EXAMINING THE OCULAR FUNDUS AND INTERPRETING WHAT YOU SEE

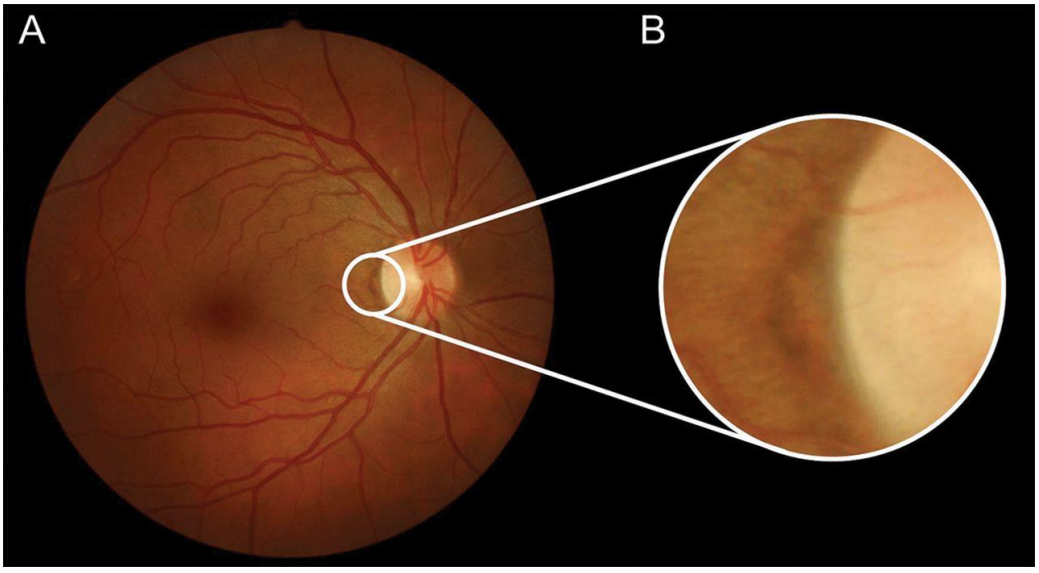
Beau B. Bruce, MD, PhD
Emory University
Atlanta, GA

Introduction

Traditionally, most neurologists would have used a direct ophthalmoscope to examine the ocular fundus (optic nerve, macula, and retina and vessels of the posterior pole of the eye). However, ocular funduscopy appears to be a dying art,[1] and emerging technologies, such as non-mydriatic ocular fundus cameras and smartphone attachments may make the direct ophthalmoscope obsolete.[2]

Methods for Examining the Ocular Fundus

Advantages of direct ophthalmoscopy have traditionally included (1) a 15× magnified view of the posterior pole that facilitates appreciation of small, dynamic changes of the ocular fundus, such as venous pulsations and circulatory changes; (2) wide availability and portability—the direct ophthalmoscope is easily carried in the pocket of a clinician's coat and can be used in settings where other methods of ocular fundus examination are unavailable; (3) relatively low cost; (4) its practicality as a tool for ocular fundus examination in critical care patients; and (5) its potential usefulness in the examination of low-amplitude nystagmus and subtle abnormalities of visual fixation. However, direct ophthalmoscopy, particularly through an undilated pupil, is difficult to master and requires considerable practice to attain the level of proficiency needed to reliably detect relevant ocular fundus findings. The classic direct ophthalmoscope's 5° field of view is too small to resolve all of the relevant details of the optic disc and retina at once and thus requires the examiner to search for relevant findings. The PanOptic direct ophthalmoscope (Welch Allyn, Skaneateles Falls, NY) was introduced in 2001 and may provide up to a 25° field of view, which results in a wider, but less magnified view of the optic disc. Pharmacologic pupillary dilation is essential to an accurate funduscopic examination and may take 30 minutes or longer. In a practice climate overshadowed by increasing time pressures, clinicians in busy practices are unlikely to spend the extra time necessary to perform a thorough funduscopic examination. Even when direct ophthalmoscopy is performed, students and physicians demonstrate a lack of confidence in their findings, further minimizing the ability of the ocular fundus examination to positively affect patient care.[3,4]



(A) Nonmydriatic ocular fundus photography. (B) Classic direct ophthalmology. The 45° field of view from the nonmydriatic fundus photograph allows simultaneous examination of the optic disc, macula, and major vascular arcades. The 5° view (15× magnification) from the classic direct ophthalmoscope is useful for detailed,

but isolated, examination of the optic disc margins, the macula, and dynamic phenomena such venous pulsations when centered on the optic disc, but adds difficulty to the integrated examination of the retina and other details of the ocular fundus. (Mackay et al. Neurol Clin Pract 2015;5:150-157)

Ophthalmoscopy has long been considered an essential part of the physical examination in patients with headache. Whereas most patients with headache who visit an emergency department have a primary headache syndrome, the detection of optic disc edema is indispensible in determining which patients have a more serious underlying cause. Patients from the Fundus photography vs Ophthalmoscopy Trial Outcomes in the Emergency Department (FOTO-ED) study were the subject of a recent study in which ocular fundus photographs were used to determine the rate and predictors of abnormal ocular fundus findings among patients with headache in an emergency department setting.[5] Of the 497 patients in the study with headache, 42 (8.5%) had relevant ocular fundus abnormalities, including isolated retinal hemorrhages, optic disc edema, grade III or IV hypertensive retinopathy, and optic disc pallor. Importantly, many of the patients with ocular fundus abnormalities had unremarkable physical examinations and 41% had normal neuroimaging studies, reinforcing the critical role of ocular funduscopy in patients with headache.

