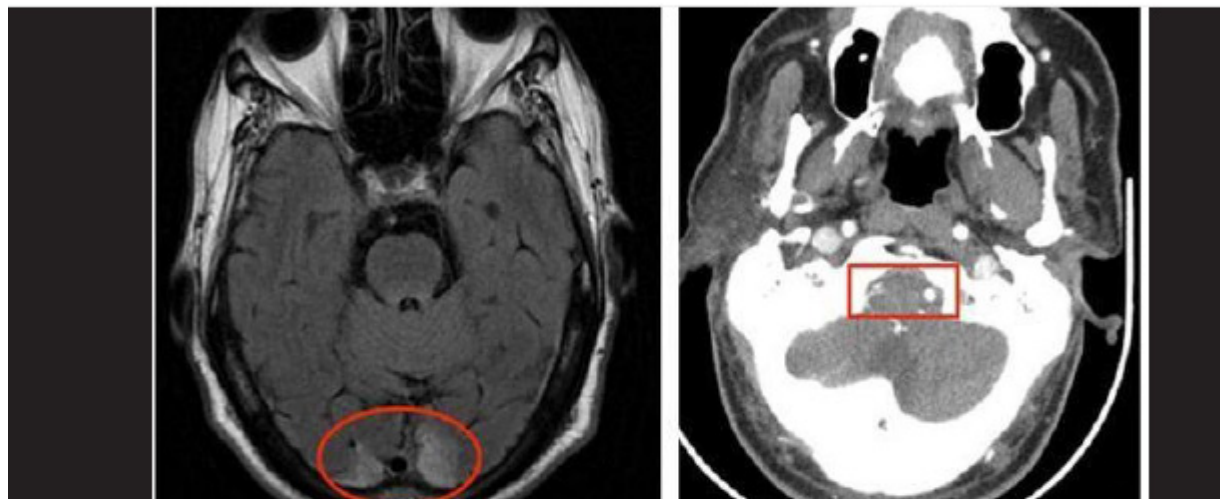


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Teaching Pupil Dilation: Faculty Perceptions Regarding Elevated Blood Pressure and Dilating Agents

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TEACHING PUPIL DILATION: FACULTY PERCEPTIONS REGARDING ELEVATED BLOOD PRESSURE AND DILATING AGENTS

Abstract

Background: To assess whether a common blood pressure threshold exists, above which faculty members at an optometry school would instruct students to abstain from dilating a patient's pupils. **Methods:** Seventy-three faculty members completed a survey about their practice habits regarding dilating the pupils of individuals who have elevated blood pressure. **Results:** The majority of optometrists surveyed (94.5%) were not concerned about using 1% tropicamide, but more than half (64.4%) were concerned about using 2.5% phenylephrine. The highest percentage of survey respondents typically refrain from dilating a patient with systolic blood pressure higher than 200 (45.2%) and diastolic blood pressure higher than 105 (34.3%). **Conclusion:** The majority of optometrists in an academic setting have reservations about using 2.5% phenylephrine in patients with elevated blood pressure. A need for this apprehension about dilation is not proven in the literature but seems to be a medical-legal concern. This clinical decision-making rationale is imparted on students, potentially shaping their practice habits.

Key Words: blood pressure, dilation, tropicamide, phenylephrine

Introduction

To be considered comprehensive, an eye examination should include visualization of the fundus through a dilated pupil. To achieve maximal mydriasis for optimal visibility, a combination of 1% tropicamide (a muscarinic receptor antagonist) and 2.5% phenylephrine (an alpha-receptor agonist) is typically used.¹ While adequate pupil dilation may be achieved with 1% tropicamide alone, some situations (e.g., dark irides, diabetes, aging) require a combination of the two drops to achieve greater dilation in a shorter time.²⁻⁵

Optometric educators guide optometry students as to when it is necessary to dilate a patient's pupils. Evidence-based clinical guidelines have been established to aid in this decision.⁶⁻⁷ While the indications for dilating the pupils are clear, the contraindications and precautions are more difficult to navigate for clinicians and students.⁸

No consensus exists on a systolic or diastolic blood pressure threshold at or above which a practitioner should abstain from dilating due to the potential risks of the dilating drops. When given systemically, phenylephrine is known to cause cardiovascular adverse effects including increases in systolic blood pressure, diastolic blood pressure and heart rate.⁹⁻¹¹ A mounting body of evidence suggests that short- and long-term increases in blood pressure, as well as short- and long-term variability in blood pressure, are associated with the development, progression and severity of cardiovascular events.¹² Adverse systemic side effects associated with topical phenylephrine have also been reported to the National Registry of Drug-Induced Ocular Side Effects.¹³ These side effects include marked increase in blood pressure, syncope, ventricular arrhythmias, pulmonary edema, myocardial infarction and subarachnoid hemorrhage.¹⁴ However, the majority of these side effects occurred with the use of 10% phenylephrine, a concentration that is not typically used in a clinical setting to dilate a patient's pupils.

Conversely, numerous studies have shown no statistically significant increase in blood pressure or other systemic side effects after the instillation of 2.5% or 10% phenylephrine and/or 1% tropicamide.^{9, 14-20} The largest clinical trial, involving 150 subjects, compared 10% phenylephrine against 1% tropicamide and found no increase in blood pressure or heart rate up to 30 minutes after either drop was administered.⁷ A meta-analysis of studies evaluating cardiovascular adverse effects of topical phenylephrine, which included eight randomized clinical trials and data on the 2.5% and 10% concentrations, found 2.5% phenylephrine did not cause an increase in blood pressure at either 20-30 minutes or 60 minutes or longer after application. Ultimately the investigators concluded that the sum of the data provided no evidence of an effect of 2.5% phenylephrine on blood pressure or heart rate and only a short-lived effect of 10% phenylephrine.²¹

The conflicting reports make it challenging for a practitioner to make an evidence-based medical decision about using 2.5% phenylephrine and/or 1% tropicamide to dilate pupils when blood pressure is elevated.¹⁵ Students at the Illinois College of Optometry (ICO) are educated about the side effects of mydriatic pharmaceutical agents in their pharmacy courses; however, guidance on when to dilate is not taught in the classroom.

The aim of this study was to poll optometrists who are involved in patient care at Illinois Eye Institute and determine what they teach their students about elevated blood pressure and pupil dilation. In addition, their dilation routine was evaluated

to see whether it correlated with their gender, years in practice or practice specialty.

Methods

This study was approved by the ICO Institutional Review Board. A survey was distributed to all 79 optometric clinical faculty at ICO. All faculty members surveyed taught at Illinois Eye Institute, the on-site clinic for ICO. No faculty who taught at satellite clinics were included in the study. The faculty represented attending doctors in primary care, pediatrics, contact lens, low vision and advanced care clinics. The survey was anonymous and inquired about gender and years in practice. The seven questions for the survey were developed by the authors based on their clinical experiences and observations. A literature review did not reveal any similar survey or research on this subject. The participants were asked questions regarding their practice habits related to dilating asymptomatic adult patients with elevated blood pressure. They were also asked questions pertaining to their opinions about specific dilating eye drops and their effect on blood pressure and any medical-legal concerns they might have regarding dilating a patient with elevated blood pressure (**Table 1**). All data were analyzed using Statistical Package for Social Sciences (IBM SPSS version 21.0, Chicago, IL). The chi-squared test of independence was used to interpret the survey results. A p value of <0.05 was considered statistically significant.

Results

Seventy-three of the 79 clinical faculty members (92.4%) participated in the study. The majority of optometrists (94.5%) were not concerned about 1% tropicamide increasing blood pressure in patients who presented with elevated blood pressure. However, more than half of the optometrists (64.4%) were concerned that 2.5% phenylephrine may increase blood pressure in individuals with elevated blood pressure. The majority of optometrists (71.2%) were concerned for medical-legal reasons about dilating a patient with elevated blood pressure.

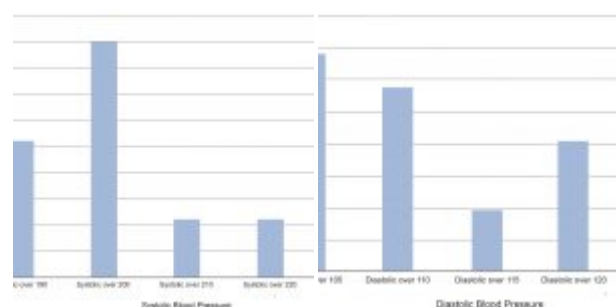


Figure 1. Survey respondents' cutoff for dilation based on systolic blood pressure.

[Click to enlarge](#)

Figure 2. Survey respondents' cutoff for dilation based on diastolic blood pressure.

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When asked at what blood pressure level they would typically not dilate an asymptomatic adult patient with 2.5% phenylephrine and 1% tropicamide, the highest percentage of faculty reported they would not dilate individuals with systolic blood pressure higher than 200 mmHg (45.2%) (**Figure 1**) and diastolic blood pressure higher than 105 mmHg (34.3%) (**Figure 2**). Neither gender nor years in practice had any significant association with dilation decision-making for tropicamide ($\chi^2_{1df} = 0.77$, $p=0.38$) and ($\chi^2_{1df} = 0.60$, $p=0.44$) respectively or phenylephrine ($\chi^2_{1df} = 0.75$, $p=0.39$) and ($\chi^2_{1df} = 0.00$, $p=0.99$) respectively. However, a significant difference was found between subspecialty optometrists and primary care optometrists with regard to practice habits and concern about the use of 1% tropicamide ($\chi^2_{1df} = 7.05$, $p=0.03$). Conversely, no statistically significant difference was found between the various subspecialties regarding concern about

TABLE 1
Survey of Optometric Clinical Faculty at Illinois Eye Institute

1. Gender	Male Female
2. How many years have you been practicing?	a. 0-5 b. 6-10 c. 11-15 d. 16-20 e. 21-25
3. Specialty	a. Primary Care b. Contact Lens c. Pediatrics/Ocular Vision d. Low Vision e. Advanced Care
4. At what blood pressure level do you typically NOT dilate an adult patient with 2.5% phenylephrine & 1% tropicamide (assuming the patient is asymptomatic and has no reason he/she must be dilated)?	Systolic: a. over 220 b. over 210 c. over 200 d. over 190 e. other _____ f. I would dilate with any systolic blood pressure Diastolic: a. over 120 b. over 115 c. over 110 d. over 105 e. other _____ f. I would dilate with any diastolic blood pressure
5. In patients with elevated blood pressure, are you concerned that the 1% tropicamide may increase blood pressure?	a. Yes b. No
6. In patients with elevated blood pressure, are you concerned that the 2.5% phenylephrine may increase blood pressure?	a. Yes b. No
7. Are you worried for medical-legal reasons about dilating a patient with very elevated blood pressure?	a. Yes b. No

Table 1. [Click to enlarge](#)

2.5% phenylephrine increasing blood pressure in hypertensive patients ($\chi^2_{1df} = 0.60$, $p=0.29$).

Discussion

Optometrists in this teaching setting tend to act conservatively when considering whether to use 2.5% phenylephrine in patients with elevated blood pressure. This approach may be guided by the small number of studies that indicate an increase in blood pressure and heart rate following administration of 10% phenylephrine.⁹⁻¹¹ Overwhelmingly, the concern seems to be driven by the medical-legal implications of using these drops in these particular individuals.

This approach with hypertensive patients and discussions while managing the cases may make students much more aware of the status of each patient's systemic health beyond the diagnosis. Students are taught to take an accurate blood pressure reading and to ask about the specifics of the patient's hypertension, including current medications and compliance and recent visits to primary care physicians. It is also important to take any physical symptoms a patient is having into account when making the decision to dilate. The students are taught to ask how a patient is feeling when they measure elevated blood pressure. Specific symptoms that would impact the decision to not dilate include dizziness, headache, nausea and vomiting. In these instances, students are taught that they should contact the primary care physician, or, in extreme cases, call for an ambulance or send the patient directly to the emergency room.

Studies that have investigated a relationship between phenylephrine and blood pressure and heart rate are limited in number, have small sample sizes or heterogeneous samples, and often include the application of tropicamide concurrently.^{9,12} There is also a lack of data available on cardiovascular adverse effects of topical phenylephrine specifically in persons with cardiovascular risk factors or a history of cardiovascular events. These unknowns may lead faculty to act more conservatively when deciding whether to use 2.5% phenylephrine in patients with elevated blood pressure.

While no blood pressure cutoff for pupil dilation is formally taught at ICO, like many aspects of clinical care, students may mirror their teachers and develop their practice habits based on those of their clinical faculty. As this study demonstrates, approaches to this particular issue vary as the long-term practice habits of students likely will.

A limitation of this study includes its small sample size, specifically of optometrists practicing in subspecialties. The small sample size prevents the data from accurately being extrapolated. Going forward, the authors would be interested in surveying other optometric educators. Assessing student perceptions about what they are learning in clinic about dilation would also inform understanding of this topic.

Medical decision-making is a complex process that is shaped by patient expectations and by doctors' efforts to maximize benefits while reducing risks. Typically, the aim is to make decisions based primarily on the highest levels of clinical evidence.²²⁻²³ However, the reality is that management decisions are often shaped by a range of other influences, including individual intuition, professional experience and concern about malpractice litigation.²⁴⁻²⁶ This is especially true in scenarios where strong evidence or clinical trial results are lacking, which ultimately leads to disparity in practices among clinicians. Clinical decision-making processes are imparted to students, potentially shaping their own practice habits and perpetuating such disparities. Optometry students should be taught about the decision-making process surrounding pupil dilation in patients with elevated blood pressure and be well aware of the positive and negative clinical and nonclinical influences on the decision. When they are aware of these aspects of the issue, they will be better equipped to make their own patient care decisions.

Conclusion

This study demonstrates that optometrists in an academic setting have reservations about using certain dilating eye drops in patients with elevated blood pressure, specifically 2.5% phenylephrine. The highest percentage of faculty typically instruct students to refrain from dilating a patient with systolic blood pressure higher than 200 and diastolic blood pressure higher than 105. A reason for concern about dilation in this scenario has not been proven in the literature but seems to be more of a medical-legal consideration.

A challenge in educating optometry students is teaching evidence-based medicine while also stressing the importance of nonclinical influences on patient management and treatment decisions. If educators understand the trends and driving forces behind specific clinical decisions, such as dilating patients with elevated blood pressure, they can create a more consistent approach to teaching and also to overall patient care.

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BILATERAL PARIETO-OCCIPITAL CORTEX INFARCTS AND THEIR EFFECTS ON THE VISUAL FIELD: A TEACHING CASE REPORT

Abstract

Cerebrovascular accidents are a leading cause of serious long-term disability. Accurate diagnosis of a cerebrovascular accident is crucial to prevent morbidity, mortality and functional loss. A case report involving a visual field defect secondary to a bilateral parieto-occipital cortex infarct is discussed. Reviews of the blood supply to the brain and the visual field pathway are presented to highlight the importance of understanding the anatomy. A discussion of ancillary testing as well as interdisciplinary care is also provided to educate on proper patient management.

Key Words: occipital lobe, visual field defect, cerebrovascular accident, stroke, vascular anatomy

Background

Cerebrovascular accidents (CVAs), also known as strokes, are the leading preventable cause of disability in nearly 130,000 people in the United States per year. Strokes lead to approximately one in 20 deaths.^{1,2} Due to their high prevalence, it is important to become familiar with strokes and their various consequences. The following case report involves a 62-year-old Indian male with non-insulin-dependent diabetes mellitus, hypertension, hypercholesterolemia and coronary artery disease status post coronary artery bypass grafting (CABG). He presented to the emergency department with complaints of bilateral blurred near vision in conjunction with a headache for a duration of one month. His case demonstrates the crucial nature of understanding the anatomy and blood flow of the brain. The appropriate use of ancillary diagnostic testing to capture the entire clinical picture is discussed. Further, this case highlights the optometrist's role in working with an interdisciplinary team to maximize patient care. The intended audiences are students, residents and clinicians in the optometric field.

Case Description

Initial visit: consult from emergency department

A 62-year-old Indian male presented to the emergency department complaining of bilateral blurred near vision in conjunction with a headache for a duration of one month. He described the headache as having a gradual onset and affecting the frontal and temporal lobes bilaterally. He also reported experiencing dizziness, intermittent tongue numbness and intermittent slurred speech. The patient denied symptoms of nausea, vomiting or disorientation. His blood pressure in the emergency room was 140/90 mmHg.

Ocular history included refractive error in both eyes and bilateral senile cataracts more advanced in the left eye. The patient had a medical history of non-insulin-dependent diabetes mellitus, hypertension, hypercholesterolemia and coronary artery disease after a CABG. His medications included atorvastatin 80 mg daily, aspirin 325-mg delayed release tablet daily, ezetimibe 10 mg daily, glipizide XL 5-g oral tablet (extended release) daily, metformin 500-mg oral tablet (extended release) daily and metoprolol succinate 25 mg daily. He had no known allergies and denied any use of smoking, drugs or alcohol. Family history included his mother being diagnosed with diabetes and hypertension.

During the ocular examination, the patient had difficulty reading the distance visual acuity chart due to uncorrected refractive error; therefore, only near visual acuity was measured. Near visual acuity without correction was 20/100, but improved to 20/40 in the right and left eye with a +2.00D spherical lens with pinhole and illumination. A manifest refraction was not performed because this was an emergency room consult. Ishihara color testing was performed with +2.00D spherical lens and the result was 14/14, right and left eye separately.

The pupils were equal, round and reactive to light and revealed (-) afferent pupillary defect in either eye. Confrontation visual fields were full to finger counting in both eyes and the extraocular muscles were full in both eyes. Goldmann tonometry intraocular pressure measurements were 15 mmHg in the right and left eye.

In the right eye, anterior segment examination revealed 360-degree arcus, two round stromal paracentral scars, nuclear sclerotic cataract 2+ with central vacuoles and posterior subcapsular cataract grade 1+. In the left eye, anterior segment examination revealed 360-degree arcus, nuclear sclerotic cataract 2+ and posterior subcapsular cataract grade 1+. Optic nerve head evaluation revealed 0.3 round, pink and distinct optic nerves in both eyes. Mild retinal pigment epithelium macular changes without any holes or tears were observed in both eyes.

