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RADIAL PERIPAPILLARY CAPILLARIES OF THE RETINA*†

I. ANATOMY: HUMAN AND COMPARATIVE

BY

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DESCRIBED herein is a superficial layer of capillaries which occupies the peripapillary region of the retina in man and some animals. These vessels have received but scant attention in the past (Michaelson, 1954; Toussaint, Kuwabara, and Cogan, 1961; François and Neetens, 1962), and then only in man. They may play an important role in some ocular disorders, and since their distribution and arrangement differ from that of the other capillaries of the retina they deserve a particular connotation. The most apt term for them would appear to be "radial peripapillary capillaries of the retina" (RPC) (Michaelson, 1954). This paper describes the RPC layer in man, rhesus monkey, cat, and pig.

Material and Method

Whole Indian ink-injected retinae of man (3 retinae: two from normal adults, one from a patient with hypertension), rhesus monkey (2 retinae), cat (20 retinae), and pig (4 retinae) were mounted on slides either in water or in glycerin jelly, and examined with the dissecting and light microscope. Descriptions of the inking and mounting procedures can be found in previous publications (Ashton, 1950; Henkind, 1966).

Observations

All the specimens examined had a fairly well defined lamina of radial peripapillary capillaries, but there were species differences in the distribution and configuration of the vessels.

Man

Examination of flat, ink-injected human retinae with the low power ($\times 6$) of the dissecting microscope revealed a particularly dense aggregation of small calibre vessels surrounding the optic nerve-head (Fig. 1, overleaf). These were most prominent immediately around the disc and in the infero- and supero-temporal segments adjoining the nerve-head (Fig. 2*a*, *b*, overleaf) where the configuration resembled a double Bjerrum arc (pointed out by Toussaint and others, 1961); to a lesser extent they could be seen infero- and supero-nasally (Fig. 2*c*), and they were not seen in the fovea or perifoveal region of the macula (Fig. 2*d*). Fig. 3 (overleaf) illustrates the distribution of these vessels in human eyes.

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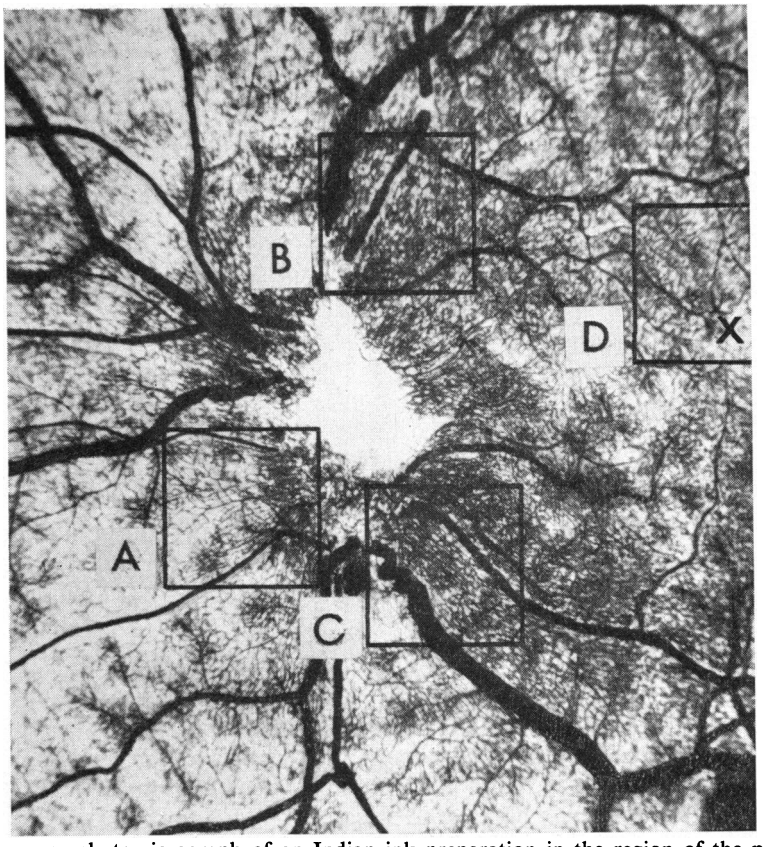
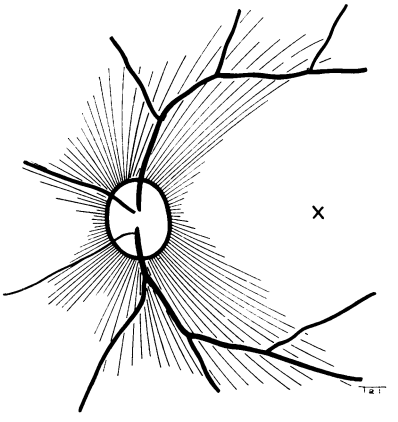


