cells*

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Summary. The ultrastructure of the hepatic perisinusoidal spaces of the fresh-water catfish was examined by electron microscopy. The hepatic sinusoidal wall of the catfish consists of endothelial cells, Ito's fat-storing cells and smooth muscle cells, but is devoid of Kupffer cells.

The present study demonstrates the sporadic occurrence of smooth muscle cells in the perisinusoidal spaces of catfish liver. This seems to be the first report on smooth muscle cells in the perisinusoidal spaces of vertebrate livers. The location of these muscle cells indicates that they may be responsible for the regulation of the sinusoidal blood flow by their contraction, thus functioning as a sphincter.

The perisinusoidal space (space of Disse) of vertebrate livers contains fat-storing cells or Ito cells (Ito et al., 1952), collagen fibers and sometimes the cytoplasmic processes of Kupffer cells. During the course of studying the fine structure of the catfish liver, we have observed the sporadic occurrence of smooth muscle cells in the perisinusoidal spaces. Focussing on this finding, the present paper describes the fine structure of the perisinusoidal space in the catfish liver.

Materials and Methods

Samples of the catfish (Parasilurus asotus), 20–30 cm in length, were obtained from a local river in September and April. The liver was perfused with saline buffered 0.1 M phosphate at pH 7.3 for 2 min through the ventricle and then followed with 3% glutaraldehyde buffered in the same way. Small pieces of the liver were removed from the fish and cut into small bits. The materials were immersed in the same glutaraldehyde fixative for 2 hr at 4°C. After dehydration in graded ethanol, the specimens were embedded in epoxy resin. Thick sections for light microscopy and thin sections for electron microscopy cut with a diamond knife on a Porter-Blum microtome were stained with toluidine blue, and uranyl acetate and lead tartrate solution, respectively. The thin sections were examined in a JEM 100B electron microscope.

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OBSERVATIONS

Light microscopy
In light micrographs of catfish liver, such lobulation as is seen in mammalian livers cannot be observed, but two regions may be distinguished: one consisting of cell plates of hepatocytes, and the other randomly packed with hepatocytes. The sinusoids occur between the cell plates or within cell masses, and finally drain into the intrahepatic veins. In some places in the sinusoidal walls, elongated fusiform cells which are stained densely with toluidine blue can be seen arrayed in a discontinuous row along the lumina (Fig. 1). These unique cells were later identified as smooth muscle cells by electron microscopy.

Electron microscopy
The sinusoidal wall of the catfish liver consists of endothelial cells, fat-storing cells and smooth muscle cells. No Kupffer cells can be found (Fig. 1, 2). The endothelial cells are attenuated and devoid of a basal lamina (Fig. 2, 3). In the perisinusoidal spaces, sparse microvilli are extended from the hepatocytes, being embedded in relatively abundant collagen fibers (Fig. 2, 3).

Ito cells can be easily identified in the perisinusoidal spaces by virtue of their characteristic appearance; the cytoplasm always contains a few lipid droplets, occasionally multivesicular bodies, and a well-developed Golgi apparatus in the juxtanuclear region (Fig. 3). Ito cells in the catfish, however, do not contain such prominent microfilaments
Fig. 2. An electron micrograph showing the two-cell thick hepatic plate of catfish at low magnification. The dark cells in Figure 1 are identified as smooth muscle cells (arrows) situated in the subendothelial spaces of sinusoidal walls. SN sinusoidal lumen, H hepatocyte, BD terminal bile ductule. ×3,900

Fig. 3. An electron micrograph showing the space of Disse at high magnification. Structural differences between the fat-storing cell (FS) and the smooth muscle cell (SM) are apparent. Note the well-developed Golgi apparatus and multivesicular body in the cytoplasm of the fat-storing cell. SN sinusoid, H hepatocyte, EC endothelial cell, LD lipid droplet. ×11,000
II. SATO and T. YAMAMOTO:

Fig. 4. An electron micrograph showing the space of Disse. Amorphous materials around the cytoplasmic processes (SM) of smooth muscle cells are well-preserved. SN sinusoid, H hepatocyte. ×14,000

Fig. 5. A closer view of the smooth muscle cell and its junctional portion to the adjacent hepatocyte. The cytoplasm is tightly packed with myofilaments arranged along the length of the cell. Note the subsarcolemmal vesicles or pits (arrow heads). A typical desmosomal attachment cannot be seen. SN sinusoid, H hepatocyte. ×18,000
as seen in other Cyprinida fishes and lack typical desmosomes connecting the cells with either endothelial cells or hepatocytes (Fig. 3).

The occurrence of typical smooth muscle cells in the perisinusoidal spaces in the catfish liver is confirmed by electron microscopy. As seen in light micrographs, these muscle cells usually occur sporadically (Fig. 1, 2). Their cytoplasm is tightly packed with myofilaments accompanying a few dense patches, and provided with subsarcolemmal vesicles or pits (Fig. 3, 4, 5). These cells are surrounded by amorphous materials (Fig. 4) and extend their cytoplasmic processes toward the adjacent hepatocytes to make close contact by attachment devices (Fig. 2, 5). No nerve fibers can be found in the perisinusoidal spaces of the catfish liver.

