THE ANATOMY OF THE CHOROID – A REVIEW

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THE ANATOMY OF THE CHOROID – A REVIEW (Abstract): The choroid is an important structure of the eye which can be involved in a lot of pathologies. Its great importance is given by functions like vascularization, thermoregulation and production of growth factors. A good knowledge of this element of the eye will help the ophthalmology specialists, especially the young ones, to understand better the pathological substrate of the diseases involving the choroid like diabetic retinopathy, age related macular degeneration wet form, choroid detachment etc. The choroid covers to the interior the fibrous tunic of the eye. It represents the posterior portion of the uvea, the anterior being represented by a thicker region, ciliary zone. Histological, choroid shows the 5 layers, from sclera to the retina: outer pigment layer, suprachoroid; two vascular layers, one external (called Haller) and one internal, Sattler; choriocapillar layer and Bruch’s membrane. The choroid blood supply is ensured by posterior ciliary arteries (PCA), branches of the ophthalmic artery. Venous drainage is achieved through vorticity veins. Choroid’s Innervation is double, sympathetic and parasympathetic through dense perivascular plexus. Key words: THE CHOROID, DIABETIC RETINOPATHY, POSTERIOR CILIARY ARTERIES

INTRODUCTION
The choroid represents the main structure of the eye which ensures the blood supply of the external layers of the retina, consisting for the most part of it from blood vessels. Except vascularization which is the main function, we can mention other equally important functions: of thermoregulation, adjust retinal position in relation with choroidal thickness, production of growth factors. These growth factors appear to play an important role in eye’s emmetropia, in the processes of changing the form of the eye in order to correct the myopia or hyperopia. One area still in research and incompletely known is the relationship between growth factors and structure changes that occur in the choroid (1).

ANATOMY AND DEVELOPMENT OF THE CHOROID
1. Development of the choroid
The choroid is the middle layer of the eye located in the posterior uveal. Eye development starts at the end of the 4th week when optical ditches appear in the cranial neural folds. After merging neural folds, optical vesicles are formed, shaped as diverticula from forebrain wall. After lens vesicles formation on the surface ectoderm, optic vesicles invaginate and form the optic cups which present a double wall. The lens vesicles then enter the optical cavity cups. Mesenchymal surrounding the optic cups differentiate to get an internal and an external layer. The inner layer will form the choroid and the external layer the sclera. Meanwhile with the development of choroid, the melanocyte precursors migrate from the neural crest toward the choroid (fig. 1). These precursors will differentiate into pigmented melanocytes starting with 7-8 month of gestation (1).

2. Anatomy of the choroid
The choroid covers to the interior the fibrous tunic of the eye. It represents the posterior portion of the uvea, the anterior being represented by a thicker region, ciliary zone. The two regions are separated at the Equator of the eye by ora serrata, shaped as a scalloped line.
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Choroid shows two faces: external which is convex and is solidarized with the sclera through vessels, ciliary nerves and lax connective tissue (lamina fusca); internal is concave and that fits the retina without adherence to it.

Also choroid has two openings, one anterior with ora serrata as demarcation and one posterior that passes through optic nerve.

3. Choroid blood supply

Choroid blood supply is ensured by posterior ciliary arteries (PCA), branches of the ophthalmic artery. Venous drainage is achieved through vorticity veins (fig. 2).

Posterior ciliary arteries (PCA) originate in the ophthalmic artery. Their number is variable being described several anatomical variants: one posterior ciliary artery (3%), two (48%), three (39%), four (8%) or five posterior ciliary arteries (2%). Nomenclature can sometimes be problematic, but classically the posterior ciliary arteries have been named in relation to the optic nerve: Medial PCA - localized medial to the optic nerve and usually there is one (70%); Lateral PCA - lateral side of the optic nerve and it might be one (75%) or two (20%); Superior PCA- in 9% of cases and is small (3).

Different PCA will divide in many smaller branches that, together with the optic nerve will perforate the sclera. Medial and lateral branches of the PCA will form long PCAs medial and lateral and the rest of the PCA branches will form short PCAs, between 10 and 20. The medial and lateral PCAs ensure the blood supply for the medial and lateral part of the choroid (2).