FIG. 1.—Low-power photomicrograph of an Indian ink preparation in the region of the posterior pole. Outlined in Square A is the nasal peripapillary area, in B the supero-temporal peripapillary area, in C the infero-temporal peripapillary area, and in D the superior portion of the macula. X marks the fovea.

FIG. 3.—Schematic diagram to illustrate the extent of the radial peripapillary capillaries in man. X marks the fovea.



With the higher power (×20) of the dissecting microscope, this layer of vessels was seen to lie superficial to the other retinal capillaries, and the individual vessels pursued fairly long straight paths which appeared to extend outwards from the optic disc. The vessels were of capillary size and they seemed to follow the course of the nerve fibres.

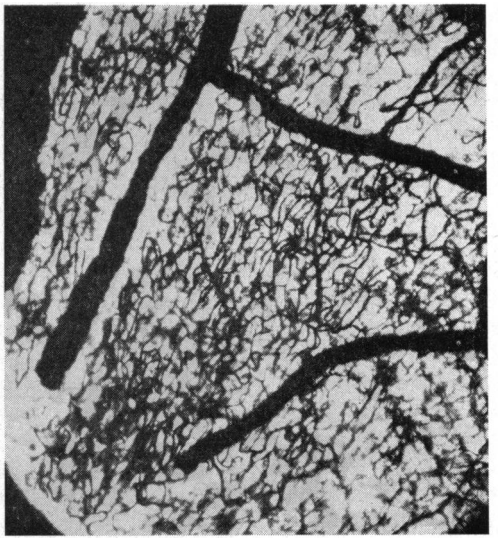
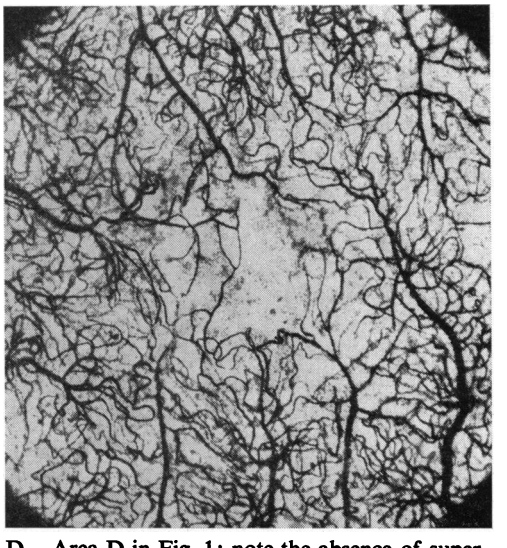


FIG. 2. A.—Higher magnification of Area C in Fig. 1, showing the dense aggregate of radially arranged infero-temporal peripapillary capillaries. × 40.

B.—Area B in Fig. 1, showing the supero-temporal peripapillary region. × 40.



C.—Area A in Fig. 1, showing the relative sparsity of radial peripapillary capillaries in the region nasal to the disc. × 40.

D.—Area D in Fig. 1; note the absence of superficial radial capillaries in the perifoveal region of the retina. × 40.