Ocular fundus examination is particularly important for neurologists, as the identification of papilledema, optic disc pallor, or retinal vascular occlusion can lead to life- and vision-saving interventions. Recent evidence suggests that even mild abnormalities of the ocular fundus, which may easily be missed with direct ophthalmoscopy through an undilated pupil, may have important implications for neurologists. For example, patients with a TIA or acute stroke are more likely to have visible abnormal retinal microvascular signs than the general population.[6] Additionally, fundus photography may have a role in stroke risk assessment by screening for signs of microvascular retinal disease.[7]

Advantages of ocular fundus photography include its ease of use, its ability to document a patient's ocular fundus appearance as a baseline for future comparison, the ability to electronically magnify regions of interest in photographs, the ability to archive and send photographs electronically, and the great potential of fundus photography as an educational tool. The nonmydriatic fundus camera's current limitations of cost, portability, and limited application in the critical care setting are likely to become less relevant as innovation continues to propel the technology's rapid evolution.

Key Tips for Direct Ophthalmoscopy of the Ocular Fundus

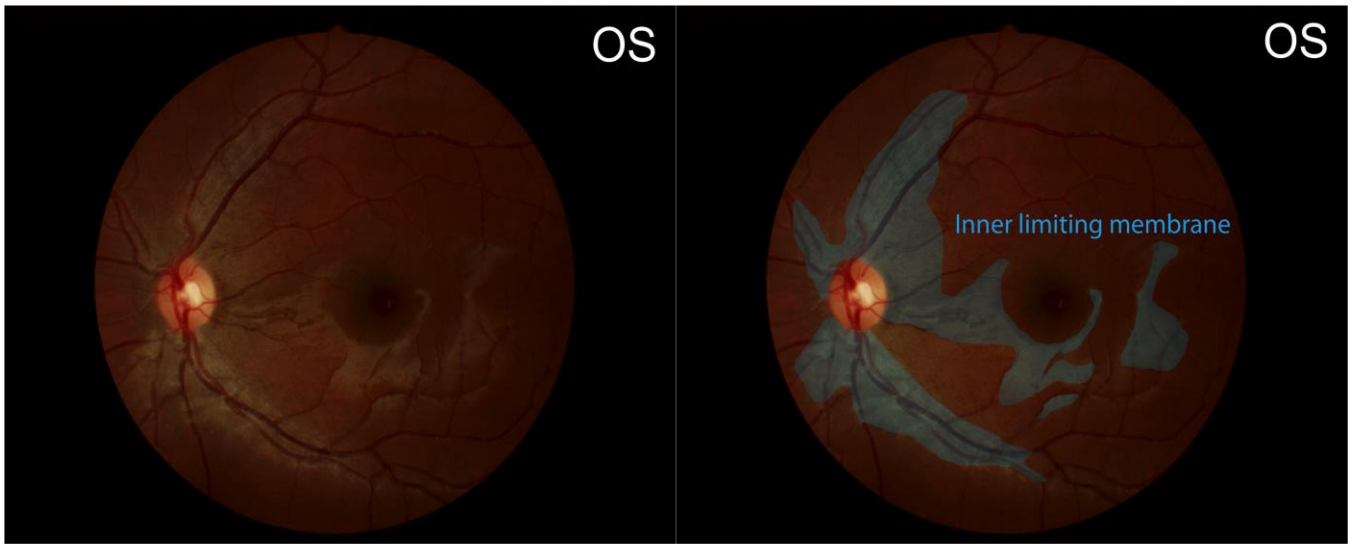
- Make sure you and the patient are oriented at the same height.
- Dilate the pupils whenever possible. This is generally safe unless the patient reports a history of *angle closure* glaucoma. Ordinary, common primary open angle glaucoma (POAG) patients are safe to dilate.
- If you want to be extra cautious, shine tangential light across the iris from the side, as long it appears flat and isn't bowing forward it should be safe to dilate.
- Regardless of whether the patient is dilated, examining the fundus with a direct ophthalmoscope is like looking through a keyhole, you have to get as close as possible.
- However, before you get close, start fairly far from the patient, identify the red reflex, and follow it in. If you lose the reflex, start over.
- Also, make it your goal to first see the optic disc. This is more comfortable for the patient because the optic nerve is our "blind spot". To accomplish this, have the patient look straight ahead while you come in from about 30 degrees temporally.
- Always use your right eye to examine the patient's right eye, and vice versa, otherwise you will definitely be uncomfortably in the patient's face if you are close enough to properly examine the patient.
- If you find this difficult, start by practicing with your dominant eye, this is the eye you look through a monocular microscope with. You can also identify your dominant eye easily using this approach: http://www.diyphotography.net/a-neat-trick-to-determine-your-dominant-eye/.
- The proper movement while examining the fundus is more along a sphere's surface than along a plane as you examine the fundus.
- Remember that the retinal vessels are like a tree branching from its trunk. Keeping that in mind, you will know how to follow them back to the optic nerve. From there you can examine each quadrant.
- Once you assess the nerve do not forget to take a look at the macula. It is located slightly inferior and temporally to the optic disc.
- Don't give up! Direct ophthalmoscopy is like many complex motor activities: driving a manual transmission car, ballroom dancing, or sailing a boat: you have to do multiple independent actions in concert for it to work. It takes practice!

