Title: Classification criteria intermediate uveitis, non-pars planitis type

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ABSTRACT

Purpose: To determine classification criteria for intermediate uveitis, non-pars planitis type (IU-NPP, also known as undifferentiated intermediate uveitis)

Design: Machine learning of cases with IU-NPP and 4 other intermediate uveitides.

Methods: Cases of intermediate uveitides were collected in an informatics-designed preliminary data base, and a final data base was constructed of cases achieving supermajority agreement on the diagnosis, using formal consensus techniques. Cases were split into a learning set and a validation set. Machine learning using multinomial logistic regression was used on the learning set to determine a parsimonious set of criteria that minimized the misclassification rate among the intermediate uveitides. The resulting criteria were evaluated on the validation set.

Results: Five hundred eighty-nine of cases of intermediate uveitides, including 114 cases of pars planitis, were evaluated by machine learning. The overall accuracy for intermediate uveitides was 99.8% in the learning set (95% confidence interval [CI] 98.7, 100) and 99.3% in the validation set (95% CI 96.1, 99.9). Key criteria for IU-NPP included unilateral or bilateral intermediate uveitis with neither 1) snowballs in the vitreous nor 2) snowbanks on the pars plana. Other key exclusions included: 1) multiple sclerosis, 2) sarcoidosis, and 3) syphilis. The misclassification rates for pars planitis were 0 % in the learning set and 0% in the validation set, respectively.

Conclusions: The criteria for IU-NPP had a low misclassification rate and appeared to perform well enough for use in clinical and translational research.

PRECIS

Using a formalized approach to developing classification criteria, including informatics-based case collection, consensus-technique-based case selection, and machine learning, classification criteria for intermediate uveitis, non-pars planitis type were developed. Key criteria included intermediate uveitis with neither vitreous snowballs nor pars plana snowbanks. Exclusions included multiple sclerosis, sarcoidosis, and syphilis. The resulting criteria had a low misclassification rate.

The intermediate uveitides encompass several diseases characterized by the vitreous being the primary site of clinically evident inflammation and an absence of choroiditis or retinitis.[1-3] Intermediate uveitides may be due to infections, such as Lyme disease or syphilis, or associated with systemic diseases, such as sarcoidosis or multiple sclerosis.[3] In the absence of a demonstrable infection or related systemic disease, they are presumed to be eye-limited and immune mediated.[3] One specific intermediate uveitic disease, pars planitis, was described in 1960 and was characterized by vitritis and pars plana snowbank formation (a collection of fibino-inflammatory debris).[3-10] However, not all cases of non-infectious intermediate uveitis without a systemic disease have snowbanks, and these cases sometimes have been lumped with pars planitis, and sometimes not, leading to confusion as to what represents pars planitis.[6-10] At the First International Workshop of the Standardization of Uveitis (SUN) Working Group, it was decided by a supermajority of participants to classify non-infectious intermediate uveitides unassociated with a systemic disease as pars planitis, if there were snowballs or snowbanks, and as intermediate uveitis, non-pars planitis type, if there were not.[2] An alternative term for intermediate uveitis, non-pars planitis type would be undifferentiated intermediate uveitis. Intermediate uveitides, including pars planitis, account for up to 15% of uveitis cases in series from tertiary eye care referral centers.[11]

The SUN Working Group is an international collaboration which has developed classification criteria for 25 of the most common uveitic diseases using a formal approach to development and classification.[12-16] Among the diseases being studied was intermediate uveitis, non-pars planitis type.

Methods

The SUN Developing Classification Criteria for the Uveitides project proceeded in four phases as previously described: 1) informatics, 2) case collection, 3) case selection, and 4) machine learning.[12-15]

Case collection and case selection. De-identified information was entered into the SUN preliminary database by the 76 contributing investigators for each disease as previously described.[14,15] Cases in the preliminary database were reviewed by committees of 9 investigators for selection into the final database.[14,15] Because the goal was to develop classification criteria,[10] only cases with a supermajority agreement (>75%) that the case was the disease in question were retained in the final database (i.e. were "selected").[14,15]

Machine learning. The final database then was randomly separated into a learning set (~85% of cases) and a validation set (~15% of cases) for each disease as described in the accompanying article.[15] Machine learning was used on the learning set to determine criteria that minimized misclassification. The criteria then were tested on the validation set; for both the learning set and the validation set, the misclassification rate was calculated for each disease. For intermediate uveitis, non-pars planitis type, the diseases against which it was evaluated were: multiple sclerosis (MS)-associated intermediate uveitis; pars planitis, sarcoid intermediate uveitis, and syphilitic intermediate uveitis. Too few cases of Lyme disease uveitis were collected in the database for analysis by machine learning.