Light microscopic examination revealed that these superficial radial capillaries were derived from arterioles lying deeper in the retina (either in the outer part of the nerve fibre layer or within the ganglion cell layer). From this origin they rose steeply to reach the superficial nerve fibres (Fig. 4, overleaf). At this level they formed parallel rows of elongated capillaries which occasionally bifurcated, but they rarely anastomosed with each other. After travelling superficially for a variable distance, the capillaries appeared to enter into the deeper tissue, where they usually joined a

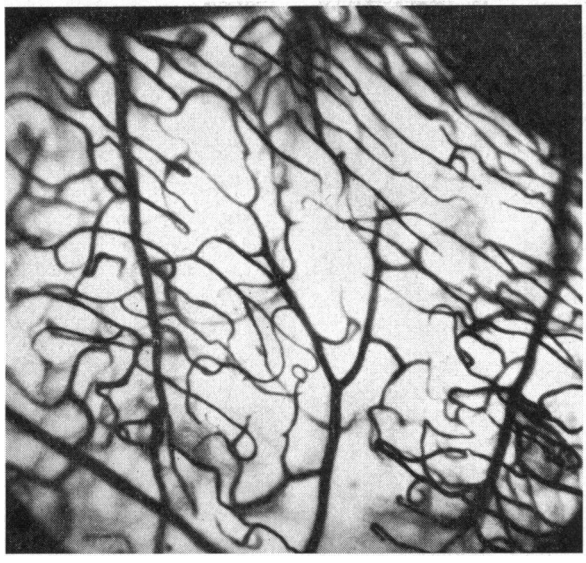


FIG. 4.—Higher magnification of an ink-injected human retina reveals the origin of the radial capillaries from more deeply placed arterioles. × 82.

venule. At their origin these superficial capillaries were sometimes in continuity with the deeper retinal capillaries, but their arrangement differed from that of the net-like deeper bed. The radial capillaries often traversed long distances (hundreds of μ to several mm.) but only occasionally did they cross major retinal arterial branches. In the temporal peripapillary region it was common to find radial superficial capillaries which arose separately from arterioles on either side of a major arterial trunk (Fig. 5) and, though the gross appearance often suggested the prolongation of a single capillary vessel which had dipped downwards before reappearing, careful examination revealed that this was rarely if ever the case.

The RPC did not seem to derive from arterioles within the disc, nor from retinal arteries which only contributed to the blood supply of the optic nerve-head, but rather from arterioles which arose in and nourished the peripapillary tissue of the retina.

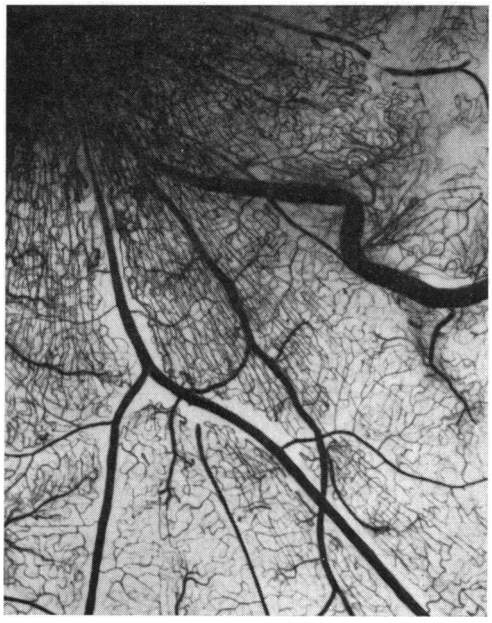


FIG. 5.—Radial capillaries are present on either side of a branch of the inferior temporal artery. They appear to arise independently from arterioles on either side of the artery (Courtesy of Prof. N. Ashton).

Monkey

Both the extent and configuration of the RPC layer in the two ink-injected retinae of the rhesus monkey were similar to those noted in the human specimens. Fig. 6 is a low-power view of the disc and macular region of a monkey. Higher magnification of the area enclosed in the square demonstrates the character of the RPC. Focusing from the superficial to the deep retinal vessels shows that the first capillaries which come into view are straight and elongated (Fig. 7*a*), while those more deeply placed have a net-like arrangement (Fig. 7*b*, *c*).