Considering the patient's age and symptoms, giant cell arteritis (GCA) needed to be ruled out. Erythrocyte sedimentation rate blood work was normal. A computed tomography (CT) scan of the head was performed and revealed chronic lacunar infarcts with mild chronic microvascular ischemic changes, but no acute complications.

Ancillary testing such as optical coherence tomography (OCT) or a visual field were not done during this visit because the patient was examined after clinic hours. An OCT of the macula and optic nerve head would reveal any occult or subtle changes that could be producing the reduced vision.

The clinical exam findings of the initial consult suggested the reduced vision was secondary to cataracts, and the headaches were deemed to be non-ocular in nature. The patient was given Tylenol for his headaches and advised to return to the eye clinic the next day for a refraction. If the refraction did not improve his vision, an OCT of the macula and optic nerve head would be performed.

Follow-up visit #1: eye clinic

Manifest refraction produced inconsistent findings with varying best distance visual acuities of 20/40- in the right eye and 20/50 in the left eye and no improvement with pinhole. The pupils were equal, round and reactive to light and revealed (-) afferent pupillary defect. Intraocular pressure and slit lamp examination findings were unchanged in either eye since the initial visit.

Macular imaging with Spectralis® OCT (Heidelberg, Germany) was unremarkable with normal foveal contour in both eyes. OCT optic nerve evaluation showed normal retinal nerve fiber layer thickness in both eyes. All other findings were unchanged from the consult the previous day. It was concluded at this visit that the patient's reduction in visual acuity was secondary to cataracts. A cataract extraction evaluation was scheduled for the next available appointment.

Subsequent visits with neurology, neurosurgery and vascular surgery specialists

The patient continued to have headaches, blurred vision, dizziness, intermittent tongue numbness and intermittent slurred speech. Due to the atypical nature of this patient's headaches, the neurologist ordered the following imaging:

- magnetic resonance imaging (MRI) of the brain, which revealed evolving late subacute infarcts involving the bilateral parieto-occipital cortices and no acute intracranial hemorrhages **(Figure 1A)**
- magnetic resonance angiography (MRA) of the brain, which revealed possible arterial dissection involving bilateral distal vertebral and proximal basilar arteries. Based on the MRA findings, the patient was started on anticoagulation therapy with heparin drip and computed tomography angiography (CTA) of the head/neck was ordered emergently.
- CTA of head/neck revealed severe stenosis of vertebral artery segments with no distinct dissection flap identified, no evidence for dissection or hemodynamically significant stenosis in the extracranial segments of the bilateral vertebral arteries, and basilar artery focal flow-limiting stenosis. **(Figure 1B)**

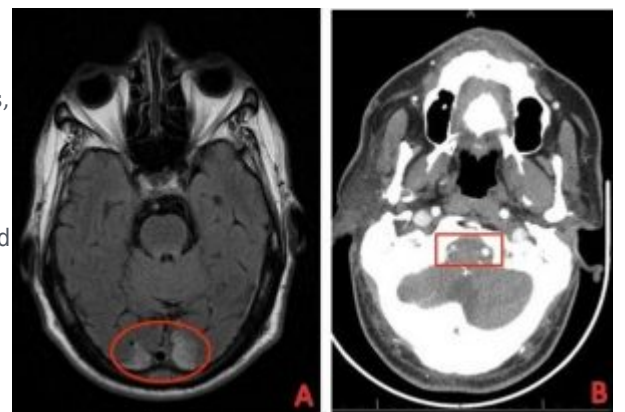


Figure 1. (A) MRI of the head without contrast revealed bilateral occipital infarcts. **(B)** CTA of the head and neck showed asymmetry of vertebral arteries.

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A vascular surgery specialist was consulted on the findings and confirmed intracranial attenuation of bilateral vertebral arteries. The patient was referred to neurosurgery. Neurosurgery decided that no neurosurgical intervention was indicated at that time. Heparin was discontinued and the patient was started on aspirin 81 mg and Plavix 75 mg for three months. The patient's symptoms were stable and a neuro-ophthalmology consult was recommended.

Follow-up visit #2: neuro-ophthalmology clinic

Ocular examination was stable from the first follow-up exam; however, visual field testing was performed. Results revealed bilateral inferior quadrantanopsia with macular sparing. **(Figure 2)** It was explained to the patient that his visual field defect secondary to his stroke was contributing to his blurry vision, especially while doing near work. Inferior field defects affect function in down gaze, which is the natural reading position. The patient was advised to continue care with the neurologist and to call immediately if symptoms worsened, as this could be a sign of changes in his neurological condition. Separate glasses were prescribed for distance and near to provide a greater reading area for the patient. In addition, prisms were discussed as a future option if the patient did not feel comfortable with the new glasses. Prisms in the glasses could potentially bring the inferior view higher in the patient's line of sight. The patient was asked to return for a repeat visual field exam in two months.

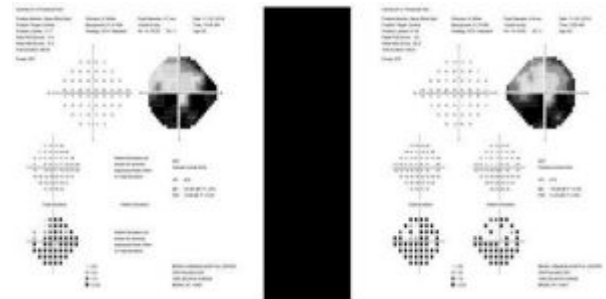


Figure 2. Distinct bilateral inferior quadrantanopsia on visual field testing correlated with the patient's bilateral parieto-occipital infarcts with macular sparing.

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At the two-month follow-up examination, clinical findings were stable. Although best-corrected distance visual acuity remained unchanged, the patient felt his vision was better. He was scheduled for repeat dilation and visual field exam in four months and instructed to return to the clinic sooner if he noticed any changes.

Education Guidelines

Learning objectives

1. Understand stroke pathology
2. Understand vascular anatomy along the visual pathway and its correlation with visual field defects
3. How to use different types of imaging to aid in diagnosing strokes
4. How to manage a patient who has experienced a stroke

Key concepts

1. Occipital lobe infarcts and corresponding visual field deficits
2. Assembling the clinical picture with diagnostic tools
3. Recognizing the importance of interdisciplinary care for successful patient management

Discussion points

1. What are risk factors for a stroke?
2. What causes a stroke?
3. Which cerebral artery supplies the occipital lobe?
4. What are the arteries that give the macula a dual blood supply?
5. Should optometric clinicians perform visual field testing on all stroke patients?
6. How can OCT be useful for this patient?
7. What are some indications for neuroimaging in optometry?
8. How can optometrists maximize care for stroke patients?
9. What should be discussed with patients who are at risk for a stroke?

Literature Review

Cerebrovascular accidents have varying neurological effects depending on the location of the lesion and vascular supply involved. It has been reported that the most common visual symptoms of stroke patients are visual field loss, blurred

vision, reading difficulty and diplopia. Less common symptoms include oscillopsia, visual hallucinations, depth impairment, photophobia and color disturbances.³ Spontaneous recovery can occur in up to 40% of patients within the first few weeks and up to six months after injury.⁴ The most common visual field defect secondary to CVA is homonymous hemianopsia respecting the vertical meridian. Other defects include homonymous quadrantanopsia or altitudinal defects. This patient presented with bilateral inferior quadrantanopsia, which ultimately formed bilateral altitudinal defect.

Approximately 75% of occipital lobe lesions are from infarctions of the middle cerebral or posterior cerebral arteries.⁵ Occipital lobe lesions normally generate contralateral homonymous scotomas that are particularly congruous. This characteristic of congruity is important because it helps differentiate occipital lobe lesions from other lesions in the visual system that produce incongruous visual field loss such as damage to the optic radiations or optic tracts.

J. Lawton Smith's review of 100 cases of homonymous hemianopic visual field defects secondary to strokes revealed that the majority of defects were due to occipital lobe lesions.⁶ Furthermore, CVAs are the most common cause of homonymous hemianopic visual field defects from the occipital lobe.⁷⁻⁹ The etiologies of infarctions in the occipital lobe are primarily emboli from the heart or vertebrobasilar artery system.⁷

Discussion

To facilitate the learning experience, the audience for this teaching case report should have basic knowledge of ocular anatomy, visual field deficits and their corresponding anatomical locations, and stroke pathology. The focus of this case presentation is to relate structure to function and vice versa. A review of ancillary testing options available to an optometrist, such as bloodwork, visual fields, OCT and radiological testing, would also be beneficial. To present this case in a teaching manner, a PowerPoint lecture should include a brief background of cerebrovascular accidents, the case presentation, learning objectives, key concepts, literature review and discussion points. A handout of images and tables should be given to the audience for visual reinforcement.

The learning objectives should be discussed by breaking down the key clinical points of the patient's exam and correlating those findings with a review of anatomy and radiologic imaging. Discussion points should be presented as stand-alone slides. The audience can be broken into smaller groups so learners have the opportunity to deliberate amongst themselves prior to coming to a consensus. Tables and images should be presented throughout the PowerPoint lecture to tie all of the information together. The audience can be given a handout of the patient's chief complaint, history and ocular examination findings from the initial emergency department consult. Other management and treatment options should be discussed from the initial visit, and the urgency of providing appropriate care should be highlighted. Concluding the presentation with the optometrist's role in managing stroke patients and patients at risk for stroke should help the audience to become better clinicians.

The patient's initial complaints of headaches with blurred vision prompted the emergency department to gather an interdisciplinary team to provide the best care for the patient. Not only was the optometrist involved, but also the neuro-ophthalmologist, neurologist, neurosurgeon and vascular surgeon.

It is important to be aware that in addition to headaches and blurred vision, the patient's chief complaints included dizziness, intermittent tongue numbness and intermittent slurred speech. These symptoms can be categorized as precursors to stroke, which is also known as transient ischemic attack (TIA). TIA symptoms cause sudden neurologic impairments that can last minutes or less than 24 hours and are considered "warning strokes." An estimated 15-30% of patients with an ischemic stroke report experiencing a preceding TIA.¹⁰

Patients are at highest risk of a subsequent stroke within the first week after a TIA (5% within 7 days), but the risk of subsequent stroke at one-year follow-up varies from 4.4% to 21%.¹¹ Common symptoms of TIA include complete paralysis of one side of the body, sudden loss or blurring of vision, dizziness, confusion, difficulty with comprehension, disorientation and dysphagia. Urgent evaluation, management and treatment can significantly reduce the risk of subsequent stroke.

TABLE 1
Risk Factors for Stroke

Family history and other factors	Behavior	Conditions
Family history	Poor diet	Previous stroke or TIA
Older age	Physical inactivity	High blood pressure
Female	Obesity	High cholesterol
Race: Blacks and Hispanics	Excessive alcohol intake	Heart disease
	Tobacco use	Diabetes
	Drug use	Sickle cell disease
	Oral contraceptives	Migraines
	Stress	Hemostatic and inflammatory factors: Hemogen and endogenous tissue type plasminogen activator
		Homocysteine

What are risk factors for a stroke?

Many factors, including age, diabetes, hypertension, hypercholesterolemia and coronary artery disease, put this patient at high risk for a stroke.^{1,12,13} **(Table 1)**

What causes a stroke?

To manage and treat a patient in whom a CVA is suspected, it is

Table 1. [Click to enlarge](#)

important to understand the various types and causes of CVA. Although hemorrhagic strokes are considered to have higher mortality risk, the majority of strokes are secondary to ischemia (10 times more frequent).¹⁴ An ischemic stroke occurs when blood is obstructed (clot) within the blood vessel. Clots can form a cerebral thrombosis or a cerebral embolism. Hemorrhagic strokes occur when the blood vessel is weakened to the extent that it ruptures and bleeds, compressing areas of the brain. Aneurysms or arteriovenous malformations are types of anomalous blood vessels that can cause intracerebral or subarachnoid hemorrhages.

Which cerebral artery supplies the occipital lobe?

The posterior cerebral artery (PCA) supplies blood not only to the occipital lobe but also to the temporal lobe, thalamus, corpus callosum and internal capsule. Branches of the PCA include the parieto-occipital artery, calcarine artery and the anterior, middle and posterior temporal arteries.¹⁵ Branches of the inferior calcarine artery supply the inferior cortex, whereas branches of the superior calcarine artery and parieto-occipital artery supply the superior cortex.⁸

What are the arteries that give the macula a dual blood supply?

The posterior cerebral artery and the middle cerebral artery both supply circulation to the visual cortex, which corresponds to the macular fibers responsible for central vision. Thus, an infarct of the middle cerebral artery can spare the macula because it can still receive nourishment from the posterior cerebral artery. In fact, the macular representation is disproportionately larger than its location in the posterior pole of the occipital lobe. It is estimated that 50-60% of the visual cortex represents only 10-30 degrees of central vision.¹⁶

Radiologic imaging in this case revealed an occlusion of the vertebrobasilar arteries. Understanding vascular anatomy is crucial for localizing the lesion and managing patients who have had stroke. The circle of Willis is an important vascular structure that sits at the base of the brain. The anterior circulation of the circle of Willis starts with the internal carotid artery (ICA), enters the cranial cavity bilaterally, and divides into the anterior cerebral artery and middle cerebral artery. The anterior communicating artery connects the anterior cerebral arteries from both sides. The posterior circulation includes a single basilar artery that anastomoses the right and left vertebral arteries. The basilar artery also leads to the PCA bilaterally and is connected to the ICA by the posterior communicating arteries.¹⁵ In this case, the patient's vertebral and basilar arteries were impaired, thus the occipital lobe was affected. His visual field loss correlated to an infarct from vertebrobasilar insufficiency. Based on anatomy, this would manifest bilaterally as was the case with this patient. Occlusion of the vertebrobasilar system can manifest not only as homonymous hemianopsia but also as tunnel vision or an altitudinal visual defect. For the patient in this case study, a bilateral inferior quadrantanopsia formed an altitudinal defect with macular sparing in both eyes.

The tip of the occipital lobe lies within the visual cortex in the region of the calcarine fissure. Inferior visual field defects localize lesions to the contralateral upper calcarine cortex and vice versa because the representation of the horizontal meridian is along the base of the calcarine fissure.^{17,18} It has been proposed that the visual cortex in the occipital lobe is arranged topographically as V1, V2 and V3 with V1 in the deeper layer and V3 in the superficial layer.¹⁸ A lesion in any of these areas would induce a quadrantanopsia visual field defect. As such, the occlusion of the parieto-occipital artery involving V1, V2 and V3 above the calcarine fissure resembles what was seen in this case: bilateral inferior quadrantanopsia visual field loss as the parieto-occipital artery feeds the superior part of the striate cortex.

Should optometrists perform visual field testing on all stroke patients?

Knowledge of common visual field patterns is helpful when considering differential diagnoses and it also gives optometrists an outlook on how patients see their world. Visual field defects can affect activities of daily living such as driving, walking, reading, etc. Stroke is the most common cause of homonymous hemianopsia, and it is commonly overlooked. In a study by Rowe and the Vision in Stroke group UK, 16% of stroke patients reported no visual symptoms, yet 85% of those patients were objectively shown to have visual impairment.³ It is important to properly evaluate patients post-stroke whether or not they have symptoms of visual impairment. Homonymous hemianopsia can impede rehabilitation and is related to worse functional outcomes in stroke patients. Therefore, visual field testing should be recommended for all patients who have suffered a stroke involving the cerebral hemispheres.⁹

How can OCT be useful for this patient?

OCT is a useful tool for detecting subtle changes in macular volume, the peripapillary retinal nerve fiber layer, macular ganglion cell layer and optic nerve head.¹⁹ In contrast, seeing retinal nerve fiber loss/atrophy on clinical examination requires at least 50% atrophy in the affected area.²⁰ GCA was considered a possible diagnosis in this case, but OCT showed normal findings in each eye, enabling any optic nerve head or macular pathology to be ruled out as a contributor to the patient's symptoms. Because the patient's infarcts were in the occipital lobe at the tip of the visual pathway, no atrophy was seen at the optic nerve head.

What are the indications for neuroimaging in optometry?

Without proper imaging, the patient in this case report could have been misdiagnosed, potentially significantly altering management and treatment options. Imaging is crucial in determining the diagnosis, extent and etiology of a stroke. Indications for neuroimaging are listed in **Table 2**. Initially, this patient underwent a CT scan that revealed chronic lacunar infarcts with mild chronic microvascular ischemic changes. Non-contrast head CT scans are the imaging modality of choice for evaluating acute stroke patients because they can identify early stroke signs and testing is relatively quick.²¹ The contrast agents used for CT scans are iodinated; therefore, allergies to iodine and renal failure are contraindications.²² MRI and CT scans are commonly ordered in cases with suspicion for infarcts, but MRI is usually preferred for imaging vertebrobasilar infarcts because MRI is less prone to artifacts and exhibits better contrast discrimination in the posterior fossa.²³

TABLE 2
Indications for Neuroimaging

Visual acuity or field loss: amaurosis fugax, optic neuropathy, scotoma, hemianopsia
Anisocoria or ptosis: Homer's syndrome, cranial nerve III palsy
Proptosis: thyroid eye disease, orbital tumor, orbital pseudotumor
Diplopia or ophthalmoplegia: ocular motor cranial neuropathy, supranuclear and internuclear ophthalmoplegia
Oscillopsia: nystagmus
Ophthalmoscopic abnormalities: papilledema

Singh P, Kaur R. A review of imaging techniques in neuro-ophthalmology. *Biol Biomed Rep.* 2012;2(2):99–107.

Table 2. [Click to enlarge](#)

MRI is superior to CT for evaluation of soft tissue. The most common MRI pulse sequences are T1 and T2 weighting, which examine how fast the tissue can become magnetized and how fast it loses magnetization. As a general rule, T1-weighted images are better for viewing anatomy and T2-weighted images are better for viewing pathology. With MRI, clinicians also have the option of fat suppression to enhance pathology recognition. Gadolinium is a contrast material commonly used in MRI to show areas of the blood-brain barrier that have been compromised. Diffusion-weighted sequences (DWI) aid better recognition of acute cerebral infarctions within the first hours of a stroke, revealing a bright lesion on the scan. Gradient echo sequences (GRE) have the ability to reveal hemorrhages in patients with underlying vascular malformations, intracerebral hemorrhages or traumatic brain injury.²² With superior resolution, MRI is commonly the modality of choice in neuro-radiological imaging.^{7,23} MRI is contraindicated in the presence of metallic devices such as pacemakers or prosthetics.

