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CLINICAL STUDY

The accuracy of the Edinburgh diplopia diagnostic algorithm

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Abstract

Purpose **To assess the diagnostic accuracy of the Edinburgh diplopia diagnostic algorithm.**
Methods **This was a prospective study. Details of consecutive patients referred to ophthalmology clinics at Falkirk Community Hospital and Princess Alexandra Eye Pavilion, Edinburgh, with double vision were collected by the clinician first seeing the patient and passed to the investigators. The investigators then assessed the patient using the algorithm. An assessment of the degree of concordance between the 'algorithm assisted' diagnosis and the 'gold standard' diagnosis, made by a consultant ophthalmologist was then carried out. The accuracy of the pre-algorithm diagnosis made by the referrer was also noted.**
Results **All patients referred with diplopia were eligible for inclusion. Fifty-one patients were assessed; six were excluded. The pre-algorithm accuracy of referrers was 24% (10/41). The algorithm assisted diagnosis was correct 82% (37/45) of the time. It correctly diagnosed: cranial nerve (CN) III palsy in 6/6, CN IV palsy in 7/8, CN VI palsy in 12/12, internuclear ophthalmoplegia in 4/4, restrictive myopathy in 4/4, media opacity in 1/1, and blurred vision in 3/3. The algorithm assisted diagnosis was wrong in 18% (8/45) of the patients.**
Conclusions **The baseline diagnostic accuracy of non-ophthalmologists rose from 24 to 82% when patients were assessed using the algorithm. The improvement in the diagnostic accuracy resulting from the use of the algorithm would, hopefully, result in more accurate triage of patients with diplopia that are referred to the hospital eye service. We hope we have demonstrated its potential as a learning tool for inexperienced clinicians.**
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Introduction

This is the last in a series of three studies assessing the accuracy of diagnostic algorithms for each of the three most commonly encountered ophthalmic presentations: diplopia, red eye(s)[1] and visual loss.[2]

Algorithms have been used in medicine for over 30 years.[3] As discussed in the previous papers,[1,2] they highlight those key aspects of both the history and the examination that help the inexperienced examiner come to the likely diagnosis. There are many excellent ophthalmology textbooks that give the novice the appropriate knowledge; however, very few indicate how to apply it, even in the three most commonly encountered scenarios described above. Our diagnostic algorithms allow the novice to start to utilize and build upon their existing knowledge by giving a framework that represents the thought processes of their more experienced colleagues. Algorithms are, therefore, simply the user-friendly version of these diagnostic and/or treatment thought processes.

Algorithms are always a compromise between having enough detail to cover the most commonly encountered diagnoses while remaining simple enough to use. They rely upon the clinician being able to clarify the history and elicit the clinical signs, which act as signposts on the road to diagnostic nirvana.

The causes of double vision range from benign; cataract, to life threatening; posterior communicating artery aneurysm. Unfortunately, most UK doctors including GPs and A+E doctors have had between 2 and 12 days ophthalmology attachment during their undergraduate training,[4] leaving them inexperienced and wary of dealing with patients presenting with eye problems; very often the referral simply states 'diplopia, please see'. The lack of diagnosis hinders the ability of the ophthalmologist to triage the referral correctly. One of the authors (MW) has created a diagnostic algorithm, which we hope acts as both a teaching tool to improve the diagnostic accuracy of inexperienced clinicians and also indicates the urgency of their referral.

Objectives

The aim of this prospective study was to assess the diagnostic accuracy of the Edinburgh Diplopia Algorithm, published in 'Ophthalmology Pocket Tutor',[5] which was created by Dr Mark Wright, Consultant Ophthalmologist and Lead for Undergraduate Ophthalmology Education at Edinburgh University.

Materials and methods

The study was approved as a service evaluation by the local audit department. Patients referred to ophthalmology clinics at Falkirk Community Hospital and Princess Alexandra Eye Pavilion, Edinburgh, with double vision over a 16-month period were included in the study. Details of the patients were collected by the clinician first seeing the patient and were passed to the investigators (Medical student/FY2-ST1 Ophthalmology). The investigators, who were blinded to the diagnosis, then assessed the patient and used the algorithm (Figure 1) to reach an 'algorithm assisted' diagnosis. An assessment of the degree of concordance between the 'algorithm assisted' diagnosis and the 'gold standard' diagnosis, defined as the diagnosis made by a consultant ophthalmologist was made.