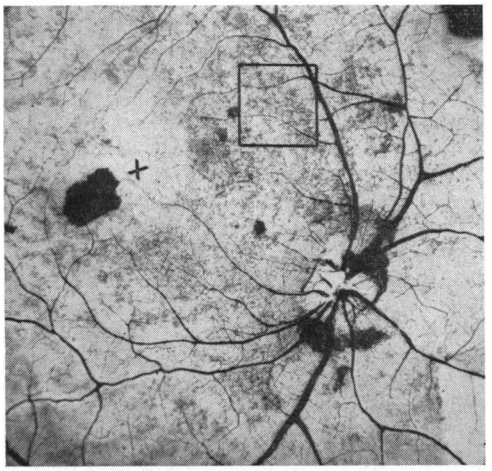


FIG. 6.—Low-power photomicrograph of an Indian ink preparation of a rhesus monkey retina in the region of the posterior pole. X marks the fovea. × 15.

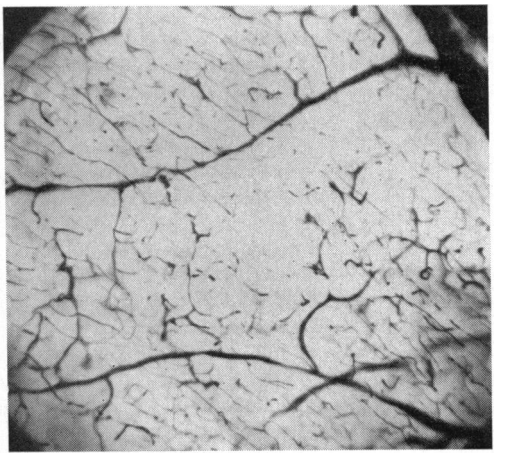
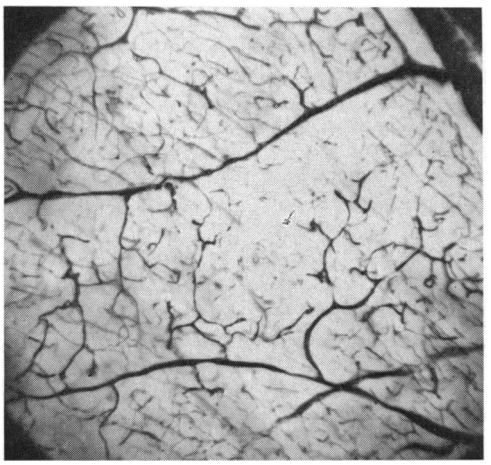
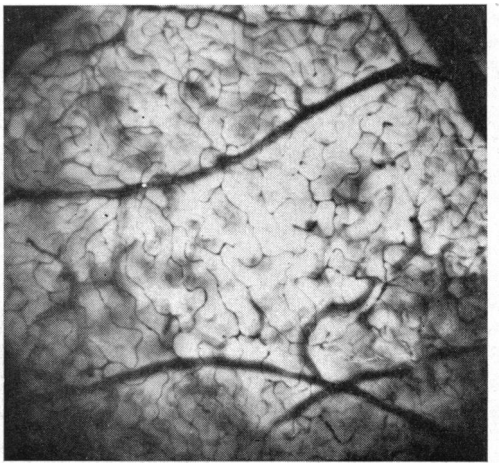


FIG. 7.—Higher magnification of area outlined in Fig. 6.
A.—Focus is on the most superficial retinal capillaries which have a radial orientation and pursue relatively long paths. × 70.



B.—Focus on the major retinal vessels which lie in the outer portion of the nerve fibre layer and in the ganglion cell layer. Few capillaries are in focus. × 70.



C.—Focus on the deepest retinal capillaries, showing their net-like configuration. × 70.

Still higher magnification emphasized the straightness of the paths taken by the superficial capillaries as compared with those in the deeper tissue (Fig. 8*a*, *b*, *c*).

