



在线全文

脑脊液/血清游离轻链指数驱动神经梅毒高效 诊断模型构建与效能评估*

邓杰伦^{1,2}, 吴思蕊², 叶飞², 黄曦悦², 李冬冬², 刘靳波^{1△}

1. 西南医科大学附属医院 医学检验部(泸州 646000); 2. 四川大学华西医院 实验医学科(成都 610041)

【摘要】目的 通过测定脑脊液(cerebrospinal fluid, CSF)和血清游离轻链(free light chains, FLC), 计算FLC指数并建立模型, 探讨该模型在神经梅毒诊断中的应用价值。**方法** 本研究纳入87例梅毒患者, 其中包括48例神经梅毒患者(NS组)和39例非神经梅毒患者(n-NS组)。收集所有纳入患者的CSF和血清样本, 检测kappa游离轻链(FLC- κ)和lambda游离轻链(FLC- λ)含量, 计算FLC指数、FLC- κ 指数和FLC- λ 指数。运用受试者工作特征(receiver operating characteristic, ROC)曲线对三个指数进行评价。建立以FLC指数为核心的神经梅毒诊断模型, 并实现对其可视化验证。**结果** 两组患者在血清梅毒初筛结果、CSF有核细胞计数、CSF微量蛋白、CSF IgG、IgG合成率、IgG指数水平及白蛋白商等指标上差异有统计学意义($P < 0.05$)。FLC- κ 指数、FLC- λ 指数、白蛋白商的ROC曲线下面积(area under the curve, AUC)分别为0.998[95%置信区间(confidence interval, CI): 0.990 ~ 1.000]、0.988(95%CI: 0.961 ~ 1.000)、0.635(95%CI: 0.496 ~ 0.751)。在FLC- κ 指数的模型中FLC- κ 指数($P < 0.05$)对神经梅毒诊断有显著影响, 在FLC- λ 指数的模型中仅FLC- λ 指数($P < 0.05$)有显著影响。围绕FLC- κ 指数建立的诊断模型其训练ROC曲线的AUC大于0.950, 其校准曲线在预测概率接近80%时预测效能较好, 在预测概率为40% ~ 60%时预测效能较弱。围绕FLC- λ 指数建立的诊断模型的AUC为0.926, 其校准曲线在预测概率接近85%时预测效能较好, 在预测概率为40% ~ 70%时预测效能较弱。**结论** FLC- κ 和FLC- λ 对神经梅毒均具有较高诊断性能, FLC指数在神经梅毒的诊断中有一定的应用价值。

【关键词】 神经梅毒 血清游离轻链- κ 血清游离轻链- λ 血清游离轻链指数 诊断模型

Construction and Efficacy Evaluation of a Highly Efficient Diagnostic Model for Neurosyphilis Driven by the Cerebrospinal Fluid/Serum Free Light Chain Index

DENG Jielun^{1,2}, WU Sirui², YE Fei², HUANG Xiyue², LI Dongdong², LIU Jinbo^{1△}. 1. Department of Laboratory Medicine, The Affiliated Hospital of Southwest Medical University, Luzhou 646000, China; 2. Department of Laboratory Medicine, West China Hospital, Sichuan University, Chengdu 610041, China

△ Corresponding author, E-mail: liujb7203@swmu.edu.cn

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[Abstract] Objective To determine free light chains (FLC) in cerebrospinal fluid (CSF) and serum, calculate the FLC index, and establish a model to evaluate its application value in diagnosing neurosyphilis. **Methods** This study included 87 syphilis patients, comprising 48 neurosyphilis patients (NS group) and 39 non-neurosyphilis patients (n-NS group). CSF and serum samples were collected from all patients to measure kappa free light chains (FLC- κ) and lambda free light chains (FLC- λ). The FLC index, FLC- κ index, and FLC- λ index were calculated. Receiver operating characteristic (ROC) curves were used to evaluate these indices. A neurosyphilis diagnostic model based on the FLC index was established and its visualization was verified. **Results** Statistically significant differences were observed between the two groups in serological syphilis screening, CSF nucleated cell count, CSF microprotein, CSF IgG, IgG synthesis rate, IgG index, and albumin quotient ($P < 0.05$). The areas under the ROC curves (AUC) for the FLC- κ index, FLC- λ index, and albumin quotient were 0.998 (95% CI: 0.990-1.000), 0.988 (95% CI: 0.961-1.000), and 0.635 (95% CI: 0.496-0.751), respectively. In the FLC- κ index model, the FLC- κ index ($P < 0.05$) significantly affected the diagnosis of neurosyphilis, while in the FLC- λ index model, only the FLC- λ index ($P < 0.05$) had a significant effect. The training ROC curve AUC for the diagnosis model based on the FLC- κ index was greater than 0.950. Its calibration curve showed good predictive performance when the predicted probability was close to 80%, but poor performance when the predicted probability was