CT, CTA and MRA are non-invasive techniques to help doctors visualize the neurovascular anatomy. Blood flow restrictions, intracranial aneurysms or arteriovascular malformations, and patients who are symptomatic for carotid artery disease with transient vision loss (amaurosis fugax) can be tested using these modalities.⁷ The advantages of CTA over MRA include better image resolution and faster results. Further, CTA is indicated for patients who have aneurysm clips or pacemakers and patients who are claustrophobic.²² The advantage of MRA is that it can be performed with or without contrast. Also, MRA can identify high-grade atherosclerotic injuries in the head and neck, carotid and vertebral artery dissection, fibromuscular dysplasia and venous thrombosis.²¹ CTA and MRA are associated with lower morbidity than cerebral arteriography, which is the gold standard for detecting aneurysmal compression. However, if the suspicion of aneurysm is significant and CTA and MRA are negative, cerebral arteriography may be warranted.²⁴

How can optometrists maximize care for stroke patients?

Co-managing the patient with the neuro-ophthalmologist, neurologist, neurosurgeon and vascular surgeon contributed to the accurate diagnosis in this case. It also enabled successful treatment and management for this patient. Without the proper referrals and the efforts of the involved physicians, the patient could have been misdiagnosed or lost to follow-up.

Optometrists play a crucial role in detecting, treating and managing stroke patients as well as patients who are at risk for stroke. Although patients can be asymptomatic post-stroke, it is important to assess them for any visual impairment. Stroke patients can have visual field defects, ocular motility defects, low vision issues or perceptual defects that can be addressed with various treatment options that optometrists can provide. These options include refraction, prisms, occlusion, orthoptic

exercises and low vision aids.³ The goal is to enhance patients' independence in conducting their activities of daily living. Thus, proper evaluation by a low vision specialist or neuro-rehabilitation optometrist can be advantageous.

What should be discussed with patients who are at risk for stroke?

The ideal treatment for stroke is prevention, which makes patient education crucial. Patients should be educated about risk factors, importance of compliance with follow-ups, and healthy lifestyle recommendations. It has been reported that more than 45% of acute stroke patients were able to regain functional independence in six months.²⁵ However, depending on the severity of the stroke and the patient's overall health, stroke can result in long-term disability or death.

The patient described in this report is now in the phases of recovery and rehabilitation with the goal of regaining independence. Stroke survivors in rehabilitation programs work with specialists in rehabilitation nursing, physical therapy, occupational therapy, speech language pathology, audiology, recreational therapy, nutritional care, rehabilitation counseling, social work, psychiatry/psychology, chaplaincy and patient/family education.²⁶

Conclusion

Cerebrovascular accidents are a leading cause of serious long-term disability. Comprehension of the vascular anatomy of the head is crucial in recognizing the potential for ischemic injuries to the visual system. It is critical that optometrists are aware of the mechanism of strokes and the potential visual and systemic consequences. Educating patients about stroke signs and symptoms gives them an idea of when to seek care and helps to save lives. As primary eyecare providers, optometrists play a key role in identifying stroke patients and patients at risk for stroke. Because patients may present with only ocular manifestations, these encounters need prompt referrals in conjunction with using diagnostic tools to help capture the entire clinical picture.

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ELECTRONIC HEALTH RECORDS, CLINICAL EXPERIENCES AND INTERPROFESSIONAL STUDENT PERCEPTIONS

Abstract

This study evaluates changes in interprofessional attitudes and perceptions for students exposed to shared electronic health records (EHR) and students not exposed to shared EHR. A longitudinal study was conducted with 70 New England College of Optometry students. The Interprofessional Education Perception Scale survey was administered three times during the second and third year of training. Optometry student perceptions of how other health professionals perceive optometry were significantly more negative for the group who experienced early shared EHR than for the group without that experience. Optometric educators should be aware of the possible clinical impact on perceptions when assessing interprofessional educational programs and consider these findings when designing a clinical curriculum.

Key Words: interprofessional education, clinical education, electronic health record

Background

Interprofessional education (IPE) is defined as “when students from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes.”¹ The pedagogical implementation of IPE has steadily gained traction within the academic community in the past decade, markedly so since the Interprofessional Education Collaborative released its Core Competencies for Interprofessional Collaborative Practice in 2011.² As such, graduate health professional schools have begun to incorporate interprofessional education objectives as part of their accreditation standards.^{2,3} The endorsement of IPE by the Institute of Medicine has been a driving force behind IPE initiatives, with the intended goals of safer and higher quality care, delivered with increased efficiency and cost effectiveness.^{2,3,4}

Many institutions of higher education have integrated specific didactic activities to train students in IPE. Among graduate professional programs with clinical training, students may also be required to complete clinical assignments with interprofessional components. These assignments may require interprofessional activities such as referral coordination, communication with other providers, and other actions necessary for patient care. These various modes of communication are even more likely given the introduction of technology and electronic health records (EHR). There is evolving acknowledgement that health information technology plays an important role in providing team-based care, which should be integrated into IPE programs.^{5,6,7} Recently proposed models include a blending of EHR use and team-based activities, with the aim of delivering “technology enhanced collaborative care.”⁷

The effectiveness of didactic and clinical IPE training programs is typically assessed through changes in perception as measured by surveys.⁸⁻¹¹ While traditional clinical experience and EHR use are pervasive in the training of healthcare professionals, there is a paucity of literature regarding whether these activities can also change perceptions in the absence of a formal didactic training component. Rather, the published literature typically includes structured IPE interventions and/or clinical experiences in which interprofessional interactions are deliberate and purposefully planned.^{8,12-17} Additionally, the use and impact of EHR alone, when shared among several different healthcare professionals does not appear among the IPE literature.

The impact that clinical assignments have on IPE perceptions is not known. A better understanding of how clinical experiences and use of EHR impact student interprofessional perceptions may allow us to improve the design of IPE programs and influence clinical training for healthcare professionals.

The purpose of this study was to determine whether the clinical experience, without a planned IPE component, impacts student professional perceptions and whether the use of interprofessionally shared EHR plays a role. For the purposes of this study, an interprofessionally shared EHR setting was defined as a system that allows providers of different disciplines, i.e., primary care providers, pediatricians, behavioral health providers, etc., to review a mutual patient’s comprehensive health record and communicate in real time.

Methods

A longitudinal study was conducted over a 22-month period, from 2015-2017, with second-year students (n=70) at New England College of Optometry (NECO). All study protocols conformed to the Declaration of Helsinki and were approved by the Internal Review Board at NECO. Approximately half the class was randomized into two groups at the beginning of

second year (**Figure 1**). The control group (n=35) was given a clinic assignment without interprofessionally shared EHR. These assignments were based at NECO owned and operated optometry clinics and private solo and group practices. The treatment group (n=35) was given a clinical assignment with interprofessionally shared EHR. These assignments were based in community health centers where multidisciplinary care was occurring. Students were assigned for the entire second year (approximately 35 weeks), during which time the focus was on building technical and communication skills. During clinical assignments, students are required to perform any combination of the following: automated pre-testing, case history, entrance testing, retinoscopy, refraction, slit lamp biomicroscopy, Goldmann tonometry and dilated fundus exams.

Students were not recruited for this study and there was no additional benefit or incentive to participation. All students received the Interdisciplinary Education Perception Scale (IEPS) survey. Only students with clinical assignments at sites meeting the eligibility criteria (year-long assignments during second year in a shared or non-shared EHR site) were included for analysis.

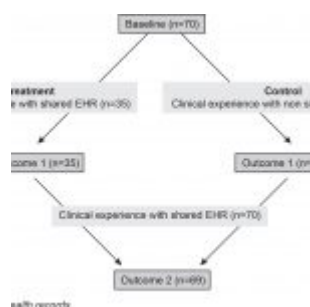


Figure 1. Study design with baseline, outcome 1, and outcome 2 of surveys.
[Click to enlarge](#)

At the conclusion of the second year, the control and treatment groups were mixed before commencing third-year assignments. Throughout third year (approximately 40 weeks), all students rotated through 1-2 semesters in a community health center, 1-2 semesters in a NECO owned and operated clinic, and a small percentage of students were assigned to Veterans Affairs or hospital-based settings. This clinical year focused on primary care with increasing responsibility for patient diagnosis and management. Competencies assessed represented a more comprehensive skill set at this time, including the ability to analyze exam data and develop differential diagnoses and treatment and management plans.

The IEPS survey, an 18-item psychometrically validated instrument that has been widely used in the published literature,^{18,19} was administered via Qualtrics before the start of second year (baseline, B), at the end of second year (outcome 1, O1), and at the end of third year (outcome 2, O2). Qualtrics is an online subscription software used for the detailed control of survey development, distribution and analysis. The IEPS assesses “competency and autonomy, perceived need for cooperation, and perception of actual cooperation.”²⁰ Each item utilizes a 7-point scale with three subcategories, as developed by this study’s investigators. The three subcategories are as follows: OD student perceptions of the optometric profession (OD-OD), OD student perceptions of other health professions (OD-Ot), and other health profession perceptions of optometry (Ot-OD). **Table 1** shows the IEPS with the subcategories.

Item	Subcategory
1. Individuals in my profession are well trained	OD-OD
2. Individuals in my profession are able to work closely with individuals in other professions	OD-Ot
3. Individuals in my profession demonstrate a great deal of autonomy	OD-OD
4. Individuals in other professions respect the work done by my profession	Od-OD
5. Individuals in my profession are very positive about their goals and objectives	OD-OD
6. Individuals in my profession tend to cooperate with other professions	OD-Ot
7. Individuals in my profession are very positive about their contributions and accomplishments	OD-OD
8. Individuals in my profession must depend upon the work of people in other professions	Od-OD
9. Individuals in other professions think highly of my profession	Od-OD
10. Individuals in my profession trust each other's professional judgment	OD-Ot
11. Individuals in my profession have a higher status than individuals in other professions	Od-OD
12. Individuals in my profession make every effort to understand the capabilities and contributions of other professions	OD-Ot
13. Individuals in my profession are extremely competent	OD-OD
14. Individuals in my profession are willing to share information and resources with other professions	OD-Ot
15. Individuals in my profession have good relations with people in other professions	Od-OD
16. Individuals in my profession have rights of other related professions	Od-OD
17. Individuals in my profession work well with each other	OD-OD

TABLE 2
Demographic and Academic Variables for Control and Treatment

	Control		Treatment	
	N	M	N	M
23-29 years	35	25.83	35	25.51
4.00-4.83	35	3.03	35	3.90
Female	25		23	
Male	10		12	
Asian	13		5	
Black	1		0	
Hispanic	1		1	
Non-Hispanic White	12		19	
Unknown	0		10	

Number of participants; M = mean

Table 1. [Click to enlarge](#) **Table 2.** [Click to enlarge](#)

A 2-sample t-test was used to compare demographic and academic variables between treatment and control groups. A 2×3 mixed ANOVA analysis was conducted with groups (control and treatment) used as the between-subjects variable and three subcategories (OD-OD, OD-Ot, and Ot-OD) used as the within-subjects variable. Follow-up univariate tests were conducted. A p-value of <0.05 was used as the threshold for statistical significance.

Results

The survey was completed by 70 participants at baseline and O1 and 69 participants at O2. One student dropped out of the study due to a leave of absence from NECO. **Table 2** shows the demographic and academic variables for all study participants. No statistically significant differences were found between treatment and control groups for age (p=0.44), sex (p=0.61), race/ethnicity (p=0.06), or GPA (p=0.81).

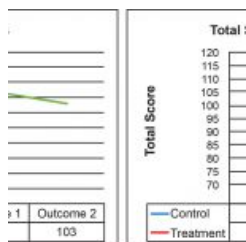


Figure 2. Total survey scores for all participants and by group at baseline, outcome 1, and outcome 2.
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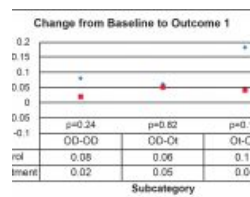


Figure 3.[Click to enlarge](#)

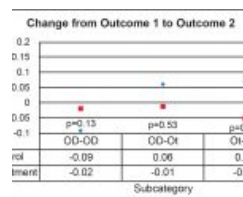


Figure 4.[Click to enlarge](#)

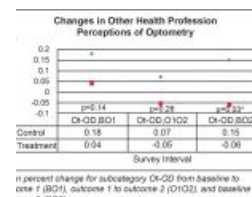


Figure 5.[Click to enlarge](#)

Total survey scores for all participants and total survey scores by group did not yield statistically significant differences from baseline to O1, or O1 to O2 (**Figure 2**). All p-values were >0.05 for this analysis.

For a 2×3 mixed ANOVA, the treatment and control groups served as the between-subjects variable, and the three subcategories (OD-OD, OD-Ot, Ot-OD) served as the within-subjects variable. Results indicated a statistically significant group \times subcategory interaction effect, $F(2, 66) = 3.36$, $p = .04$, $\eta^2 = .09$ (a moderate effect). Follow-up univariate tests detected a significant change, $F(1, 67) = 4.68$, $p = .03$, $\eta^2 = .065$ (a moderate effect), between baseline and O2 on “other health profession perceptions of optometry.”

There were no significant change differences between the groups concerning “OD student perceptions of the optometric profession” or “OD student perceptions of other health professionals.” **Figures 3 and 4** show the mean percentage change by subcategory from baseline to O1, and O1 to O2. **Figure 5** shows the mean percentage change for subcategory Ot-OD from baseline to O1, O1 to O2, and baseline to O2. While the treatment group scores attenuated by .06 (-6%), the control group scores increased by .15 (+15%).

Discussion

This study investigated the evolution of optometry student professional perceptions throughout the second and third year of optometry school at New England College of Optometry. Overall, student professional perceptions changed very little during this time period. Furthermore, it was found that during the second year of the OD program, perceptions of those assigned to a shared EHR setting did not significantly change compared to those assigned to a clinic without shared EHR. However, at the completion of the third year, when all students had assignments with shared EHR, students whose exposure to shared EHR was delayed until the third year maintained consistently more positive perceptions of how others view optometry. Conversely, those who were exposed to shared EHR earlier thought that other professions viewed optometry more negatively than those who did not have early exposure to a shared EHR setting.

This calls into question whether there is something inherent in the clinical experience that impacts the way students perceive other professions’ view of optometry. Perhaps students with early exposure to more integrated clinical environments experience negative or mixed first impressions with other health professionals, resulting in negatively shifting perceptions. Furthermore, students in siloed clinical environments may be more likely to be protected from positive and negative interactions with other health professionals, allowing a steadily positive perception to persist. In other words, students in an isolated clinical environment may be more positive about the profession because they do not have the opportunity to experience the contrary.

A study among nurses and physicians by Foronda et al. noted that “Egos, lack of confidence, lack of organization and structural hierarchies hindered relationships and communications.”²¹ We posit that similar mechanisms may be affecting second- and third-year optometry student professional perceptions, particularly when they are exposed early to interprofessionally shared EHR settings. Additionally, the year in which students are exposed to the type of clinical environment could be an additional factor shaping their perceptions. Perhaps the nature and amount of clinical responsibility placed on a student in the second year vs. the third year cultivates more or less confidence when working with other professionals.

Importantly, the results of this study raise questions about the role of formal didactic IPE instruction in optometric education. Specifically, would professional perceptions shift if students were better prepared to handle the interprofessional components of a clinical assignment? Although this study was not designed to answer this question, this has been identified as an area of future research.

Among the strengths of this study is the use of natural observation of the clinical educational process. The participants in

this study were not specifically educated or primed with respect to IPE prior to survey administration. Additionally, the IEPS survey was chosen specifically because it did not use the term “interprofessional” or ask about shared learning or team work. This allowed for an unbiased assessment of interprofessional perceptions. Second, there was no intentionally designed didactic component in this study, as is the case with the majority of the IPE literature. A common approach in the IPE literature involves a didactic intervention with students of several disciplines learning about IPE and taking surveys before and after intervention. Because our study did not include this exercise, it allowed for a more focused evaluation of the clinical experience and how it impacts perceptions during the second and third year of optometric training.

There were several limitations to this study. It reflects only two years of data collection, which does not include the fourth year of optometry school. The investigators plan to collect a third year of survey data to determine whether these short-term shifts in perception persist through the final year of the program. It is possible that perceptions are more easily impacted with students earlier in their optometric tenure but equalize by graduation. Additionally, student clinical grades were not factored into the analysis of this study. It is, therefore, unknown how student clinical performance and grades impact the evolution of interprofessional perceptions. Furthermore, the findings of this study do not address how student perceptions impact performance or patient outcomes/perceptions. It would be beneficial to know whether the positive or negative shift in perceptions affect student performance and, ultimately, patient care, but data was not gathered to address this important question.

Conclusion

While the overwhelming majority of IPE literature includes a specifically structured interprofessional intervention, this study offers some evidence of the shift in student perceptions during more traditional clinical exposure. Overall, student perceptions changed very little during clinical assignments. However, students whose exposure to interprofessionally shared EHR was delayed tended to have more positive perceptions of how other professionals view optometry, while those exposed earlier in their education tended to have more negative perceptions of how other professionals view optometry. The long-term impact and whether it affects clinical performance requires further investigation.

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THE USE OF OCT IN DIFFERENTIAL DIAGNOSIS OF ELEVATED OPTIC DISCS

Abstract

Optical coherence tomography (OCT) can aid in the differential diagnosis of optic nerve head (ONH) elevation. Specific OCT hallmarks, such as “V contour” and a “lumpy-bumpy” appearance, associated with optic disc edema and optic nerve head drusen, respectively, were investigated in isolation from line scans added to photographs of various elevated ONHs in a web-based survey distributed among Australian and New Zealand optometrists. Despite randomization of participants into a control (n=91) and intervention group (n=106), who were offered a short education on the investigated OCT feature, diagnostic accuracy was solely correlated with self-reported experience with OCT scans. As such, the provision of educational material did not result in anticipated improvement of clinical acumen for differentiation of elevated pathological optic discs from elevated non-pathological optic discs.