Interpreting What You See

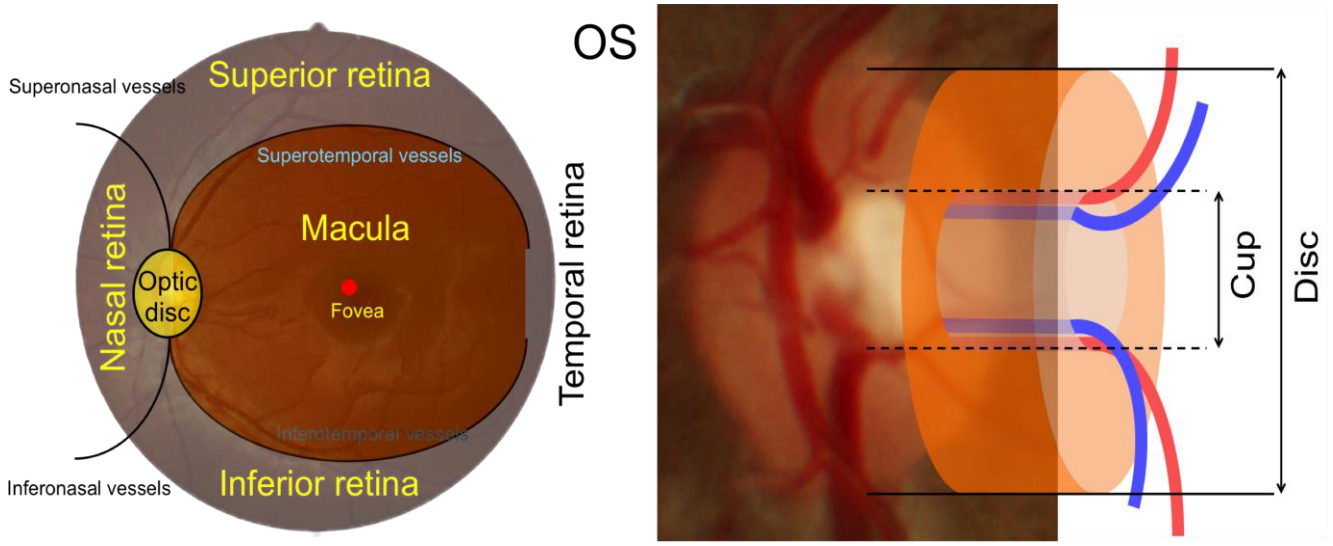
The following sections will discuss interpreting fundus photographs, but the same principles apply to direct ophthalmoscopy. However, a discussion of fundus photography interpretation also permits a discussion of common artifacts seen on photographs that will be useful as this technology becomes more widely deployed.

Normal Fundus

The first task is to identify which eye is in the photograph. In order to do this, imagine yourself looking at the patient: the optic disc (the optic nerve) is always on the same side as the nose. On this photograph, the optic disc is on the left, meaning that this is a photograph of the left eye.

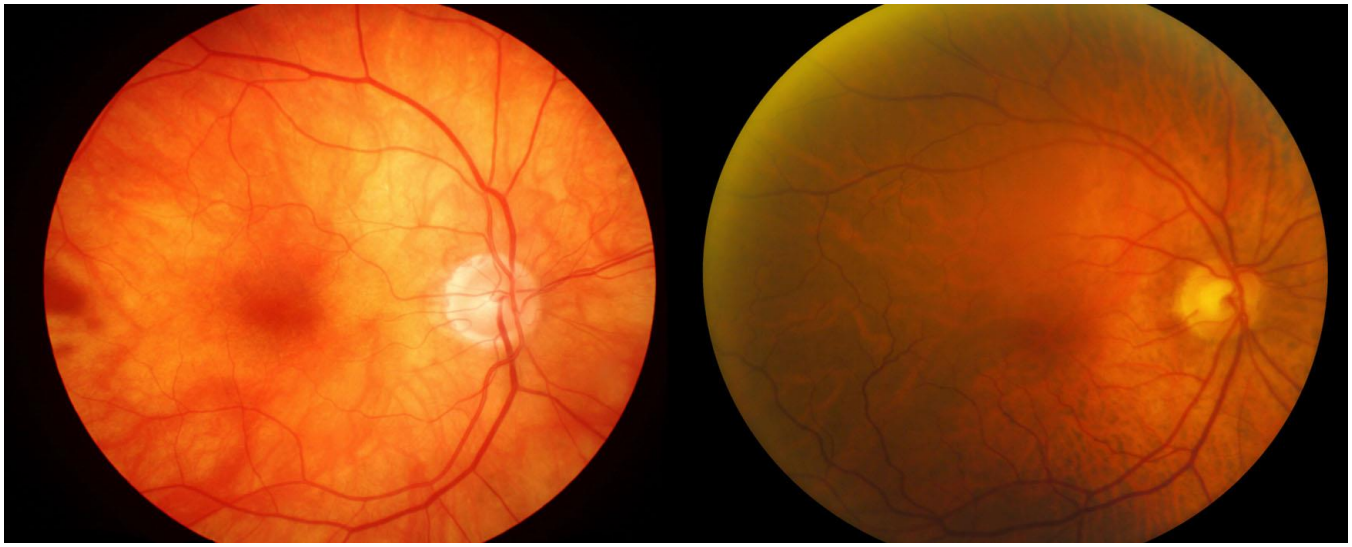


This fundus is normal, but shows one of many normal variations. Indeed, non-ophthalmologists can be confused by the reflective regions in the upper-left figure, which we have highlighted in the upper-right figure. This reflective region is frequently seen in young people and is called the inner limiting membrane.



The left figure above shows the anatomical regions of the ocular fundus. The retinal vessels emerge from the optic disc into four arcades (superonasal, superotemporal, inferonasal, inferotemporal vessels). The macula is the portion of the retina surrounded by the temporal vessels. The fovea is the center of the macula. Despite its small size, the fovea is responsible for most of our visual acuity. Beyond the macula, the retina is broken down into superior, inferior, temporal and nasal regions.

The right figure above shows you a normal optic disc: a pinkish-orange ring with a sharp edge surrounding a whiter center. The "3-D" figure to the right illustrates how the en face appearance on photographs arises from the structure of the optic nerve's disc and cup components. The "cup-to-disc ratio" is the ratio between the vertical length of the optic disc and the vertical length of the center of the disc devoid of optic fibers (i.e., the cup, whitish part of the optic disc).