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△ 通信作者, E-mail: liujb7203@swmu.edu.cn

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40%-60%。The AUC for the diagnosis model based on the FLC- λ index was 0.926, with good predictive performance when the predicted probability was close to 85%, and poor performance when the predicted probability was 40%-70%.

Conclusion FLC- κ and FLC- λ have high diagnostic performance for neurosyphilis, and the FLC index has certain application value in the diagnosis of neurosyphilis.

[Key words] Neurosyphilis Kappa free light chains Lambda free light chains Free light chains index
Diagnostic model

神经梅毒(neurosyphilis, NS)是由苍白密螺旋体(*Treponema pallidum*, TP)入侵中枢神经系统(central nervous system, CNS)所引发的感染性疾病。未经治疗的梅毒患者中约40%可发生神经系统感染^[1]。研究显示梅毒患者在感染后的任一阶段均可转变为神经梅毒,故而随着梅毒发病率的上升,神经梅毒发病率也有上升的趋势^[2]。

神经梅毒的临床表现复杂且缺乏特异性,受个体性因素影响较大,其临床症状也因累及部位不同而异,导致神经梅毒的诊断难以明确^[3]。目前,神经梅毒的诊断主要依靠于脑脊液(cerebrospinal fluid, CSF)样本的非梅毒螺旋体血清学试验、梅毒螺旋体血清学试验、CSF白细胞计数和总蛋白量等。其中,非梅毒螺旋体血清学试验包括性病研究实验室试验(venereal disease research laboratory test, VDRL)、快速血浆反应素试验(rapid plasma reagin test, RPR)和甲苯胺红不加热血清学试验(toluidized red unheated serum test, TRUST);梅毒螺旋体血清学试验包括梅毒螺旋体颗粒凝集试验(*Treponema pallidum* particle agglutination assay, TPPA)和荧光梅毒螺旋体抗体吸附试验(fluorescence treponemal antibody absorption, FTA-ABS)^[4],但这些方法存在一定的假阳性和假阴性。青霉素的广泛使用,亦使得CSF检查的异常结果可能被掩盖^[5],加之神经梅毒患者可能存在与艾滋病病毒等其他病原体的并发感染,临床表现更加复杂,诊断更加困难^[6],严重影响治疗策略选择和疗效的评估^[7]。整体而言,现有的实验室检查缺乏较为敏感和特异的方法,目前亟需一个更好的标志物来辅助神经梅毒的诊断。

游离轻链(free light chains, FLC)是由未与重链结合的免疫球蛋白形成的小分子蛋白质,以游离状态存在于血液和其他体液中,它们在调节免疫系统,特别是在炎症反应中扮演着重要角色^[8]。在病毒性脑炎中,将游离轻链相关检测与传统病毒检测方法进行对比,发现FLC的产生与释放几乎是即时的,FLC水平可以作为神经炎症的早期指标^[9]。有研究发现蜚传脑炎患者在治疗后血清FLC- λ 下降,CSF FLC- λ 升高,可能反映鞘内免疫球蛋白合成或血脑屏障破坏^[10]。亦有研究发现,临床孤立综合征(clinically isolated syndrome, CIS)和多发性硬化症

(multiple sclerosis, MS)患者的FLC- κ 和FLC- λ 以及同种型的Q_{FLC}、FLC指数和FLC鞘内分数均升高,FLC指数在检测MS/CIS患者中表现出了最高的准确性^[11-12]。以上研究均提示FLC指数可能在神经系统疾病的诊断中具有一定的研究价值^[13-14]。

