LEARNING OBJECTIVES

1. List epidemiologic associations between retinal microvascular abnormalities and cardiovascular and neurologic disease
2. Describe key research findings related to the use of non-mydriatic ocular fundus photography in ophthalmic and non-ophthalmic settings
3. Explain the implications of the increasing use of ocular fundus photography on patient care, medical education, and clinical research

CME QUESTIONS

1. Retinal microvascular findings have been associated with the long-term risk of:
   a. Heart failure
   b. Incident stroke
   c. Dementia
   d. a & b
   e. a, b, & c
2. True or false: For ophthalmologists, fundus photography provides higher sensitivity, specificity, and inter-reviewer agreement for diabetic retinopathy than ophthalmoscopy.
3. The Fundus Photography vs. Ophthalmoscopy Trial Outcomes in the Emergency Department (FOTO-ED) study found that among patients presenting to the emergency department of one university hospital with headache, focal neurological deficits, visual changes, or markedly elevated blood pressure:
   a. About 10-15% had findings of urgent relevance (optic disc edema, isolated intraocular hemorrhage, grade IV hypertensive retinopathy, retinal vascular occlusion, and optic disc pallor)
   b. Emergency physicians examined these patients with the direct ophthalmoscope less than 15% of the time
   c. When photographs were provided, emergency physicians reported them to be helpful over a third of the time
   d. Emergency physicians, without additional training, were able to identify about 50% of the emergent abnormalities on fundus photographs seen during the course of the study
   e. All of the above

KEYWORDS

1. Ocular Fundus Photography
2. Non-Mydriatic
3. Telemedicine
4. Emergency Medicine

INTRODUCTION

Examination of the ocular fundus is a fundamental component of the general physical examination and critical to the diagnosis of life- and sight-threatening medical conditions among patients with certain presenting complaints, such as headache. In addition, population-based studies have shown the prognostic value of retinal microvascular findings in cardiovascular and neurologic disease. Yet, the examination of the ocular fundus is infrequently and inadequately performed in most non-ophthalmic settings. Non-mydriatic ocular fundus photography is a promising alternative to direct ophthalmoscopy, particularly when combined with telemedicine. The Fundus Photography vs. Ophthalmoscopy Trial Outcomes in the Emergency Department (FOTO-ED) study is discussed as an example of the use of non-mydriatic ocular fundus photography in an acute, non-ophthalmic setting. The implications of non-mydriatic fundus photography on medical education, patient care, and clinical research are also addressed.

THE OCULAR FUNDUS – A UNIQUE VIEW OF THE BRAIN AND ITS MICROVASCULATURE

Ophthalmoscopy is a key element of the physical examination. Despite the rapid progress that has been made in various diagnostic medical technologies (e.g., neuroimaging), visualization of the ocular fundus is often the only diagnostic clue to the identification of potentially...
serious ophthalmic and neuro-ophthalmic diseases. Examination of the fundus is necessary for the diagnosis of various disorders causing acute visual loss that require urgent management (e.g., retinal detachment), the detection of warning signs of impending visual loss and potentially catastrophic neurologic complications (e.g., papilledema, central retinal artery occlusion, anterior ischemic optic neuropathy), and to determine the severity of certain medical conditions (e.g., hypertensive crisis).

Fundus examination should be routine in the detection of vision- and life-threatening signs in patients presenting with headache, focal neurologic deficits, and severely elevated blood pressure, and in the evaluation of patients with acute visual changes. Indeed, several life-threatening intracranial disorders, such as intracranial mass, cerebrospinal fluid shunt malfunction, hydrocephalus, meningitis, and cerebral vein thrombosis often present to the emergency department with headache and associated papilledema, which most commonly presents with headache, generally has an otherwise unremarkable physical examination and may go undetected. Failure to examine the ocular fundus is of particular concern in the setting of idiopathic intracranial hypertension (IIH), allowing us to easily observe the optic nerve and retina, and 2) their supporting vasculature, containing both large and small vessel components that are supplied by the anterior cerebral circulation like the majority of the brain. The retinal and cerebral microvascularizations share embryological origins and are very similar anatomically and physiologically. Both are barrier circulations sharing mechanical (luminal tight junctions) and metabolic components (e.g., transport proteins: GLUT-1, P-glycoprotein, and transferrin), and both circulations also have autoregulatory mechanisms to maintain constant blood flow in the face of changes in systemic blood pressure. However, the ocular fundus has the unique distinction of being the only CNS structure, as well as the only part of the body’s microvasculature, that can be directly visualized allowing us to easily observe the retinal microvascular changes that occur when homeostasis is disturbed. As blood pressure increases, vasoconstriction (arteriolar narrowing) occurs. As retinal autoregulatory mechanisms fail, blood and fluid leak from vessels (microaneurysms and hemorrhages) and ischemia ensues (cotton wool spots). In addition, retinal thromboembolic events can be directly visualized as emboli and vascular occlusions.

