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Fluorescein Angiography of the Optic Nerve Head: Normal Aspects

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ABSTRACT—The fluorescein angiographic characteristics of the optic nerve head are described. Strictly related to the angioarchitecture of the optic nerve head, an explanation of each angiographic phases is given. The Author discusses the permeability features to the dye of the different structures of the disc.

Key words: **Optic Nerve Head, Fluorescein Angiography.**

Papillitis, optic neuritis, papilledema, ischemic optic neuropathy, primary disc tumors are some of the commonest disorders involving the optic nerve head (ONH). They are quite different in nature but sometimes not so easy to differentiate. Fluorescein angiography has introduced a new dimension in the anatomical, physiological and clinical study of the ONH. Even though the pathogenesis of many diseases of the optic disc still remains obscure, the introduction of fluorescein angiography has been of crucial importance in establishing what disorders of perfusion and permeability can be the cause of diseases such as anterior ischemic optic neuropathy.

The interpretation of angiographic pictures of the disc is usually quite complex due to its peculiar microvasculature with its great variability even among normals. According to Hayreh (1) the ONH can be divided into three layers: the lamina cribrosa, the prelaminar region and the superficial nerve fibers layer; behind the lamina cribrosa there is the retrolaminar region which for physiological implications can be considered part of the ONH. The lamina cribrosa is directly supplied by branches of short posterior ciliary arteries and sometimes from branches of the Zinn-Haller's circle, when present. The prelaminar region is supplied mainly by branches which originate from the peripapillary choroid; these vessels have a typical sectorial distribution and can better be seen on the temporal side. No vessels coming from central retinal artery can be detected in this layer. The superficial layer is nourished by branches of peripapillary retinal arterioles and, less frequently, by some central artery branches at the site of the disc. The superficial capillaries are connected to the superficial peripapillary radial plexus. Contributions coming from the prelaminar region are also seen in this superficial layer (cilio-retinal vessels). The retrolaminar region is supplied by collaterals of pial vessels which are feeded by the peripapillary choroid, the Zinn-Haller's circle and

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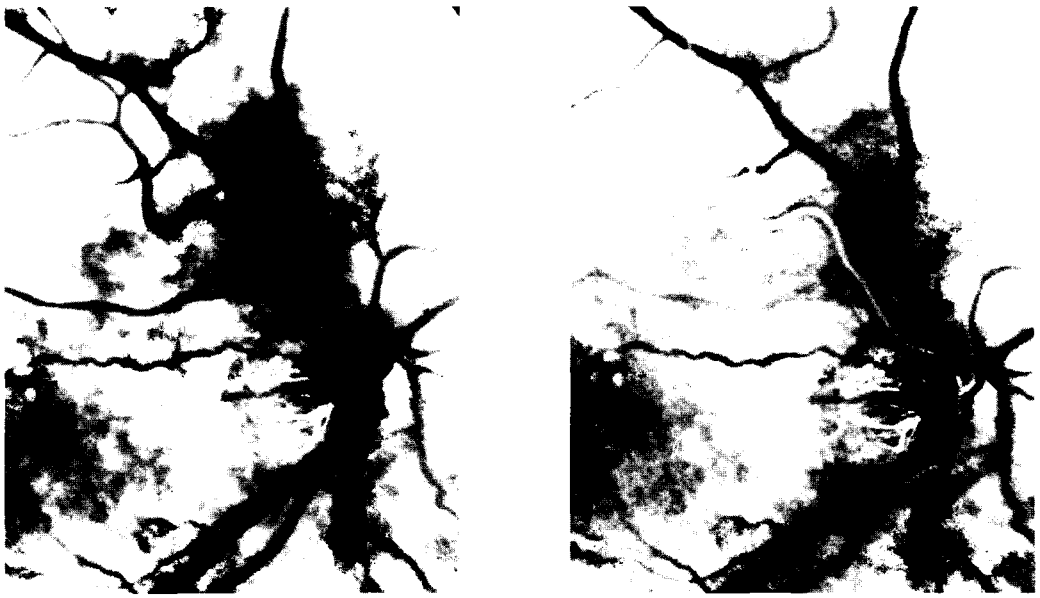

Fig. 1 (sequential pictures). Note on the left some prelaminar arteries on the temporal side of the disc. The choroid is almost completely filled. On the right the central retinal artery is being injected.