当前FLC在神经梅毒诊断中的应用研究仍存在空白。本研究采用免疫散射比浊法检测CSF与血清中的FLC水平,通过计算FLC指数构建诊断模型,系统评估该模型对神经梅毒的诊断效能,旨在为临床提供新型辅助诊断策略。

1 资料与方法

1.1 研究对象

本研究回顾性纳入2019年12月-2024年4月四川大学华西医院确诊的87例梅毒患者,其中神经梅毒(NS组)48例,非神经梅毒(n-NS组)39例,分别作为研究组与对照组。收集所有患者的血清和CSF配对样本,并于-80℃条件下长期冻存备用。本研究中神经梅毒患者定义为符合《梅毒、淋病和生殖道沙眼衣原体感染诊疗指南(2020年)》中神经梅毒疑似条件,同时CSF TRUST检测阳性。非神经梅毒患者定义为仅血清TPPA检测呈阳性,无任何神经梅毒症状且CSF TPPA及CSF TRUST检测阴性。研究对象的排除标准为: HIV检测阳性或样本明显被血液污染。本研究获四川大学华西医院生命科学伦理审查委员会审批(批准号: 20242234)。

1.2 研究方法

纳入患者的人口学特征和实验室指标等进行分析和总结。采用日本奥林巴斯光学显微镜BX43测定CSF常规;采用日本富士梅毒螺旋体抗体检测试剂盒(明胶颗粒凝集法)测定TPPA;采用瑞士罗氏电化学发光免疫自动分析仪Cobas e801及配套试剂盒测定梅毒螺旋体抗体和生化项目;采用德国西门子全自动蛋白分析仪BN II System及配套试剂盒测定白蛋白、IgG、FLC- κ 和FLC- λ 。其中,针对FLC- κ 和FLC- λ 随机选取三个n-NS组患者的样本对和三个NS组患者样本对按照试剂说明书的推荐稀释比例进行测试,以处于系统线性范围内为理想稀释倍数,最终n-NS组血清FLC- κ 、血清FLC- λ 、CSF FLC- κ 、CSF

FLC-λ稀释倍数分别确定为1 : 100、1 : 20、1 : 1、1 : 5; NS组血清FLC-κ、血清FLC-λ、CSF FLC-κ、CSF FLC-λ稀释倍数分别确定为1 : 100、1 : 20、1 : 20、1 : 5。由公式计算出白蛋白商($Q_{\text{Alb}} = \text{CSF Alb/Ser Alb}$)、FLC-κ商($Q_{\text{FLC-}\kappa} = \text{CSF FLC-}\kappa/\text{Ser FLC-}\kappa$)、FLC-λ商($Q_{\text{FLC-}\lambda} = \text{CSF FLC-}\lambda/\text{Ser FLC-}\lambda$),并进一步计算 FLC-κ指数($\text{FLC-}\kappa \text{ index} = Q_{\text{FLC-}\kappa}/Q_{\text{Alb}}$)和FLC-λ指数($\text{FLC-}\lambda \text{ index} = Q_{\text{FLC-}\lambda}/Q_{\text{Alb}}$)。

1.3 统计学方法

采用DxAI智慧科研平台、R版本4.2.3和Python版本3.11.4完成统计分析。

数值变量用 $\bar{x} \pm s$ 表示,组间比较采用t检验。不服从正态分布的连续变量用中位数(P_{25}, P_{75})表示,组间比较用Mann-Whitney U检验。分类变量用例数(%)表示,组间比较用卡方检验。 $P < 0.05$ 为差异有统计学意义。运用受试者工作特征(receiver operating characteristic, ROC)曲线分别分析各指标在神经梅毒中的诊断价值,基于约登指数得出最佳诊断临界值。

按照下述标准进行变量二分类:性别男性为1,女性

为0;有核细胞根据神经梅毒诊断标准分为0和1;红细胞根据细胞有无分为0和1;其余指标根据ROC曲线分析确定的最佳临界值分为0和1。采用logistic回归对变量进行筛选。使用ROC曲线和校准曲线对构建的诊断模型进行验证。

