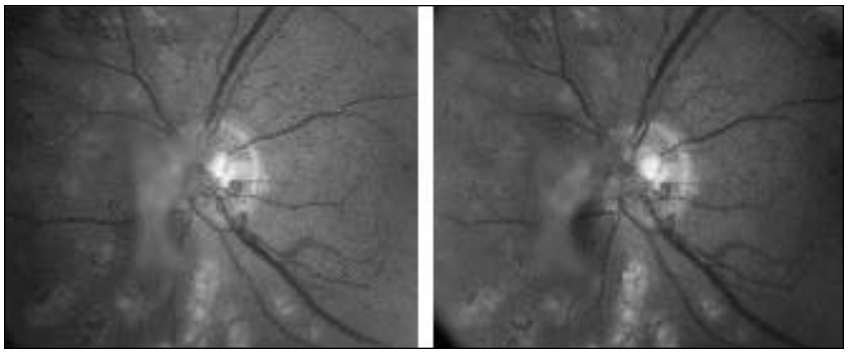
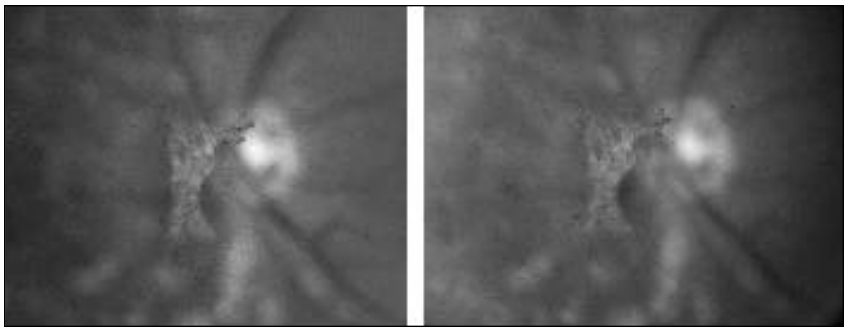


A

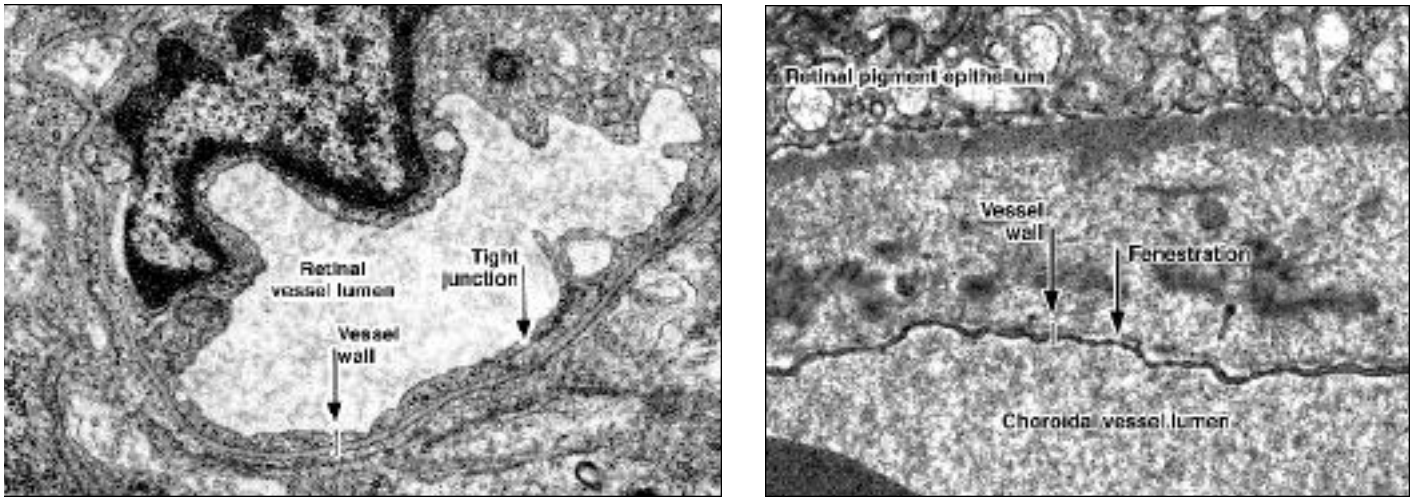


B

FIGURE 8-1
Information loss due to "improper" focus, not "poor" focus. The stereo pair in Ais adequately focused at the level of the optic nerve. However, the clinician will not be able to adequately assess elevated neovascularization, which requires a different level of focus, shown in stereo pair B.

better understand where you are now and so that the steps you take are always in the right direction."[3] The principle is encountered by the medical student in the second year in Introduction to Physical Diagnosis or a similar course. A philosophy of examination from such a course that I have always remembered comes from a widely used textbook on internal medicine: "The detection of a few scattered petechiae, a faint diastolic murmur, or a small mass in the abdomen is not a question of keener eyes and ears or more sensitive fingers, but of a mind directed to be alert to these findings. Skill in physical diagnosis reflects a way of thinking more than a way of doing."[4] Detection of subtle changes—that is, maximizing information—increases with preparation of the mind before the task. The photographer needs to develop a "way of thinking" to complement the technical training to help prepare for the photograph.