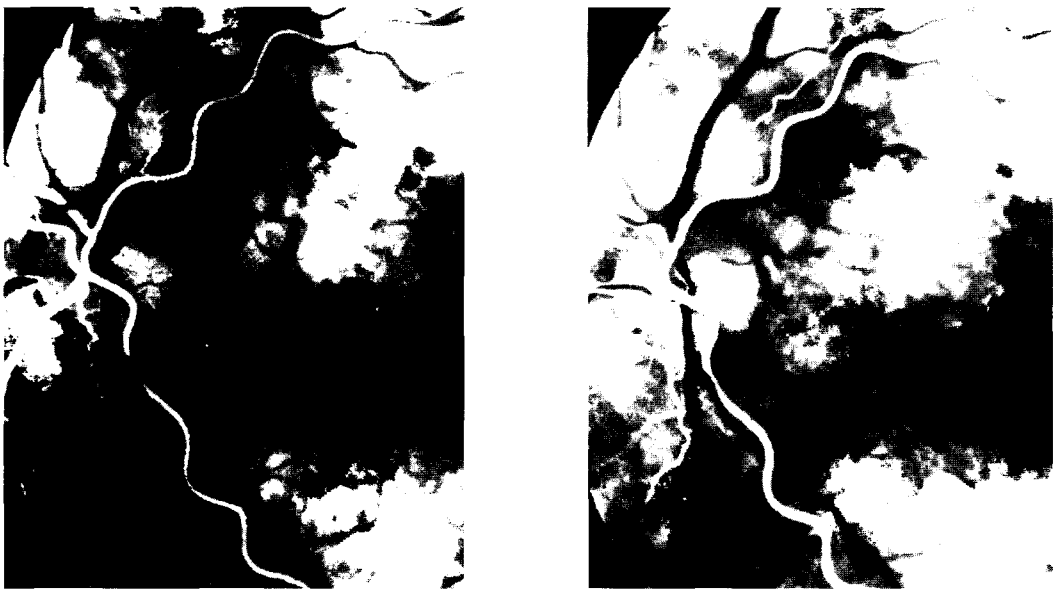

Fig. 2 (sequential pictures). On the left patchy choroidal filling is visible, central retinal artery is already injected; on the temporal side of the disc the sectorial distribution of the prelaminar circulation is evident. On the right the vessels of the prelaminar layer are filled.

from branches of short posterior ciliary arteries. Collaterals of central retinal artery have also been described in this region. The venous blood flows toward collector vessels which are tributary of the central retinal vein, even though some venous vessels tributary of the choroid exist, they constitute an important shunt system between retinal veins and choroid. Thus, it is clear that most of the ONH arterial blood supply depends upon the short posterior ciliary arteries.

Technical innovations on fluorescein angiography allow us today to study the microvascularization of the ONH, particularly from a dynamic point of view. To avoid pseudofluorescence, the use of highly selective filters is mandatory. If an overlapping in the transmission spectrum of the two filters (exciter filter and barrier filter) exists, non-fluorescent light is not prevented from reaching and exposing the film, with significant loss of quality in the angiogram. To study the perfusion characteristics of the superficial and the deeper disc vasculature, rapid sequential fundus photographs are also useful. The angiographic phases in the ONH can be schematically summarized as follows:

a. retrolaminar and laminar phases;
b. prelaminar phase;
c superficial retinal capillary filling;

Late phases of the angiogram allow us to study the permeability characteristics to the dye at the level of the ONH.