2 结果

2.1 患者临床资料特点

患者临床特征如表1所示。NS组在血清梅毒初筛、CSF有核细胞计数、CSF微量蛋白、CSF IgG、IgG指数、IgG合成率、白蛋白商值,以及游离轻链相关参数(FLC-κ商、FLC-λ商、FLC-κ指数、FLC-λ指数)均显著高于n-NS组,组间差异具有统计学意义($P < 0.05$)。其余指标两组差异无统计学意义。

2.2 患者鞘内免疫多指标的诊断效能

鞘内免疫相关指标的ROC曲线分析结果(图1、表2)显示,各指标在神经梅毒诊断中的灵敏度与特异性存在显著差异。其中FLC-κ指数的诊断效能最为突出,曲线下面

表 1 NS组和n-NS组患者基本情况及临床特征
Table 1 Basic information and clinical characteristics of patients in the NS group and the nNS group

Index	NS group (n = 48)	n-NS group (n = 39)	P
Sex			0.006
Female	8 (16.667)	17 (43.590)	
Male	40 (83.333)	22 (56.410)	
Age/yr.	50.813 ± 10.024	55.000 ± 16.880	0.183
Serological indicators			
TP-ECLIA (COI)	218.000 (188.000,264.000)	81.080 (12.200,121.000)	< 0.001
Serum IgG/(g/L)	11.300 (9.410,13.400)	11.700 (10.200,13.400)	0.665
Serum Alb/(g/L)	39.400 (37.200, 42.000)	38.400 (34.400, 41.100)	0.136
CSF indicators			
CSF NC/(× 10 ⁶ L ⁻¹)	4.000 (0.000, 20.000)	0.000 (0.000, 2.000)	< 0.001
CSF RBC/(× 10 ⁶ L ⁻¹)	0.000 (0.000, 4.000)	0.000 (0.000, 2.000)	0.397
CSF mAlb/(g/L)	0.760 (0.540, 0.970)	0.450 (0.340, 0.500)	< 0.001
CSF GLU/(mmol/L)	3.610 (3.280, 4.310)	3.810 (3.430, 4.050)	0.726
CSF CL/(mmol/L)	126.000 (122.000, 128.000)	125.000 (123.000, 126.700)	0.181
CSF IgG/(g/L)	0.240 (0.093, 0.359)	0.040 (0.025, 0.057)	< 0.001
CSF Alb/(g/L)	0.349 (0.213, 0.419)	0.213 (0.176, 0.332)	0.014
IgG index	2.274 (1.623, 3.486)	0.485 (0.451, 0.566)	< 0.001
IgG synthesis rate	106.128 (28.043, 153.195)	0.000 (0.000, 0.768)	< 0.001
Q _{Alb}	0.009 (0.005, 0.011)	0.006 (0.004, 0.008)	0.045
Q _{FLC-κ}	1.763 (0.642, 2.654)	0.028 (0.015, 0.038)	< 0.001
Q _{FLC-λ}	0.633 (0.229, 1.113)	0.032 (0.027, 0.041)	< 0.001
FLC-κ index	198.818 (114.313, 342.224)	3.788 (2.676, 8.930)	< 0.001
FLC-λ index	87.626 (43.126, 139.859)	4.909 (3.716, 7.786)	< 0.001

TP-ECLIA: *Treponema pallidum*-electrochemiluminescence immunoassay; Alb: albumin; CSF: cerebrospinal fluid; NC: nucleated cell; RBC: red blood cell; mAlb: microalbumin; GLU: glucose; CL: chlorine; FLC: free light chain; COI: cut-off index; Q_{Alb}: albumin quotient; Q_{FLC-κ}: κ-free light chains quotient; Q_{FLC-λ}: λ-free light chains quotient. Data are presented as $\bar{x} \pm s$, case (%), or median (P_{25}, P_{75}).

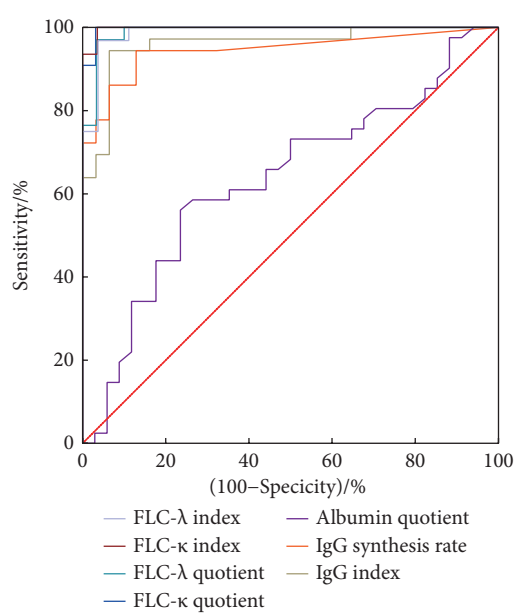


图 1 鞘内免疫相关指标ROC曲线

Fig 1 ROC curve of intrathecal immune-related indices

All abbreviations are given in the footnote to Table 1.