Retrospectively, patient's notes were reviewed to obtain information regarding the referral. We looked at: the type of referrer (Optometrist, GP, A&E, and other doctor); whether an attempted diagnosis was made on the referral and whether that diagnosis was correct, again measured against the 'gold standard' diagnosis. This allowed us to estimate the 'baseline', algorithm naive, diagnostic accuracy of the various referral groups.

Results

Fifty-one patients were assessed during the study. Six patients were subsequently excluded: two were asymptomatic at the time of their assessment, one patient had undergone decompression surgery prior to being assessed by the investigator, one had oscillopsia, not diplopia, and in two cases the diagnoses were made by junior ophthalmologists (GPST and ST2), which did not meet the consultant 'gold standard'. Forty-five patients were selected for the study.

Pre-algorithm accuracy of referrals with diplopia

Referral information was available for 91% (41/45) of patients. The breakdown of referrer by type was; GP 44%, Optometrist 36%, A+E and 'other' hospital doctors 20%. Overall the pre-algorithm accuracy of referral of patients with diplopia was 24% (10/41) of cases. A&E and other hospital doctors were the most accurate source of referral at 38% (3/8). GPs provided the correct diagnosis in 28% (5/18) of referrals, and optometrists were correct in 13% (2/15) of the cases. In 54% (22/41) of the patients the referrer did not make an attempt to diagnose the cause of the diplopia; for the purposes of the analysis these were classified as incorrect diagnoses.

Diagnostic accuracy of the algorithm-assisted diagnoses

Overall, the algorithm-assisted diagnosis was correct in 82% (37/45) of the patients. The 'gold standard' ophthalmologists made seven of the eight possible diagnoses contained within the algorithm: diagnosis of cortical abnormality was not made.

The algorithm correctly diagnosed: cranial nerve (CN) III palsy in 6/6, CN IV palsy in 7/8, CN VI palsy in 12/12, internuclear ophthalmoplegia (INO) in 4/4, restrictive myopathy in 4/4, media opacity in 1/1, and blurred vision in 3/3.

Analysis of the incorrect algorithm-assisted diagnoses

The algorithm-assisted diagnosis was wrong in 18% (8/45) of the cases. The two sources of diagnostic error are either defects in the algorithm; 16% (7/45), or failure of the inexperienced clinician to elicit a clinical sign; 2% (1/45).

Seven incorrect diagnoses were made due to problems with the algorithm. Five 'gold standard' diagnoses were not one of the diagnostic endpoints of the algorithm; Myasthenia Gravis (MG), Miller Fisher syndrome, post head injury diplopia, Herpes Zoster Ophthalmicus (HZO) with secondary extra-ocular muscle palsies and an isolated inferior rectus under action post thalamic stroke. MG was incorrectly diagnosed as a CN III palsy. 80% of patients with MG first present with diplopia and or ptosis.[6] In this case the patient presented with vertical diplopia and ptosis (but no anisocoria), which led to the algorithmic diagnosis of a CN III palsy. The hallmark of MG is variability and the ability to mimic any pattern of ocular dysmotility. For both these reasons it's both difficult and beyond the remit of our algorithm to include MG as one of the diagnostic endpoints. We would extend the same argument to the patient with Miller Fisher syndrome.

'Post head injury diplopia' was incorrectly diagnosed as a CN VI palsy and 'HZO with secondary extra-ocular muscle palsies' was incorrectly diagnosed as a CN IV palsy. In the first case, the patient had intermittently present horizontal diplopia that was worse for distance requiring prismatic correction. The second patient's vertical diplopia was associated with an intermittently present ptosis without anisocoria. Both these cases were seen by a consultant without adult squint expertize and