a. *retrolaminar and laminar phases:* these are the

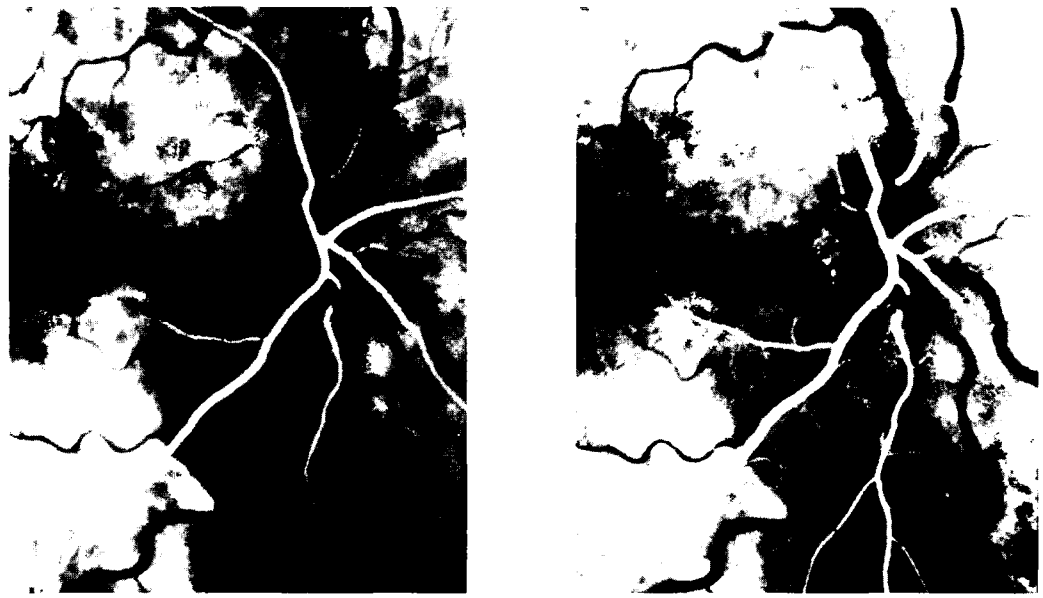

Fig. 3 (sequential pictures). Note on the left uneven choroidal filling, central retinal artery is completely injected. After few moments (on the right) some prelaminar vessels become visible on the temporal side of the disc.

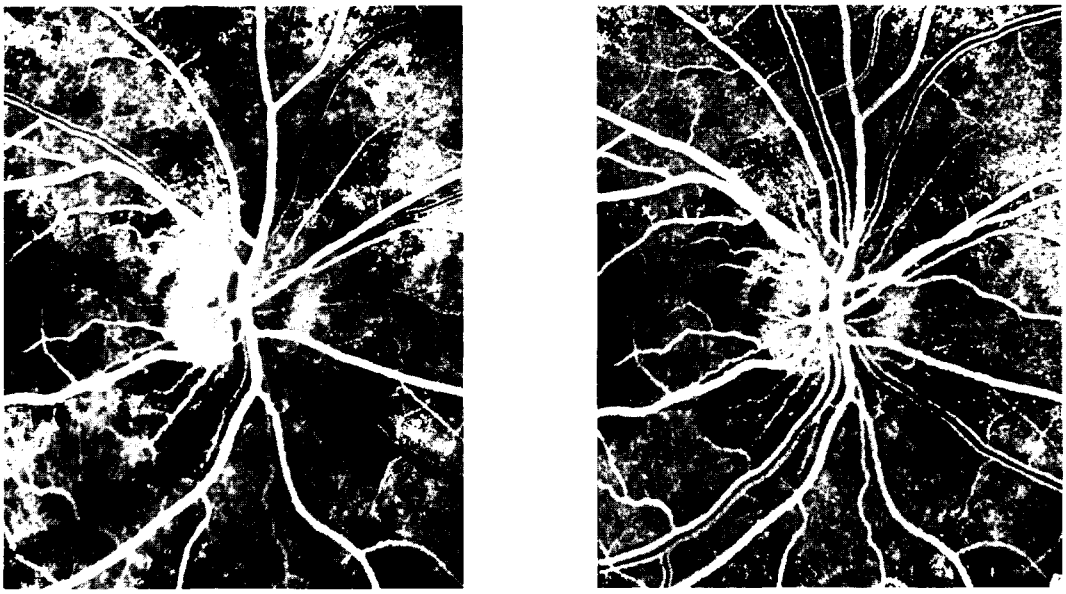

Fig. 4 (sequential pictures). With the filling of the central retinal vein, many superficial small vessels become visible at the level of the disc. They appear connected to the peripapillary radial plexus.

first angiographic manifestation after the injection of fluorescein; they preceed the choroidal flush (occurring about 8 seconds after injection) but are seldom observed because of the deep localization of the vessels at this level.

b. *the laminar phase* (figs. 1 and 2): previous phases are followed by the prelaminar filling; the vessels of this region, to confirm their strict dependence on the choroidal vasculature, become evident when the peripapillary choroid is being injected, at the same time of or soon after the patchy choroidal filling. The prelaminar vessels do not fill simultaneously but appear gathered in functional units supplying single sectors of the ONH. The temporal side is usually seen first; if present, a cilio-retinal artery becomes evident in this phase. In 10% of the subjects the choroidal filling comes after the retinal artery filling (fig. 3); in this case the prelaminar vessels are not easily seen.

c. *superficial capillary filling* (fig. 4): the last phase concerns the superficial retinal capillaries filling; these vessels are supplied by central retinal artery and its branches, but they become more evident with the filling of the peripapillary radial plexus which is predominantly venous in nature.

d. *late phases of the angiogram* (fig. 5): in the subsequent phases the fluorescein leaves the choroidal and retinal vessels and stains the choroidal tissue and the sclera. This results in a background fluorescence par-

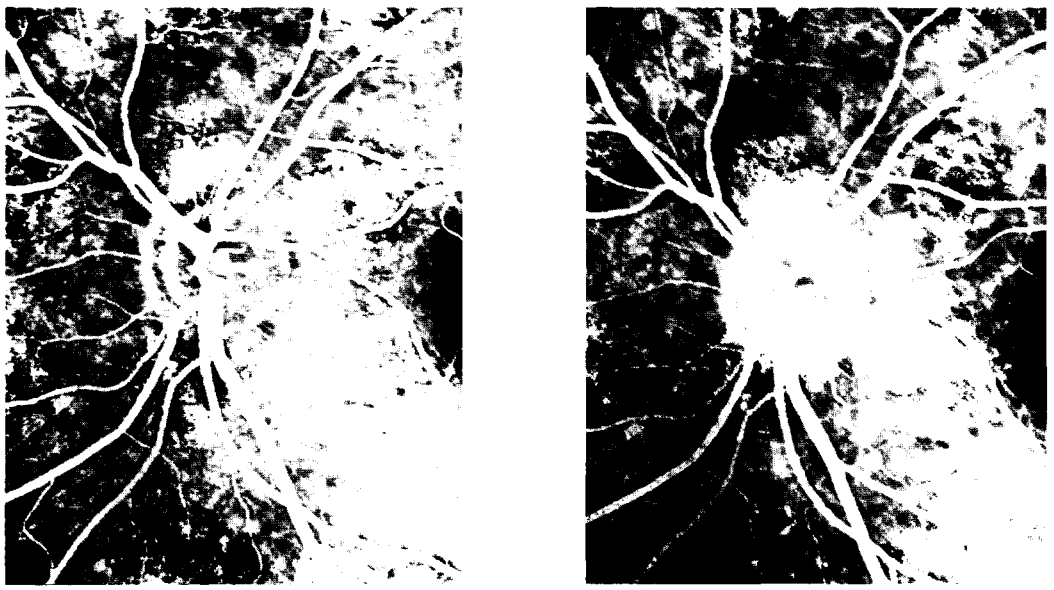

Fig. 5 (sequential pictures). Late phases of the angiogram. (On the left) a hyperfluorescent halo is visible surrounding the disc. This is due to leakage from the peripapillary choriocapillaris. After 10 minutes (on the right) the dye has entered the optic nerve head tissue and the disc appears hyperfluorescent.

tially masked by the pigment epithelium. Around the disc a hyperfluorescent halo can be seen because of the leakage from the peripapillary choriocapillaris, then the dye enters little by little the tissue of the ONH. This diffusion of fluorescein accounts for the fluorescence of the disc visible in the late phases of the angiogram. In normal eyes the capillaries of the ONH (retrolaminar, laminar, prelaminar and superficial layer) do not allow the passive transit of substances from the blood because of tight junctions between the endothelial cells (2,3). The ONH is surrounded, at the level of the choroid, by a glial ring (tissue of Jacoby) which allows free passage of molecules from the choroid. This sleeve continues anteriorly to form the glial tissue of Kuhnt which circumscribes the ONH at the level of the neuroretina. The glial cells of this tissue because of intercellular tight junction, form a watertight barrier to the passage of substances from the ONH to the neuroretina.

These observations underline that, at the level of the ONH, there is a physiological interruption of the blood-brain barrier. Even though the precise meaning of this fact is not well understood as yet, some Authors suggest that it can be implicated in the pathogenetic mechanisms of certain ONH disorders (4).

Therefore, an accurate interpretation of the fluorescein angiography, through the study of the perfusion (early phases) and the permeability (late phases) characteristics of disc vessels can give critical information to clarify the clinical aspects of many optic nerve diseases.

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