**RETINAL MICROVASCULAR CHANGES PREDICT LONG-TERM CARDIOVASCULAR AND NEUROLOGIC OUTCOMES**

Numerous studies have related retinal microvascular changes with the long-term risk of cardiovascular disease. Chronic arteriolar changes, characterized by generalized arteriolar narrowing and arteriovenous nicking, are markers of long-term, cumulative damage from hypertension based on their association with blood pressure measured 5-8 years before retinal photography. Conversely, focal arteriolar narrowing, retinal hemorrhages, microaneurysms, and cotton-wool spots are markers of acute hypertension based on their association only with concurrently obtained blood pressure measurements. Retinal microvascular changes are also associated with increased risks of left ventricular hypertrophy, ischemic heart disease, congestive heart failure, renal dysfunction, and cardiovascular mortality. In fact, retinal microvascular changes have been associated with twice the risk of incident congestive heart failure, even among otherwise low-risk individuals, and sub-analyses of the Beaver Dam Eye Study have found that individuals with retinal microaneurysms, exudate, and retinal hemorrhages are twice as likely to die from cardiovascular events as those without these signs.

From a neurologic perspective, retinal microvascular abnormalities are strongly associated with long-term risk of stroke. Indeed, the large, middle-age-population-based Atherosclerosis Risk in Communities Study (ARIC) study found that retinal microvascular abnormalities, particularly microaneurysms and soft exudates, predict subclinical strokes independent of the patient’s hypertensive and diabetic status. Other investigators have also found a similar relationship between hypertensive retinopathy and silent brain infarction in patients without a history of stroke or TIA, independent of the patient’s current hypertensive status. Likewise, multiple population-based studies have similarly found a relationship between retinal microvascular changes and stroke, after controlling for traditional stroke risk factors. In particular, retinal microvascular changes that are more reflective of acute blood pressure changes (i.e., focal arteriolar narrowing, retinal hemorrhages, microaneurysms, and cotton-wool spots) tend to portend a higher risk of incident stroke than those that appear to be markers of cumulative long-term hypertensive damage (i.e., generalized retinal arteriolar narrowing and arteriovenous nicking). Microvascular changes are also associated with dementia, as cerebrovascular cognitive impairment, typically related to small vessel disease with resultant white matter lesions and lacunar infarctions, causes 20% of dementia. Retinal microvascular changes correlate with magnetic resonance imaging (MRI) signs of cerebral white-matter lesions, and retinal exudates correlate with the presence of lacunar infarction. The ARIC study investigated the relationship between retinal microvascular abnormalities and cognitive
impairment in a stroke-free population and found that the presence of retinal microvascular abnormalities (retinopathy, microaneurysms, retinal hemorrhages, and exudates) was independently associated with lower cognitive function.\(^7\) Microaneurysms and retinal hemorrhages were the most consistent findings linked to diminished cognitive function.\(^7\) The ARIC investigators also found that retinopathy and arteriogenous nicking on photography obtained at baseline were independently associated with 10-year cerebral ventricular enlargement, but not 10-year sulcal widening, suggesting a microvascular etiology for subcortical, but not cortical cerebral atrophy.\(^20\)