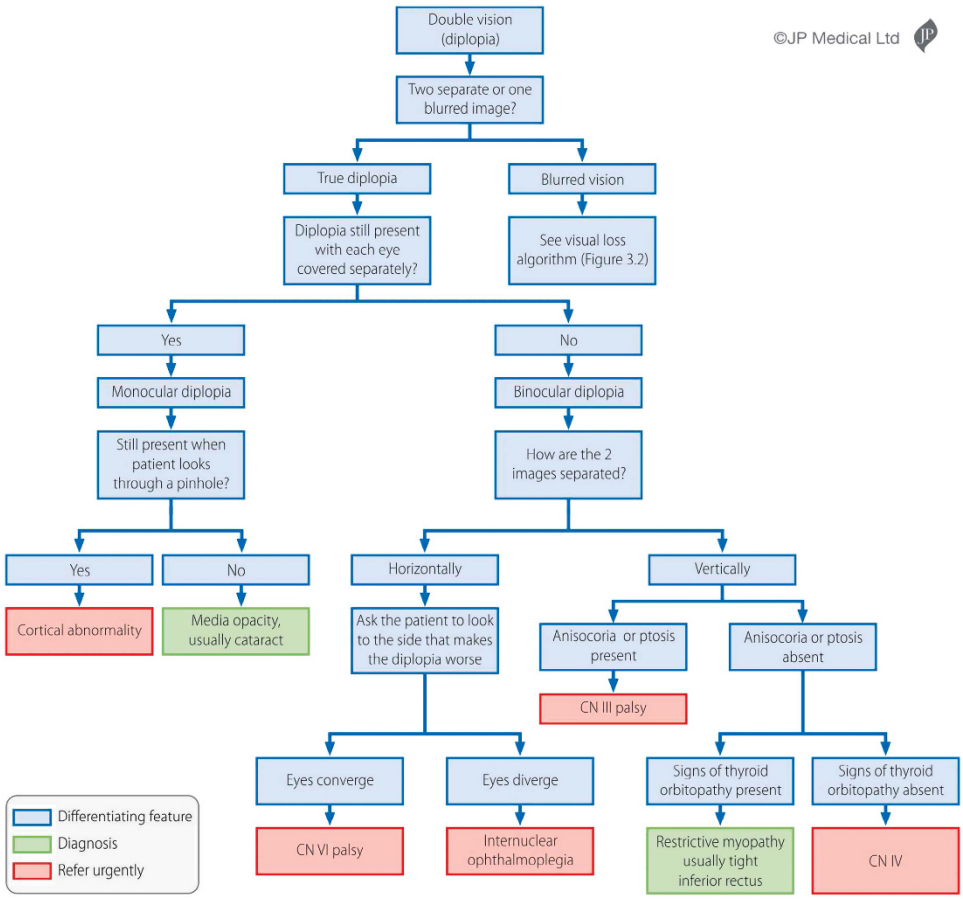

Figure 1 The Edinburgh Diagnostic Diplopia Algorithm.[5]

in our opinion, in neither of these two cases were a definitive diagnosis made. They were, however, included and classified as incorrect diagnoses. 'Isolated inferior rectus under action post thalamic stroke' was incorrectly diagnosed as a CN IV palsy.

In two cases, the patient's diplopia reflected dual pathology; CN III and CN IV palsies secondary to HZO incorrectly diagnosed as a CN III palsy and CN III and CN VI palsies secondary to cerebrovascular disease, which was incorrectly diagnosed as a CN III palsy. The diagnosis of dual pathology involves complex decision making and is beyond the remit of the algorithm.

Discussion

The merits of algorithms have already been alluded to. They are in use in various areas of healthcare, such as in the diagnosis of hematuria[7] or DVT.[8] Diagnostic algorithms have been suggested to reduce time, effort and bias and cost of care and errors.[9,10] There are currently very few algorithms in publication that aid in the diagnosis of diplopia; a literature search revealed only two that followed a flowchart format.[11,12] The first of these[11] was designed for ophthalmologists and does not lead the user to a specific diagnosis; the second[12] was designed for optometrists and relies on the referrer being able to distinguish 'comitancy' from 'non-comitancy', which some non-experts may not understand, and has fewer 'end points'. As far as we can ascertain, neither have been validated.

The baseline (pre-algorithm) diagnostic accuracy in this study of 24% demonstrates a need for a diagnostic aid when non-ophthalmologists assess patients who present with diplopia. Both of the investigators (TY and LB) were truly novices in ophthalmological terms, having had 5 and 7 days, respectively, of undergraduate ophthalmology teaching. LB recruited 31 cases during her foundation training program that did not have any ophthalmological posts and 17 cases after securing her Ophthalmology ST post. Their overall algorithm-assisted diagnostic accuracy was an impressive 82%. This represents a greater than threefold improvement when compared with the algorithm naive group, which included groups who had significantly more experience, for example, optometrists. We could not find any published studies on the diagnostic accuracy of inexperienced clinicians

assessing patients with diplopia with which to compare our results.