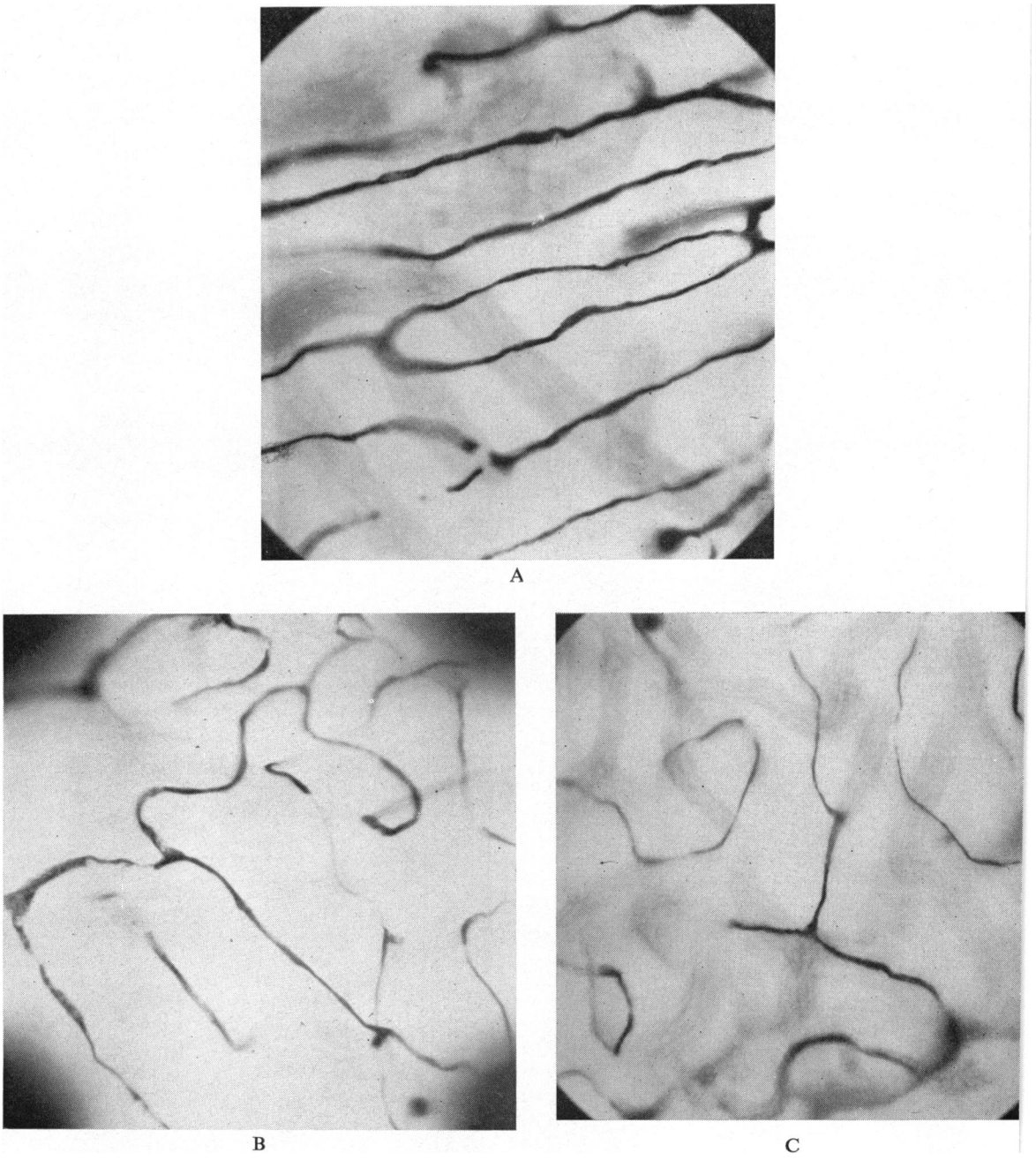


FIG. 8.—Higher magnification of region outlined in Fig. 6. × 337.
A.—Superficial capillaries radially arranged and pursuing elongated paths.
B and C.—Capillaries occupying deeper levels follow tortuous paths and do not occupy as distinct a level as those seen in the superficial nerve fibre layer.

