

The Yield of Neuroimaging in Patients Presenting to the Emergency Department With Isolated Neuro-Ophthalmological Complaints

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Abstract

Background: Neuro-ophthalmological emergencies require prompt assessment and management to avoid vision or life-threatening sequelae. The decision to perform a neuroimaging procedure is currently based on the clinical judgement 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,

Methods: This study was conducted by reviewing the electronic medical records of patients presenting to the Emergency Department (ED) with isolated neuro-ophthalmologic complaints between January 1st, 2013 and September 30th 2019. We collected data on the clinical presentation, neuroimaging procedures and results, consults, and diagnoses.

Results: We reviewed the charts of 211 patients of whom 50.7% were females and had a mean age of 41.2 ±21.4 years. 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=0.038) or visual field changes (p=0.014) at presentation were associated with having positive findings on imaging. Physical exam findings of a visual field defect (p=0.016), abnormal pupil reactivity (p=0.028), afferent pupillary defect (p=0.018), or abnormal optic disc exam (p=0.009) were also associated with positive findings on imaging.

Conclusion: Neuroimaging is more likely to yield positive findings in patients presenting to the ED with blurred vision or changes in visual field and in those found to have visual field irregularities, afferent pupillary defects or abnormal optic discs on physical exam. 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.

Key Messages

• What is already known about this subject?

The advancements in neuroimaging is allowing physicians to distinguish brain lesions. The most commonly used imaging modalities by neuro-ophthalmologists would be the Brain Computed tomography (CT) and Magnetic resonance imaging (MRI). There is overuse of such imaging especially in non-indicated cases. There are however, some findings on history and physical exam that would suggest positive findings on imaging. Multiple studies previously commented on those findings separately.

• What are the new findings?

Our study presents grouping of risk indicators in both history and physical exam (mainly ophthalmological) that would suggest an abnormal neuroimaging in the setting of neuro-ophthalmological emergencies. They are blurred vision, or changes in visual field on history taking. While visual field irregularities, abnormal pupil

reactivity with or without afferent pupillary defect or abnormal optic discs, on physical exam. We finally suggest an algorithm to follow by the ED team in approaching neuro-ophthalmological emergencies as well as a tabulation of different scenarios that could be faced. Adding to that, information on appropriate imaging, urgency as well as feared conditions.

• How might these results change the focus of research or clinical practice?

The mentioned risk factors are important to guide the ED physician towards neuroimaging while individualizing each case to prevent time-consuming, resource-draining, and sometimes unnecessary workup/imaging.

Background:

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 (NEDS) between 2006–2011, 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 sensitive than Magnetic Resonance Imaging (MRI) in assessing soft tissue. This makes MRI the modality of choice for most neuro-ophthalmological presentations, but MRIs ⁵ are not readily available in ED settings ⁵. Over the past several years, the use of CT and magnetic resonance imaging (MRI) has increased dramatically, but with an increased financial burden where the cost per clinically significant and relevant finding was \$1,764.19 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.

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.

Materials And Methods:

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 Emergency Department (ED) at the American University of Beirut Medical Center in Lebanon, the largest tertiary care center in the country, between January 1st, 2013 and September 30th, 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.

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. Patients whose discharge diagnosis was not related to neuro-ophthalmology (e.g. retinal detachment, abrasion, cataracts... etc.) were excluded from the study.

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.

Data Analysis:

Data was analyzed using the statistical package for the social sciences (IBM SPSS) 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's Chi-square and Fisher's exact tests.

The Institutional Review Board (IRB) at the American University of Beirut approved this study for meeting ethical standards.

Results:

We identified a total of 1298 patients who presented with ophthalmologic complaints between January 1st, 2013 and September 30th 2019. After excluding those who were found to have purely ophthalmologic diagnoses as described in the methods section, 211 patients were included in the study (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).

Table 1
The Characteristics of Patients Presenting to the Emergency Department with Isolated Neuro-ophthalmological Complaints

Age in years – Mean (Standard deviation)						41.2 (21.4)
Characteristics						Count (Percentage)
Gender						107 (50.7)
Female						104 (49.3)
Male						
Laterality						113 (53.6)
Unilateral						98 (46.4)
Bilateral						
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)	

Age in years – Mean (Standard deviation)	41.2 (21.4)
Physical Exam Findings	71 (33.6)
<i>Decreased visual acuity</i>	20 (9.5)
<i>Abnormal extraocular movements</i>	19 (9.0)
<i>Abnormal optic disc exam</i>	17 (8.1)
<i>Abnormal anterior chamber exam</i>	14 (6.6)
<i>Abnormal posterior chamber exam</i>	14 (6.6)
<i>Afferent pupillary defect</i>	10 (4.7)
<i>Visual field defect</i>	7 (3.3)
<i>Abnormal pupil reactivity</i>	

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.

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 (%)
<i>Migraine</i>	43 (20.4)
<i>Ocular migraine</i>	42 (19.9)
<i>Isolated cranial nerve palsy</i>	18 (8.5)
<i>Ischemic stroke</i>	17 (8.1)
<i>Retinal vein/ Retinal artery occlusion</i>	10 (4.7)
<i>Psychosomatic</i>	10 (4.7)
<i>Optic neuritis</i>	8 (3.8)
<i>Demyelinating lesion other than optic neuritis</i>	8 (3.8)
<i>Intracranial mass</i>	5 (2.4)
<i>Myasthenia gravis</i>	4 (1.9)
<i>Intracranial bleed</i>	3 (1.4)
<i>Ischemic optic neuropathy</i>	3 (1.4)
<i>Other</i>	5 (2.4)

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.

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)

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.