The two above pictures show two variants of normal fundus. The left picture show a “blond” fundus with "tangled" orange streaks coursing behind the retina vessels. These streaks are normal choroidal vessels. In addition, the left picture appears "yellow" in the center. This is related to low pigmentation in the fundus, as frequently seen in blond patients, or those with a thin retina, as seen in highly myopic patients. The right picture shows a “tigroid” appearance seen in patients who have more darkly pigmented retinas. This is most often seen in patients with brown eyes and darker skin colors. Here you see dark pigments between the choroidal vessels giving the appearance of tiger stripes.

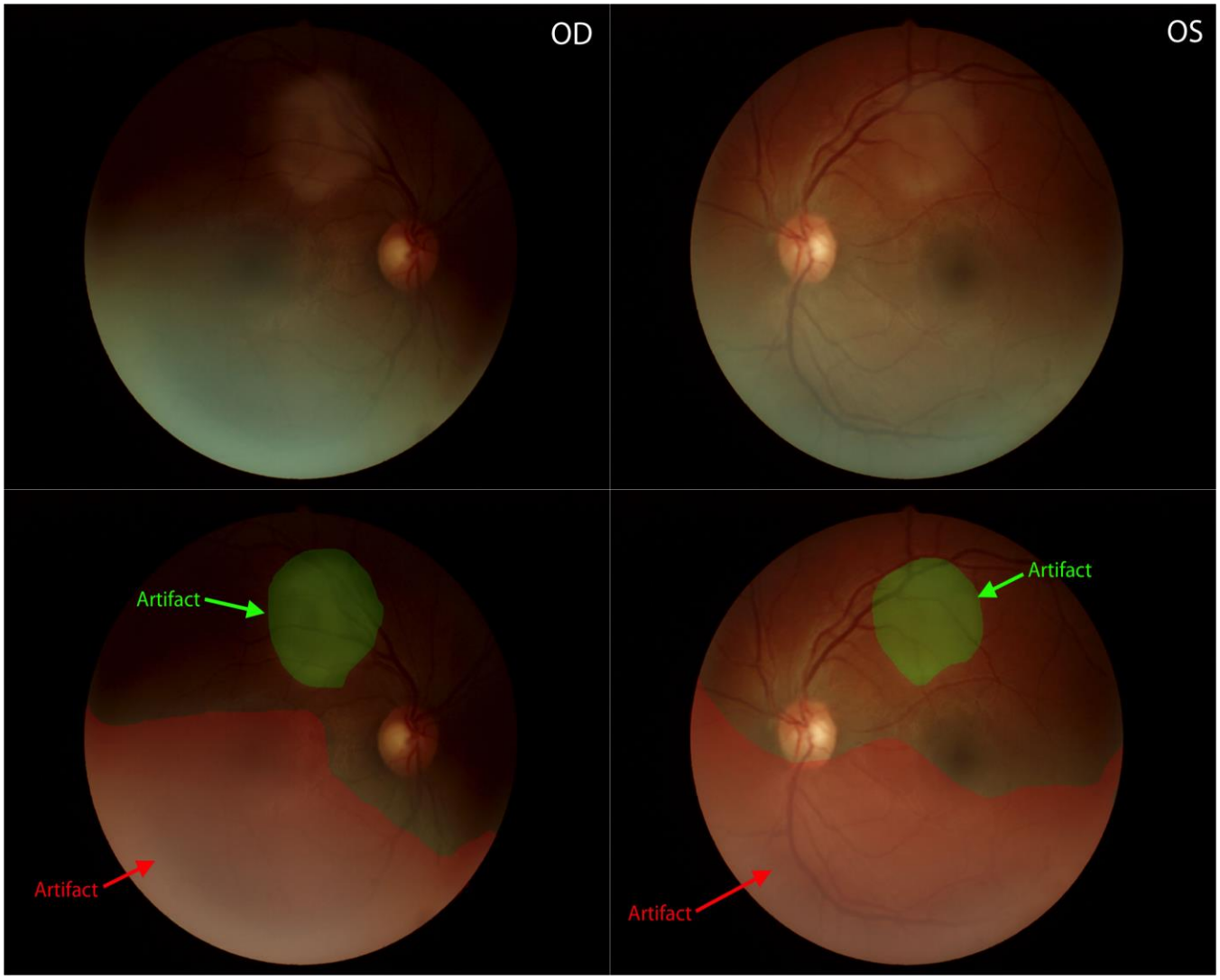
Artifacts

Sometimes, artifacts appear on fundus photographs, often due to camera-to-patient misalignment or insufficient pupillary size.

In case of doubt, check if the presumed artifact is still present or has moved in relation to the retina on another photograph in the same eye or if it is still present in the same area on a photograph of the other eye (as shown on these photographs). Indeed, the cloudy white area above the fovea (labeled in green) on these two photographs is artifactual.