Cat

In the adult cat the RPC layer is obvious around the disc and along the paths of the superior and inferior vessels (Henkind, 1965) (Fig. 9).

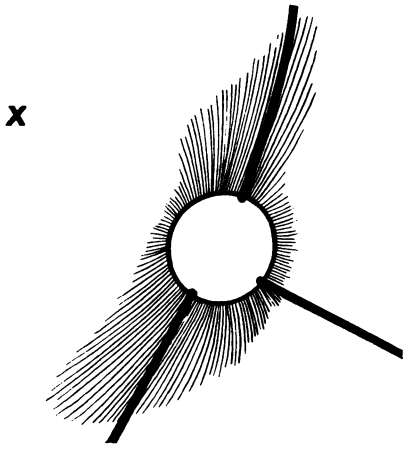


FIG. 9.—Schematic illustration to show the extent of the radial peripapillary capillaries in the right eye of a cat. X marks the apparent location of the fovea.

Though not as dense as in man or monkey, the RPC layer in the cat is well developed (Fig. 10*a*, *b*, overleaf), and the individual capillaries pursue non-anastomosing courses which may be several millimetres in length (Fig. 10*b*).

Pig

In the pig the RPC layer completely surrounds the optic nerve-head, but is most prominent in extent and density above and at the sides of the disc, and much less evident inferiorly (Fig. 11). In this species the larger retinal vessels lie upon or just within the inner retinal surface, and the RPC occupy the superficial portion of the nerve fibre layer (Fig. 11).

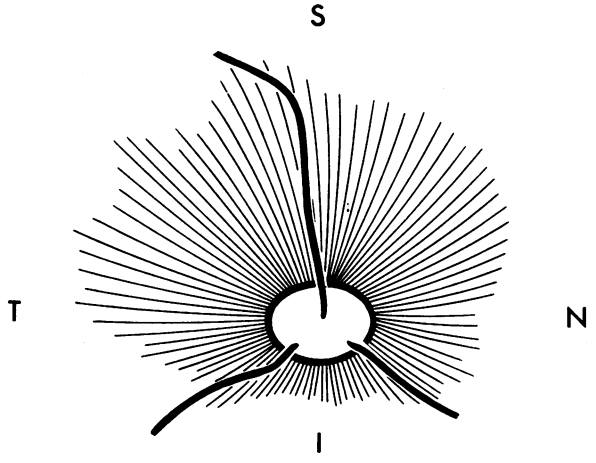


FIG. 11.—Schematic diagram illustrating the extent of the radial peripapillary capillaries of the pig. S–superior, N–nasal, I–inferior, T–temporal.

Discussion

Radial peripapillary capillaries are present in man, monkey, cat, and pig. They have been mentioned previously only in man, and then only briefly. Both Toussaint and others (1961) and François and Neetens (1962) felt that these capillaries arose