**OPHTHALMOSCOPY – USEFUL, BUT NEGLECTED**

Despite its diagnostic and prognostic value, ocular fundus examination is often neglected by non-ophthalmic physicians due to several factors: 1) limited training in performing the technical skill,\(^21,22\) 2) inability to recognize important ophthalmoscopic findings and interpret their relevance,\(^23,24\) and 3) increasing demands on physician’s time, coupled with under appreciation of the value of the examination.\(^25\) U.S. third-year medical students in one study attempted direct ophthalmoscopy only 11% of the time in which an ocular fundus examination was clinically indicated.\(^26\) Forty-seven percent of medical student clerks at one Canadian university had minimal confidence in their ability to use direct ophthalmoscopy to examine the ocular fundus through an undilated pupil,\(^27\) and 43% of general practitioners surveyed in the United Kingdom lacked confidence in using the direct ophthalmoscope.\(^22\) In a survey of hospital physicians, all said that ophthalmoscopy was important but only 3 of 72 performed it routinely. Half of these physicians indicated they would perform ophthalmoscopy for patients with diabetes, hypertension, visual impairment, and neurologic symptoms, but on review of 100 case notes, ophthalmoscopy was documented on only 3 patients; 9 with diabetes and 35 with hypertension had no ophthalmoscopy reported. When a subset of these physicians were tested with the direct ophthalmoscope, they correctly diagnosed abnormalities in half of the patients could not recall having ophthalmoscopy performed, while 95.7% recalled being examined with a stethoscope.\(^28\)

**NON-MYDRIATIC FUNDUS PHOTOGRAPHY – AN ALTERNATIVE TO OPHTHALMOSCOPY?**

Non-mydriatic digital retinal imaging has several advantages compared to ophthalmoscopy. For example, studies of non-mydriatic fundus photography in diabetic retinopathy screening (the most extensively studied area in retinal imaging) have found it to have higher sensitivity, specificity, and inter-examination agreement than ophthalmoscopy, even among ophthalmologists.\(^29,30\) In contrast to ophthalmoscopy, non-medical personnel can assist by obtaining high-quality images for later review, even after only limited training. One study comparing images obtained by a trained ophthalmic photographer (with 20 years of experience) and two non-professional photographers (one with 2 days and the other with 1 hour of training) found no difference in the image quality based on the ratings of two retina specialists.\(^31\)

Non-mydriatic fundus photography is already routinely used to screen for treatable, sight-threatening eye diseases, such as diabetic retinopathy, within at-risk populations.\(^32\) Indeed, there is level I evidence that single field fundus photography can identify patients with diabetic retinopathy who require referral for ophthalmic evaluation and management.\(^33\) The capabilities of ocular fundus photography have also been shown both in the diagnosis of referral-warranted retinopathy of prematurity and in the telemedical diagnosis of cytomegalovirus retinitis in HIV-positive patients in underserved countries, although assessment of both of these conditions typically requires pupillary dilation.\(^34,35\)

**THE FUNDUS PHOTOGRAPHY VS. OPHTHALMOSCOPY TRIAL OUTCOMES IN THE EMERGENCY DEPARTMENT (FOTO-ED) STUDY**

The importance of timely and accurate ocular fundus examination is particularly evident in the emergency department (ED) where failure to correctly evaluate the ocular fundus places patients at risk for poor outcomes and exposes their caregivers to significant medicolegal liability.\(^36\)

Yet, even in the ED, examination of the ocular fundus is not consistently performed. For example, two studies of headache management in the ED found documentation of ophthalmoscopy in only 37–48% of cases.\(^37,38\) Non-mydriatic ocular fundus photography appears to overcome many barriers to an adequate ophthalmoscopic examination in the ED because many physicians are reluctant to perform routine dilation of patients for ophthalmoscopic examination, pupillary dilation takes up to 30 minutes, and most patients prefer not to have their pupils dilated.\(^24\) In addition, neurologic patients represent a unique population in which pupillary reflexes can be critical for monitoring clinical status. We hypothesized that the undilated views of the ocular fundus provided by non-mydriatic ocular fundus photography would be useful in overcoming important obstacles to appropriate patient examination in the ED. Therefore, the FOTO-ED study was developed as an interdisciplinary project between neuro-ophthalmology and emergency medicine in order to improve ophthalmologic care in the ED by evaluating whether non-mydriatic fundus photography was a better alternative to direct ophthalmoscopy.
The FOTO-ED study was conducted in 2 phases between April 2009 and August 2011. The first phase evaluated the routine clinical use of direct ophthalmoscopy by ED physicians, whereas the second phase evaluated the routine use of non-mydriatic ocular fundus photography as interpreted by the ED physicians. In both phases, all patients had non-mydriatic ocular fundus photographs obtained. The inclusion criteria for the FOTO-ED study were adult patients presenting to the ED with a presenting complaint or condition of one or more of the following: headaches, focal neurologic deficits, diastolic blood pressure (DBP) ≥120 mmHg, or acute visual changes. Patient demographics, including age, gender, race, presenting vital signs, height, and weight, were prospectively collected in the ED. Photographs of the posterior pole of the ocular fundus (optic disc, macula, and major retinal vessels) were obtained from both eyes of enrolled patients at presentation by trained nurse practitioners or a medical student using a commercially available, Food and Drug Administration–approved, non-mydriatic ocular fundus camera (Kowa nonmyD-series cameras; Kowa Optemed, Inc., Torrance, CA). The images were automatically electronically transferred to a Health Insurance Portability and Accountability Act-compliant database for review. Throughout the FOTO-ED study, relevant ocular fundus abnormalities were defined as optic disc edema, isolated intraocular hemorrhage, grade III/IV hypertensive retinopathy, retinal vascular occlusion, and optic disc pallor.