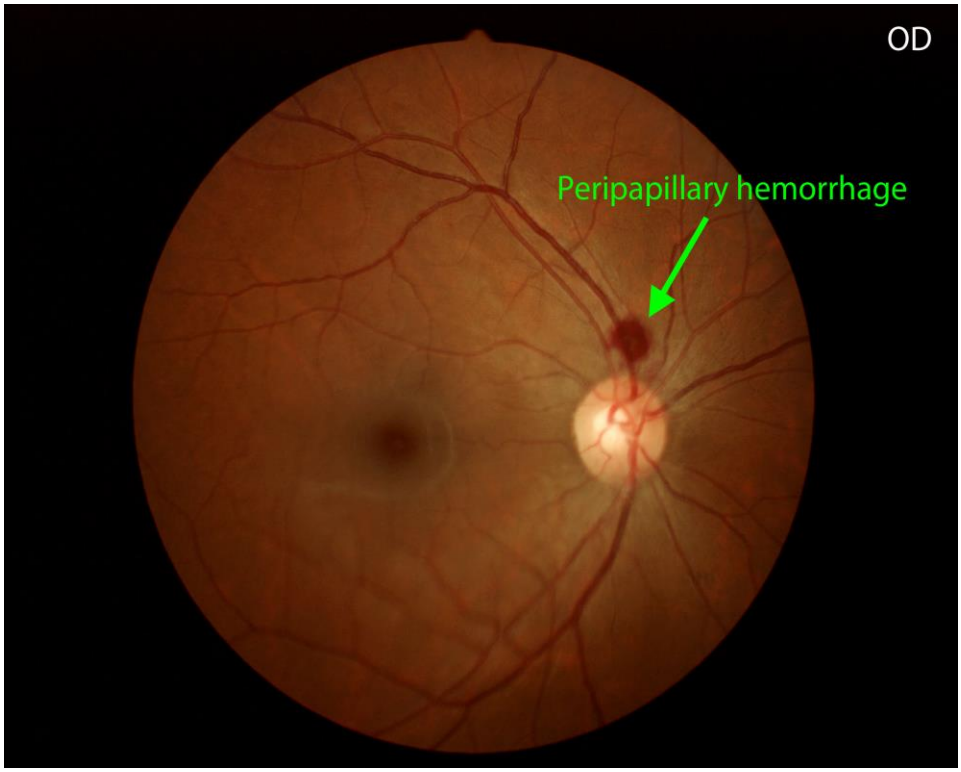
The bilateral whitish areas seen inferiorly (labeled in red) are also artifactual and related to the small pupillary size.

Although the quality of these photographs is suboptimal, all major findings can be easily ruled out.



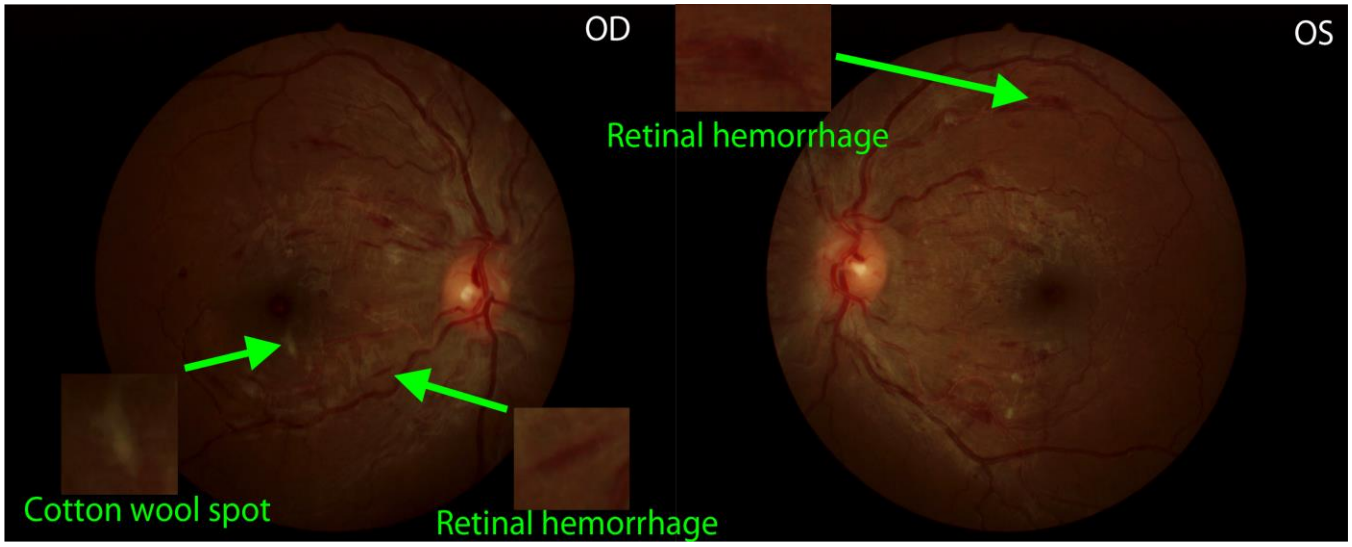
Hemorrhages

Retinal hemorrhages are frequent retinal abnormalities. They can be isolated, as shown in this photograph, or associated with other retinal abnormalities as discussed below. They appear as well-formed red-colored regions. Their shape varies according to their localization within the layers of the retina - the common shapes are flame, splinter, and blot. This photograph shows a typical blot shape.



Severe hypertensive retinopathy

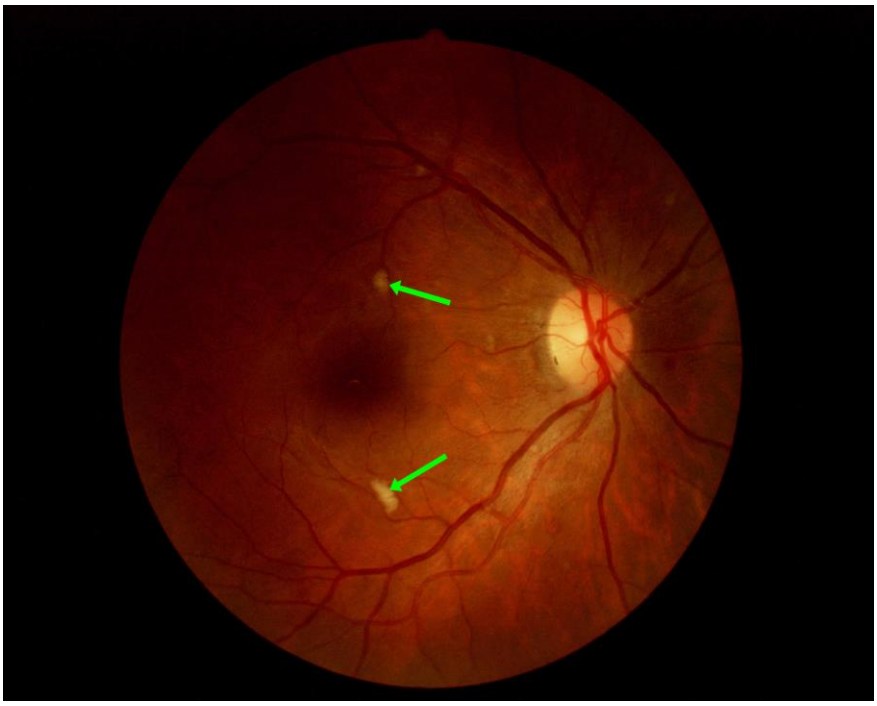
In these photographs, several retinal hemorrhages are seen, but they are not isolated as seen previously, and are instead associated with other abnormalities.