Key Words: optic nerve head, papilledema, elevated optic disc, differential diagnosis, optical coherence tomography

Background

One of the challenges facing the ophthalmic care provider in clinical practice is the presentation of an elevated optic nerve head (ONH). The most critical initial assessment aims to differentiate true papilledema from pseudopapilledema due to the fundamentally different implication regarding appropriate care.¹ Papilledema, one of the most common reasons for optic disc edema (ODE), is triggered by raised intracranial pressure and requires urgent management to circumvent a potentially fatal outcome. Pseudopapilledema, on the other hand, comprises a variety of conditions that can be managed through routine reviews, most commonly buried optic nerve head drusen (ONHD), obliquely inserted optic discs or crowded optic discs.^{2,3}

The increasing use of optical coherence tomography (OCT) in primary ophthalmic practice has allowed the in-vivo visualization of the retinal layers, thereby improving patient management in optic nerve and retinal disorders. Given the time and cost involved in obtaining OCT scans, it is vital for practitioners to gauge the overall significance of it as a diagnostic tool and evaluate OCT features that are better suited to add to diagnostic accuracy. It is commonly acknowledged that education can improve the application of individual techniques. Therefore, the interpretation of OCT may well depend on the familiarity of the practitioner with the method.³⁻⁷

Recent studies have suggested that OCT can improve differential diagnosis between true swelling and pseudopapilledema.^{2, 8-10} The retinal nerve fiber layer (RNFL) has been extensively studied as an important contributor to ONH disease,^{2, 11-17} and thinning or thickening can be present in both ODE or ONHD depending on the stage of the disease.^{16,18} A recent study by Johnson et al⁸ describes specific features on OCT that can provide guidance to practitioners for differentiation of ODE and ONHD. The study also suggests that RNFL thickness values may assist in the differentiation between ODE and ONHD, but the authors identify unique image features that are associated with these two ONH changes. ODE is characterized by the formation of a “lazy V contour” created by a subretinal hyporeflective space adjacent to the ONH. ONHD presents with a “lumpy-bumpy” internal contour of the optic nerve.⁸ The “lazy V contour” and the “lumpy-bumpy” appearance proposed to be diagnostic for ODE and ONHD, respectively, may be difficult to distinguish from each other and from tilted or crowded optic discs.¹ Consequently, it was of interest to evaluate these particular features as diagnostic markers and consider integration into future recommendations regarding OCT image interpretation. Aside from the differentiation of pathological optic discs from non-pathological optic discs, we were also interested in differentiating obliquely inserted and crowded optic discs from each other.¹⁹⁻²³ Unlike papilledema and ONHD, crowded optic discs and tilted, obliquely inserted optic discs generally do not require treatment. This differentiation is clinically important to avoid both potential false positive and false negative diagnoses.

To our knowledge, there have been no studies assessing the diagnostic accuracy of OCT hallmarks in the differentiation of pathological optic discs from non-pathological optic discs or examining the impact of educational material on clinical acumen. The current study, therefore, investigated en-face OCT scans using a previously established, individual OCT observation, and aimed to establish its value as a diagnostic parameter in isolation. A web-based clinical study was designed to test the hypothesis that this particular feature enhances differential diagnosis of ONH pathologies if highlighted in the form of respective educational material. Isolated 2D imaging and line scan presentation of individual eyes were chosen to ensure standardized conditions for all study participants and enable evaluation of the investigated feature in the absence of other diagnostic markers, such as RNFL thickness. Although this presentation does not reflect clinical settings, it allows assessment of specific OCT hallmarks to optimize this tool for differential diagnosis of ONH elevation and examines the impact of isolated information on the clinical diagnosis process.

Methods

Case compilation

We developed a case series of elevated optic discs from 40 patients seen at the Centre for Eye Health (CFEH). CFEH is a specialized referral-only imaging and diagnostic center staffed by highly trained optometrists and consulting ophthalmologists. All clinical data were retrospectively collected from patients previously seen at CFEH who had undergone routine ONH examination. Patients were only included in the study if they were unambiguously diagnosed by two optometrists and a consulting ophthalmologist. Diagnoses of ONHD were based on B-scan ultrasonography and fundus autofluorescence and included cases that were classified as buried ONHD on the basis that diagnosis could not be made from ONH photography. If papilledema was suspected, patients were immediately referred to hospital care for further investigation. Only patients with a diagnosis of idiopathic intracranial hypertension confirmed by the consultant hospital ophthalmologist were included as ODE cases in this study. One pathological disc of incipient vein occlusion was included in the case series. In the classification of non-pathological discs, the discs were categorized as congenitally crowded or obliquely inserted. Crowded discs are a congenital variation: a small optic disc with ill-defined margins and no obvious cupping, likely a consequence of the standard number of ganglion cell and optic nerve axons entering at a small optic disc.^{20,21} Obliquely inserted optic discs are a congenital condition thought to lie within the ocular colobomata spectrum. In these cases the optic nerve penetrates the eye at an oblique angle causing height differences most commonly between the nasal and temporal rim, with the relative elevation causing the appearance of blurring of the disc margins and suspicion of a swollen optic disc.²² For the purpose of this study, disc elevation leading to indistinct margins was mapped per quadrant for each disc, and disc size was recorded. Discs were classified as crowded if at least two quadrants were elevated with indistinct margins in the context of a small disc measured on the retinal photography software ($<2.4\text{mm}^2$).^{20,21} Obliquely inserted discs were defined if the degree of torsion of the longest disc diameter was beyond 15 degrees.¹⁹⁻²³

Written consent was obtained from patients following the tenets of the Declaration of Helsinki and ethics protocols approved by the Human Research Ethics Advisory panel of the University of New South Wales (UNSW) Sydney, Australia.

Cases were chosen to reflect the quantity and quality of patients seen in optometry-driven primary eye care, although cases of ODE were limited to papilledema only. As such, the study comprised five papilledematous discs, 18 “normal” discs (8 obliquely inserted, 10 crowded), 16 discs with ONHD and one other pathological disc (incipient vein occlusion). For each patient, a color 2D photo was taken with a Kowa Nonmyd WX-3D at 34° field angle (20° horizontal and 27° vertical, 12 megapixel digital resulting in 72 dpi resolution of the final image). An OCT line scan through the center of the ONH was isolated for each patient from a 15×10° or 15×20° OCT volume scan consisting of 97 B-scans spaced 33 µm at ART 23 using the Spectralis OCT (digital resolution of 3.9 µm axially by 6 µm laterally). This single line scan for each patient was chosen independently by two optometrists to best represent the condition, and decided by a third optometrist if equivocal, to ensure standardized conditions for case reviews. The OCT line scans were chosen based on images identified in the literature as specific to the optic disc condition.^{8-10, 20-22} Image sizes were adjusted to provide views of the ONH. Examples of clinical information, including all five papilledema cases are provided in **Appendix A**.

Survey development

Although the survey was completely anonymous, basic demographic and background information about participants’ therapeutic endorsement (TE), geographic distribution, age, gender, number of OCT scans performed per week, and confidence in interpreting OCT was collected for basic statistical information and to gauge the expertise of participants with OCT. The body of the survey aimed to assess the use of specific parameters of OCT to assist with diagnosis. To isolate these parameters, presentation of patient data was standardized as 2D images and OCT line scans, and variables likely to independently influence diagnosis, such as bilateral data or RNFL thickness, were purposefully eliminated. Based on these criteria, participants were asked to classify ONH images of all 40 patients into one of four categories: papilledema, ONHD, other pathological disc, or normal disc. For normal discs, the subcategories of crowded or oblique optic disc were available (**Appendix B**). At the end of the initial assessment of all 40 images, participants were randomly allocated into a control or

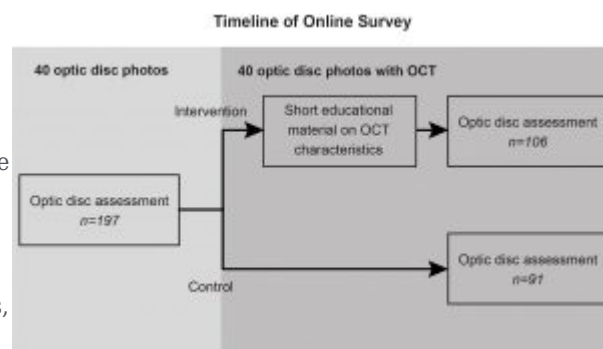


Figure 1. All participants (n=197) were initially asked to assess optic disc photos alone. Participants were then randomized into intervention (n=106) and control (n=91) groups. The intervention group was shown short educational material on OCT characteristics. Both groups then assessed the optic disc with OCT information. [Click to enlarge](#)

intervention group (**Figure 1**). The control group immediately proceeded to a second assessment round, while the intervention group was provided with a short education summarizing the main OCT characteristics of true swelling, ONHD, obliquely inserted optic discs and crowded optic discs (**Appendix C**). The same patients were then assessed again in randomized order, but OCT line scans were provided alongside the original ONH images. Once a diagnosis was submitted, optometrists were not able to access the case again. The completed survey was piloted on 12 optometrists from the CFEH and the School of Optometry and Vision Science UNSW Sydney, Australia, prior to distribution. Minor amendments were made based on feedback regarding comprehension before the case series was deployed online via Survey Monkey (<http://www.surveymonkey.com>).

Participants and collection of data

Practicing optometrists registered with Optometry Australia (4,073, comprising 94% of Australia's practitioners) and the New Zealand Association of Optometrists (570, comprising 84% of New Zealand's practitioners) were invited to participate in the study via an e-mail through the respective associations. The invitation letter provided access to the online case series and contained details regarding confidentiality of information, research purpose and informed consent in accordance with the UNSW Sydney Human Research Ethics Advisory Panel. Anonymous participation was limited to a single entry for each participant as identified by their IP address. The number of participating optometrists needed for this study was calculated to detect statistical significance of 5% improvement with 95% power at a p-value=0.01. Assuming 72.5 mean accuracy and equal standard deviation of 5.74 based on the pilot study, this amounted to at least 91 subjects in either group. The online study only remained open until the required number of responses was obtained.

Statistical analysis

After excluding entries with more than 5% of answers missing, a total of 197 entries were analyzed with 106 and 91 optometrists in the intervention and control groups, respectively. Data analysis was performed using IBM SPSS Statistics (Version 21; SPSS Inc., Chicago, IL, USA). The primary outcomes were the number of correct diagnoses (score out of 40) and diagnostic accuracy. Both variables were normally distributed in either cohort (D'Agostino & Pearson omnibus normality test) and were reported as mean and standard deviation (SD). Comparisons between and within groups were tested with chi-squared goodness of fit and paired t-test, respectively. A generalized estimating equations (GEE) model was applied to assess the effect of the intervention on the change in correctly diagnosed patients with the addition of OCT imaging to account for repeat diagnoses. An independent working correlation matrix structure was chosen for a model defined by a normal distribution and identity link function testing for categorical variable intervention in addition to age category, gender, TE, average number of OCTs performed per week and confidence with OCT interpretation.

Results

Diagnoses of potential ONH swelling from ONH photography without and with the addition of OCT line scans for 40 patients were completed by 197 Australian and New Zealand optometrists. Basic demographic details (age and gender) and parameters potentially influencing outcomes, including status of TE, number of OCT scans performed per week, and self-reported confidence in using OCT were equally distributed between the two cohorts (**Table 1**). The number of cases correctly diagnosed was normally distributed in both the control and intervention groups based on ONH photography before ($p=0.22$ and 0.44 , respectively) and after the addition of OCT line scans ($p=0.22$ and 0.53 , respectively), but differed significantly between the two diagnostic modes for the control group only (paired samples T-test) (**Table 2**). This was reflected by a decrease in diagnostic accuracy from $66\% \pm 8.9$ (26.3 average number of

TABLE 1
Similarity of Optometrists in the Control and Intervention Groups

		Control n = 91	Intervention n = 196	X ² test
Age	18-24	5	7	3.7, df=4, p=0.45
	25-34	28	32	
	35-44	27	29	
	45-54	20	16	
	>55	11	22	
Gender	F/M	42/49	51/55	0.1, df=1, p=0.78
TE	Yes/No	57/34	62/44	0.4, df=1, p=0.55
Average number of OCTs per week	None	33	51	5.1, df=4, p=0.27
	Rarely	13	14	
	<5	18	20	
	5-10	16	16	
	>10	11	5	
Confidence [†]	Yes/No	49/42	47/58	1.8, df=1, p=0.78

TE = therapeutic endorsement, endorsed for scheduled medicines
[†]self-reported confidence in interpreting OCT scans

Table 1. [Click to enlarge](#)

TABLE 2
Average Numbers of Correct Diagnoses (out of 40)

	Control	Intervention	Independent samples T-test control/intervention
ONH photography Mean (STD)	26.3 (3.6)	26.4 (3.8)	0.06; df=195; p=0.96
OCT line scan Mean (STD)	25.3 (4.2)	26.9 (3.2)	2.91; df=195; p=0.004
Paired samples T-test ONH/OCT	-2.44; df=90; p=0.02	-1.26; df=105; p=0.21	

STD = standard deviation
 Results of T-test indicate significant differences between individual groups

Table 2. [Click to enlarge](#)

diagnoses) to $63\% \pm 10.6$ (25.3) in the control group, and change from $66\% \pm 9.4$ (26.4) to $67\% \pm 7.9$ (26.9) in the intervention group amounting to a significant difference between the two groups for the OCT line scan (independent samples T-test) (Table 2).

GEE analysis confirmed the significant change from baseline between the control and intervention group after correcting for age, gender, TE, number of OCTs performed per week or confidence in OCT analysis (1.5; 95% CI 0.4-2.7; p-value=0.006). None of these variables was associated with differences between the two groups or overall diagnostic accuracy based on ONH photography, while overall diagnostic accuracy from line scans was correlated with the participant group (control or intervention) as well as the average number of OCT scans performed per week ($p < 0.01$). The difference in change was caused by curbing a subgroup of optometrists who diagnosed fewer patients correctly after the addition of OCT line scans in the control group compared to no significant change between ONH and ONH & OCT assessments in the intervention group (**Figure 2**).

The impact of investigated OCT parameters on diagnostic accuracy was of particular interest with regard to individual pathology. For the purpose of analysis, the discs were classified into five papilledema cases, 17 other pathological optic discs, and 18 non-pathological optic discs. While non-pathological optic discs included eight obliquely inserted and 10 crowded discs, other pathologies were in essence limited to ONHD and a single case of incipient vein occlusion. Most strikingly, diagnostic accuracy across all 197 participants decreased 13% with the inclusion of OCT line scans for papilledema (from 69% to 56%), while other pathologies showed a 3% decrease (from 64% to 61%) and non-pathological discs were diagnosed 3% more accurately on average (from 68% to 71%). A closer look at the control and intervention groups exposed that the loss of diagnostic accuracy for papilledema cases was mainly caused by a relatively greater loss in the intervention group, while the control group showed almost identical gain and loss of diagnostic accuracy for this particular group (**Figure 3**).

Participants in the Control and I

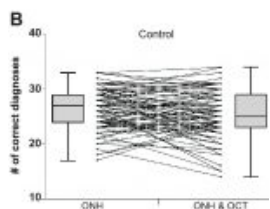


Figure 2. The number of correct answers for individual optometrists ranged between 15 and 34 (A), with a similar distribution for the control and intervention group if diagnosis was made from ONH photography only (y-axis), but the control group performed worse if OCT was included (x-axis) (B, C). The change is illustrated by box-and-whisker plots, whereby the box presents the 25th to 75th percentile with the median marked by the engulfed line and the whiskers outlining the range of the obtained answers. Individual changes depicted in between highlight the higher variability in results for the control group (B) after adding OCT line scans as a diagnostic test.

[Click to enlarge](#)

More specifically, of all misdiagnosed papilledema cases, 7.4% were classified as ONHD, 51% as “other pathology,” and 41.6% as normal (of these, 80% crowded and 20% obliquely inserted) based on photo presentation only. Following the introduction of the OCT scans, the unidentified papilledema cases were diagnosed as ONHD in 35.3% of cases, as “other pathology” in 22.7% of cases, and interpreted as normal in 42% of cases (54% crowded and 46% obliquely inserted). In the intervention group, percentages were 35.3% and 40.4% for ONHD, 45.6% and 10.3% for “other pathology” and 44.4% (81% crowded and 19% obliquely inserted) and 49.3% (61% crowded and 39% obliquely inserted) for normal with presentation of photo alone and after addition of the OCT line scan, respectively.

Both the control and intervention groups had only marginally more loss than gain with other pathologies cases. This was also true for non-pathological discs in the control group, while the intervention group had a large gain of diagnostic accuracy with these patients (**Table 3**).

Discussion

Some OCT parameters, such as RNFL thickness, can yield a sensitivity of 98% distinguishing between diseased and healthy ONH, yet specificity lags behind at 77%.^{8-10, 18, 24} Measuring the peripapillary total retinal thickness may be even more sensitive in detecting mild papilledema than the measurement of RNFL thickness alone.^{25, 26} While there was a statistically significant increase in overall diagnostic accuracy in the intervention group vs. the control group, there was a relative loss in the diagnostic accuracy in critical cases. Our study suggests that the assessment of an isolated structural feature from OCT line scans previously described by Johnson et al and Flores-Rodriguez does not aid differential diagnosis in the absence of a full spectrum of clinical information of optic disc elevation.^{8, 24} It may, in fact, decrease diagnostic accuracy, possibly due to over-interpretation of isolated information or, alternatively, due to the limited experience of participating optometrists with performing OCT scans at all during their practice.

A similar observation was made in a previous study by Kulkarni et al,²⁷ who investigated the effect of extensive tutorials in the differentiation between mild papilledema and buried ONHD on the basis of OCT images and RNFL measurements. It should be highlighted that the conclusions of this study were based on results from five participating clinicians only and all presented eyes were pathological with the exception of two ONHD cases, which had one unaffected fellow eye each. In contrast, the current study aimed to reflect representative skills of a broad range of optometrists and mimic the prevalence of types of elevated optic discs typically seen in clinical practice in the presence of a reasonably large number of non-pathological discs. Despite significant differences in the design, both studies highlight the limited effect of provided educational material in conjunction with isolated diagnostic parameters, despite OCT imaging being increasingly used in general practice.