Table 4
The Imaging Procedures Performed on Follow-up* for Patients Presenting with Isolated Neuro-ophthalmological Complaints

Type of Imaging Procedures Performed on Follow Up	Count (%)		
	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)
*Imaging ordered upon following up in the outpatient clinics or later during admission.			

Having a presenting symptom of blurry vision (p-value = 0.038) or complaining of a change in visual field (p-value = 0.014) was significantly associated with having positive findings on neuroimaging. Moreover, physical exam findings of a visual field defect (p-value = 0.016), abnormal pupil reactivity (p-value = 0.028), afferent pupillary defect (p-value = 0.018), or abnormal optic disc exam (p-value = 0.009) 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).

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		P-Value
Characteristics	96 (100)	Normal	Abnormal	
Gender	49 (51.0)	38 (77.6)	11 (22.4)	0.691
Female	47 (49.0)	38 (80.9)	9 (19.1)	
Male				
Laterality	41 (42.7)	31 (75.6)	10 (24.4)	0.459
Unilateral	55 (57.3)	45 (81.8)	10 (18.2)	
Bilateral				
Symptoms Present at Presentation				
Blurred vision	82 (83.3)	62 (75.6)	20 (24.4)	0.038
Yes	14 (14.6)	14 (100)	0 (0.0)	
No				
Transient vision loss	24 (25.0)	18 (75.0)	6 (25.0)	0.562
Yes	72 (75.0)	58 (80.6)	14 (19.4)	
No				
Change in visual field	27 (28.1)	17 (63.0)	10 (27.0)	0.014
Yes	69 (71.9)	59 (85.5)	10 (14.5)	
No				
Floaters	9 (9.4)	6 (66.7)	3 (33.3)	0.389
Yes	87 (90.6)	70 (80.5)	17 (19.5)	
No				
Double vision	29 (30.2)	21 (72.4)	8 (27.6)	0.284
Yes	67 (69.8)	55 (82.1)	12 (17.9)	
No				
Eye pain	14 (14.6)	9 (64.3)	5 (35.7)	0.160
Yes	82 (83.3)	67 (81.7)	15 (18.3)	
No				

	Total	Imaging Findings		P-Value
Characteristics	96 (100)	Normal	Abnormal	
Eye droop	8 (8.3)	6 (75.0)	2 (25.0)	0.670
Yes	88 (91.7)	70 (79.5)	18 (20.5)	
No				
Headache	42 (43.8)	34 (81.0)	8 (19.0)	0.704
Yes	54 (56.3)	42 (77.8)	12 (22.2)	
No				
Dizziness	17 (17.7)	14 (82.4)	3 (17.6)	1.000
Yes	79 (82.3)	62 (78.5)	17 (21.5)	
No				
Nausea/Vomiting	44 (45.8)	35 (79.5)	9 (20.5)	0.933
Yes	52 (54.2)	41 (78.8)	11 (21.2)	
No				
Physical Exam Findings				
Decreased visual acuity	28 (29.2)	19 (67.9)	9 (32.1)	0.080
Yes	68 (70.8)	57 (83.8)	11 (16.2)	
No				
Visual Field Defect	10 (10.4)	5 (50.0)	5 (50.0)	0.016
Yes	86 (89.5)	71 (82.6)	15 (17.4)	
No				
Abnormal extraocular movements	12 (12.5)	8 (66.7)	4 (33.3)	0.266
Yes	84 (87.5)	68 (81.0)	16 (19.0)	
No				
Abnormal pupil reactivity	4 (4.2)	1 (25.0)	3 (75.0)	0.028
Yes	92 (95.8)	75 (81.5)	17 (17.7)	
No				
Afferent pupillary defect	9 (9.4)	4 (44.4)	5 (55.6)	0.018
Yes	87 (90.6)	72 (82.8)	15 (15.6)	
No				

	Total	Imaging Findings		P-Value
Characteristics	96 (100)	Normal	Abnormal	
Abnormal optic disc exam	8 (8.3)	3 (37.5)	5 (62.5)	0.009
Yes	88 (91.7)	73 (83.0)	15 (17.0)	
No				
Abnormal anterior chamber exam	3 (3.1)	3 (100)	0 (0.0)	1.000
Yes	93 (96.9)	73 (78.5)	20 (21.5)	
No				
Abnormal posterior chamber exam	5 (5.2)	5 (100)	0 (0.0)	0.580
Yes	91 (94.8)	71 (78.0)	20 (22.0)	
No				

Sub-analysis was done based on the type of imaging done (CT versus 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 = 0.049)

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.

Table 7: Various neuroophthalmological scenarios in the Emergency Department, with appropriate imaging. 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

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 (4 th , 6 th or complete, pupil sparing 3 rd)	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's	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	H and E	No	1			

vision/ optic nerve swelling	suggestive of Arteritic Ischemic optic neuropathy					
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 minutes	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's Triad	yes	2	MRI/ CT	with and without	Intracranial bleed/ Cerebrovascular accident (CVA)/ tumor/ posterior cortical atrophy

Discussion:

Our study focused on the neuro-ophthalmological presentations in the Emergency Department (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 consultation⁸. In our study, more than three 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 three quarters of the images were read as normal or with findings unrelated to the 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 signs¹¹. 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 two 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, one 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 60ies, 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 MRV 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).

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 afferent pupillary defect 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.

Abbreviations

ED: Emergency Department

CT: Computed Tomography

CTA: Computed Tomography Angiography

MRI: Magnetic Resonance Imaging

MRA: Magnetic Resonance Angiography

MRV: Magnetic Resonance Venography

H and E: History and Physical Exam

APD: Afferent Pupillary Defect

IRB: Institutional Review Board

Declarations

- **Ethics approval and consent to participate:** 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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