The numerous white lesions look like small pieces of cotton lying on the retina. They are called "cotton wool spots." Cotton wool spots are non-specific, and correspond to microinfarction of retinal nerve fibers.

The third abnormality is optic disc edema in the left eye. Optic disc edema is described in more detail below.

The combination of optic disc edema, retinal hemorrhages, and cotton wool spots typically indicate severe hypertensive retinopathy when these findings occur together bilaterally.

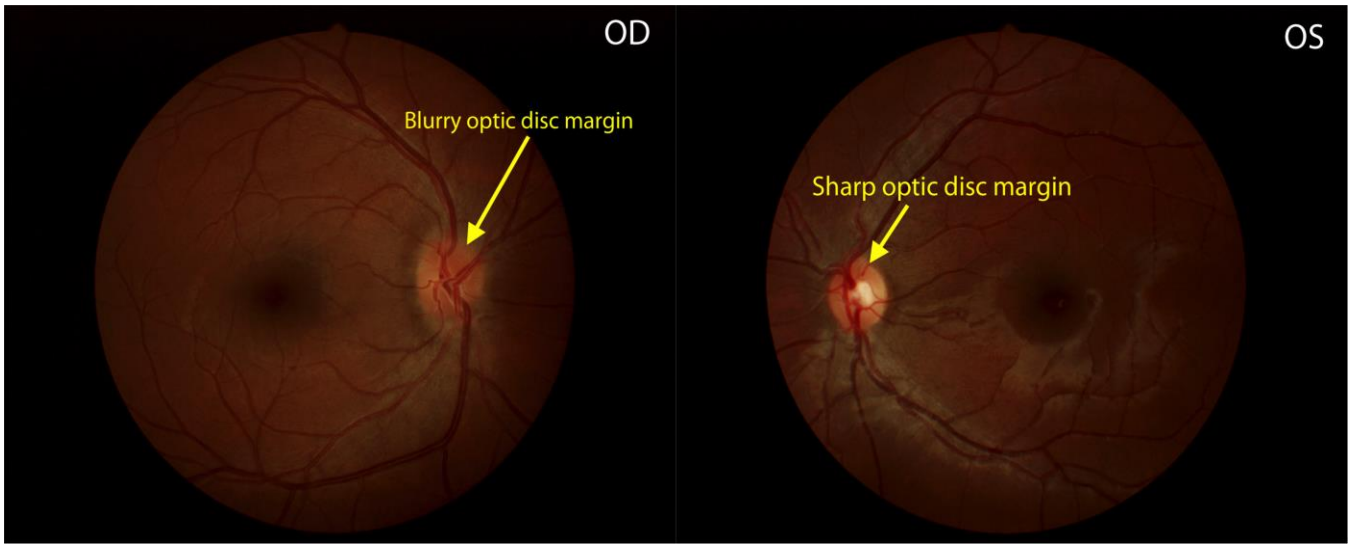


Cotton wool spots are sometimes difficult to spot, especially when associated with other findings, as seen in the previous photographs. To better understand their appearance, the above photograph shows two isolated cotton wool spots (green arrows).

Optic Disc Edema

The edge of the optic disc should be sharp and clearly demarcated from the retina. The optic disc is also usually flat. Both of these features are seen on the photograph of the left eye (OS).

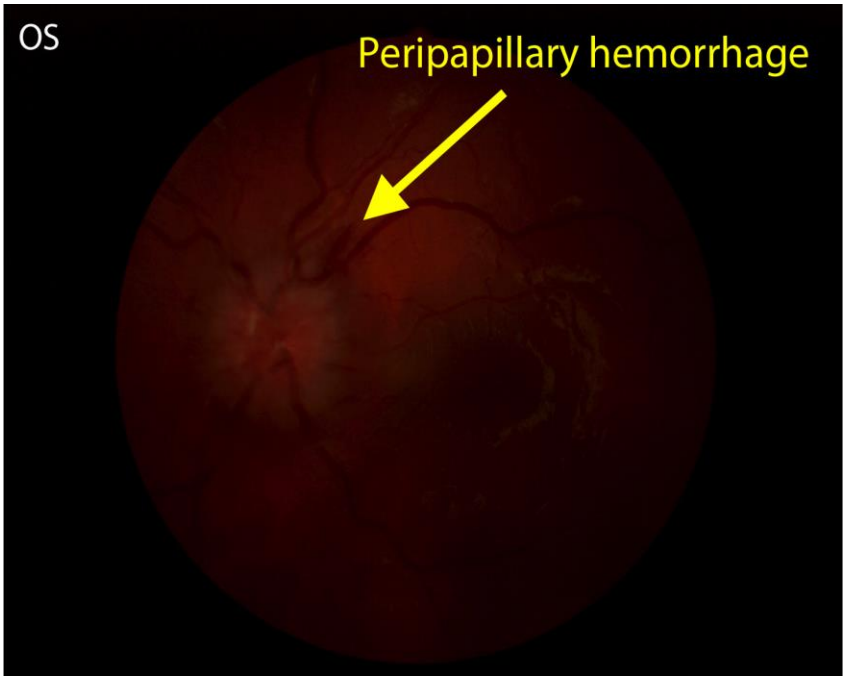
In this case, the edge of the right optic disc (OD) is indistinct and if you follow the blood vessels into the disc you can appreciate some areas where they appear to be reaching the edge of an elevation at the optic disc margin before crossing over the a bump where the optic disc is edematous. These features are strongly suggestive of optic disc edema, which is mild in this case.