Australian and New Zealand optometrists in the control and intervention groups of the current study had similar age distribution and experience levels. A web-based survey was utilized to enable convenient access for the participants, and we assumed that practicing optometrists in Australia and New Zealand possess core skills relating to the interpretation of

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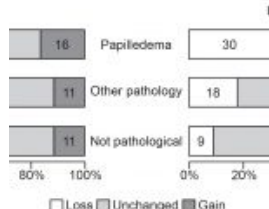


Figure 3. The percentage loss or gain of accurate diagnoses after reviewing OCT line scans compared to the original results from ONH photography alone was recorded overall (top) and for individual disease statuses in relation to those diagnoses that remained unchanged (light grey), regardless of whether these diagnoses were initially correct or incorrect. Of note, while changes were relatively consistent within the control group, a large number of practitioners misclassified papilledema after the addition of OCT scans in the intervention group, who showed otherwise similar gain in diagnostic accuracy to the control group.

[Click to enlarge](#)

TABLE 3
is in Percentages from (loss) and to (gain) Correct Diagnosis of OCT Line Scans for Control (A) and Intervention

Loss	Unchanged	Gain
Papilledema	16%	73%
Other pathology	11%	71%
Not pathological	11%	80%

Table 3. [Click to enlarge](#)

OCT. Questions we posed to study participants included whether they felt self-confident in the interpretation of OCT scans, number of OCT scans performed per week, and if they were therapeutically endorsed. While diagnostic accuracy was correlated with self-reported experience with OCT scans, none of the parameters was found to have an impact on the comparison between the control and intervention groups, perhaps reflecting an overall lack of knowledge base regarding imaging techniques. This result is contrary to previous studies in which TE impacted results.^{28,29} This is likely a consequence of the current study assessing a clinical skill as opposed to theoretical skills, further supported by the number of OCT scans performed by participating optometrists being associated with the number of correct diagnoses obtained from OCT line scans. Thus, short-term didactic training may be more effective when the teaching is combined with standard clinical training techniques and a sound understanding of the constraints of imaging technology.^{5,30,31}

While some combinations of clinical tests and education can improve sensitivity and maintain or improve specificity,^{4,32,33} the 4% significant difference between our control and intervention groups was caused by preventing a decrease in incorrect diagnoses with the addition of OCT line scans possibly counteracting some of the inexperience with interpretation of this technique. The concurrent 30% loss in correct papilledema diagnoses could be a consequence of the relatively small number of pathological discs within the case series, which aimed to provide a more realistic representation of the number of papilledema cases seen in clinical practice, a subset of patients with idiopathic intracranial hypertension.³⁴ Alternatively, it could reflect over-confidence by the participants or lack of feedback during the case series, leading to a less conservative decision after integrating the provided education material on a specific image feature.³⁵⁻³⁷

Interestingly, while diagnostic accuracy of pathological optic discs decreased, diagnostic accuracy in the identification of non-pathological optic discs improved in the intervention compared to the control group. This suggests that adjunct techniques and educational information have the potential to positively impact the false positive rate. This improvement, however, may be at the expense of the incorrect diagnosis of pathologies, an undesirable outcome in critical cases.⁵ Even though the educational material was reduced to information on a single image feature described by Johnson et al,⁸ it did reduce the variability in accuracy within the intervention cohort, a result also achieved by long-term programs targeting unification of originally diverse cohorts.³⁸ Overall, however, the outcomes highlight the difficulties in providing guidance on isolated diagnostic parameters in the education on OCT interpretation in lieu of comprehensive clinical training. Clinical assessment for potential ODE or ONHD should include B-Scan ultrasonography, the current gold standard for ONHD diagnosis, or short-wave fundus autofluorescence (SW-FAF), which is considered the least invasive way to detect ONHD owing to its ability to cause the drusen to appear hyper-autofluorescent.^{39,40} SW-FAF indeed has had the highest sensitivity and specificity in differentiating ONHD from papilledema on red and green filters.⁴¹ Most importantly, technological advances need to be assimilated into an existing knowledge base rather than taught as an isolated diagnostic skill.^{4,42,43} It may be that short-term training is inadequate and that more extensive, continued training is required to improve the diagnostic accuracy of clinicians.⁴⁴⁻⁴⁶ Integration of potentially more successful teaching strategies, such as extensive long-term training on OCT interpretation, increased exposure to new technology, and performance feedback prior to final assessments might need to be considered in the future. Former use of technology, group learning activities and instructor feedback in particular have been identified as key to successful online education.⁴⁷⁻⁴⁸

Limitations of the study

This study was limited to the investigation of an isolated clinical test parameter, which cannot reflect actual diagnostic accuracy achieved in a clinical setting. Furthermore, as the OCT line scans were chosen by optometrists who were aware of the diagnosis, a potential selection bias could have been present. OCT scans were reduced to a single line scan to provide optimal and standardized visualization for all participants and enable direct comparison to previous published images.⁸ Because the case series was deployed online, we could not control for the screen resolution or environment used to view the images. In addition, time allowed by participants in the intervention group to study differential diagnosis using the provided details on OCT interpretation may have varied.

The concept of the usefulness of OCT for diagnosis of pathological optic discs was comparatively short to avoid unreasonable time constraints, and participating optometrists were not provided with sample questions on which to practice their skills or interactive feedback prior to being assessed. The educational material provided was limited to the description of a single, isolated imaging feature. Future studies will focus on expanded provision of educational materials through integration of related diagnostic markers, such as RNFL thickness measurements and optimized educational intervention to increase consistency of knowledge acquisition.

As with any anonymous online study, we also cannot control potential self-selection bias. Basic characteristics of participants reflecting their clinical experience, such as TE, the number of OCT scans performed per week, and self-reported confidence with OCT did not differ between the control and intervention groups. However, the information

provided by participating optometrists did indicate a lack of familiarity with the assessed technique, which could significantly hamper its use to support clinical diagnosis.

Conclusion

This study highlights the potential pitfalls in applying simplified diagnostic principles, such as isolated image features, which can have no or negative impact on sensitivity. While OCT is becoming an integral tool in daily clinical optometric practice, interpretation of results should only be undertaken by appropriately trained practitioners in conjunction with comprehensive clinical data. As a consequence, professionals should be encouraged to continuously expand their care knowledge base through comprehensive, contemporary education to ensure integration of fast advancing technology for optimal diagnostic outcomes.

Acknowledgements

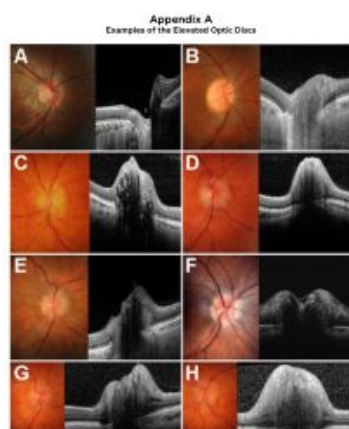
This work was supported, in part, by a grant from the National Health and Medical Research Council of Australia (1033224) and Centre for Eye Health – an initiative of UNSW Sydney Australia and Guide Dogs NSW/ACT. Guide Dogs NSW/ACT is also a partner on the NHMRC grant. Dr Zangerl holds a Faculty Research Grant awarded by the School of Optometry and Vision Science, UNSW Sydney.

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The entire case series consisted of non-pathological discs, e.g., (A) obliquely inserted or (B) crowded discs, other pathology, most commonly (C) bared optic nerve head drusen, and (D-H) disc drusen with confluent papilloedema. Participants were initially presented with 20 colour photos (A-H, left column) taken with a Hovrva Hovrva W6 (30° field angle, 20° horizontal and 27° vertical, 12 megapixel digital resulting in 72 dpi resolution of the final image). Subsequently, 15x9° (A-F) or 15x20° (G-H) OCT volume scans (A-H, right column) consisting of 87 B-scans spaced 53 µm at JMT 25 using the Spectralis OCT (digital resolution of 3.9 µm axially by 6 µm laterally) were added and the assessment was repeated in randomized order.

Appendix A.
[Click to enlarge](#)

Appendix B
Multiple Choice Answers Presented to the Participants

Examples of correctly answered questions:

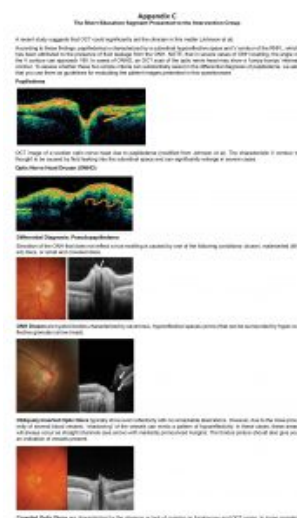
8. Identify the reason for the elevated optic nerve head:

<input checked="" type="checkbox"/> A Papilloedema	<input type="checkbox"/> D Normal disc
<input type="checkbox"/> B Optic disc drusen	<input type="checkbox"/> E Crowded optic disc
<input type="checkbox"/> C Other pathological disc	<input type="checkbox"/> F Obliquely inserted optic disc

9. Identify the reason for the elevated optic nerve head:

<input type="checkbox"/> A Papilloedema	<input checked="" type="checkbox"/> D Normal disc
<input type="checkbox"/> B Optic disc drusen	<input type="checkbox"/> E Crowded optic disc
<input type="checkbox"/> C Other pathological disc	<input checked="" type="checkbox"/> F Obliquely inserted optic disc

Appendix B. [Click to enlarge](#)



Appendix C.
[Click to enlarge](#)



Elizabeth Wong is a Senior Staff Optometrist at the Centre for Eye Health in Sydney, Australia, where she has a special interest in glaucoma. She teaches undergraduate optometry students and delivers continuing professional development to the optometric profession in the form of webinars and workshops. Elizabeth was recently admitted as a Fellow of the American Academy of Optometry.

Jaclyn Chiang is a Senior Staff Optometrist at the Centre for Eye Health in Sydney, Australia, and is involved in the development of continuing education material and clinical research in optic disc pathology.

Dr. Hennessy is a Senior Staff Specialist Ophthalmologist at Prince of Wales Hospital in Randwick, NSW, Australia, and Centre for Eye Health in Sydney, Australia, and a Senior Lecturer at University of New South Wales Sydney. He has long-standing expertise in optic nerve head physiology and pathology and has developed a significant track record teaching and publishing in this area.

Dr. Kalloniatis, a leader in the field of retinal neurochemistry and a pioneer of the amino acid characterization of the retina, is Director of the Centre for Eye Health in Sydney, Australia. He has worked closely with Prince of Wales Hospital Ophthalmology to develop new models of healthcare delivery, education, dissemination of health-related information and scientific research. Dr. Kalloniatis has to his credit more than 100 publications in peer-reviewed journals and distinguished awards, most recently the "Excellence in Senior Leadership 2015" award presented by University of New South Wales Sydney and the 2017 distinguished alumnus award from the University of Houston College of Optometry.

Dr. Zangerl [bzangerl@cfeh.com.au], who completed a well-rounded education in the field of medicine and genetics, has dedicated more than 18 years to the research of blinding disorders, maintaining a strong focus around differential diagnosis and prevention and treatment of various degenerative eye diseases through application of advanced technologies. Dr. Zangerl's current affiliation with the Centre for Eye Health and the School for Optometry and Vision Science at the University of New South Wales Sydney, Australia, allows her to integrate current research outcomes into a contemporary curriculum for medical professionals and evaluate its effectiveness in clinical practice.

RECIPIENTS OF THE 2018 ASCO EDUCATIONAL STARTER GRANTS

The Association of Schools and Colleges of Optometry (ASCO), along with The Vision Care Institute, LLC, an affiliate of Johnson & Johnson Vision Care Inc., awarded two Educational Starter Grants this year. The recipients and their research projects are:

- Shankaran Ramaswamy, PhD, MCPHS University — “Relationship Between Grit and Academic Performance in Optometry Students”
- Joshua Cameron, PhD, Western University of Health Sciences — “Advantages of 3D Printed Physical Models Over Computer Generated Models and Textbooks”

ASCO applauds all of the faculty who submitted grant applications this year and appreciates their commitment to improving teaching and learning and moving the profession forward.



AMIODARONE OCULAR TOXICITY, EMPHASIZING OPTIC NEUROPATHY: A TEACHING CASE REPORT

Abstract

Amiodarone is one of the most effective antiarrhythmic drugs, but its use is limited by toxicity affecting many organs including the eyes. Corneal verticillata is the most common ocular finding associated with amiodarone therapy. A less common but potentially sight-threatening complication is optic neuropathy. Amiodarone-induced optic neuropathy shares many clinical features with non-arteritic ischemic optic neuropathy making clinical diagnosis difficult. However, several important distinctions exist including an insidious onset, bilateral involvement, male predilection and delayed resolution of disc edema. This case report highlights the unique features of amiodarone-associated optic neuropathy and presents appropriate diagnostic and management strategies.

Key Words: amiodarone, ocular toxicity, optic neuropathy, optic disc edema, whorl keratopathy, corneal verticillata, non-arteritic ischemic optic neuropathy

Background

Amiodarone is the most common antiarrhythmic drug prescribed for treatment of atrial fibrillation. Its efficacy has been challenged by its ubiquitous organ toxicity resulting in nearly 50% of long-term users discontinuing the drug.¹ Ocular toxicity most commonly presents as corneal deposits referred to as whorl keratopathy or corneal verticillata, which occur in the majority of amiodarone users.^{1,2} Whorl keratopathy is typically asymptomatic with reported glare and halos occurring in less than 5% of patients.¹ This report is aimed toward third- and fourth-year optometric students and optometrists.

The rare occurrence of optic neuropathy can be debilitating to vision. Various studies have reported the incidence of amiodarone optic neuropathy to be as high as 2.0%; however, the exact incidence is unknown.^{3,4} Most cases of amiodarone-associated optic neuropathy occur within a year of treatment initiation.^{1,5} Characteristics include gradual onset, bilateral involvement and slow resolution. Amiodarone-induced optic neuropathy remains a controversial diagnosis because it shares many clinical features with non-arteritic ischemic optic neuropathy (NAION), the most common optic nerve disorder causing sudden onset vision loss in elderly patients.⁴ Patients on amiodarone therapy often have the same risk factors as patients who experience NAION, making it difficult to separate the two diagnoses.^{1,6} However, several distinguishing clinical features highlighted in this case suggest amiodarone-associated optic neuropathy is a distinct clinical entity.

Case Description

A 70-year-old Caucasian male complained of intermittent left upper visual field disturbances for two days. He described it as a window shade moving up and down that he initially noticed upon awakening. He also experienced soreness during extreme eye movements.

The patient's medical history was remarkable for hypertension, which was controlled with three medications: lisinopril QPM, terazosin QPM and metoprolol BID. In-office blood pressure was 135 mmHg/81 mmHg. He was also taking atorvastatin daily to control hypercholesterolemia. Due to history of a myocardial infarction, he was prescribed aspirin, clopidogrel and warfarin. His medical history was also remarkable for atrial fibrillation, treated with amiodarone for the past nine months. His dosage of amiodarone was 200 mg BID with an initial higher loading dose. Drug allergies included sulfa drugs and tamsulosin. He had a 40-year history of heavy alcohol and tobacco use, both of which he stopped three years prior.

Best-corrected Snellen visual acuity was 20/20 in each eye with no change in manifest refraction. There were no gross defects or constriction identified on confrontation visual fields or extent of fields. Extraocular motilities were full without pain or diplopia. Pupils were equal, round and reactive with no afferent pupillary defect (APD).

Anterior segment findings were remarkable for gray lines extending into whorl-like patterns on the inferior corneal epithelium in both eyes, which were not noted at his last eye examination six months ago. The patient also had mild nuclear sclerotic cataracts. Goldmann applanation tonometry intraocular pressures were 10 mmHg OD and 12 mmHg OS.

Both optic nerve heads appeared crowded with heaping rim tissue (**Figure 1**). The left optic nerve appeared to have blurred margins inferiorly with an overlying disc hemorrhage superior-nasally. Cup-to-disc ratios were 0.05 OD and 0.1 OS, which was consistent with the previous eye examination. Other retinal findings, including macula, vasculature and

periphery, were normal in both eyes.



Figure 1. Fundus photography taken at the patient's first visit. **(A)** Right optic nerve head exhibits an indistinct inferior disc margin. **(B)** Left optic nerve head has a small cup-to-disc ratio, blurring of the inferior disc margin and a Drance hemorrhage (arrow). No apparent hyperemia or pallor is observed in either eye. [Click to enlarge](#)

Visual field testing was ordered prior to dilation and revealed mild to moderately reduced superior-temporal defects extending from the blind spot in the left visual field. Optical coherence tomography (OCT) (**Figure 2**) confirmed elevated rim tissue in both eyes, especially inferiorly in the left eye. Posterior pole analysis showed retinal nerve fiber layer (RNFL) thickening into the arcuate bundles but not extending into the fovea. Ganglion cell layer and inner plexiform layer analysis of the fovea and perifovea revealed normal thickness values (**Figure 3**).