The paradigm proposed in this chapter is based on the clinical use of the photograph. Remember the perfect photograph of the macula when the physician was interested in the optic nerve? Perhaps not as obvious, but just as important, is the technically perfect photograph focused at the level of the optic disc when the clinician is interested in documenting elevated neovascularization of the disc (NVD) in proliferative diabetic retinopathy. The blood vessels may be sufficiently elevated to be out of the plane of sharpest focus, and the photograph will not be very useful to the physician 4 weeks later when assessing the response of the NVD to panretinal photocoagulation (Figure 8-1). The photographer needs to have this information before taking the photograph. Therefore, a useful framework for preparing for a photograph is a categorization of its purpose—that is, *why* was the photograph ordered? Table 8-1 lists three common reasons clinicians order fundus photographs: documentation, diagnosis, and treatment. Briefly considering this table before actually taking a photograph is useful, especially for the inexperienced photographer. In the



A B

FIGURE 8-8
Electron micrographs of ocular blood vessels. A. Tight junction in a retinal capillary that forms part of a blood-retinal barrier. B. Fenestrations in a choroidal vessel that allow passage of small molecules into the extracellular space. (Courtesy of I. Wallow.)

tation in the RPE cells, recognized by the early pathologists and responsible for the name *macula lutea*.[12] This pigmentation typically masks the choroidal vessels. In contrast, in lightly pigmented individuals or individuals without pigment, such as in an albino, the choroid may be easily visualized.

The choroid is the layer of blood vessels between the RPE and the sclera. In addition to location, the anatomy of the *choroidal circulation* differs from that of the retinal circulation in several important ways. First, the choroidal vessels do not have tight junctions. In fact, the choriocapillaris or small choroidal vessels are fenestrated—they are built to leak (Figure 8-8B). As a result, small molecules such as fluorescein freely diffuse into the extravascular space. Substances that leak out of the choroid are prevented from entering the retina by the outer blood-retinal barrier, the RPE. Rather than a single arterial source as in the retina, the choroid is supplied by multiple long and short posterior ciliary arteries, which are branches of the ophthalmic artery. In an angiogram, the choroidal circulation fills earlier than the retinal circulation because of the supply from the posterior ciliary arteries. Finally, the choroid is not a simple progressive branching type of vascular bed as is the retina but consists of an interlocking network (anastomosis) of blood vessels that function as lobules (Figure 8-9).[13] The lobular arrangement of the choroid can sometimes be seen in the early phases of a fluorescein angiogram or in certain pathologic situations, but the pattern is rapidly lost because of dye diffusion through the fenestrated capillaries. Because of the multiple sources of arterial supply to the choroid, it is not as susceptible to occlusion by embolic disease as is the retinal circulation; however, the blood supply can be interrupted by a diffuse process. In fact, choroidal ischemia due to occlusion of posterior ciliary arteries can be an important angiographic finding in temporal arteritis, an inflammation that generally causes occlusion of a number of different arteries.

Except for the blood vessels, normal retina is optically clear. It has to be, since the photoreceptors are at the “bottom” of the retina, and light

in 15% of individuals, and up to 30% of eyes.[14] When present, cilioretinal vessels will fill with the choroidal circulation.

After the appearance of dye in the choroid, it next enters the retinal arteries (*arterial* phase), followed very rapidly by the veins over the next 1–2 seconds, the *arteriovenous* phase. Initially dye does not fill the veins but is visible along the edge of the vessel walls in a very characteristic pattern (Figure 8-10C). This pattern is a result of laminar flow of blood in the vessel. As anyone who fishes for trout knows, water (or blood) flows through a stream (or blood vessel) in one of two patterns—either laminar or turbulent. "In laminar flow, all the molecules of water move parallel to each other in a single direction. In turbulent flow, there are countless little eddies and whirlpools that move the water in all directions as the main current moves downstream."[15] When dye moves from the smaller venous branches into the peripheral "lamina" of fluid along the wall of the larger veins, it tends to move in a position that stays in constant relation to the vessel wall. After a short period of time, however, there is sufficient mixing of dye to cause the entire vessel to fluoresce.

In a normal eye, the central macula appears to be less fluorescent than surrounding tissue (Figure 8-11A). The decreased fluorescence is a consequence of two features of normal anatomy shown schematically in Figure 8-11B. First, retinal blood vessels are not found in a circular area approximately 500 microns (0.5 mm) in size in the center of the macula. This region is called the *foveal avascular zone* (FAZ) and includes the fovea, a specialized retinal section that contains a higher concentration of cones. The FAZ is responsible for the sharpest vision and is important to the clinician because it is a guide in laser treatment. In some individuals the perifoveal capillaries cannot be well visualized, but failure to do so does not necessarily indicate an abnormality. In addition to an absence of dye in retinal vessels in the FAZ, dye in the underlying choroid is not well visualized because the RPE contains a higher amount of pigment here compared to other regions.