The following photograph is challenging because it is dark, probably due to an insufficient pupillary size.

Nevertheless, even though the retina is poorly seen, close examination of the optic disc shows a very blurry edge consistent with severe optic disc edema. There is also a flame shaped hemorrhage at the superotemporal margin of the disc, which is frequently seen with more severe disc edema.

Always remember that even when the photograph quality is poor, a thorough examination of the picture can often provide useful information, particularly about the optic disc.



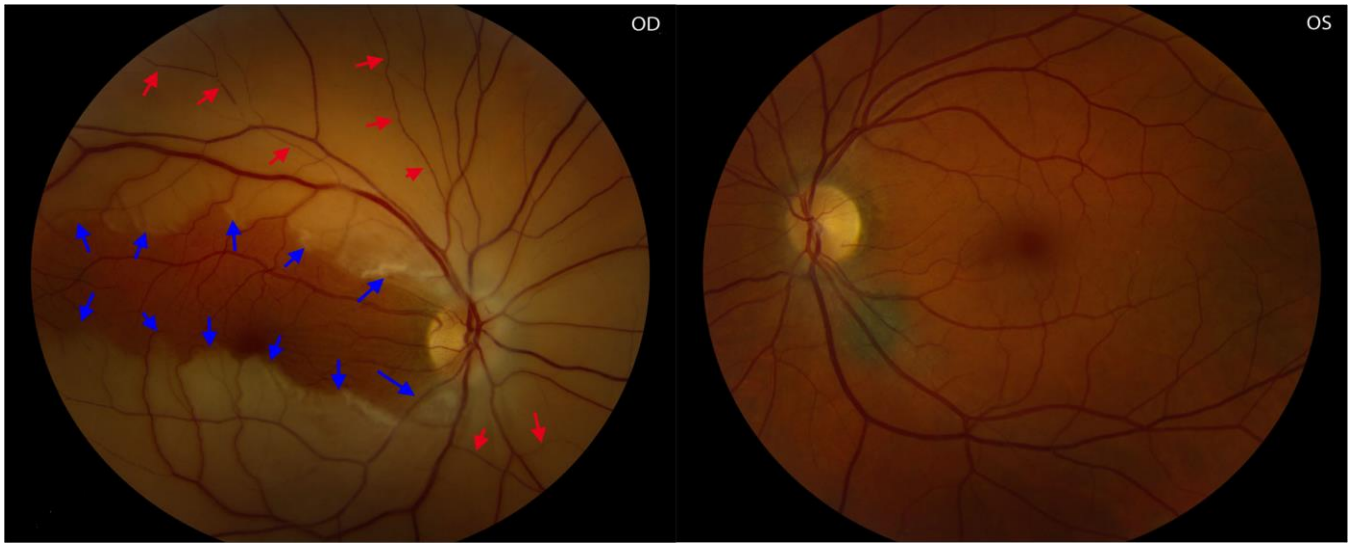
Central retinal artery occlusion

This photograph shows a central retinal artery occlusion in the right eye (OD). Clinical signs are obvious in this picture, but can be subtler, leading to misdiagnosis.

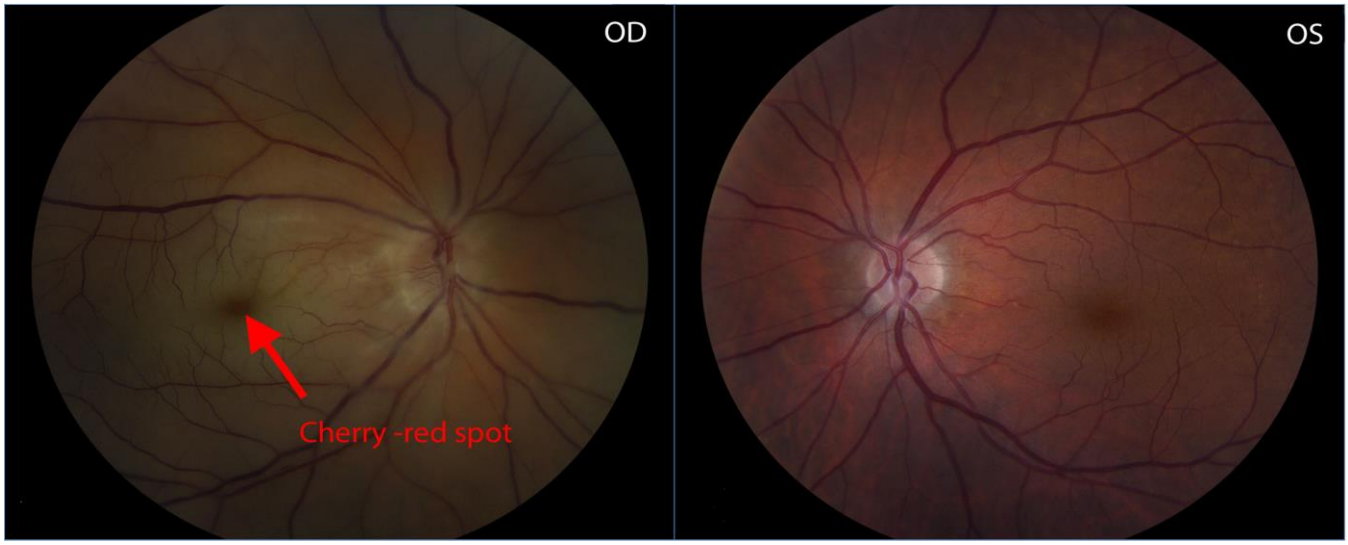
The right eye picture shows the contrast between the normal, spared retina and the white, ischemic retina. So, when a patient complains of sudden, unilateral, and severe visual loss, check carefully for following abnormalities that are seen in this picture:

- absence, "boxcar" appearance, or severe thinning of the retinal arteries (red arrows)
- a whitening of the retina in the region of the occlusion, corresponding to ischemic retina (blue arrows).