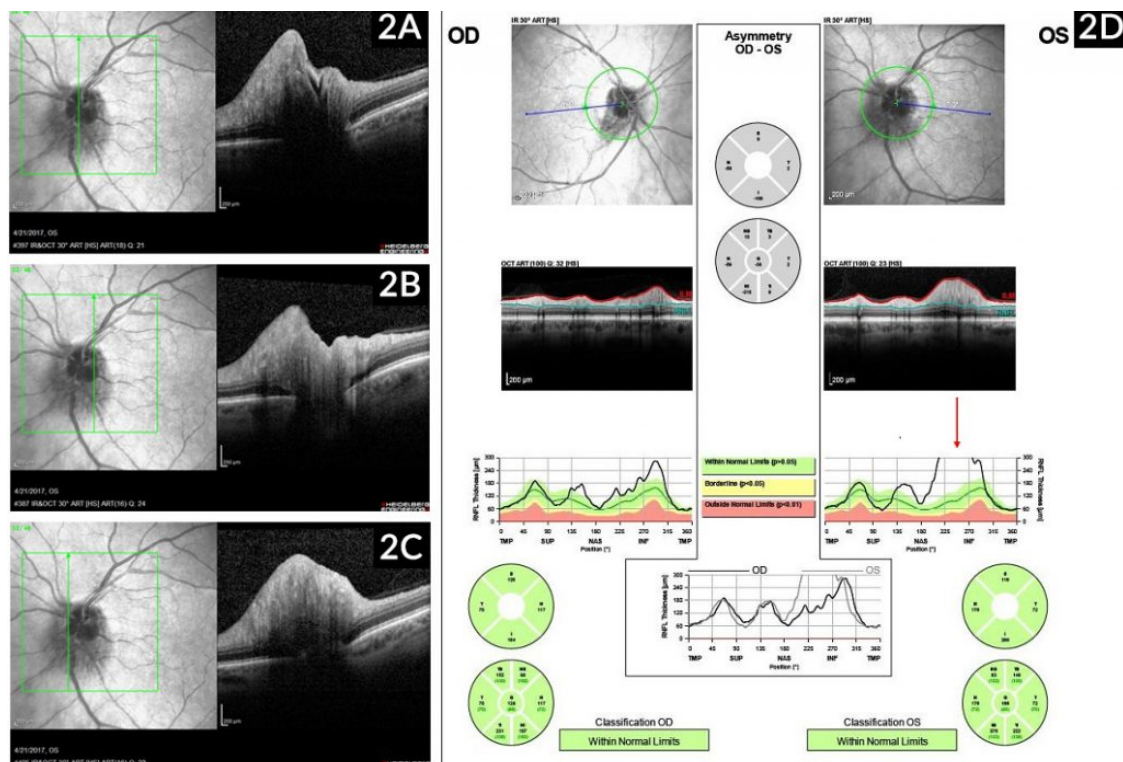


Figure 2. **(A-C)** A dense vertical OCT of the left optic nerve head shows elevated rim tissue inferiorly. In the infrared image, the hyporeflexivity of the edematous inferior peripapillary RNFL can be seen. **(D)** OCT circumpapillary RNFL also shows thickening, especially inferiorly OS, compared to the normative database. [Click to enlarge](#)

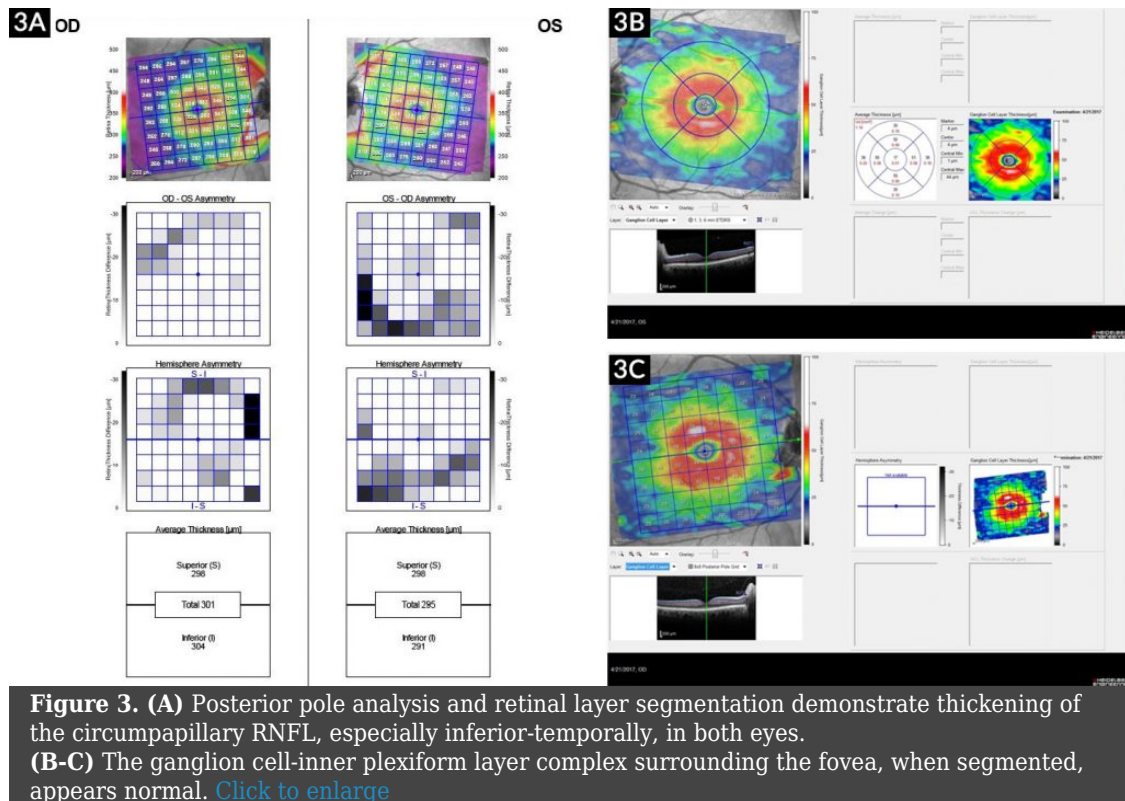


Figure 3. (A) Posterior pole analysis and retinal layer segmentation demonstrate thickening of the circumpapillary RNFL, especially inferior-temporally, in both eyes. **(B-C)** The ganglion cell-inner plexiform layer complex surrounding the fovea, when segmented, appears normal. [Click to enlarge](#)

Differential diagnoses included amiodarone-induced optic neuropathy, NAION and arteritic anterior ischemic optic neuropathy. The latter, a sequela of giant cell arteritis, was suspected secondary to the patient's age, visual disturbance and presentation of optic disc edema. In response to questions, the patient denied jaw claudication, headaches, scalp tenderness or diplopia. Erythrocyte sedimentation rate (ESR) and c-reactive protein (CRP) testing was ordered that day. Results were 27 mm/H and 7.5 mh/L, respectively, which may be normal for this patient considering his age and vascular conditions such as hypertension, hypercholesteremia, and atrial fibrillation. Due to a low suspicion of giant cell arteritis, a temporal artery ultrasound or biopsy was not pursued. A carotid ultrasound, electrocardiogram and complete blood count, recently ordered by cardiology, were recorded as normal. Concerns of amiodarone-induced optic neuropathy were discussed with the patient's cardiologist, who recommended discontinuation of amiodarone and initiation of sotalol.

At the patient's one-month follow-up visit, visual field testing showed severe superior and inferior arcuate defects in both eyes, with central visual acuity of 20/20 OD and OS remaining intact. The patient noted issues with light and dark adaptation along with flashes of light. Both optic nerve heads were edematous 360° with indistinct margins and multiple Drance and peripapillary hemorrhages. Due to the worsening of bilateral optic disc edema, brain imaging was necessary to rule out a mass or lesion. Magnetic resonance imaging (MRI) (**Figure 4**) showed non-specific vasculitis throughout the brain, which prompted a referral to neurology. To detect any underlying conditions that could cause vasculitis, neurology ordered c-ANCA, p-ANCA, atypical p-ANCA, anti-myeloperoxidase and anti-proteinase 3 tests, all of which were negative. ESR and CRP were repeated due to the worsening disc edema and visual field, but levels remained stable.

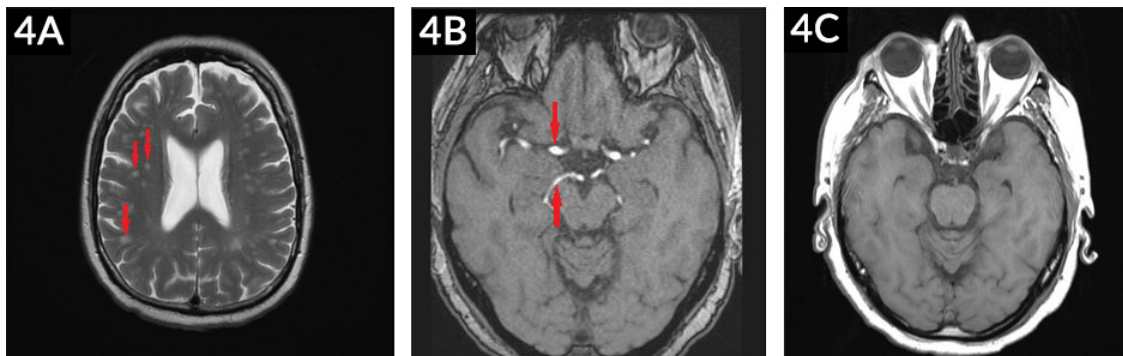


Figure 4. T2-weighted MRI images reveal approximately 40 subcortical white matter lesions (<1cm) throughout both cerebral hemispheres. MRA of head and neck are normal. No signs of acute infarction, aneurysm or stenosis are observed. [Click to enlarge](#)

At his three-month follow-up visit, the patient felt his symptoms had improved significantly, but examination findings showed persistent disc hemorrhages and stable visual field defects (**Figure 5**). The disc swelling had resolved, but thinning of the RNFL was present (**Figure 6**).

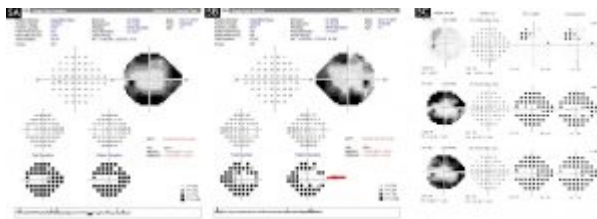


Figure 5. (A-B) A 24-2 visual field test at the three-month follow-up visit demonstrates deep superior and inferior arcuate defects in both eyes, with central islands remaining OU. (C) A progression report for the left eye shows an initial early arcuate defect developing into deep bi-arcuate defects that persist from the three- to six-month follow-up visits. [Click to enlarge](#)

By his six-month follow-up appointment, the patient reported his visual field had stabilized with mild inferior dimming. His central vision remained intact. Visual field testing showed stable, deep superior and inferior arcuate defects in each eye. Although the persistent disc hemorrhages had resolved, OCT showed further thinning of the circumpapillary RNFL since the three-month follow-up visit. The insidious onset of bilateral disc edema, along with the findings from imaging and lab testing, led to the diagnosis of optic neuropathy influenced by amiodarone. The patient was educated on the likely permanent visual field defects and advised to return in six months or as needed. He was also informed about low vision rehabilitation to help him cope with peripheral vision loss.

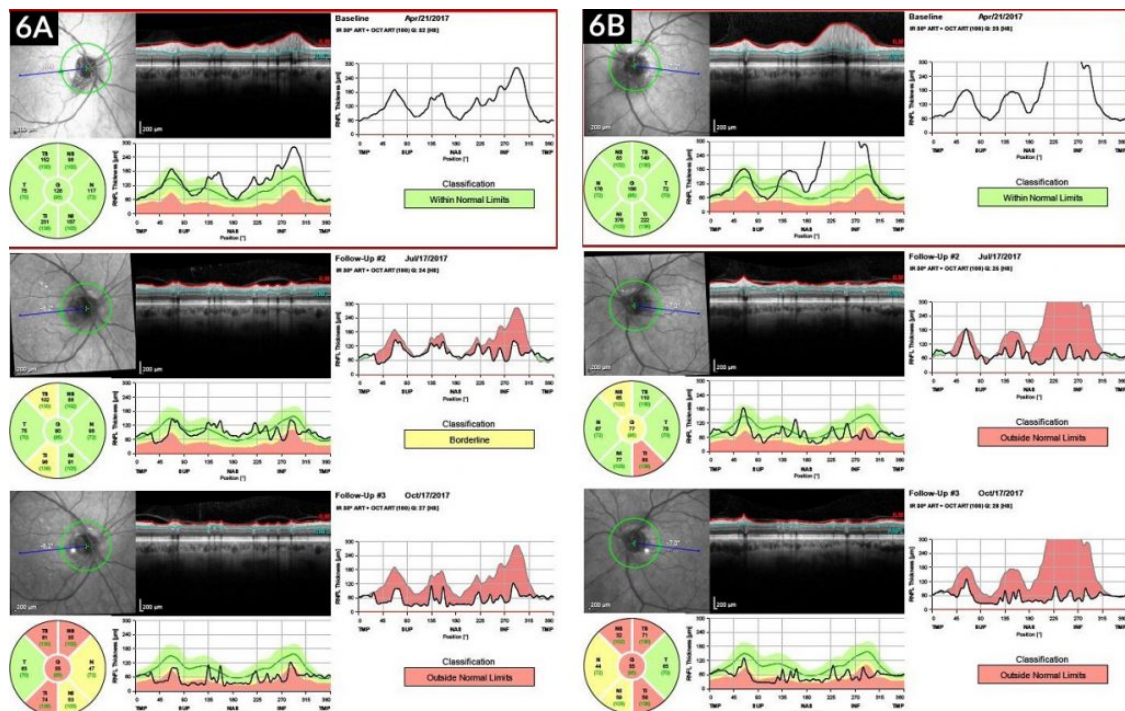


Figure 6. OCT circumpapillary RNFL progression reports show resolution of disc edema in both eyes by the three-month follow-up visit, but progressive atrophy compared to the normative database. Disc hemorrhages are still present at the three-month follow-up visit. [Click to enlarge](#)

Educational Guidelines

Key concepts

1. Gaining expertise in amiodarone's ocular side effects
2. Critical thinking in differentiating various optic nerve neuropathies
3. Managing patients with ocular toxicity from amiodarone use

Learning objectives

1. Gaining basic knowledge of the drug amiodarone
2. Understanding the adverse ocular effects of amiodarone
3. Extracting case history with exhaustive inquiry
4. Performing comprehensive vision and ocular examination with detailed evaluation of the optic disc
5. Identifying the stages of optic disc edema using the Frisen scale
6. Utilizing various tools, tests and technology to diagnose and assess progression
7. Differentiating various optic neuropathies based on patient presentation and history
8. Understanding management options and visual prognosis of amiodarone-associated optic neuropathy
9. Ensuring full patient care by collaborating with various specialists

Discussion points

1. Basic knowledge and concepts related to the case
 - a. Identify characteristics and prevalence of amiodarone toxicity
 - b. Describe the clinical presentation of amiodarone optic neuropathy

- c. Identify clinical features of amiodarone optic neuropathy that distinguish it from ischemic optic neuropathy
- d. Describe diagnostic tools and appropriate ancillary testing that aid in diagnosis

2. Differential diagnosis

- a. What are differential diagnoses based on the patient's symptoms?
- b. What are differential diagnoses for unilateral vs. bilateral optic disc edema?
- c. What is the appropriate work-up to exclude differential diagnoses?

3. Critical thinking

- a. Should amiodarone be discontinued when neuropathy is identified? How do you make that decision as a healthcare provider?
- b. What is the appropriate follow-up for patients currently taking amiodarone with no signs of neuropathy?
- c. What is the visual prognosis of amiodarone toxicity?
- d. Were brain imaging and blood work necessary in this patient's case?
- e. Is amiodarone-induced optic neuropathy a diagnosis of exclusion?
- f. What are the differences between non-arteritic ischemic optic neuropathy and amiodarone-induced optic neuropathy?

Literature Review

Amiodarone

Amiodarone is approved by the Food and Drug Administration (FDA) for the treatment of refractory ventricular arrhythmias,^{7,8} but it is often prescribed for atrial arrhythmias such as atrial fibrillation or flutter. An initial higher dose (800 to 1600 mg daily) is needed to achieve therapeutic plasma levels because, with a bioavailability of approximately 30%, the drug is poorly absorbed. Maintenance dose (100 to 400 mg daily) varies depending on multiple factors, including heart rate.⁹ Amiodarone's primary mechanism of action is to block potassium channels, but it also weakly blocks sodium and calcium channels as well as beta and alpha adrenergic receptors. Direct effects on the myocardium cause a delayed repolarization and an increased duration of action potential.¹⁰ The half-life of amiodarone is long yet variable. It has been reported in the literature ranging from 13 days to 180 days.^{1,4,5,8-10} Elimination occurs mostly by hepatic metabolism.⁹ Geriatric patients have a slower drug clearance and may be more sensitive to adverse effects.¹⁰

Long-term oral therapy can lead to accumulation in tissue and adverse effects including pulmonary disease, thyroid dysfunction, cardiac toxicity, skin reactions, gastrointestinal and genitourinary problems, neurological dysfunction, ocular toxicity and drug interactions.⁷⁻⁹

Clinical manifestations

Whorl keratopathy, also known as corneal verticillata, is the most common ophthalmologic finding in amiodarone patients, with a prevalence of 70-100% with long-term therapy.^{9,11} These corneal microdeposits appear in a brown or gray swirl-like or whisker-like pattern at the junction of the middle and lower thirds of the corneal epithelium. Lacrimal gland secretion of amiodarone results in accumulation of these microdeposits on the corneal surface.¹¹ The keratopathy can be classified into three stages⁹ (**Table 1**), although stepwise classification serves minimal practical value.¹¹ Clinically, this keratopathy is indistinguishable from that caused by chloroquine derivatives or Fabry disease.⁹ The microdeposits do not typically reduce visual acuity, but some patients may experience halos around lights, especially at night, and photophobia.^{9,11} These symptoms can also be attributable to age-related lens changes and other sequelae.⁹ These ocular adverse effects are typically dose- and duration-dependent, as shown by a meta-analysis of 1,465 patients that found an incidence of 1.5% with low-dose intake compared to 0.1% incidence with placebo.⁷ The keratopathy disappears within 3-20 months of discontinuation of the medication.^{9,11} Cataracts from amiodarone use have also been noted. These punctate, yellowish-white lens opacities are located in the anterior subcapsule within the pupillary margin in a vertical pattern of about 2 mm in diameter.⁹ A study performed by Ingram et al. of more than 100 patients found lid irritation to be the most common ocular symptom associated with amiodarone. This is most likely from photosensitivity of the eyelid skin,¹¹ which occurs in 10-15% of patients.¹⁰ There are rare reports of dry eyes, macular degeneration,¹⁰ multiple chalazia⁹ and thyroid eye disease.¹²

TABLE 1
Whorl Keratopathy Stages*

Stage 1	fine or faint gray or golden-brown punctate opacities coalesced into a horizontal linear pattern in the inferior cornea
Stage 2	number and density of horizontal lines increase, resembling a whisker-like pattern
Stage 3	numerous curved, denser lines forming whorl patterns, branching lines sometimes extending into visual axis

*Mäntylä M, Tuppura K, Ikaheimo K. Ocular Side Effects of Amiodarone. *Surv Ophthalmol.* 1998;42(4):360-366.