The study adhered to the principles of the Declaration of Helsinki. Institutional Review Boards (IRBs) at each participating center reviewed and approved the study; the study typically was considered either minimal risk or exempt by individual IRBs.

Results

Two hundred nine cases of intermediate uveitis, non-pars planitis type were collected, and 114 (55%) achieved supermajority agreement on the diagnosis during the "selection" phase and were used in the machine learning phase. These cases of pars planitis were compared to 475 cases of other intermediate uveitides, including 112 cases multiple sclerosis-associated intermediate uveitis, 226 cases of pars planitis type, 52 cases of sarcoidosis-associated intermediate uveitis, and 85 cases of syphilitic intermediate uveitis. The details of the machine learning results for these diseases are outlined in the accompanying article.[15] The

characteristics at presentation to a SUN Working Group Investigator of cases with intermediate uveitis, non-pars planitis type are listed in Table 1. The criteria developed after machine learning are listed in Table 2. Key features are the presence of inflammation primarily in the vitreous, absence of snowballs and snowbanks, and the exclusion of syphilis, multiple sclerosis, and sarcoidosis. The overall accuracy for intermediate uveitides was 99.8% in the learning set (95% confidence interval [CI] 98.7, 100) and 99.3% in the validation set (95% CI 96.1, 99.2).[16] The misclassification rate for intermediate uveitis, non-pars planitis type in the learning set was 0% and in the validation set 0%.[16]

Discussion

The classification criteria developed by the SUN Working Group for intermediate uveitis, non-pars planitis type have a low misclassification rate, indicating good discriminatory performance against other intermediate uveitides.

Intermediate uveitis, non-pars planitis type is to some extent a diagnosis of exclusion. It must have the features of an intermediate uveitis, but not be pars planitis, multiple sclerosis-associated intermediate uveitis, sarcoidosis, syphilis, or Lyme disease. The type of uveitis most often seen with Lyme disease is an atypical intermediate uveitis or an anterior and intermediate uveitis, but disease indistinguishable from intermediate uveitis, non-pars planitis type has been described.[17,18] Lyme uveitis is sufficiently uncommon that we were unable to collect a sufficient number of cases for analysis. Nevertheless, it would be prudent to exclude Lyme disease in cases of intermediate uveitis from Lyme disease endemic areas or in Lyme disease exposed patients. However, in Lyme disease non-endemic regions, there appears to be little value to screening for Lyme disease.[19]

Other than the presence of snowballs and snowbanks with pars planitis, and a diagnosis of multiple sclerosis with multiple sclerosis-associated intermediate uveitis, there are no other differences on ocular examination that reliably distinguish among the three diseases.[16,20,21] HLA-DR2 and its split antigen HLA-DR15 are risk factors for both pars planitis and multiple

sclerosis,[9,10,22] so that it is unhelpful in distinguishing between them.[23] There are patients, albeit few, with pars planitis with bilateral vitritis and unilateral snowbanks;[6,7] There has been a suggestion that snowbanks might herald more severe disease,[7] but the SUN cross sectional data did not confirm that.[20] In our opinion, these patients should be classified as having pars planitis and not two diseases. Patients with pars planitis with snowballs without snowbanks tend to be older and appear to have an age distribution similar to that of intermediate uveitis, non-pars planitis type. Long-term follow-up studies, perhaps with immunogenetic typing and neuro-imaging, might clarify whether these should be considered three distinct diseases or whether pars planitis without snowbanks should be lumped with intermediate uveitis, non-pars planitis type. However, at this time, it is recommended that patients be classified as: 1) pars planitis with snowbanks; 2) pars planitis without snowbanks; or 3) intermediate uveitis, non-pars planitis type.

None of the cases included in this series had clinical evidence of multiple sclerosis. However, the data did not include whether every case underwent neuro-imaging for multiple sclerosis. Among patients with intermediate uveitis without multiple sclerosis at presentation the rate of developing multiple sclerosis can be estimated at ~2% to 4%/year,[9,10] so that neuro-imaging to exclude multiple sclerosis is likely to have a low yield and is not routinely recommended.[24] Instead, exclusion should be based on clinical grounds (the absence of relevant neurological lesions or a history of relevant neurological lesions). Nevertheless, some patients with follow-up will develop multiple sclerosis and have their diagnosis updated over time.

About 10% of the patients in the SUN data base for intermediate uveitis, non-pars planitis type were over 50 years of age and thus at greater risk for intraocular lymphoma.[25] Intraocular lymphoma accounts for ~1.5% of cases of “uveitis” in the elderly presenting to tertiary eye care referral centers, and ~10% of cases which undergo diagnostic vitrectomy.[26] Hence it would be unreasonable to require vitrectomy confirmation of the absence of intraocular

lymphoma as part of the criteria. Nevertheless, suspicion of lymphoma based on ocular characteristics should lead to appropriate diagnostic studies (e.g. diagnostic vitrectomy) in clinical care.