积(area under the curve, AUC)达0.998[95%置信区间 (confidence interval, CI): 0.990 ~ 1.000], 最佳诊断阈值为

27.260时, 灵敏度100%、特异度 96.4%, 约登指数0.964, 提示其对神经梅毒具有极高的诊断价值。FLC-λ指数的 AUC为0.988(95%CI: 0.961 ~ 1.000), 最佳阈值19.500时, 对应灵敏度96.9%、特异度98.8%, 约登指数0.932, 虽诊断性能优异但略低于FLC-κ指数。相比之下, 白蛋白商的 AUC仅为0.635(95%CI: 0.496 ~ 0.751), 提示其在神经梅毒诊断中参考价值有限。

2.3 神经梅毒诊断模型建立

采用logistic回归, 最终确定变量为性别(男性=1, 女性=0)、年龄(≥ 48 岁=1, < 48 =0)、CSF有核细胞计数($\geq 5 \times 10^6 L^{-1}$ =1, $< 5 \times 10^6 L^{-1}$ =0)、CSF红细胞计数(有红细胞=1, 无红细胞=0)、CSF氯($\geq 125.4 mmol/L$ =1, $< 125.4 mmol/L$ =0)、血IgG($\geq 12.65 g/L$ =1, $< 12.65 g/L$ =0)和白蛋白商(≥ 0.008 =1, < 0.008 =0), 故将这七种变量分别与FLC-κ指数和FLC-λ指数组合。各自将8个变量纳入多因素逻辑回归分析, 分别建立神经梅毒诊断模型。

两种模型的逻辑回归结果如表3、表4所示, 在FLC-κ指数的模型中FLC-κ指数($P < 0.05$)对神经梅毒诊断有显著影响, 在FLC-λ指数的模型中仅FLC-λ指数($P < 0.05$)有显著影响。两个模型的训练ROC曲线和校准曲线如图2

表 2 ROC曲线参数

Table 2 ROC curve parameters

Characteristics	<i>n</i>	AUC (95% CI)	Sensitivity	Specificity	YI	OTV
IgG index	67	0.960 (0.910-0.996)	0.944	0.936	0.88	0.668
IgG synthesis rate	67	0.945 (0.884-0.991)	0.944	0.935	0.815	5.299
Q_{Alb}	75	0.635 (0.496-0.751)	0.561	0.765	0.326	0.008
$Q_{FLC-\kappa}$	65	0.997 (0.987-1.000)	1.000	0.969	0.969	0.108
$Q_{FLC-\lambda}$	64	0.990 (0.969-1.000)	0.971	0.967	0.937	0.063
FLC-κ index	59	0.998 (0.990-1.000)	1.000	0.964	0.964	27.260
FLC-λ index	59	0.988 (0.961-1.000)	0.969	0.817	0.932	19.500

AUC: area under the curve; YI: Youden index; OTV: optimal threshold value. The other abbreviations are given in the footnote to Table 1. Due to missing data in some patient records, cases with missing variables were excluded from the analysis, resulting in varying sample sizes for different variables.