Note: all stages are invisible to the naked eye and only viewable under biomicroscopy

Table 1. [Click to enlarge](#)

Amiodarone has also been associated with visual disturbances secondary to optic neuropathy. The exact annual incidence of amiodarone-associated optic neuropathy is unknown. Various reports estimate an incidence of 0.36% to 2.0% in amiodarone users, but specific parameters are often not specified.^{3,4} A few reports detected a male predilection for amiodarone-associated optic neuropathy.^{1,5,6} Gender differences in body mass, fat distribution enzymatic activity and hormonal stimuli¹ may account for a slightly faster drug clearance in females.⁵

A few key features can aid in diagnosing amiodarone-associated optic neuropathy as well as differentiating it from other pathologies. The optic neuropathy associated with amiodarone is described as having an insidious onset, slow progression and protracted disc swelling.⁴ Most cases that present with these clinical features are simultaneously bilateral, but can be asymmetric.^{4,6} A small percentage of cases that were reported to present unilaterally were either eventually bilateral,⁶ not attributable to amiodarone,¹³ or symptomatically unilateral but bilaterally edematous.¹ Visual acuity at presentation ranges significantly from 20/15 to light perception.^{1,4} Visual field can be normal, but most patients present with altitudinal defects, arcuate defects or a generalized depression.¹³ A case series review by Johnson et al. found that only 9% of cases of amiodarone optic neuropathy had normal visual fields at presentation, and almost half of patients presented with either altitudinal or arcuate defects. Visual field loss is also typically permanent.⁶

A review of eighty cases of amiodarone-induced optic neuropathy by Passman et al. found that the average interval between starting amiodarone and onset of visual disturbances was approximately nine months, with a median of six months and a range of 1-84 months. After discontinuing the medication, 58% of 61 patients experienced improvement in visual acuity, 21% had unchanged visual acuity, and 21% had worsening of visual acuity. Permanent <20/200 visual acuity in at least one eye resulted in 20% of cases.¹ Even with discontinuation of amiodarone intake, optic atrophy can develop after resolution of disc swelling.⁹

Cheng et al. performed a retrospective population-based cohort study involving 6,175 amiodarone-treated patients and 24,700 age- and gender-matched controls to determine whether amiodarone use was associated with an increased risk of optic neuropathy. Optic neuropathy developed in 17 amiodarone-treated patients (0.3%) and 30 control patients (0.1%). Analysis of this data, with adjustments for age, gender and comorbidities, showed a two-fold increased risk of optic neuropathy. Longer exposure to amiodarone also increased the risk of optic neuropathy, but average daily dose did not demonstrate a correlation.⁵ However, this study did not evaluate the features of optic neuropathy (i.e., bilateral or unilateral, type of vision loss, duration of disc edema). Therefore, appropriate classification and cause is difficult to properly assess. Another limitation of the study is that the patients treated with amiodarone had a higher proportion of medical comorbidities than the controls. A correspondence by Mindel et al. reports that these incidence rates may be biased estimates due to these limitations.¹⁴

Pathophysiology

The pathophysiology of amiodarone neuropathy is not completely understood. It is believed that the drug's lipophilic nature, high volume of distribution, and high tissue affinity result in ultrastructural changes in the optic nerve head.^{5,6} In-vitro studies indicate that low-dose amiodarone causes inhibition of lysosomal sphingomyelinase activity and high-dose amiodarone leads to intracellular lipid accumulation and probable phospholipidosis.^{5,9} Histopathology after amiodarone use shows lysosome-like intracytoplasmic membranous lamellar bodies.^{1,15} These lamellar inclusion bodies have been found in nearly all ocular tissues, including retrobulbar optic nerve large-diameter axons, extraocular muscle fibers, cornea, conjunctiva, scleral, lens, iris, ciliary body, choroid, retinal pigment epithelium, ganglion cells and endothelium of ocular blood vessels.⁹ It is theorized that these inclusions mechanically or biochemically inhibit axoplasmic flow, resulting in optic disc edema. The resulting optic nerve head edema can persist as long as axonal transport is inhibited, which results in delayed resolution of optic nerve swelling.^{1,5,9,15} These bodies are also seen in peripheral nerves that have been affected by

amiodarone-associated peripheral neuropathy. The peripheral nerves have shown signs of demyelination and large axon loss, which is absent in the retrobulbar optic nerve axons, possibly due to different types of myelination or other etiology.^{1,16} Amiodarone can also cause vasodilation, possibly leading to oxidative damage and optic neuropathy.⁵

Differential diagnosis

TABLE 2

Differences Between Amiodarone-Associated Optic Neuropathy and NAION

Amiodarone-associated optic neuropathy	Non-arteritic ischemic optic neuropathy (NAION)
Mostly bilateral	Generally unilateral
Insidious onset	Acute onset
Slow vision or visual field deterioration	Any vision or visual field loss complete at onset
Protracted disc swelling for months	Resolution of disc swelling within weeks
Not associated with a crowded disc/small cup-to-disc ratio	Associated with a crowded disc/small cup-to-disc ratio

Table 2. [Click to enlarge](#)

The most obvious differential diagnosis for amiodarone-induced optic neuropathy is NAION. NAION is the most common cause of vision loss from optic nerve disease in individuals older than 50 years with an incidence of 0.3%.⁵ The incidence of NAION in patients with cardiac dysrhythmia is higher than this because many patients taking amiodarone often have severe vascular disease.^{5,17} Amiodarone-associated optic neuropathy is indistinguishable from NAION with regard to optic disc appearance, but the two clinical entities differ in multiple aspects (Table 2). NAION initially presents unilaterally, while amiodarone-associated optic neuropathy often presents bilaterally simultaneously as expected with systemic toxicity.^{3,4,14} Vision loss is sudden and complete at onset of NAION, unlike the insidious onset with protracted disc swelling in amiodarone-associated optic neuropathy. NAION also typically resolves in a few weeks¹⁸ compared to months. NAION generally occurs in patients with a small optic nerve cup-to-disc ratio or crowded disc, but this has not been an identifiable risk factor in cases of amiodarone-associated optic neuropathy. Amiodarone-associated optic neuropathy has a predilection toward men, whereas NAION has no gender predilection.^{1,5,6}

Along with NAION, there are other conditions that are important to consider given the clinical presentation of optic disc edema. Although amiodarone-associated optic neuropathy typically presents bilaterally, it may present asymmetrically, which warrants thorough investigation to rule out other potential causes of unilateral disc edema. Differential diagnoses include neoplastic, inflammatory, infectious, metabolic, demyelinating, hereditary and vascular etiologies. Neoplastic causes such as optic nerve glioma or optic nerve sheath meningioma can be ruled out based on neuroimaging. Inflammatory etiologies such as sarcoidosis or systemic lupus erythematosus will likely present with other signs of intraocular or systemic inflammation. Infectious causes such as syphilis, Lyme disease, or cat-scratch disease are best identified through bloodwork.¹⁹ The most common demyelinating cause is optic neuritis secondary to multiple sclerosis. Optic neuritis can result in optic disc edema; however, onset is usually unilateral, acute and painful and typically occurs in younger patients.²⁰

Differential diagnoses for bilateral optic disc edema include an intracranial mass, malignant hypertension, systemic medications, toxic/nutritional neuropathy, meningitis and pseudotumor cerebri. A space-occupying lesion must always be considered in cases of bilateral disc swelling;¹⁹ however, no lesions were identified in this case based on neuroimaging. The patient in this case report presented with a blood pressure of 135 mmHg/81 mmHg, which ruled out malignant hypertension. Aside from amiodarone, other systemic drugs have been found to be associated with optic disc edema, including tuberculostatic drugs, antimicrobial agents, antiepileptic drugs, disulfiram, halogenated hydroquinolones, antimetabolites, tamoxifen and phosphodiesterase type 5 inhibitors. Toxins, such as metals, organic solvents, methanol and carbon dioxide, as well as nutritional deficits, such as vitamin B, folic acid and proteins with sulfur-containing amino acids can also cause optic neuropathy.²¹

Pseudotumor cerebri, or idiopathic intracranial hypertension (IIH), presents with bilateral disc swelling. In contrast to amiodarone optic neuropathy, IIH often presents with headaches, nausea or transient vision loss, and patients are typically young, overweight females of childbearing age. IIH is a diagnosis of exclusion and must be ruled out with neuroimaging including MRI and magnetic resonance venography. Diagnosis is confirmed with lumbar puncture showing elevated opening pressure. Finally, to avoid unnecessary neuroimaging, causes of pseudopapilledema should not be overlooked. Optic disc drusen can present with unilateral or bilateral disc edema; however, appropriate ancillary testing such as OCT, fundus autofluorescence or B-Scan ultrasonography can help differentiate pseudo from true optic disc edema.¹⁹

Diagnostic tools

A comprehensive examination including pupil dilation is necessary for accurate diagnosis, and several ancillary tests are crucial when amiodarone optic neuropathy is suspected.

Pupil testing should be performed prior to instillation of dilation drops. A relative afferent pupillary defect (RAPD or APD) indicates unilateral or asymmetric disease of the retina or optic nerve.²² It is estimated that at least 25% of RNFL loss is required to induce an APD.²³ The swinging flashlight test can detect an APD, but in the case of bilateral symmetric optic neuropathy, an APD may be absent.²² Clinical grading of an APD is explained in **Table 3**. This grading system is comparable to the neutral density filter grading system, in which neutral density filters in increasing amounts are placed in front of the non-APD eye until an equal pupillary response is achieved.²⁴

Color vision testing can be beneficial when optic nerve disease is suspected because the degree of dyschromatopsia may be greater than the degree of visual acuity loss. Dyschromatopsia was previously thought to be related to the degree of whorl keratopathy in amiodarone users. Research suggests that blue color vision deficiency is a manifestation of amiodarone optic neuropathy. In a case series by Johnson, Krohel and Thomas, acquired color vision loss was found in 40% of patients with amiodarone optic neuropathy.⁶ Pseudoisochromatic color plates often miss mild cases of acquired dyschromatopsia, but they are commonly used as a gross test of color vision. To distinguish acquired from congenital abnormalities, arrangement tests should be used. The Farnsworth Panel D-15 test, along with the more sensitive Lanthony desaturated 15-hue test, entails the patient arranging 15 colored discs in order of hue and intensity under standard lighting conditions. The lengthier, more detailed Farnsworth-Munsell 100-hue test requires arranging 85 discs compared to its shorter version of 21 chips.²⁵

Red color desaturation may occur in cases of optic neuropathy. A red-capped bottle can be presented to each eye separately for observation of saturation differences, such as a faded or washed-out red. Cone isolation contrast sensitivity testing, such as ColorDx by Konan, uses a newer, more precise technology to detect early degradation in functional vision.²⁶ Contrast sensitivity and electrophysiological tests may also show abnormalities, but, like color vision testing, are not diagnostic.²⁷

While the characteristics of a swollen optic nerve head and its pathophysiology of obstructed axoplasmic transport are well-understood, diagnosis is not always simple. The Frisen scale²⁸ (**Table 4**) describes anterior optic nerve edema based on retinal swelling, excluding variable vascular components such as hemorrhages, hyperemia, venous stasis and cotton-wool spots. Stage 0 of the Frisen scale is defined as a fairly normal disc, allowing for variation of normal. Smaller discs may have more margin blurring in one quadrant as overflow is expected. Stage 1 describes excessive blurring of the nasal optic disc margin with a subtle grayish halo. Stage 2 demonstrates elevation of the nasal border and blurring of the entire temporal margin. Here, the halo encompasses the entire disc, and concentric or radiating retinochoroidal folds may be present. In stage 3, the temporal border is also elevated, which obscures major blood vessels. Here, the halo has finger-like extensions. These changes are more pronounced in Stage 4 with disappearance or compression of the

TABLE 3
Clinical Grading of an Afferent Pupillary Defect

Grade	Neutral density filter	Pupillary response
Grade 1	0.4 log units	Weak initial constriction followed by greater re-dilation
Grade 2	0.7 log units	Initial stalling followed by greater re-dilation
Grade 3	1.1 log units	Immediate dilation
Grade 4	2.0 log units	Immediate dilation following prolonged illumination of the good eye for 6 seconds
Grade 5	Infinity	Immediate dilation with no secondary constriction

Table 3. [Click to enlarge](#)

TABLE 4
Frisen Scale: Clinical Grading of Optic Disc Edema

Stage	Description of retinal nerve fiber swelling
Stage 0	Normal, smaller optic discs (smaller scleral canal) result in smaller cup-to-disc ratio and spilling of nerve tissue, blurring of pole margins; distinct temporal margin
Stage 1	Excessive blurring of nasal optic disc margin; subtle grayish halo
Stage 2	Elevation of nasal border; blurring of entire temporal margin; subtle grayish halo 360°; Paton's folds may be present
Stage 3	Elevation of temporal border; obscuration of major blood vessels; finger-like extensions protruding from halo
Stage 4	Elevation of whole optic nerve head; disappearance or compression of optic cup; total obscuration of central retinal artery or vein
Stage 5	Dome-shaped protrusion of optic nerve head

Table 4. [Click to enlarge](#)

optic cup or total obscuration of a central retinal artery or vein. Stage 5 is defined as a dome-shaped protrusion of the optic nerve head.²⁸

Visual field testing is an important tool in both the diagnosis and management of amiodarone optic neuropathy. Many patients present with visual field disturbances that gradually worsen over time and become permanent. Visual field defects often present as altitudinal or arcuate defects⁶ or a general depression.¹³ Thus, visual field testing is a crucial diagnostic and management tool for predicting visual prognosis and facilitating appropriate patient education.

The number of published studies in which OCT was used to monitor the behavior of disc edema in patients with amiodarone-associated optic neuropathy is limited. As stated earlier, the disc swelling is typically bilateral, insidious and prolonged compared to the swelling in NAION.⁴ A study by Akbari et al. evaluated peripapillary RNFL thickness and macular thickness, specifically ganglion cell-inner plexiform layer (GCIPL) thickness, in NAION patients. At initial presentation, peripapillary RNFL and outer macula thickness were elevated. This edema began to decrease by the one-month follow-up, but the GCIPL of the macula began to show thinning until about six months. This is likely due to neuronal loss,²⁹ with areas of damage commonly correlating with visual field loss.³⁰ This may be similar in amiodarone-associated optic neuropathy, although swelling may be present for a longer duration. OCT can be used to observe retinal edema, followed by axonal thinning and atrophy.³¹

Less threatening conditions should also be considered, especially in the absence of disc hemorrhages. Optic disc drusen sometimes display a bumpy appearance on funduscopy, exhibit hyper-autofluorescence on fundus autofluorescence, and reveal a hyper-reflective border with posterior shadowing on cross-sectional OCT. A narrow scleral channel or hyperopic disc can have a crowded appearance that is not considered edematous.³²

Some, but not many, studies utilizing optical coherence tomography angiography (OCTA) in patients with amiodarone-associated optic neuropathy have been published. Evaluations of optic disc blood flow in NAION eyes portray significant non-perfusion, which correlates with the degree of mean deviation of visual field loss. Fluorescein angiography may exhibit similar results but is a more invasive technique.³⁰

Optic disc edema with unknown etiology may warrant brain imaging and additional laboratory or serological testing. Bilateral presentations may be secondary to increased intracranial pressure, malignant hypertension, brain mass or lesion, infection, inflammation or toxicity. Unilateral optic disc edema can result from optic neuritis, ischemia or compression, but these can also occur bilaterally.³³

Management

Patients using amiodarone who report visual disturbances should be promptly examined, and additional testing should be ordered as indicated above. Amiodarone-associated optic neuropathy is a diagnosis of exclusion. Imaging to rule out a cerebral mass or other etiologies is needed, especially in the case of visual disturbances and absence of disc edema.^{6,27} Patients taking amiodarone have serious cardiovascular illnesses, making it difficult to associate neuropathies with amiodarone rather than a manifestation of systemic disease. If optic neuropathy due to amiodarone usage is highly suspected, consultation with the patient's cardiologist is necessary to discuss discontinuation and substitution with another antiarrhythmic drug. Abrupt cessation of amiodarone without a therapeutic alternative can lead to a potentially fatal arrhythmia.^{7,8,10,13} Once diagnosed, patients should also be aware of the visual prognosis and lengthy timeline of resolution.