The ideal triage system enables the patient to be assessed by the most appropriate person at the first visit. The algorithm correctly identified the four patients who after simple clarification of the history (blurred vision not double) or examination (monocular blurring, ie, cataract) would then have been triaged to the correct clinic. Patients presenting with acute CN III palsies should be seen urgently as this may be the only indication that they have a life-threatening posterior-communicating artery aneurysm.[13] All six patients with an isolated CN III and both patients who had a CN III as part of dual pathology (these two cases were classified as incorrect algorithm assisted diagnoses) were correctly identified as having a CN III palsy. There is data to suggest that the likelihood of serious underlying pathology varies with the type of palsy, that is, CN III palsies are much more likely to have a serious underlying cause than a CN IV palsy,[14–16] hence the reason for trying to have a provisional 'algorithm assisted' diagnosis of a CN III or CN IV as opposed to a referral that simply states 'vertical diplopia – please see'. The ideal algorithm should allow the user to demonstrate very high sensitivity with respect to the most serious conditions; cranial nerve palsies and INO and also to have high levels of specificity for the more minor conditions; cataract so that all patients that need an urgent referral get one. Our results demonstrate that the algorithm has satisfied both these criteria.

One of the benefits to the inexperienced clinician of using the algorithm when assessing patients who present with diplopia is that it acts as a clinical prompt reminding the novice not only of what aspects of the history and examination to check but when to do so, for example, establishing whether the diplopia is monocular or binocular before determining whether it is vertical or horizontal.

One of the conditions that was incorrectly diagnosed; MG did not appear in the algorithm for the reasons already discussed. Although we recognize that ocular MG is an important cause of diplopia, it accounts for only 2–4% of all patients presenting with diplopia.[17,18] The most common causes of true binocular diplopia are CN palsies, INO, and restrictive myopathy[17,18] all of which are included in the algorithm. There are a number of limitations of this study, the main one being the sample size. This in part reflected our desire to have very inexperienced investigators (LB and TY) who, for the majority of the duration of the study were working out with an ophthalmology department and as a consequence limited the number of cases we could recruit. The marked differences in the diagnostic accuracy of inexperienced clinicians without and with the algorithm suggest that the results would not change significantly with a larger sample size.

This is the first time the diagnostic accuracy of any diplopia algorithm has been assessed. The overall diagnostic accuracy of the Edinburgh Diplopia Algorithm is 82%. The baseline diagnostic accuracy of non-ophthalmologists rose from 24 to 82% when patients were assessed using the algorithm. The improvement in the diagnostic accuracy resulting from the use of the algorithm would, hopefully, result in more accurate triage of patients with diplopia that are referred to the hospital eye service. We hope we have demonstrated its potential as a learning tool for inexperienced clinicians. A number of open access learning tools including downloadable copies of the five diagnostic algorithms and narrated lectures accompanying the algorithms are available at https://www.eemec.med.ed.ac.uk/pages/resources/mw-ophthalmology-page.

Summary

What was known before

- Diplopia is a relatively common presenting complaint in patients attending A+E, optometrists, and GPs and can be the presenting symptom of a life threatening disease.
- To date, there are no validated diagnostic algorithms to help often inexperienced clinicians come to the correct diagnosis, which would aid hospital triage.
- We could not find any published studies on the diagnostic accuracy of inexperienced clinicians assessing patients with diplopia.

What this study adds

- The baseline diagnostic accuracy of non-ophthalmologists; optometrists, hospital doctors, and GPs was 24% indicating a need for a diagnostic aid.
- The overall diagnostic accuracy of the Edinburgh Diplopia Algorithm is 82% even when used by very inexperienced clinicians.
- The diagnostic improvement resulting from the use of the algorithm should result in more accurate triage of patients referred to the hospital eye service.

Conflict of interest

MW has received minimal royalties from the sales of 'Ophthalmology Pocket Tutor' where the algorithm has been published. The remaining authors declare no conflict of interest.

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