Ultrastructure of the human posterior tunica vasculosa lentis during early gestation*

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Abstract. In human embryos with a gestational age of from 7.6 to 14.0/15.0 weeks, the posterior tunica vasculosa lentis (TVL) was examined by both scanning and transmission electron microscopy. Even at the very early age of 7.6 weeks the tunica was found to be fully developed. It consisted of a radiating network of tortuous capillaries. Their walls were composed of a continuous layer of endothelial cells, surrounded by a basement membrane and a discontinuous sheath of pericytes. The thickness of the basement membrane increased with increasing gestational age. As opposed to previous studies, the endothelial cells exhibited transitory fenestrations. In the neighborhood of the posterior TVL macrophages were found.

Introduction

To the clinician remnants of the fetal hyaloid vasculature are a well-known finding. In particular, the pediatric ophthalmologist engaged in the care of premature infants often encounters such structures (Gans 1959; Roper-Hall 1960; Forrester 1960; Hornblass 1971; Roth 1977).

During a defined period of intrauterine life these intraocular blood vessels are responsible for the nutrition of the embryonic and fetal lens. They consist of the hyaloid artery and a well-organized capillary system. The so-called vasa hyaloidea propria branching from the two to three main trunks of the hyaloid artery build up the hyaloid vascular system proper, which communicates with the posterior tunica vasculosa lentis (TVL). The latter connects via the capsulopupillary TVL with the pupillary membrane or anterior TVL (Dejean 1958; Duke-Elder and Cook 1963; Mann 1964; Brini et al. 1968; Jaffe 1969). Later in fetal life all of these vessels normally regress.

Our present knowledge of the structure of the human hyaloid vasculature is mainly due to historic embryological studies using light microscopy (Lange 1908; Jokl 1927; Terry 1942). The few ultrastructural studies available were performed on the rat (Breakevelt and Hollenberg 1970; Hollenberg and Dickson 1971), the rabbit (Jack 1972a-c), and the monkey (Hamming et al. 1977; Townes-Anderson and Raviola 1982). Only Mikawa (1965) applied electron microscopy to study the posterior TVL in man up to the 150 mm stage (fifth month).

Until now no complete ultrastructural report has existed on the intraocular vascular system in man. In the present paper we will describe the hyaloid vasculature in the human embryo with a gestational age from 7.6 to 14.0/15.0 weeks, using scanning and transmission electron microscopy.

Materials and methods

For our study we used 14 eyes from human embryos, which were obtained after legal abortions. The abortions were performed because of socio-medical indications and the aspiration-curettage technique was used.

The age of the embryos was determined by measuring the length of one or more of the following bones: tibia, femur, radius, and humerus (Kelemen et al. 1984). The ages ranged from weeks 7.6 to 14.0/15.0 of gestation (postconception). The maximal postmortem delay for fixation was 20 min.

Light and transmission electron microscopy

The eyeballs were fixed as a whole in 2% paraformaldehyde and 2% glutaraldehyde in 0.1 M cacodylate buffer, pH 7.4, with the addition of 0.3% CaCl_2 for 8 h to 11 days before postfixation with 2% osmium tetroxide in cacodylate buffer, pH 7.2, for 2 h. Thereafter, the eyes were dissected. The lenses were dehydrated in a graded series of ethanol, blockstained for 10 minutes in 1% uranyl acetate at the 70% ethanol grade, transferred to propylene oxide, and embedded in Durcupan ACM (Fluka, Basel, Switzerland).

Sections were cut on LKB and Reichert ultramicrotomes. Thick sections (0.5 μm) were stained with toluidine blue for light microscopy. Thin sections were stained with uranyl acetate and lead citrate. Electron micrographs were taken with the Zeiss EM 109.

Scanning electron microscopy

The eyes were fixed as a whole in 2% paraformaldehyde and 2% glutaraldehyde in 0.1 M cacodylate buffer, pH 7.2, for 5–9 h and postfixed in 2% osmium tetroxide in cacodylate buffer, pH 7.2, for 2 h. Thereafter, the eyes were dissected. The lenses were dehydrated in a graded series of acetone, blockstained for 10 minutes in 1% uranyl acetate at the 70% ethanol grade, transferred to propylene oxide, and embedded in Durcupan ACM (Fluka, Basel, Switzerland).

Sections were cut on LKB and Reichert ultramicrotomes. Thick sections (0.5 μm) were stained with toluidine blue for light microscopy. Thin sections were stained with uranyl acetate and lead citrate. Electron micrographs were taken with the Zeiss EM 109.

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Results

During the period studied, the total diameter of the lens is only about 1 mm. In spite of this disadvantage, localization and harvesting of the lens was possible in all cases. The basic structure of the posterior TVL is principally established in week 7.6. The posterior surface of the lens is completely covered by a sheath of capillaries in a netlike array (Fig. 1). The vessels take a radiating and tortuous course from the posterior pole of the lens to the periphery and communicate through numerous intercapillary bridges (Fig. 3).

The capillaries consist of an endothelial lining, followed by a discontinuous sheath of pericytes and surrounded by a common basement membrane (Figs. 4, 5). In cross-sections up to nine or even more endothelial cell profiles can be recognized per vessel diameter, but a pericyte is not always present.

It is often not possible to differentiate between endothelial cells and pericytes based on their ultrastructural appearance. However, the cytoplasm of the pericytes seems more electron-translucent and the chromatin, especially in the marginal zone of the nucleus, has a more clumped appearance than in endothelial cells.

The endothelial cells are connected by tight junctions, which are located toward the luminal end of the intercellular space (Fig. 6). On one or both sides of the intercellular

Fig. 1. Week 9.0. SEM posterior surface of the lens with the TVL. The cleft (arrow) and deepening in the center of the lens (hollow arrow) are due to artificial shrinkage; × 720

face of the lenses was then examined in a Philips SEM 505.