The typical cherry red spot sign (where only the fovea appears red) is missing in this picture, because this patient has a large blood vessel supplying the central portion of the macula.



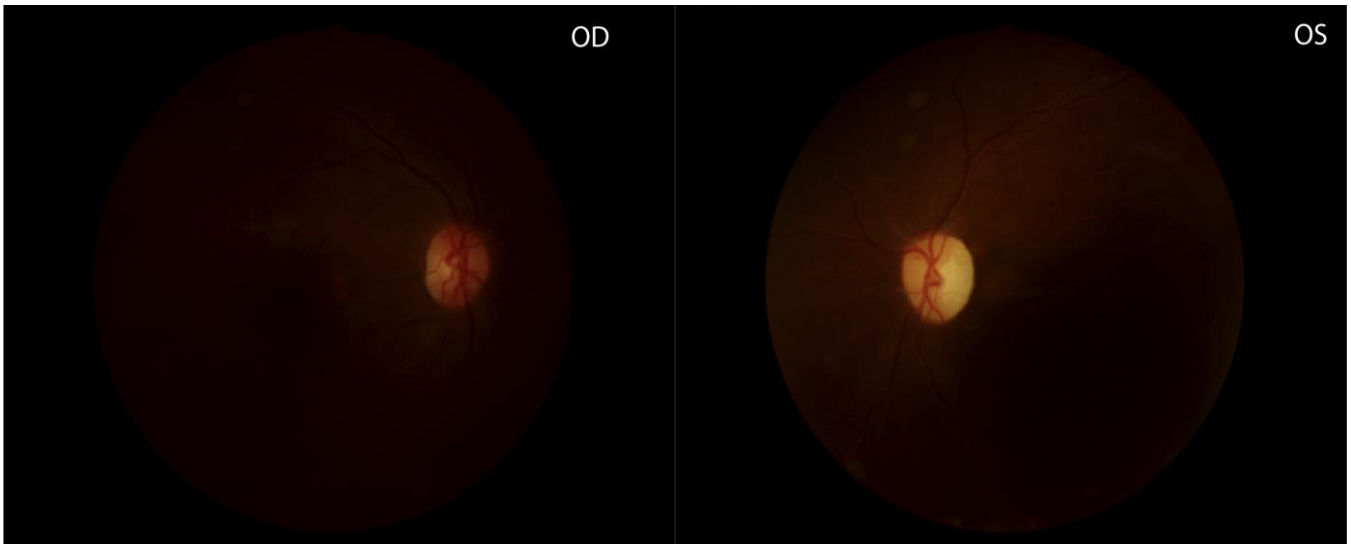
The picture below shows a subtler, and more typical, retinal vascular occlusion in the right eye (OD) with a cherry-red spot in addition to abnormal retinal arteries and retinal whitening (compare to the patient's left eye [OS]).



Optic disc pallor

The optic disc is usually pink-orange as seen in other pictures. This picture shows an abnormally white optic disc in the left eye raising concern for optic disc pallor.

However, color assessment of the optic disc is highly subjective and can be influenced by photographic exposure, leading to mis- or overdiagnosis. If visual loss is unilateral, the best way to determine if pallor is present is to compare the optic disc color of the patient's two eyes, like the figure below.



Moderate to severe pallor is never associated with color changes only. Note that there is also a lack of small vessels on the temporal part of the left optic disc (OS) in the region of pallor compared to the right optic disc.

Again, due to photographic quality, the retinas are essentially unanalyzable, but optic discs can still be evaluated accurately.

While color assessment of the optic disc is often challenging, requiring comparison of both optic discs, sometimes the optic disc is so severely affected, as in this picture, that we do not need the fellow eye to conclude that pallor is present. However, again note that color is not the only abnormality present that suggests optic disc pallor.

References

(Some sections of text adapted from reference #1.)

1. Mackay DD, Garza PS, Bruce BB, Newman NJ, Biousse V. The demise of direct ophthalmoscopy: A modern clinical challenge. Neurol Clin Pract. 2015;5:150–157.

2. Bruce BB, Biousse V, Newman NJ. Nonmydriatic ocular fundus photography in neurologic emergencies. JAMA Neurol. 2015;72:455–459.

3. Kelly LP, Garza PS, Bruce BB, Graubart EB, Newman NJ, Biousse V. Teaching ophthalmoscopy to medical students (the TOTeMS study). Am J Ophthalmol. 2013;156:1056–1061.e10.

4. Mackay DD, Garza PS, Bruce BB, et al. Teaching Ophthalmoscopy to Medical Students (TOTeMS) II: A One-Year Retention Study. Am J Ophthalmol. 2014;157:747–748.

5. Thulasi P, Fraser CL, Biousse V, Wright DW, Newman NJ, Bruce BB. Nonmydriatic ocular fundus photography among headache patients in an emergency department. Neurology. 2013;80:432–437.

6. Cooper LS, Wong TY, Klein R, et al. Retinal Microvascular Abnormalities and MRI-Defined Subclinical Cerebral Infarction The Atherosclerosis Risk in Communities Study. Stroke. 2006;37:82–86.

7. Vuong LN, Thulasi P, Biousse V, et al. Ocular fundus photography of patients with focal neurologic deficits in an emergency department. Neurology. 2015;85:256–262.