Phase I – Only Direct Ophthalmoscopy Available to Emergency Physicians
In the first phase of the FOTO-ED study, 350 adult patients were enrolled. The median age of patients was 44.5 years (interquartile range [IQR] 31–59 years), and 220 (63%) were women. The presenting complaints and conditions were headache in 228 (65%), acute focal neurologic deficit in 100 (29%), acute visual change in 92 (26%), and DBP ≥120 mmHg in 21 (6%). Patients could have more than one presenting complaint or condition. The performance of ED physicians and the findings on direct ophthalmoscopy were prospectively recorded, with the physicians unaware of the photography results.

During routine evaluation, ED physicians performed direct ophthalmoscopy on only 48 of the 350 patients (14%; 95% confidence interval [CI]: 10–18%). In 44 enrolled patients, relevant ocular findings (13%; 95% CI: 9–17%) were identified with the use of non-mydriatic fundus photography by the neuro-ophthalmologist reviewing the images: 13 cases of optic nerve edema, 13 cases of intraocular hemorrhages, 10 cases of hypertensive retinopathy (grade III or IV), 4 cases of arterial vascular occlusion, and 4 cases of optic nerve pailor. Eleven of the findings were known before patients presented to the ED. Of the remaining 33 relevant findings, 6 were identified by ophthalmologic consultants, but the other 27 neither had a consult requested nor were identified by the ED physicians. Thus, 82% (95% CI: 65–93%) of the findings unknown at the time of ED presentation were missed by routine ED care. For each photography session, the nurse practitioner rated the ease and speed of fundus photography and patients rated the ease, speed, and comfort of non-mydriatic photography on a 10-point Likert scale (10 best) and mean scores for each scale were 8.7 or better. The quality of the photographs was of some diagnostic value for 97% of enrolled patients. Median photography time was 1.9 minutes (IQR: 1.3–2.9).

We concluded from the first phase that direct ophthalmoscopy was infrequently and poorly performed in the emergency department and that non-mydriatic fundus photography was a feasible alternative to direct ophthalmoscopy.

Phase II – Fundus Photography Provided to Emergency Physicians
Among 478 patients screened for eligibility, 354 were enrolled in phase II of the FOTO-ED study. Eighty-six patients were ineligible (56 too ill, 13 non-focal neurologic complaints, 14 unable to be located, 3 other reasons), and 33 patients refused participation. Using the EMR automated screening process, 345 of the enrolled subjects (97%) were identified, with the remainder identified by active surveillance by study personnel. Five eligible patients (3 headache, 2 focal neurologic) who triggered the automated process were missed by study staff.

The median age of the patients was 45.9 years (IQR: 33–57) and 251 (71%) were women. Two hundred six patients (58%) had headache, 123 (35%) had focal neurologic symptoms, 56 (16%) had acute visual changes, and 21 (6%) had DBP ≥120 mmHg (patients were allowed to have more than 1 presenting complaint). Thirty-five patients (10%; 95% CI: 7%–13%) had relevant findings identified by neuro-ophthalmologist review of the photographs, including 6 patients with disc edema, 6 with grade III/IV hypertensive retinopathy, 7 with isolated intraocular hemorrhages, 15 with optic disc pailor, and 1 with a retinal vascular occlusion. Among the 354 enrolled patients, the ED physicians reviewed the photographs of 239 patients (68%) and reported that the photographs were helpful in their evaluation of 125 patients (35%; 95% CI: 30–41%). The ED physicians identified 16 of the 35 relevant findings (46%) during their review of the fundus photographs.