表 3 含FLC-κ指数的logistic回归分析结果

Table 3 Results of logistic regression analysis including FLC-κ index

Predictor	<i>B</i>	SE	<i>Z</i>	<i>P</i>	OR (95% CI)
(Intercept)	−66.541	26.212	−2.539	0.011	0.000 (0.000-0.000)
Age	0.048	0.036	1.33	0.183	1.049 (0.980-1.133)
CSF NC	0.062	0.048	1.297	0.194	1.064 (1.007-1.202)
CSF RBCL	−0.002	0.002	−1.118	0.264	0.998 (0.992-1.000)
CSF CL	0.512	0.207	2.471	0.013	1.669 (1.171-2.693)
Serum IgG	−0.309	0.206	−1.502	0.133	0.734 (0.459-1.053)
Q_{Alb}	−55.961	113.494	−0.493	0.622	0.000 (0.000-0.000)
FLC-κ index	0.046	0.014	3.378	0.001	1.047 (1.025-1.082)
Sex	1.415	1.453	0.974	0.330	4.118 (0.294-120.489)

B: partial regression coefficient; SE: standard error; OR: odds ratio. The other abbreviations are given in the footnote to Table 1.

表 4 含FLC-λ指数的logistic回归分析结果

Table 4 Results of logistic regression analysis including FLC-λ index

Predictor	B	SE	Z	P	OR (95% CI)
(Intercept)	−28.109	14.204	−1.979	0.048	0.000 (0.000-0.000)
Age	0.018	0.024	0.732	0.464	1.018 (0.972-1.069)
CSF NC	0.064	0.036	1.77	0.077	1.065 (1.012-1.156)
CSF RBC	−0.001	0.001	−1.365	0.172	0.998 (0.995-1.000)
CSF CL	0.206	0.112	1.839	0.066	1.229 (1.000-1.562)
Serum IgG	−0.083	0.117	−0.709	0.479	0.921 (0.740-1.177)
Q _{Alb}	−61.862	57.869	−1.069	0.285	0.000 (0.000-0.000)
FLC-λ index	0.040	0.011	3.643	<0.001	1.040 (1.022-1.067)
Sex	1.784	0.898	1.987	0.047	5.957 (1.17-44.405)

B: partial regression coefficient; SE: standard error; OR: odds ratio. The other abbreviations are given in the footnote to Table 1.

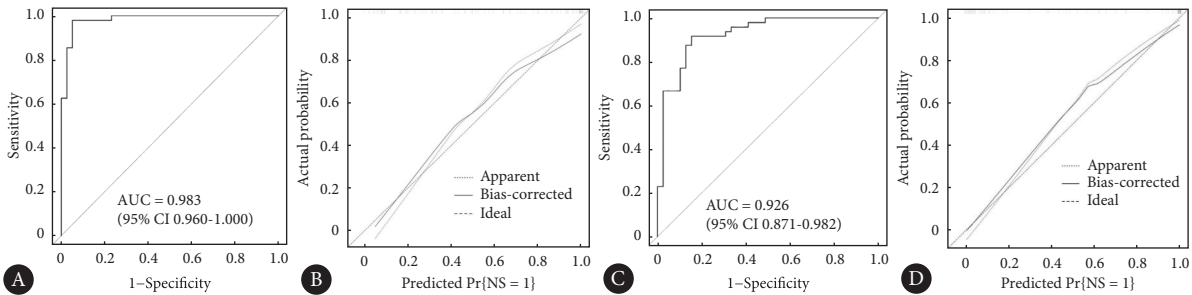


图 2 两个模型的ROC曲线和校准曲线

Fig 2 The ROC curves and calibration curves of the two models

AUC: area under the curve. The other abbreviations are given in the footnote to Table 1. A, The ROC curve of the model including the FLC-κ index; B, the calibration curve of the model including the FLC-κ index; C, the ROC curve of the model including the FLC-λ index; D, the calibration curve of the model including the FLC-λ index.

所示。围绕FLC-κ指数建立的诊断模型其训练ROC曲线的AUC大于0.950,说明其能在95%的情况下将神经梅毒患者和非神经梅毒患者区分开,其校准曲线在预测概率接近80%时预测效能较好,在预测概率为40%~60%时预测效能较弱。围绕FLC-λ指数建立的诊断模型的AUC为0.926,略低于前者;其校准曲线在预测概率接近85%时预测效能较好,在预测概率为40%~70%时预测效能较弱。

3 讨论

根据2019年全球疾病负担研究的数据,自2010年以来,梅毒的年标准化发病率(age-standardized incidence rate, ASR)平均每年上升了1.25%^[15]。这表明,当前的梅毒防控工作正面临严峻挑战。同时这也意味着,随着全球梅毒发病率的升高,神经梅毒的发病率也将会同步上升^[16]。