As the angiogram progresses to the *venous* phase, fluorescence fills the veins and decreases in intensity in the arteries (Figure 8-10D). In the *recirculation* phase, dye that has already exited the eye through the venous system reenters, and the intensity of fluorescence in the arteries and veins is approximately equal (Figure 8-10E). Subsequently the overall intensity of fluorescence continues to decrease—the *late* phase—as dye is further diluted and excreted.

Abnormal Fluorescein Angiogram

Initially it is useful to characterize the findings in the abnormal fluorescein angiogram using the "second level" of clinical information discussed previously—concentrate on what differs from normal. With this starting point for analyzing a fluorescein angiogram, one must learn to recognize variations from the normal patterns as areas of either decreased fluorescence (*hypofluorescent*) or increased fluorescence (*hyperfluorescent*) (Table 8-4). A hypofluorescent area may be due either to an absence of dye or blockage of the dye by some other material such as blood (Figure 8-12A). A hyperfluorescent area compared to a normal eye can be due to an increase in the amount of dye, termed either *staining*, *pooling*, or *leakage*, or to better visualization of a "normal" amount of dye (window defects) (Figure 8-12B). Clinical examples can show how the purpose of the test emphasizes aspects of technique.

passively recording events. The ability to apply photographic technique in this manner requires an understanding of normal ocular anatomy, normal and abnormal fluorescein patterns, and clinical information and experience. Table 8-5 is included as a "jump start" for beginning and intermediate photographers who want to achieve this goal. It truly is a pleasure to have the photographer as an active participant on the medical care team.

Table 8-5. Disease-Specific Fundus Photography and Fluorescein Angiography

Age-related macular degeneration		
Nonexudative	Colors	Drusen, pigment change. Severity of disease, absence of fluid or hemorrhage, change with time.
	Location	RPE disease; macula.
	FA	May be required to ensure absence of CNV.
	Other	
Exudative	Colors	Document subretinal fluid or hemorrhage in macula, response to treatment.
	Location	RPE disease; macula.
	FA	Demonstrate CNV; imaging of FAZ important for treatment. Used to decide if treatable and then to guide laser treatment. Occasionally diagnostic.
	Other	Stereo FAis very important—required for accurate diagnosis of CNV. The pattern alone is insufficient.
Artery occlusion		
	Colors	Retinal edema, possibly an embolus in an arteriole. May look normal weeks after the event.
	Location	Retinovascular disease. Any field.
	FA	To assess restoration of perfusion and ischemia, and determine prognosis. Include disc in field.
	Other	
Acute multifocal posterior placoid pigment epitheliopathy (AMPPE)		
	Colors	Acute lesions are flat and white; resolve without pigment changes. (see Serpiginous Choroiditis)
	Location	RPE/choroid; Posterior pole.
	FA	Acute lesions block early in the study with late staining.
	Other	
Birdshot		
	Colors	Retinal edema, papilledema, depigmented areas, progressing to numerous deeply depigmented patches showing choroidal vessels.
	Location	RPE/choroid. Depigmentation scattered in posterior pole, often sparing macula.
	FA	Macular edema may be present. Early choroidal lesions not visible.
	Other	
Central serous retinopathy		
	Colors	Fluid under RPE and/or neurosensory retina.
	Location	RPE; Macula.
	FA	Occasionally to rule out choroidal neovascularization. Occasionally to guide treatment in recurrent, persistent, or bilateral cases.
	Other	Stereo is important since leak is deep. Also can show elevation of neurosensory retina. Document with green filter.
Choroidal nevus/tumor		
	Colors	Document extent of lesion. Assessment of growth. Assist diagnosis in some cases. Red filter may help define borders and assist in focusing.
	Location	Choroid; any field. Achoroidal lesion but may be highly elevated; focus on base of lesion for extent, apex of lesion to indicate depth. Wide-angle view may be useful.
	FA	May be used to image tumor vascularization.
	Other	Stereo helpful to give some indication of elevation; differential focusing for stereo.
Coats disease		
	Colors	Serous retinal detachment; often massive amounts of hard exudate.
	Location	Retinovascular disease; macula or periphery.
	FA	Diagnostic. Demonstrates areas of involvement with irregular vessel dilation, leakage, and nonperfusion.
	Other	Wide angle may be useful. May require FAduring EUAfor young children.
Cytomegalovirus retinitis		
	Colors	Retinal hemorrhage, multiple gray and white retinal lesions in active disease. Progresses to area of atrophic retina with underlying RPE disturbance. Wide angle useful.
	Location	Retinitis; any field.
	FA	
	Other	