DISCUSSION

The structure of teleost livers has been extensively studied from a phylogenetic viewpoint by light and electron microscopy (DAVID, 1961; ITO et al., 1962; YAMAMOTO, 1965; WELSCH and STORCH, 1973; TAKAHASHI et al., 1978; NOPANITAYA et al., 1979a; TANUMA, 1980; EASTMAN and DEVRIES, 1981; FERRI and SEsso, 1981a, b; SAKANO and FUJITA, 1982). These studies have established that the sinusoidal wall in the teleost liver consists of endothelial cells and Ito cells containing prominent cytoplasmic microfilaments, but is devoid of Kupffer cells and smooth muscle cells. Further, Ito cells in Cyprinida fishes have been known to be frequently attached by desmosomes to their neighboring cells, providing the liver with a supportive framework (NOPANITAYA et al., 1979b; FUJITA et al., 1980; SHIN, 1981). The Ito cells in the catfish liver, however, lack prominent cytoplasmic microfilaments and desmosomal attachments with neighboring cells. Thus, they do not appear to play a significant role as a supportive element of the liver.

The most marked finding in the present study is the sporadic occurrence of typical smooth muscle cells in the perisinusoidal spaces. Earlier physiological studies showed the presence of inlet and outlet sphincters in the hepatic lobules of various vertebrates (IRWIN and MACDONALD, 1953; BLOCH, 1955; KNISELY et al., 1957; others). No investigations, however, showed anatomical evidence for the sphincter mechanism in the sinusoids. MCCUSKEY (1966) attempted to elucidate the localization of sinusoidal sphincters and suggested that the spincters consisted of reticulo-endothelial cells which were located at the junctions of sinusoids with portal venules and central venules as well as intersinusoidal sinusoids. Furthermore, he stated that the sphincter endothelial cells were capable of reducing the sinusoidal lumen to zero or nearly zero by bulging into the lumen. Thus, most interpretations on the regulation of sinusoidal blood flow seem to be based on the sphincter mechanism by endothelial cells.

Since the smooth muscle cells have not so far been reported to occur in the perisinusoidal spaces of vertebrate livers, they may be specific to catfish. The location of the muscle cells indicates that they are involved in the regulation of blood flow through the sinusoids, and moreover, their contraction possibly affects the flow of intercellular tissue fluids in the liver, because of connections to the hepatocytes by attachment devices. However, the question of why the smooth muscle cells which might represent true sphincters occur only in the perisinusoidal spaces of this fish remains to be solved.
REFERENCES

Bloch, E. H.: The in vitro microscopic vascular anatomy and physiology of the liver as determined with the quartz-rod method of transillumination. Angiology 6: 340-349 (1955).

David, H.: Zur submikroskopischen Morphologie intrazellulärer Gallenkapillaren. Acta anat. 47: 216-224 (1961).

Eastman, J. T. and A. L. DeVries: Hepatic ultrastructural specialization in antarctic fishes. Cell Tiss. Res. 219: 489-496 (1981).

Ferri, S. and A. Sesso: Ultrastructural study of the endothelial cells in teleost liver sinusoids under normal and experimental conditions. Cell Tiss. Res. 219: 649-657 (1981a).

Fujita, H., T. Tamaru and J. Miyagawa: Fine structural characteristics of the hepatic sinusoidal walls of the goldfish (Carassius auratus). Arch. histol. jap. 43: 239-254 (1952).

Irwin, J. W. and J. MacDonald: Microscopic observations of the intrahepatic circulation of living guinea pigs. Anat. Rec. 117: 1-15 (1953).

Ito, T., S. Satsumi, K. Kano and N. Tsukagoshi: Studien über die sog. “Fettspeicherungszellen (fat-storing cell)” in der Leber von verschiedenen Wirbeltieren. (Japanese text with German abstract). Arch. histol. jap. 3: 1-15 (1953).

Knisely, M. H., F. Harding and H. Debacker: Hepatic sphincters. Science 125: 1023-1026 (1957).

McCuskey, R. S.: A dynamic and static study of hepatic arterioles and hepatic sphincters. Amer. J. Anat. 119: 455-478 (1966).

Nopanitaya, W., J. L. Carson, J. W. Grisham and J. G. Aghajanian: New observations on the fine structure of the liver in goldfish (Carassius auratus). Cell Tiss. Res. 194: 249-261 (1979a).

Nopanitaya, W., J. Aghajanian, J. W. Grisham and J. L. Carson: An ultrastructural study on a new type of hepatic perisinusoidal cell in fish. Cell Tiss. Res. 190: 35-42 (1979b).

Sakano, E. and H. Fujita: Comparative aspects on the fine structure of the teleost liver. Okajimas Pol. anat. jap. 58: 501-520 (1982).

Shin, Y. C.: Some observations on perisinusoidal lipocyte (Ito cell) of Carassius auratus liver as revealed by electron microscopy. Acta anat. nippon. 56: 133-144 (1981).

Takahashi, Y., H. Tsubouchi and K. Kobayashi: Effects of vitamin A administration upon Ito’s fat-storing cells of the liver in the carp. Arch. histol. jap. 41: 339-349 (1978).

Tanuma, Y.: Electron microscope observations on the intrahepatic bile canalicules and sequent bile ductules in the crucian, Carassius carassius. Arch. histol. jap. 43: 1-21 (1980).

Welsch, U. N. and V. N. Storch: Enzyme histochemical and ultrastructural observations on the liver of teleost fishes. Arch. histol. jap. 36: 21-37 (1973).

Yamamoto, T.: Some observations on the fine structure of the intrahepatic biliary passages in goldfish (Carassius auratus). Z. Zellforsch. 65: 319-330 (1965).

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