神经梅毒的临床表现多种多样且缺乏特异性,包括急性中风、精神症状如认知障碍、人格障碍、痴呆等,且经常出现多种症状组合的综合征^[16-17]。这意味着,相关临床表现在神经梅毒患者中的诊断价值相对有限。

目前较为常用的指标中,有研究表明CSF-VDRL的特

异度非常高,在排除样本的污染的前提下特异度能够达到100%,但在MARRA等的研究中其灵敏度仅为49%~68%^[18],更有研究提出其灵敏度仅为27%^[19]。这意味着,当CSF-VDRL阴性结果不能完全排除神经梅毒。CSF-RPR特异性为99.3%,而灵敏度为75%,这说明其诊断特性与CSF-VDRL存在一定的相似性,均具有较高的特异度,但是在灵敏度方面则有所欠缺,可能导致较高的漏诊率^[18]。CSF-TPPA在一些研究中表现出较高的灵敏度和特异性,特别是当CSF-VDRL结果为阴性时,CSF-TPPA可以提供有用的辅助诊断信息^[20]。

研究表明,在多发硬化症、病毒性脑炎等中枢神经系统疾病中均可观察到FLC水平异常^[21-23]。本研究采用散射比浊法精准定量FLC,构建FLC-κ与FLC-λ指数评估体系,发现二者在神经梅毒诊断中均表现良好,二者AUC均大于0.9且阴、阳性预测值较高,这表明FLC指数在神经梅毒诊断中存在较好的诊断价值,且FLC-κ指数在诊断价值的评估方面略优于FLC-λ指数。

本研究首次将鞘内体液免疫相关指标纳入神经梅毒诊断体系,以FLC-κ和FLC-λ指数作为核心变量,构建新型

诊断模型。结果显示,基于FLC- κ 指数与FLC- λ 指数的诊断模型AUC分别达到0.983和0.926,均展现出较高的诊断效能,为神经梅毒的诊断提供了可靠依据。Logistic 回归分析显示,男性、高龄、CSF氯、CSF有核细胞和FLC指数升高是NS患者的危险因素,与研究结果相似^[24-25]。NS患者中男性比例高于女性,这种性别差异可能与男性更高的性活跃度增加了梅毒螺旋体暴露风险有关。随着年龄的增长,NS的风险增加,这不排除梅毒患者病程延长导致疾病恶化的可能性。值得注意的是,虽然在单变量分析中CSF氯浓度的组间不存在显著差异($P=0.181$),但在多变量模型中,加入FLC- κ 指数后,它显示出独立的预测价值($P=0.013$),这表明其效应可能被其他变量掩盖。

尽管本研究模型包含多个变量,但这些变量均基于客观的实验室检测指标,避免了主观判断,有利于标准化应用。并能实现实验室的自动化智能化检测,大力缩短神经梅毒的诊断时效,尽早帮助临床获得正确的治疗和干预。

本研究同时也存在局限性。其一,作为单中心研究,受特定地理位置的制约,研究结果的普适性可能受限,地区间疾病谱、人群特征及环境因素的差异或对结论产生影响;其二,由于标本为脑脊液临床难以获取或样本量相对不足,可统计效力可能受限。后续研究将通过扩大样本规模、纳入多中心数据,进一步验证研究结论的稳健性与可靠性,并增加模型泛化能力。

综上所述,CSF FLC- κ 和CSF FLC- λ 指数在神经梅毒诊断中展现出较好的效能。其中,FLC- κ 指数灵敏度极高,二者均具备高特异性,为疾病诊断提供了关键生物学指标。此外,本研究创新性地整合性别、年龄、脑脊液细胞及生化指标、免疫相关参数,构建了包含FLC- κ 指数或FLC- λ 指数的神经梅毒诊断模型。

* * *

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Author Contribution DENG Jielun is responsible for conceptualization, data curation, formal analysis, visualization, and writing--original draft. WU Sirui and HUANG Xiyue are responsible for data curation and investigation. YE Fei is responsible for methodology and project administration. LI Dongdong is responsible for conceptualization and funding acquisition. LIU Jinbo is responsible for supervision and writing--review and editing. All authors consented to the submission of the article to the Journal. All authors approved the final version to be published and agreed to take responsibility for all aspects of the work.

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