We concluded that non-mydriatic fundus photographs were used by ED physicians more frequently than they performed direct ophthalmoscopy (68% vs. 14%), that their detection of relevant abnormalities improved (46% vs. 0%), and that ocular fundus photography often assisted with ED care even when the photographs were normal (e.g., the absence of papilledema in a patient with potential shunt malfunction). The increased frequency of both viewing...
the fundus and diagnosing abnormalities was particularly remarkable given that the emergency physicians had not received any additional training.

BEYOND THE EMERGENCY DEPARTMENT Education

Non-ophthalmic physicians have also read non-mydriatic photographs for diabetic retinopathy screening in two large-scale projects. The first study reported the characteristics of 742 patients referred for ophthalmic care by 24 trained general practitioners who reviewed the photographs for evidence of diabetic retinopathy within a nationwide screening program in Singapore, but the article did not discuss false negatives (missed diagnoses). In the other study, four trained general practitioners in Spain deemed the photographs of 2036 of 2750 patients (74%) normal and sought ophthalmologic consultation for the remainder. Among those sent for review, 392 (55%) did not have diabetic retinopathy, suggesting that the general practitioners had a low threshold for referral to avoid false negatives. Ophthalmologists also reviewed a sample of 240 of the patients that the general practitioners had read as normal and found that 16 of these (7%) had diabetic retinopathy, but that only two patients (1%) had treatable diabetic retinopathy. The authors concluded that the general practitioners had acceptable sensitivity (particularly relevant for a screening technique), but were concerned about specificity and recommended additional training to avoid inappropriate referrals.

The demonstration that non-ophthalmic physicians are capable of reviewing photographs for key conditions in various settings, combined with the technical advantages of non-mydriatic fundus photography over direct ophthalmoscopy, suggest that non-mydriatic photography may be an acceptable (and in some cases a better) alternative to direct ophthalmoscopy. Moreover, it seems likely that educational efforts at the allied health, medical school, and post-graduate levels may be best directed at teaching students and clinicians how to read photographs rather than how to perform the technical skills of direct ophthalmoscopy. In fact, two longitudinal studies by Lippa et al. of a sustained, multi-year ophthalmology curriculum emphasize the difficulties of teaching direct ophthalmoscopy in a way that has a lasting effect. For example, while there was initially a 46% documentation rate of ophthalmoscopy in one of the medical students’ third year rotations, there were no documented fundoscopic examinations during the students’ fourth year internal medicine clerkship. In addition, only 23% of the students had purchased an ophthalmoscope by completion of medical school. Of further concern, 13% to 16% of students stated that a direct ophthalmoscope was not important for clinical duties, and 5% to 6% stated that there was a “dearth of opportunities” for its use in clinical encounters.

We have investigated the use of fundus photography as an alternative to direct ophthalmoscopy in the education of medical students. We studied 138 first-year medical students, 119 (86%) of whom completed all required elements for the study. For learning ophthalmoscopy, 85 (71%) preferred humans to patient simulators. For learning relevant features of the ocular fundus, 92 (77%) preferred photographs to ophthalmoscopy on simulators or humans. The students’ accuracy was better when interpreting fundus photographs than when performing ophthalmoscopy on simulators, and their performance improved after specific teaching about assessing fundus photographs before testing (P = 0.02). Examination of the ocular fundus was found to be easier and less frustrating when using photographs than when using ophthalmoscopy on simulators or humans. Eighty-four students (70%) said they would prefer to have fundus photographs instead of using the ophthalmoscope during upcoming clinical rotations.

In a one-year follow-up study of the same students, 107 (90%) of which participated, the students’ self-reported median frequency of fundus examination over the preceding year was <10% (interquartile range: 0%-20%). Of 107 students, 85 (79%) felt uncomfortable with ophthalmoscopy, 47 (44%) stated they would not perform ophthalmoscopy during general physical examinations, and 81 (76%) stated they would prefer using photographs over ophthalmoscopy for fundus examination. Students continued to be more accurate using photographs than ophthalmoscopy and still preferred photographs for examining the ocular fundus. Although both groups performed significantly worse in identifying relevant fundus features than they did 1 year prior, the difference was equal in the 2 groups and likely related to a lack of fundus examination skill reinforcement in the interim. Most students felt uncomfortable with ophthalmoscopy, which may cause avoidance of ocular fundus examination in clinically appropriate situations. Of concern, 20% of students cited discouragement by their clinical preceptor as their primary reason for not performing ophthalmoscopy, which suggests that postgraduate education may be needed to create a long-term change in the use and performance of fundus examination.