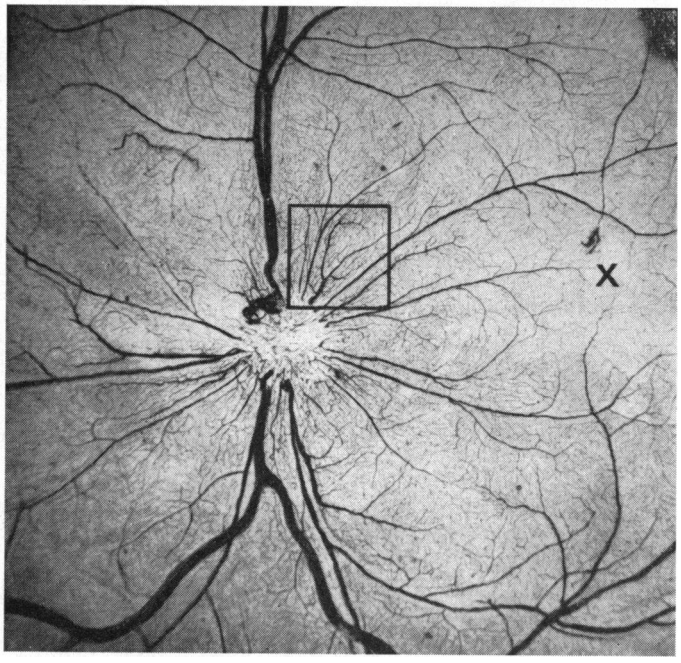
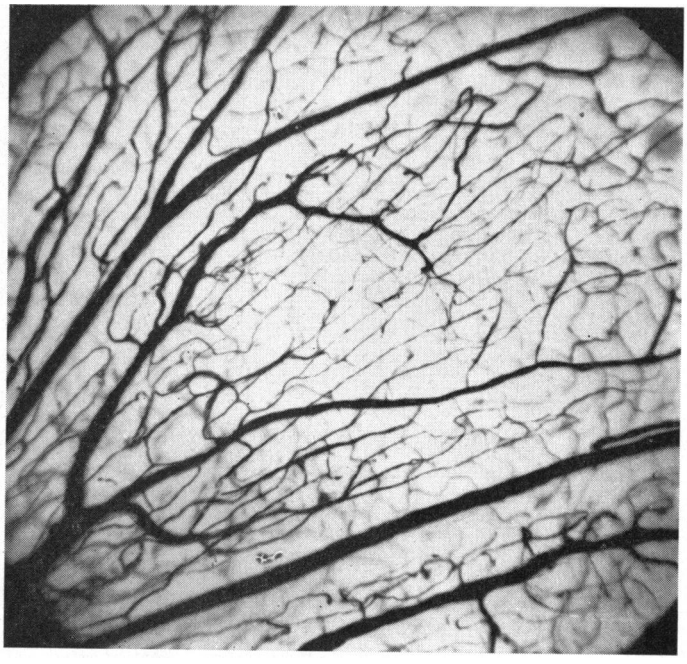


FIG. 10. A.—Low-power photomicrograph of an Indian ink preparation of a cat retina. X marks the location of the fovea. Note that there is a common inferior vein which bifurcates well below the disc. × 21.



B.—Higher power photomicrograph of area outlined in Fig. 10A. Note the long path of the superficial radial peripapillary capillaries. × 94.

from arteries which nourished the disc, but the present study demonstrates that they emanate mainly from intraretinal arterioles at the posterior pole, and not from the vessels on or of the disc. The RPCs have certain features which distinguish them from other retinal capillaries:

(1) They pursue relatively long straight paths;
(2) They rarely anastomose with each other in their superficial location;
(3) They are limited in distribution to the posterior pole, where they seem to be intimately associated with the superficial nerve fibres.

The RPCs probably nourish the inner portion of the nerve fibre layer around the disc, and it is in this location that the nerve fibres are thickest. According to Wolff and Penman (1951), the innermost nerve fibres near the disc derive from ganglion cells at the posterior pole, and these may be the fibres supplied by the RPC layer. Since the distribution of the RPCs resembles the pattern formed by a double Bjerrum scotoma, one wonders about their role in glaucoma and particularly in the pathogenesis of glaucomatous field defects. They may also be significant in the pathogenesis of "cotton wool" patches, and "flame-shaped" haemorrhages. The physiological and pathological implications of these vessels will be considered in another communicaton.

Summary

The radial peripapillary capillaries of the retina are found in a number of animals, and their extent and configuration in the pig, cat, monkey, and man are described. These vessels appear to nourish the superficial nerve fibres surrounding the optic nerve-head, and they may play a role in a variety of ocular lesions and disorders.

I should like to thank Prof. Norman Ashton for his guidance in this work, and the Department of Medical Illustration of the Institute of Ophthalmology, London, for the illustrations.

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