Many case reports highlight similar presentations, in which bilateral optic neuropathy occurred after a patient was placed on amiodarone and optic nerve swelling persisted for a few months. In such cases, after discussion with cardiology, amiodarone dosage was decreased or stopped, with resulting resolution of optic nerve swelling and hemorrhages.^{9,13,34}

The presence of whorl keratopathy is not an indication to discontinue amiodarone because visual symptoms are rare and not sight-threatening.⁹ Corneal refractive laser surgery is contraindicated in patients using amiodarone as it may affect laser accuracy and postoperative healing.^{10,35}

Patients with amiodarone-associated optic neuropathy may present to eyecare professionals for irritation of the eyelids, which can be caused by a variety of mechanisms. Consideration of skin photosensitivity should be on the list of differentials in patients taking amiodarone.¹¹ Ultraviolet radiation protection, cool compresses, and soothing creams may alleviate this drug-induced photosensitivity similar to a sunburn. A corticosteroid cream may be needed for significant inflammation, and an antibacterial cream may be necessary to prevent skin infection if the skin blisters and breaks.^{10,36}

There has not been consensus on a follow-up protocol for patients taking amiodarone. Amiodarone manufacturers

recommend routine screenings, but do not specify time intervals. The Heart Rhythm Society suggests a baseline evaluation for patients with pre-existing visual impairment.¹ Many physicians recommend an annual comprehensive examination, with an expedited appointment with onset of any visual symptoms.^{4,5,10} Johnson et al. recommend a few evaluations within the first year of starting amiodarone as ocular toxicity occurs at an average time point of nine months. Because onset is insidious, periodic evaluation is needed rather than at longer intervals.⁶ Beneficial testing at baseline and follow-up may include OCT of the optic nerve head, visual field testing and color vision testing. If ocular toxicity is suspected, physicians should report examination findings, drug dose, drug duration, concomitant drugs and follow-up findings to the FDA's MedWatch program to increase publicity of a potentially serious drug reaction.¹

Discussion

Due to a \$22.8 million judgment against Wyeth-Ayerst Pharmaceuticals in 1997,² the FDA added optic neuropathy as a caution in the amiodarone package insert, but not in a black box warning as a serious or life-threatening risk.^{1,2,37} Other drugs, including ethambutol, have long been accepted as a cause of optic neuropathy with an incidence of <1%. Similar to amiodarone, there are no evidence-based studies to demonstrate true causation.¹

Many question the existence of amiodarone-associated optic neuropathy.^{1,3,5,17,38,39} A trial by Mindel et al. that involved 1,600 patients and compared amiodarone to placebo did not find any cases of bilateral vision loss.³ However, results were based solely on patients who answered "yes" to the query of optic neuritis. A comprehensive eye examination was not performed on these patients, and analysis included only patients who had bilateral vision loss, not mildly reduced visual acuity or visual field defects.¹

Direct causation between amiodarone usage and optic neuropathy remains unproven, and many consider the clinical findings to be a variant of NAION.^{5,38,39} Patients share similar features and systemic risk factors, such as hypertension, diabetes mellitus and older age, which complicates the ability to distinguish the two conditions.^{1,6} Challenges exist to establishing the relationship between amiodarone and optic neuropathy. Additional research is needed as numerous historical reports have not included pertinent information such as funduscopic features, visual field findings, time course and clinical outcomes. This task is challenging because using a placebo medication on a patient with a life-threatening condition is not ethical. A study comparing incidence of optic neuropathy in patients taking amiodarone vs. another antiarrhythmic medication may be warranted. Sotalol's efficacy is comparable, but amiodarone has the least recurrence of atrial fibrillation.¹⁰

Conclusion

Amiodarone, although an extremely effective antiarrhythmic drug, can have numerous adverse systemic and ocular effects, some of which are rare but serious. Controversy persists as to whether prolonged, bilateral optic neuropathy occurs secondary to amiodarone use or the plethora of vascular issues exacerbated by amiodarone. Presentation of vision or visual field loss varies significantly and generally has a slow onset, progression and resolution. To distinguish amiodarone-induced optic neuropathy from NAION, differences in laterality and duration of disc edema should be considered. Early recognition is important as the long half-life of amiodarone can lead to severe damage even after cessation of the drug. Active inquiry regarding visual manifestations, thorough clinical evaluation and deliberate ancillary testing can prompt an early diagnosis and facilitate appropriate management. In collaboration with cardiology, attempts should be made to discontinue amiodarone if amiodarone-associated optic neuropathy is highly suspected.

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STATISTICAL LITERACY ISN'T JUST FOR RESEARCHERS

Statistical literacy is the ability to interpret data and use it to understand the world, make comparisons and, ultimately, make decisions. It is becoming a necessity for people to possess at least some level of statistical literacy because they are inundated with statistics in everyday life — on the news, in political polling and in advertising, to name just a few examples. In health care, statistical information, from health studies in particular, is often presented to patients in relation to disease risk and incidence, appropriateness of screening tests, survival rates, mortality rates, treatments, and so on. Unfortunately, as explained by German psychologist Gerd Gigerenzer, there exists a phenomenon of “collective statistical illiteracy” whereby “the majority of people do not understand what health statistics mean, or even consistently draw wrong conclusions without noticing.”¹ For instance, Gigerenzer has pointed out, “few are aware that higher survival rates with cancer screening do not imply longer life, or that the statement that mammography screening reduces the risk of dying from breast cancer by 20% in fact means that one less woman out of 1,000 will die of breast cancer.”¹

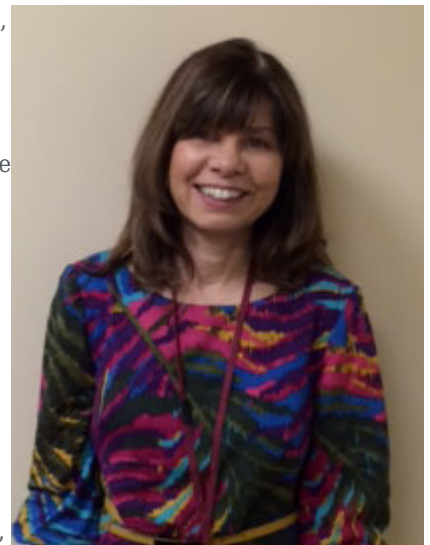
Healthcare providers are also inundated with information that requires statistical literacy, specifically data to support evidence-based patient care decisions. It is essential that providers understand the benefit of diagnostic and treatment options, as well as interpretation of positive and negative test results and false-positive rates.² Few studies have investigated healthcare providers’ statistical literacy. One study found low statistical literacy among obstetrics-gynecology residents.³ From their work training gynecologists in risk communication, Gigerenzer et al. reported that only 21% of 160 gynecologists could correctly name the positive predictive value of screening mammography.⁴ Wegwarth et al. concluded that “Most primary care physicians mistakenly interpreted improved survival and increased detection with screening as evidence that screening saves lives. Few correctly recognized that only reduced mortality in a randomized trial constitutes evidence of the benefit of screening.”⁵ A literature search of Google Scholar, PubMed and ERIC found no studies related to statistical literacy in optometry.

The Association of Schools and Colleges of Optometry reports that 20 out of 23 U.S. optometric institutions require a course in statistics for admission into the program.⁶ The remaining three institutions strongly recommend a course.⁶ However, a basic undergraduate course in statistics does not necessarily give future optometrists the skills needed to be statistically literate. The American Optometric Association designates as an ethical duty of the optometrist “to involve the patient in care and treatment decisions in a meaningful way, with due consideration of the patient’s needs, desires, abilities and understanding, while safeguarding the patient’s privacy.”⁷ If patients are to participate in their own care, they need a basic understanding of statistics.

Statistical literacy needs to be a priority for all healthcare providers, optometrists included. As providers, it is our ethical duty to provide patients with the appropriate information for making decisions about their care. As educators, it is our responsibility to provide and reinforce through role-modeling the statistical concepts our students need to interpret and use data as they care for patients.

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Students Can Apply to Be Part of Clinic Trip



Optometry students who wish to participate in the 2019 Student OneSight clinic trip can apply until Dec. 15, 2018 at www.luxotticaeyecare.luxottica.com. The trip will take place May 11-18, 2019, and students selected for the trip will be notified of the clinic location in January 2019. On the OneSight clinic trip, optometry students work under the supervision of Luxottica Retail-affiliated doctors performing comprehensive eye exams for a community in need. They help support a core team of Luxottica volunteers in the frame fitting, manufacturing and dispensing of new eyewear. Expenses associated with the clinic, including air fare, accommodations and meals are covered.

The 2019 trip is a partnership between OneSight, Luxottica and the National Optometric Student Association. In May 2018, two groups of students traveled to Oaxaca, Mexico and helped to provide eye care to more than 7,000 people in nine clinic days.

Also: Luxottica brands Pearle Vision, LensCrafters, LensCrafters at Macy's, Target Optical and Sears Optical offer optometry residents and recent optometry school graduates the opportunity to earn extra money while gaining clinical experience with flexible, part-time opportunities in the lane. E-mail Luxotticaeyecare@luxottica.com for more information.

Student Grant Program Focuses on Public Health



National Vision Holdings Inc. is now accepting entries for its annual grant program. The 2018-2019 program focuses on optometrists' role in public health. The company is challenging students to explain how they will make an impact by combatting a national or regional public health issue as a future Doctor of Optometry. A flyer with additional information and entry requirement details is available in the [Students section of the Optometry Careers page](#) at the company's website. Completed applications can be e-mailed to Carly Schenck or mailed to National Vision, Inc., Attn: Carly Schenck, Communications Manager, Professional Services, 2435 Commerce Ave., Building #2200, Duluth, GA 30096.

Also: National Vision supports mission trips through the chapters of Student Volunteer Optometric Services to Humanity (SVOSH) by providing \$1,000 per optometry school each year to defray trip costs. Other assistance is available as well. For more information or to take advantage of these programs, [e-mail Kristen Reynolds](#) or call her at (470) 448-2139.

Public-Private Strategic Partnership Takes Aim at Myopia



[Johnson & Johnson Vision](#) has entered into a \$26.35 million research collaboration with the Singapore National Eye Centre and the Singapore Eye Research Institute to help combat myopia, a serious threat to eye health around the world. According to Paul Stoffels, MD, Vice Chairman of the Executive Committee and Chief Scientific Officer, Johnson & Johnson, "The incidence of myopia is increasing at an alarming rate around the world and if left unchecked, the human and financial toll could skyrocket in the coming decades, especially in Asia."

The public-private strategic partnership aims to create a deeper understanding of how myopia develops, how it progresses and how it may be intercepted. It will focus on developing tools for identifying those at risk for developing high myopia, conduct research on the underlying mechanisms of the condition, progress novel therapies, and discover and validate methods of preventing onset and progression.

Also: TIME magazine named ACUVUE OASYS with Transitions Light Intelligent Technology as one of the "Best Inventions of 2018" in its annual round-up spotlighting groundbreaking innovations worldwide. The two-week contact lenses not only correct vision but also help reduce exposure to bright light indoors and outdoors, including filtering blue light and blocking UV rays that can affect eye comfort and vision.

Next-Generation of Back-Side Lens Technology



HOYA Vision Care launched the Array 2 lens, building on the flexible backside platform of Array 1 to include Binocular Harmonization Technology (BHT). As explained by the company, the benefits of BHT are most pronounced for the more than 70% of patients who have a difference in vision-correction prescription from their left to right eye. The Array 2 lens design with BHT ensures that both eyes receive the appropriate accommodative support for achieving optimal binocularity.

in order to minimize non-adaptation and maximize comfort.

Array 2 lenses are available in a broad range of materials, treatments and coatings and are available in many of the most popular vision plans. Contact your HOYA territory sales manager or visit the [HOYA Vision Care website](#) for details.

New Artificial Tear Incorporates Osmoprotection



Allergan introduced REFRESH REPAIR, the first and only artificial tear in the United States with CMC, HA (inactive ingredient) and Osmoprotectants. REFRESH REPAIR helps to promote healing of the cornea and conjunctival epithelia as well as visual performance and comfort in patients who have dry eyes. Osmoprotection is designed to safeguard epithelial cells against hyperosmotic stress by displacing salts with restorative, organic osmolytes.

Among the findings of clinical evaluations, REFRESH REPAIR was shown to extend tear breakup time, and 70% of patients reported that the thickness of the drop is just right. Visit refreshbrand.com/doc for more information.

Contact Lens Recycling Program Diverts 31,000 Pounds

BAUSCH + LOMB

See better. Live better.

Bausch + Lomb announced that its ONE by ONE Recycling Program has recycled a combined total of more than five million units of used contact lenses, blister packs and top foils (31,000 pounds) since the program's inception in November 2016. The program is made possible through a collaboration with TerraCycle, a world leader in the collection and repurposing of hard-to-recycle post-consumer waste. The Bausch + Lomb ONE by ONE Recycling Program is available to optometrists and their patients in the United States. To register or learn more, [click here](#).

Also: The LUMIFY (brimonidine tartrate ophthalmic solution 0.025%) redness reliever eye drop was named a Product Showcase winner in the healthcare and over-the-counter category at the [National Association of Chain Drug Stores' 2018 Total Store Expo](#).

Platform Integrates Multimodal Diagnostic Imaging



The Integrated Diagnostic Imaging (IDI) platform from ZEISS digitally integrates data from diagnostic devices, combining modalities into individualized assessments to help doctors make optimal treatment decisions quickly and efficiently. IDI

works with ZEISS gold-standard instruments such as CIRRUS OCT, Humphrey Field Analyzer HFA3, the CLARUS 500 ultra-widefield retinal camera, and the new VISULAS green therapeutic laser.

According to vitreoretinal specialist Peter A. Karth, MD, MBA, integration is crucial. "One of the biggest challenges in retina practices today is viewing and integrating multimodal imaging to efficiently and fully assess macular disease in busy clinics," says Dr. Karth. "I consider the ZEISS Integrated Diagnostic Imaging platform to be a key part of patient management, giving me the data integration that I need to make the best decisions for my patients."

[Click here for more information](#) about the ZEISS Integrated Diagnostic Imaging platform.

Free App Aids Contact Lens Fitting and Education



CooperVision's OptiExpert app, a digital reference used by tens of thousands of eyecare professionals worldwide, has come to the United States and Canada for the first time. The U.S. and Canadian versions of OptiExpert contain three primary features:

A Multifocal Calculator for making the fitting process for presbyopic patients simpler and more efficient

A Toric Calculator that provides a timesaving model for calculating and evaluating the recommended diagnostic toric contact lens

Oxygen Profiles that provide credible clinical support to aid upgrade discussions with patients, including a clear visual demonstration of oxygen transmissibility levels of CooperVision silicone hydrogel contact lens compared to other products.

The app is available for free from the Apple App Store and Google Play. Also visit the [OptiExpert webpage](#) for more information.

Annual Scholarship Competition is Now Open



Walmart and Sam's Club Health & Wellness announced the opening of its 2019 Project Foresight national scholarship competition. First-year, second-year and third-year students enrolled in one of the 23 ASCO member optometry schools in the United States and Puerto Rico are eligible to participate in this annual competition.

To participate, students should submit an essay (written or video) on their own unique practice idea, i.e., something that would impact one practice, multiple practices or the entire profession. The idea should reflect the vision of Walmart & Sam's Club Health and Wellness, which is to provide quality, affordable and accessible healthcare for everyone. This year, one winner from every school that participates will receive a \$2,000 award to be split as a scholarship and travel grant for attending the 2019 Optometry's Meeting in St. Louis. One student will be selected as the grand prize winner and receive a \$5,000 scholarship and traveling trophy.

For more information, students can reach out to the Regional Talent Specialist who supports their school. The deadline for submitting an entry form and essay is Feb. 1, 2019. Submissions should be e-mailed to [Dr. Ramon Yalldo](#).

Early Detection of Diabetic Eye Disease



New from Diopsys is the Chromatic Flash Vision Screener, an in-office screening test designed to detect early changes in retinal function in patients with diabetes. Using red-on-blue flash electroretinography in an undilated eye, the test protocol provides quantitative measurements of retinal function. Using a handheld mini-Ganzfeld, a red flash of light is presented on a blue background, and the electrical potential of the retina is recorded using patented skin sensors placed just below the lower eyelashes. Results are analyzed against healthy reference range data to help doctors understand the probability of the patient developing retinopathy. The testing protocol is part of the Diopsys Full Field Electroretinography module and is compatible with all new Diopsys platforms. Find more information about the new test [here](#).

FDA Clears Multi-modal Imaging Device with Swept Source OCT



Topcon Medical Systems announced that its DRI OCT Triton Series has received 510(k) clearance from the FDA. The DRI OCT Triton features easy image capture and a 1-micron, 1050-nm light source with a scanning speed of 100,000 A-scans/second. The multi-modal instrument incorporates a built-in retinal camera, eye tracking during capture of selected scans, and combines the company's years of expertise in OCT imaging, color, red-free, fluorescein angiography and fundus autofluorescence imaging with the diagnostic power of swept source OCT.

For more information, visit www.topconmedical.com.

Device Manufacturer, Optometry School Enter into Partnership



Haag-Streit USA and the University of California, Berkeley, School of Optometry have initiated a new partnership. The partnership, which includes a donation of equipment to the school, demonstrates the school and company's shared commitment to providing students with exemplary clinical training and pursuing advances in eye care and research. "Haag-Streit's gift will transform the pre-clinic at Berkeley Optometry," says Dean and Professor John Flanagan, PhD, DSc(hon), FCOptom, FAAO. "Our partnership with Haag-Streit USA creates the opportunity for our students, who are introduced to the teaching laboratory as early as their first semester, to be trained on the best medical and diagnostic equipment from the start."

New Technology Links EHR and Product Ordering



Rev360, provider of RevolutionEHR and a suite of practice advancement solutions, announced the availability of

RevAlliance. RevAlliance utilizes a proprietary order processing technology infrastructure to connect RevolutionEHR users directly with their vision-correcting product suppliers, all from within RevolutionEHR. Rev360 CEO Dr. Scott Jens calls RevAlliance “the fastest, most accurate end-to-end product ordering and delivery experience in the market.”

Currently participating RevAlliance product partners include CooperVision, HOYA, New Era, OOGP and WVA, and additional partners will be announced soon. There is no cost for RevolutionEHR users to join RevAlliance and take advantage of its ordering efficiency and accuracy, transparent product pricing, and discounts and rebates.

[Click here for more information](#) about RevAlliance.

New Slit Lamp Series Debuts



Marco has introduced a new line of slit lamps, the Ultra M Series, which it says features elegant and intelligent design, progressive engineering and functional flexibility. Attributes of the Ultra M Series include multiple color correction filters, single element LED, patented integrated background illuminator, extended slit aperture and wider field of view, fully incorporated transformer and cabling, and intelligent operator and patient interfaces. Marco describes the slit lamp series as an “inspiring orchestration of the Ultra Optics pedigree.”

For more information on Ultra M Series design enhancements, visit www.MARCO.com.

CALL FOR SUBMISSIONS: 3RD WORLD CONGRESS OF OPTOMETRY

The World Council of Optometry (WCO) invites educators, optometrists, researchers, public health experts and students to participate in the 3rd World Congress of Optometry by submitting abstracts for continuing education lectures, workshops and the scientific program. The Congress will be held in partnership with the American Academy of Optometry, Oct. 23-27, 2019, in Orlando, Fla.

- The submission window for lectures and workshops is open Jan. 1-31, 2019
- The submission window for the scientific program and posters is open May 1-31, 2019