Alternatives to Physician Photography Readings

As technology continues to advance, one can ask the controversial question of whether the general physician of the future even needs basic fundus interpretation skills. In fact, Bhargava et al. reported on 367 diabetic patients assessed by both non-physician graders and family physicians compared to a reference standard of a retinal specialist. They found that the non-physician graders with one year of rigorous training followed by yearly auditing had better agreement with the retinal specialists.
ophthalmologists. To achieve levels of diagnostic capability comparable to the family physicians. The non-physician graders also had better sensitivity (70%) than the family physicians.47

While it is promising that the majority of diabetic retinopathy screening could be offloaded from retinal specialists and general practitioners to non-ophthalmic readers, developments in automated, computerized reading takes this one step further, by potentially taking the task of reading photographs completely out of the hands of human reviewers. Although efforts to develop automatic methods to identify features of diabetic retinopathy have been ongoing for over 20 years,48 only recently have they begun to achieve levels of diagnostic capability comparable to ophthalmologists.49 For example, two groups have recently reported sensitivity of at least 90% with 100% specificity using their comprehensive assessment algorithms.50,51 Automatic detection and severity assessment of optic disc edema using photographs has also shown promising results.52

Improving the Mobility of Non-Mydriatic Fundus Cameras

A major limitation of table-top cameras is that they are unable to assess patients who are too ill or too young to sit at the camera. Technology is already addressing this issue with several new, portable devices for retinal photography, some of which are non-mydriatic, such as EyeQuick (Eye Quick, El Paso, TX; http://www.eyequick.com), VersaCam (Nidek Co., Ltd., Fremont, CA; http://www.nidek-intl.com/products/diagnosis/ds-10.html), and Pictor Plus (Volk Optical, Mentor, OH; http://www.volk.com/pictorplus). Many of these devices can also capture video for the assessment of dynamic phenomena (e.g., spontaneous venous pulsations). In addition to these dedicated devices, special adapters are available that allow the attachment of smartphones to ophthalmoscopes and slit lamps (e.g., iExaminer [Welsh Allyn, Skaneateles Falls, NY; http://www.welchallyn.com/en/microsites/iexaminer.html]), albeit generally for mydriatic photography (see also “Smart Phoneography” on http://eyewiki.aao.org/). However, these devices are substantially more difficult to use than a tabletop camera, have narrower fields of view, and can only obtain photographs of lower quality. Further scientific and technological progress in imaging science and engineering will be required to produce the ideal “digital ophthalmoscope.” Continued improvements will facilitate the examination of very young pediatric patients, sicker patients in the ED and other settings, and patients in intensive care units.

Telemedicine

Advancements in telemedicine, particularly via nearly ubiquitous mobile devices (e.g., smartphones and tablets), will allow expert reviewers to assess emergent images in a timely fashion. For example, in a subanalysis of the FOTO-ED study, a five-point overall quality rating assigned by two reviewers to the same 100 photographs on a desktop computer and the iPhone 3G was compared. A very high intra- and inter-rater agreement on the iPhone (kappa=.96) and high agreement of the same reviewer between the two devices (0.82-0.91) was found. Notably, both reviewers on average rated the same image as higher quality on the iPhone compared to the desktop computer (chi square >36, p<0.001).53 Likewise, Kumar et al. found that the ophthalmologists who reviewed images of patients for the telemedical diagnosis of diabetic retinopathy had very high agreement (kappa=.9) and gave high scores to the image quality on the iPhone 4.54 These studies suggest that today’s mobile devices already possess the quality needed for tele-ophthalmology.

CONCLUSION

Further advancements in non-mydriatic fundus photography and telemedicine not only have the potential to improve patient care, but may also facilitate clinical research in areas that are currently intractable. The expansion and validation of non-mydriatic fundus photography and its interpretation by non-ophthalmic reviewers and by telemedicine may offer the early diagnosis required for clinical trials in neuro-ophthalmology analogous to emergent stroke treatment trials for conditions such as central retinal artery occlusion, anterior ischemic optic neuropathy, and traumatic optic neuropathy.55 In addition, these techniques hold promise for risk stratification and predictive health in both acute and chronic neuro-ophthalmic diseases, such as transient ischemic attack, although their role remains to be fully elucidated.

CME ANSWERS

1. e
2. True
3. e

REFERENCES:


