Observational Study

Medicine

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The yield of neuroimaging in patients presenting to the emergency department with isolated neuro-ophthalmological complaints

A retrospective chart review

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Abstract

Neuro-ophthalmological emergencies require prompt assessment and management to avoid vision or life-threatening sequelae. The decision to perform a neuroimaging procedure is based on the clinical judgment of the medical team, without defined indications. This study aims to identify presenting symptoms and physical exam findings associated with relative positive findings on neuroimaging studies. Electronic medical records of patients presenting to the emergency department (ED) with isolated neuro-ophthalmologic complaints between January 1, 2013 and September 30, 2019 were reviewed. We collected data on the clinical presentation, neuroimaging procedures and results, consults, and diagnoses. Two hundred eleven patients' charts were reviewed. Most presented with unilateral eye complaints (53.6%), and the most common symptoms were blurred vision (77.3%) and headaches (42.2%). A total of 126 imaging procedures were performed of which 74.6% were normal, while 25.4% showed relevant abnormal findings. Complaining of blurry vision (P = .038) or visual field changes (P = .014) at presentation as well as having a visual field defect (P = .016), abnormal pupil reactivity (P = .028), afferent pupillary defect (P = .018), or abnormal optic disc exam (P = .009) were associated with positive findings on imaging. Neuroimaging is more likely to yield positive findings in patients presenting to the ED with visual field irregularities, afferent pupillary defects, or abnormal optic discs. These findings – when combined with the proper clinical setting – should lower the threshold to proceed with neuroimaging in the emergency department. Based on our results, larger-scale studies might lead to a well-structured algorithm to be followed by ED physicians in decision making.

Abbreviations: APD = afferent pupillary defect, CT = computed tomography, ED = emergency department, MRI = magnetic resonance imaging.

Keywords: emergency department, emergency predictors, neuroimaging, neuroophthalmology, yield of imaging

1. Introduction

1.1. Background/rationale

Eye complaints are some of the common presenting chief complaints to the emergency department (ED). According to the nationally representative data from the United States Nationwide Emergency Department Sample between 2006 and 2011, an estimated 11,929,955 visits to EDs occurred in the United States for ophthalmic conditions, a mean of nearly 2 million visits per year. Out of those visits, 41.2% are for emergent conditions.[1] Neuro-ophthalmological emergencies are one of the most challenging presentations that require urgent evaluation and management to avoid vision or life-threatening sequelae.[2–4] The differential diagnosis is often broad, and the presenting chief complaints include eye pain, blurred vision, vision loss, diplopia, ptosis, and positive visual phenomena (flashes, dots, lights, or colors). Hence, emergency physicians are often faced with the challenge and need for prompt imaging and consultations.

The increased speed of testing and wider availability has made computed tomography (CT) scans the most commonly used imaging modality in the ED. However, they are less

TEZ and DEH contributed equally to this work.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

This study and its protocol was approved by the Institutional Review Board (IRB) at the American University of Beirut (AUBMC). The IRB has waived the need for obtaining informed consent. The data collection, analysis and manuscript hold no Personal Identifiable Data of patients or their charts. Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

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How to cite this article: El Zahran T, El Hadi D, Mostafa H, Mansour H, Hashim I, Tahhan S, Bou Ghannam A. The yield of neuroimaging in patients presenting to the emergency department with isolated neuro-ophthalmological complaints: A retrospective chart review. Medicine 2023;102:4(e32740).

Received: 2 December 2022 / Received in final form: 3 January 2023 / Accepted: 4 January 2023

http://dx.doi.org/10.1097/MD.0000000000032740

sensitive than magnetic resonance imaging (MRI) in assessing soft tissue. This makes MRI the modality of choice for most neuro-ophthalmological presentations, but MRIs are not readily available in ED settings.[5] Over the past several years, the use of CT and MRI has increased dramatically, but with an increased financial burden where the cost per clinically significant and relevant finding was $1764.19.[6] Additionally, the use of imaging is abused and in some cases, history and physical exam are enough for proper diagnosis and management.[7] In their study, Mehta et al found that only 28.9% of neuroimaging tests requested by neuro-ophthalmologists resulted in an abnormal finding relevant to the patient's neuro-ophthalmic condition.[6]

1.2. Objectives

In this study, we aim to identify the most common chief complaints and physical exam findings that are more likely to be associated with significant and clinically relevant findings on neuroimaging in the ED. These findings will guide the emergency physician in selectively choosing patients that require neuroimaging and in choosing the appropriate imaging modality in order to prevent time-consuming, resource-draining, and often unnecessary radiation exposure.

2. Materials and methods

2.1. Study design and selection of participants

This is a retrospective cross-sectional study that was conducted by reviewing the electronic medical records of all patients presenting to the ED at the American University of Beirut Medical Center in Lebanon, the largest tertiary care center in the country, between January 1, 2013 and September 30, 2019 with isolated neuro-ophthalmologic complaints. We assessed the demographics, presentations, physical exam findings, consultations, imaging studies and findings, and diagnoses of these patients. The described research adhered to the tenets of the Declaration of Helsinki. A data abstraction form was created a priori with a set of variables to be extracted from each chart in order to ensure accuracy, reliability and consistency and decrease any risk of bias.

2.2. Data collection and management

We reviewed the electronic health records (patient charts, imaging reports, physicians' notes) of all patients presenting to the ED with neuro-ophthalmological complaints including vision change, blurriness, vision difficulty, visual disturbance, vision loss, decrease in vision, double vision, orbital pain, eye drooping, floaters, disturbance in the visual field. Exclusion criteria included patients who presented with eye symptoms not pertaining to neuro-ophthalmology including -but not restricted to- conjunctivitis, keratitis, foreign body, corneal abrasion, chemical injury, chalazion, retinal detachment, uveitis, scleritis, etc. Patients with a history of trauma at admission or in the recent past (3 months) were excluded from the study as well.

Abnormality in imaging was defined as a lesion documented by a radiologist in a report to be matched to the patient's presentation by a neuro-ophthalmologist who excluded abnormalities in imaging that did not contribute to the possible neuro-ophthalmological disease, such as chronic abnormal findings, and findings anatomically not related to the visual pathway or to any neuro-ophthalmic pathology. That way, the significance in the results is true significance to neuro-ophthalmological imaging findings and not just any irregularity reported by radiology.

The relevant abnormal findings on imaging that we considered as positive findings included space occupying pathologies like subarachnoid bleed, intracranial bleed, and intracranial masses, vascular pathologies, mainly thrombosis and aneurysm, and inflammatory pathologies like active demyelinating disease and optic neuritis.

2.3. Data analysis

Data was analyzed using the Statistical Package for the Social Sciences (IBM SPSS, Armonk, NY: IBM Corp) version 25. Continuous variables were described using the mean and standard deviation, while categorical variables were presented as frequencies and percentages. Statistical differences across the categories of the outcome variables for categorical covariates were determined using Pearson Chi-square and Fisher exact tests.

The institutional review board at the American University of Beirut approved this study for meeting ethical standards.

3. Results

After excluding patients who presented to the ED and were found to have purely ophthalmologic diagnoses as described in the methods section, 211 patients were included in the study between January 1, 2013 and September 30, 2019 (Table 1). Our sample included 107 (50.7%) females and the patients' age ranged between 5 and 94 years with a mean of 41.2 ± 21.4 years.

Most patients (53.6%) had unilateral eye complaints while 98 (46.4%) had bilateral complaints. The most commonly reported symptom at presentation was blurry vision (77.3%), followed by headaches (42.2%), change in visual field (20.4%), transient vision loss (24.6%), double vision (23.2%), eye pain (21.8%), floaters (11.4%), dizziness (10.9%), and eyelid droop (5.2%). In addition, 40.3% had associated nausea/vomiting (Table 1).

The ophthalmology and neurology teams were both consulted in 20.4% of the cases, while 26.5% received only ophthalmology consults and 28.9% received only neurology consults. Physical exam findings were documented by the ED team as well as by the consultants. On physical examination, the presence of decreased visual acuity was the most common finding (33.6%), followed by abnormal extraocular movements (9.5%) and abnormal optic disc exam (9.0%) (Table 1).

Of the 211 patients, 176 (83.4%) received their final diagnosis in the ED, while the rest required further workup either on outside basis or upon admission. The most common diagnoses were migraine (20.4%) followed by ocular migraine (19.9%), isolated cranial nerve palsy (8.5%) and ischemic stroke (8.1%) (Table 2). Most patients (67.3%) were treated and discharged home while 32.7% required hospital admission.

A total of 126 imaging procedures were performed in the ED (Table 3). Ninety-four of them (74.6) were head CTs of different modalities, with only 14 (14.9% of the CT scans) showing relevant abnormal findings. Six of the patients with normal CT scans proceeded to do an MRI, with 3 (50%) yielding positive findings on the MRI. Three of the patients with abnormal CT scans proceeded to do a subsequent MRI, with 2 (67.7%) showing abnormal results. Thirty-two brain MRIs (25.4%) of different modalities were performed, with 18 (56.3% of the MRIs) showing relevant abnormal findings.

Multiple patients underwent follow up imaging studies (Table 4). A total of 93 follow up imaging procedures were performed, of which 6 (6.3%) were CT scans and 87 (93.7%) were MRIs. Most of the follow up images were normal (62.4%) while 35 (37.6%) showed relevant abnormal findings.

Having a presenting symptom of blurry vision (P = .038) or complaining of a change in visual field (P = .014) was significantly associated with having positive findings on neuroimaging. Moreover, physical exam findings of a visual field defect (P = .016), abnormal pupil reactivity (P = .028), afferent pupillary defect (APD) (P = .018), or abnormal optic disc exam (P = .009)

Table 1

The characteristics of patients presenting to the emergency department with isolated neuro-ophthalmological complaints.

Age in yr – mean (standard deviation)					41.2 (21.4)
Characteristics					Count (Percentage)
Gender					
Female					107 (50.7)
Male					104 (49.3)
Laterality					
Unilateral					113 (53.6)
Bilateral					98 (46.4)
Symptoms at presentation	CT in ED (% out of the patients with the symptom)	Abnormal CT in ED (% out of CTs performed)	MRI in ED (% out of the patients with the symptom)	Abnormal MRI in ED (% out of MRIs performed)	Total number of patients with a given symptom at presentation
Blurred vision	73 (44.8)	11 (15.1)	18 (11.0)	11 (61.1)	163 (77.3)
Headache	36 (40.4)	3 (8.3)	10 (11.2)	6 (60.0)	89 (42.2)
Change in visual field	23 (53.5)	5 (21.7)	8 (18.6)	5 (62.5)	43 (20.4)
Transient vision loss	21 (40.4)	4 (19.0)	6 (11.5)	2 (33.3)	52 (24.6)
Double vision	25 (51.0)	5 (20.0)	6 (12.2)	5 (83.3)	49 (23.2)
Eye pain	9 (19.6)	1 (11.1)	8 (17.4)	4 (50.0)	46 (21.8)
Floaters	7 (29.2)	1 (14.3)	5 (20.8)	2 (40.0)	24 (11.4)
Dizziness	15 (65.2)	1 (6.7)	3 (13.0)	2 (66.7)	23 (10.9)
Eye droop	6 (54.5)	0 (0.0)	3 (27.3)	2 (66.7)	11 (5.2)
Associated nausea/ vomiting	36 (42.4)	4 (11.1)	15 (17.6)	7 (46.7)	85 (40.3)
Physical exam findings					
Decreased visual acuity					71 (33.6)
Abnormal extraocular movements					20 (9.5)
Abnormal optic disc exam					19 (9.0)
Abnormal anterior chamber exam					17 (8.1)
Abnormal posterior chamber exam					14 (6.6)
Afferent pupillary defect					14 (6.6)
Visual field defect					10 (4.7)
Abnormal pupil reactivity					7 (3.3)

CT = computed tomography, ED = emergency department, MRI = magnetic resonance imaging.

Table 2

The final diagnoses reached in the emergency department for patients presenting with isolated neuro-ophthalmological complaints.

Final diagnosis reached in ED (N = 176)	Number of patients with diagnosis (%)
Migraine	43 (20.4)
Ocular migraine	42 (19.9)
Isolated cranial nerve palsy	18 (8.5)
Ischemic stroke	17 (8.1)
Retinal vein/retinal artery occlusion	10 (4.7)
Psychosomatic	10 (4.7)
Optic neuritis	8 (3.8)
Demyelinating lesion other than optic neuritis	8 (3.8)
Intracranial mass	5 (2.4)
Myasthenia gravis	4 (1.9)
Intracranial bleed	3 (1.4)
Ischemic optic neuropathy	3 (1.4)
Other	5 (2.4

ED = emergency department.

was also significantly associated with having positive findings on neuroimaging. Age, gender, laterality of the chief complaint, the team recommending the imaging procedure (ED, ophthalmology, or neurology), other presenting symptoms, and other physical exam findings did not have any statistically significant association with having positive findings on neuroimaging (Table 5).

Sub-analysis was done based on the type of imaging done (CT vs MRI). The associations aforementioned were lost except for visual field defect on physical exam that was found to be associated with abnormal CT brain imaging (P = .049)

4. Discussion

Our study focused on the neuro-ophthalmological presentations in the ED of one of the largest tertiary care centers in the country. To our knowledge there is no other study that looked at neuroophthalmological complaints in the ED, but there are studies that looked at general eye complaints among which neuroophthalmological complaints constituted around 30 percent of the consults. This was the highest subspecialty requiring consultation.[8] In our study, more than 3 quarters of the presentations required consults and they were almost equally divided between ophthalmology, neurology, and both. No specific consults were made to the neuroophthalmologist, as the medical center is an academic institute and the first line of consult would be the resident on call.

When it comes to chief complaints, blurry vision was by far the most frequent followed by headaches, while ocular traumas and red eyes were the most common non-neuroophthalmological eye emergencies in other studies.[1,9] Around half of the neuroophthalmological presentations to the emergency department were nonemergent such as migraine, ocular migraine, and psycho-somatization, which constituted around 50% of the diagnoses. This was in accordance to what Chana et al found when assessing all eye related ED visits in The United States but was more than what Kang found in Taiwan (only 20% had nonemergent eye conditions).[1,10]

We focused in this study on the various neuroimaging modalities used in the emergency department when faced with neuroophthalmological complaint. Although few studies before looked at neuroimaging use in neuroophthalmological diseases, none of them tackled this issue in the ED setting.[6,7]

We found that 57.8% of our patients underwent neuroimaging. Brain CT scans were more commonly done (74.65%), compared to brain MRIs (25.4%). Around 3 quarters of the images were read as normal or with findings unrelated to the

Table 3

The imaging procedures performed in the emergency department for patients presenting with isolated neuro-ophthalmological complaints.

Type of imaging procedures performed in the ED	Normal	Abnormal	Total
CT head with contrast	8 (72.7)	3 (27.3)	11 (8.7)
CT head without contrast	65 (85.5)	11 (14.5)	76 (60.3)
CT angiography head/neck	7 (100)	0 (0)	7 (5.5)
MRI brain with gadolinium	3 (25.0)	9 (75.0)	12 (9.5)
MRI brain without gadolinium	3 (42.9)	4 (57.1)	7 (5.5)
MR angiography brain	7 (70.0)	3 (30.0)	10 (7.9)
MRI orbit	1 (33.3)	2 (66.7)	3 (2.4)
Total	94 (74.6)	32 (25.4)	126 (100)

CT = computed tomography, ED = emergency department, MRI = magnetic resonance imaging.

Table 4

The imaging procedures performed on follow-up* for patients presenting with isolated neuro-ophthalmological complaints.

	Count (%)		
Type of imaging procedures performed on follow up	Normal	Abnormal	Total number of imaging procedures
CT head with contrast	2 (100)	0 (0)	2 (2.1)
CT head without contrast	3 (75.0)	1 (25.0)	4 (4.2)
CT angiography head/neck	0 (0)	0 (0)	0 (0)
MRI brain with gadolinium	27 (69.2)	12 (5.7)	39 (41.9)
MRI brain without gadolinium	7 (70.0)	3 (30.0)	10 (10.8)
MR angiography brain	16 (57.1)	12 (42.9)	28 (30.1)
MRI orbit	3 (3.2)	7 (7.5)	10 (10.8)
Total	58 (62.4)	35 (37.6)	93 (100)

CT = computed tomography, MRI = magnetic resonance imaging.

* Imaging ordered upon following up in the outpatient clinics or later during admission.

chief complaints. Of all the CT images done, only 14.9% had clinically relevant abnormal findings compared to 56.3% with MRIs. Along the same lines, a study found no increased diagnostic value in brain CTs done for patients with isolated double vision without other neurologic signs.[11] This shows that brain imaging is overused partly because most ED physicians as well as some ophthalmologists and neurologists are uncomfortable and inexperienced in diagnosing neuro-ophthalmological conditions. In this tertiary care center, an MRI would usually require hospital admission to be performed sometimes the following day, hence, the number of MRIs done in the ED was too little to draw conclusions from.

The 2 symptomatic presentations that were significantly more likely to yield a clinically relevant positive finding on imaging were blurred vision and changes in the visual field. It is important, however, to note that a significant percentage of patients had blurred vision (77%) which might reduce the importance of this symptom in predicting positive findings on neuroimaging. As for the signs, visual field defects, abnormal pupil reactivity, APD, and abnormal optic disc exam were predictors of relevant abnormal brain imaging. This was consistent with other similar studies that showed highest diagnostic yield in patients with an abnormal pupil reactivity (with an ARPD)[6,12] or with a visual field defect.[13] All those physical exam parameters could be assessed by the ED physician at the bedside.

Abnormal findings on brain imaging that were considered related to the neuro-ophthalmological presentation included hemorrhage or hypodensity suggestive of stroke, acute lacunar infarcts, inflammation, metastatic lesions involving the visual or ocular motor pathways, and demyelinating diseases. A sub-analysis separating the abnormal findings on CT versus MRI was performed. The only association that remained significant was visual field defect on physical exam. This finding predicted an abnormality on CT scan but not on MRI. The lack of significance in the latter is probably attributed to the small sample size of MRI images done in the ED and it paves the way for future studies with a larger population and a higher number of imaging performed (especially MRI) to possibly achieve significance.

While using a CT scan in the ED for its speed and low cost[5] is a quick and sometimes necessary way to rule out certain entities, like bleeding or small orbital fractures,[14] it is rarely helpful in diagnosing neuro-ophthalmological conditions. Therefore, 1 should be careful when ordering CT scans as some pathologies warrant an MRI, the gold standard diagnostic tool for most neuro-ophthalmic conditions,[12] while others can be diagnosed using proper history and physical exam without the need for any image.

One example of an unnecessary CT scan is for a patient aged in the 60s, who is diabetic and with new onset diplopia. Assessment of the patient showed abducens nerve palsy with no other significant findings. This is most likely microvascular and brain imaging initially is not warranted. Another example is for an adolescent patient also presenting with new onset double vision, after a period of headaches, nausea and vomiting. Eye exam is significant for papilledema. Such a patient will need an MRI and magnetic resonance venography of the brain and CT scan alone is not sufficient. Table 1 summarizes the most common neuroophthalmologic conditions and the need for imaging in various scenarios. As front liners, ED physicians and consultants have the responsibility to make such decisions while considering the cost-effectiveness of the resources, and the additional information the image would add to the working diagnosis. The ED physician should be attentive to both the presentation and physical exam to assess urgency, the need for consultation (ophthalmology or neurology) and threat to sight or life (Table 6). Limitations to this study lies in its retrospective nature. Therefore, some charts had missing information. These results could be generalizable to any emergency department setting that encounters such neuro-ophthalmologic complaints and are able to provide imaging services in the ED.

Table 5

The association between selected covariates and obtaining a positive finding on imaging procedures performed on patients presenting with isolated neuro-ophthalmological complaints.

	Total	Imaging findings		
Characteristics	**96 (100)**	**Normal**	**Abnormal**	***P* value**
Gender				.691
Female	49 (51.0)	38 (77.6)	11 (22.4)	
Male	47 (49.0)	38 (80.9)	9 (19.1)	
Laterality				.459
Unilateral	41 (42.7)	31 (75.6)	10 (24.4)	
Bilateral	55 (57.3)	45 (81.8)	10 (18.2)	
Symptoms present at presentation				
Blurred vision				**.038**
Yes	82 (83.3)	62 (75.6)	20 (24.4)	
No	14 (14.6)	14 (100)	0 (0.0)	
Transient vision loss				0.562
Yes	24 (25.0)	18 (75.0)	6 (25.0)	
No	72 (75.0)	58 (80.6)	14 (19.4)	
Change in visual field				**.014**
Yes	27 (28.1)	17 (63.0)	10 (27.0)	
No	69 (71.9)	59 (85.5)	10 (14.5)	
Floaters				.389
Yes	9 (9.4)	6 (66.7)	3 (33.3)	
No	87 (90.6)	70 (80.5)	17 (19.5)	
Double vision				.284
Yes	29 (30.2)	21 (72.4)	8 (27.6)	
No	67 (69.8)	55 (82.1)	12 (17.9)	
Eye pain				.160
Yes	14 (14.6)	9 (64.3)	5 (35.7)	
No	82 (83.3)	67 (81.7)	15 (18.3)	
Eye droop				.670
Yes	8 (8.3)	6 (75.0)	2 (25.0)	
No	88 (91.7)	70 (79.5)	18 (20.5)	
Headache				.704
Yes	42 (43.8)	34 (81.0)	8 (19.0)	
No	54 (56.3)	42 (77.8)	12 (22.2)	
Dizziness				1.000
Yes	17 (17.7)	14 (82.4)	3 (17.6)	
No	79 (82.3)	62 (78.5)	17 (21.5)	
Nausea/vomiting				.933
Yes	44 (45.8)	35 (79.5)	9 (20.5)	
No	52 (54.2)	41 (78.8)	11 (21.2)	
Physical exam findings				
Decreased visual acuity				.080
Yes	28 (29.2)	19 (67.9)	9 (32.1)	
No	68 (70.8)	57 (83.8)	11 (16.2)	
Visual field defect				**.016**
Yes	10 (10.4)	5 (50.0(	5 (50.0)	
No	86 (89.5)	71 (82.6)	15 (17.4)	
Abnormal extraocular movements				.266
Yes	12 (12.5)	8 (66.7)	4 (33.3)	
No	84 (87.5)	68 (81.0)	16 (19.0)	
Abnormal pupil reactivity				**.028**
Yes	4 (4.2)	1 (25.0)	3 (75.0)	
No	92 (95.8)	75 (81.5)	17 (17.7)	
Afferent pupillary defect		4 (44.4)		**.018**
Yes	9 (9.4)	72 (82.8)	5 (55.6)	
No	87 (90.6)		15 (15.6)	
Abnormal optic disc exam				**.009**
Yes	8 (8.3)	3 (37.5)	5 (62.5)	
No	88 (91.7)	73 (83.0)	15 (17.0)	
Abnormal anterior chamber exam				1.000
Yes	3 (3.1)	3 (100)	0 (0.0)	
No	93 (96.9)	73 (78.5)	20 (21.5)	
Abnormal posterior chamber exam				.580
Yes	5 (5.2)	5 (100)	0 (0.0)	
No	91 (94.8)	71 (78.0)	20 (22.0)	

Bold: statistically significant.

Table 6

Steps to follow by the ED team when encountering a patient with a neuro-ophthalmological complaint.

1. Obtain a full history, including questions on blurred vision, visual field defects and diplopia.
2. Bedside ophthalmological exam: vision, color vision, confrontational visual field of each eye separately, pupillary reflex testing looking for an APD, cranial nerves assessment including ocular motor, trigeminal, facial and vestibulocochlear nerves, and finally an initial assessment of the optic disc with a direct ophthalmoscope.
3. Based on this initial survey, the ED physician would have the appropriate information to proceed with imaging, to be followed/ or done in parallel with a specialist's consultation: Neurology or Ophthalmology.
4. The consulted party would then assess its need for further imaging based on their own assessment.

APD = afferent pupillary defect, ED = emergency department.

Table 7

Various neuroophthalmological scenarios in the emergency department, with appropriate imaging.

Symptom/sign	Condition	Brain imaging in ED	Urgency	Type of image	Gadolinium	Feared condition
Diplopia +/- ptosis	History and exam (H and E) suggestive of microvascular nerve palsy (4th, 6th or complete, pupil sparing 3rd)	No	0			
Diplopia/ptosis	Third nerve palsy - otherwise	yes	3	MRI brain + MRA/CTA	with	Cerebral aneurysm
Diplopia	Not suggestive of microvascular nerve palsy	yes	2	MRI brain/brainstem	with and without	Cranial nerve inflammation, infiltration, compression, demyelination
Diplopia	After orbital trauma	yes	2	CT orbit	without	Orbital fracture with entrapment
Diplopia +/-ptosis	History and exam suggestive of myasthenia gravis	No	1	CT chest	with	Thymoma
Isolated Ptosis	Isolated	Depends on history	1			
Oscillopsia/nystagmus	New onset	yes	2	MRI brain brainstem	with and without	Demyelination tumor, inflammation, infiltration
Anisocoria with ptosis	Horner	Yes	3	MRI/MRA/CTA brain and neck up to the thoracic vertebra	with	Carotid dissection
Anisocoria	Tonic pupil	No	0			
Decrease in vision/optic nerve swelling	H and E suggestive of Non arteritic ischemic optic neuropathy	No	0			
Decrease in vision/optic nerve swelling	H and E suggestive of arteritic ischemic optic neuropathy	No	1			
Visual Field defect	Bitemporal hemianopsia/junctional scotoma	Yes	3	CT/MRI brain/sella	with and without	Pituitary apoplexy/optic chiasmal compression
Visual field defect	Homonymous hemianopsia	Yes	3	CT/MRI brain	with and without	Intracranial bleed/cerebrovascular accident (CVA)/tumor
Transient vision loss	Lasting seconds to min	yes	3	CT/MRI MRA/CTA Of brain and neck	with	Transient ischemic attack, embolism
Transient blurry vision	Lasting 20–60 minutes followed by headaches	no	1			
Bilateral Optic nerve swelling + headaches	Papilledema	Yes	2	MRI MRV	with	Tumor, cerebral venous thrombosis
Scintillating scotoma	Followed by headaches	no	0			
Positive visual disturbances	Flashes, visual snow, palinopsia	No	1			Epilepsy
Optic nerve swelling	H and E suggestive of drusen	No	0			
Decrease vision, eye pain +/-optic nerve swelling	H and E suggestive of optic neuritis	yes	2	MRI brain and orbit with fat suppression	with and without	demyelinating disease
Decrease vision with optic nerve swelling or pallor	Not suggestive of optic neuritis or ischemic optic neuropathy	yes	2	MRI brain and orbit with fat suppression	with and without	Compressive/infiltrative
Multiple cranial nerve palsies	combination of 2, 3, 4, 5 and 6	yes	3	MRI/MRA/MRV or CT/CTA/CTV	with	Orbital apex or cavernous pathologies including aneurysm, thrombosis and carotid cavernous fistulas
Optic ataxia, simultagnosia ocular motor apraxia	Ballint Triad	yes	2	MRI/CT	with and without	Intracranial bleed/cerebrovascular accident (CVA)/tumor/posterior cortical atrophy

Urgency 0–3. 0: imaging not needed, 1: imaging can be done on an outside basis, 2: imaging is needed in ED or after admission, 3: imaging needed urgently for possible life-threatening conditions.
CT = computed tomography, CTA = computed tomography angiography, ED = emergency department, H and E = history and physical exam, MRA = magnetic resonance angiography, MRI = magnetic resonance imaging, MRV = magnetic resonance venography.

We conclude that risk indicators for abnormal neuroimaging in the setting of neuro-ophthalmological emergencies are blurred vision, or changes in visual field on history taking. While visual field irregularities, abnormal pupil reactivity with or without APD or abnormal optic discs, are risk factors related to physical testing. Although those factors are important and -if present- should sway the ED physician towards neuroimaging (Table 7) but still individualizing each case is of utmost importance to prevent time-consuming, resource-draining, and sometimes unnecessary workup/imaging.

Author contributions

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