PCAs branches will continue the branching ensuring a systematic blood supply for the choroid. Finally, each choriocapilar arteriole will capilarize and will serve a choriocipilar lobule (4).

4. Choroid’s Innervation

Choroid’s innervation is double, sympathetic and parasympathetic through dense perivascular plexus. Parasympathetic innervation comes from the pterigoplatan ganglion (5) through fiber mainly cholinergic rich in nitric oxide (6). Some studies also indicate the presence of parasympathetic fibers which originate in the ciliary ganglion (7).

The Sympathetic innervation of the choroid originates from the superior cervical ganglion. The fibers are noradrenergic and cause vasoconstriction (8).

Sensory innervation is realized by related sensory fibers that reach the ophthalmic nerve via long ciliary nerves in the trigeminal ganglion Gasser. It has been demonstrated that these fibers represent the basis of vasodilatation reflex mediated by peptide as P substance and calcitonin gene-related peptide (9).

HISTOLOGICAL STRUCTURE OF THE CHOROID

Histologically, in literature for the choroid were described variable between 4 and 6 layers,
depending if the vascular layer is considered a single or double layer and if lamina fusca is considered belonging to the choroid or sclera (1).

Classically, as described by Hogan, choroid shows the 5 layers, from sclera to the retina: outer pigment layer, suprachoroid; two vascular layers, one external (called Haller) and one internal, Sattler; choriocapilar layer and Bruch’s membrane (fig. 3).

At birth, choroid thickness is measuring about 200um and with age its thickness decreases to get 80um at 90 years (10).

1. **External pigment layer or the suprachoroid** – is a transition zone between the sclera and the choroid. It consists of elastic connective tissue and collagen fibers arranged in thin lamellae, fibroblasts and melanocytes. The outer layer is called the lamina fusca and consists of fibroblasts and flattened fusiform melanocytes. This layer contains also myelinated axons disposed in bunches (11).

2. **Choroidal vascular layers** – are two: the outer layer of Haller and the inner layer of Sattler, outer layer of Haller consists of large vessels, especially vortex veins. They form spirals in their pathway and finally confluence in four spiraled venous trunks located in the most superficial place of the vascular layer. The location of these trunks is posterior to the equator and are systematized in two upper trunks and two lower trunks (nasal and temporal). These trunks perforates the sclera and drains into the ophthalmic vein. Vortex veins do not have a segmental distribution (3). Sometimes has been described also the chorio-vaginal vein leaving the choroid and perforating the sclera with the optic nerve and draining into venous plexus of the optic nerve (3).

Various studies have shown by post-mortem injection the existence of arterio-arterial and arteriovenous anastomoses in the choroid. Interarterial anastomoses are made between branches of anterior and posterior ciliary arteries at the equator. Because of these anastomosis occlusion of a vessel does not produce the infarction choroid (12).

Settler inner layer consists of medium and small caliber vessels, especially by arteries that originate in the short posterior ciliary arteries (1).

Extravascular stroma consists of fibroblasts, elastin fibers, smooth muscle fibers and giant melanocytes localized perivascular. Also, there can be found mast cells, macrophages and lymphocytes (13).

3. **Choriocapilar layer** – consists of branching of choroidal vessels forming an extensive capillary network. Each arteriole capilarize forming separate hexagonal region (1). Capillaries are large in size, between 20 and 40 um, but in the foveal region, where is the highest density of capillaries, these measures only 10um in diameter (14). Due to this vast network of capillaries, the speed of red blood cells drops to 77% compared to speed in retinal capillaries (15). Capillaries shows high permeability to proteins in order to maintain an increased oncotic pressure in extravascular stroma. This contributes to facilitating the fluid exchange between the retina and choroid (1).

Choriocapilars are located in a single plane as a continuous layer forming a continuous anastomotic network which stretches along the entire choroid (3).

4. **Bruch Membrane** – is a transparent layer with homogeneous appearance mainly represented by an endothelial basement membrane of the capillars from the choriocapilars layer (1).

**CONCLUSIONS**

Due to its huge importance in pathology we consider that knowing very well all the things about this structure of the eye, will help especially the young specialist to increase the quality and accuracy of their medical attitude in front of the pathologies involving the choroid.
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