The presence of any of the exclusions in Table 2 suggests an alternate diagnosis, and the diagnosis of pars planitis should not be made in their presence. In prospective studies many of these tests will be performed routinely, and the alternative diagnoses excluded. However, in retrospective studies based on clinical care, not all of these tests may have been performed. Hence the presence of an exclusionary criterion excludes pars planitis, but the absence of such testing does not always exclude the diagnosis of pars planitis if the criteria for the diagnosis are met. Nevertheless, because of the overlapping features of sarcoidosis-associated intermediate uveitis, including snowballs, a reasonable effort should be made to exclude sarcoidosis, including as a minimum, chest imaging, for all cases of intermediate uveitis, non-pars planitis type.[27]

Classification criteria are employed to diagnose individual diseases for research purposes.[14] Classification criteria differ from clinical diagnostic criteria, in that although both seek to minimize misclassification, when a trade-off is needed, diagnostic criteria typically emphasize sensitivity, whereas classification criteria emphasize specificity,[15] in order to define a homogeneous group of patients for inclusion in research studies and limit the inclusion of patients without the disease in question that might confound the data. The machine learning process employed did not explicitly use sensitivity and specificity; instead it minimized the misclassification rate. Because we were developing classification criteria and because the typical agreement between two uveitis experts on diagnosis is moderate at best,[14] the selection of cases for the final database ("case selection") included only cases which achieved supermajority agreement on the diagnosis. As such, some cases which clinicians would diagnose with intermediate uveitis, non-pars planitis type may not be so classified by these classification criteria.

In conclusion, the criteria for intermediate uveitis, non-pars planitis outlined in Table 2 appear to perform sufficiently well for use as classification criteria in clinical research.[15,16]

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264 **Table 1. Characteristics of Cases with Intermediate Uveitis, Non-Pars Planitis Type**

Characteristic	Result
Number cases	114
Demographics	
Age, median, years (25^{th} 75^{th} percentile)	37 (23, 52)
Gender (%)	
Men	37
Women	63
Race/ethnicity (%)	
White, non-Hispanic	68
Black, non-Hispanic	5
Hispanic	4
Asian, Pacific Islander	3
Other	8
Missing	12
Uveitis History	
Uveitis course (%)	
Acute, monophasic	4
Acute, recurrent	4
Chronic	86
Indeterminate	6
Laterality (%)	
Unilateral	29
Unilateral, alternating	0
Bilateral	71
Ophthalmic examination	
Keratic precipitates (%)	
None	82
Fine	13
Round	3
Stellate	0
Mutton Fat	1
Other	1
Anterior chamber cells (%)	
Grade 0	59
½+	17
1+	16
2+	7
3+	2
4+	0
Hypopyon (%)	0
Anterior chamber flare (%)	
Grade 0	82
1+	16
2+	3
3+	0
4+	0
Iris (%)	

Normal	91
Posterior synechiae	9
Sectoral iris atrophy	0
Patchy iris atrophy	0
Diffuse iris atrophy	0
Heterochromia	0
Intraocular pressure (IOP), involved eyes	
Median, mm Hg (25th, 75th percentile)	14 (12, 17)
Proportion patients with IOP>24 mm Hg either eye (%)	4
Vitreous cells (%)*	
Grade 0	3
½+	14
1+	39
2+	35
3+	9
4+	1
Vitreous haze (%)*	
Grade 0	31
½+	14
1+	34
2+	17
3+	3
4+	2
Vitreous snowballs†	0
Pars plana snowbanks†	0
Peripheral retinal vascular sheathing or leakage	19
Macular edema	47

*All cases had either vitreous cells or haze; only 2 cases had haze without evident cells. †No cases had snowballs or snowbanks, as the diagnosis then would be pars planitis.

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Table 2. Classification Criteria for Intermediate Uveitis, Non-Pars Planitis Type

Criteria

1. Evidence of intermediate uveitis
    a. vitreous cells AND/OR vitreous haze
    b. if anterior chamber cells are present, anterior chamber inflammation less than vitreous
    c. no evidence of retinitis

AND

2. No evidence of pars planitis
    a. neither vitreous snowballs NOR
    b. pars plana snowbanks

Exclusions

1. Multiple sclerosis, defined by the McDonald criteria[28]
2. Positive serology for syphilis using a treponemal test
3. Evidence of sarcoidosis (either bilateral hilar adenopathy on chest imaging or tissue biopsy demonstrating non-caseating granulomata)
4. Positive serology for Lyme disease, either IgG or IgM (e.g. positive ELISA AND Western blot with requisite number of bands for assay used)
5. Evidence of intraocular lymphoma on diagnostic vitrectomy