



在线全文

针灸治疗干预下脑梗死恢复期患者并发肺部感染的 列线图预测模型构建及验证*

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【摘要】目的 分析针灸治疗干预下的脑梗死恢复期患者并发肺部感染的危险因素,并构建列线图模型。**方法** 按照建模集与验证集7:3比例,选择2022年1月—2024年1月期间在院内治疗的350例脑梗死患者为建模集。同时选择2024年2月至2024年12月收治的150例脑梗死患者作为验证集。收集患者一般资料、实验室指标及针灸干预变量,在建模集中使用LASSO回归筛选变量后进行多因素logistic回归,基于多因素回归结果建立列线图预测模型,分别在建模集和验证集中进行模型评价。**结果** 脑梗死恢复期患者肺部感染发生率26.20%(131/500),其中建模集患者95例,共检出147株病原菌,以革兰阴性菌为主。建模集中,LASSO回归及logistic多因素向后逐步回归法筛选出肺部感染的危险因素为年龄增加(OR=1.043, 95%CI: 1.010~1.077)、进食评估问卷调查工具-10(EAT-10)评分升高(OR=1.249, 95%CI: 1.125~1.387)、有侵入性操作(OR=2.715, 95%CI: 1.340~5.501)、美国国立卫生研究院卒中量表(NIHSS)评分升高(OR=2.477, 95%CI: 1.951~3.144)、白蛋白降低(OR=0.856, 95%CI: 0.786~0.931)、前白蛋白降低(OR=0.992, 95%CI: 0.987~0.997)、留针时间为30 min(OR=2.439, 95%CI: 1.146~5.191)、针灸疗程<14 d(OR=2.463, 95%CI: 1.157~5.243)以及发病后>3 d介入针灸治疗(OR=2.660, 95%CI: 1.190~5.942)。据此构建列线图模型,该模型在建模集和验证集中的曲线下面积(AUC)为0.916(95%CI: 0.877~0.954)、0.923(95%CI: 0.874~0.973),校正曲线证实模型预测概率与实际概率吻合度较高,应用可产生正向临床净效益。**结论** 基于Lasso-Logistic回归构建的列线图模型能够识别针灸干预下的脑梗死恢复期患者肺部感染风险,通过量化风险因素可指导患者优化针灸治疗方案、实现精准干预,降低感染风险。

【关键词】 针灸 脑梗死恢复期 肺部感染 列线图 预测模型

Development and Validation of a Nomogram Prediction Model for Pulmonary Infection in Cerebral Infarction Patients During the Recovery Phase After Acupuncture Treatment

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【Abstract】Objective To analyze the risk factors for pulmonary infection in convalescent patients with cerebral infarction under acupuncture and moxibustion intervention, and to develop a nomogram model. **Methods** According to a modeling-to-verification set ratio of 7:3, 350 patients with cerebral infarction treated in the hospital from January 2022 to January 2024 were selected as the modeling set. At the same time, 150 patients with cerebral infarction admitted from February 2024 to December 2024 were selected as the verification set. General patient information, laboratory indicators, and acupuncture intervention variables were collected. After screening variables using LASSO regression in the modeling set, multivariate logistic regression was performed. Based on the results of the multivariate regression, a nomogram prediction model was established, and the models were evaluated in the modeling and validation set, respectively. **Results** The incidence of pulmonary infection in patients with cerebral infarction during convalescence was 26.20%(131/500), including 95 patients in the model group. A total of 147 pathogen strains were detected, mainly Gram-negative bacteria. Modeling concentration, LASSO regression, and multivariate stepwise logistic regression were

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used to identify factors influencing pulmonary infection: increased age (OR = 1.043, 95%CI: 1.010-1.077), higher Eating Assessment Tool 10 (EAT-10) score (OR = 1.249, 95%CI: 1.125-1.387), invasive procedures (OR = 2.715, 95%CI: 1.340-5.501), higher National Institutes of Health Stroke Scale (NIHSS) score (OR = 2.477, 95%CI: 1.951-3.144), lower albumin (OR = 0.856, 95%CI: 0.786-0.931), lower prealbumin (OR = 0.992, 95%CI: 0.987-0.997), needle retention time of 30 min (OR = 2.439, 95%CI: 1.146-5.191), acupuncture course less than 14 d (OR = 2.463, 95%CI: 1.157-5.243), and initiation of intervention acupuncture treatment more than >3 d after onset (OR = 2.660, 95%CI: 1.190-5.942). Based on these factors, a nomogram model was constructed, with areas under the curve (AUC) of 0.916 (95%CI: 0.877-0.954) and 0.923 (95%CI: 0.874-0.973). The calibration curve showed that the predicted probabilities of the model were in close agreement with the observed probabilities, and its application could yield positive net clinical benefits. **Conclusion** The nomogram model constructed used Lasso-logistic regression can identify the risk of pulmonary infection in patients with cerebral infarction during convalescence after acupuncture treatment. Quantifying risk factors can guide patients in optimizing acupuncture treatment plans, achieving precise intervention, and reducing the risk of infection.

[Key words] Acupuncture Recovery period of cerebral infarction Pulmonary infection Nornogram prediction model

脑卒中是全世界第二大常见死因,每年超过600万人死于该病,近年呈现显著年轻化趋势^[1]。其中脑梗死约占全部脑卒中的70%以上,我国每年新发脑梗死病例超287万,发病人数居于全球首位^[2]。最新数据显示,我国60岁以上人群脑梗死患病率已达3.5%,40-60岁人群发病率相较于十年前上升30%^[3]。肺部感染是脑梗死恢复期常见并发症,在不同地区和国家发病率约2.4%~65%^[4],我国学者相关报道中^[5],脑梗死患者肺部感染发生率20%~50%不等,不仅影响神经功能恢复,还引起多器官功能衰竭、提高病死率。

现代药理学研究证实^[6],针灸可通过抑制神经炎症、改善微循环等有效改善脑梗死运动、认知以及吞咽障碍后遗症。并随着中医整体理念的发展,针灸治疗在脑梗死肺炎中也展现出独特治疗价值。相关证据表明^[7],针灸刺激特定穴位可有效改善患者免疫功能,减轻肺部炎症症状。我国为针灸应用大国,约60%的脑梗死患者接受过针灸治疗。尽管针灸在神经重症领域的应用日益广泛,但现有研究多基于西医临床指标,忽略针灸治疗参数的潜在价值,导致针灸治疗的脑梗死恢复期患者肺部感染的预测受限^[8]。

本研究首次聚焦于针灸治疗的脑梗死患者这一群体,探究此类人群肺部感染现状及其危险因素,旨在识别针灸干预下的脑梗死患者肺部感染高风险人群,同时基于针灸相关参数优化临床针灸治疗方案,为针灸治疗防治肺部感染提供更具临床转化价值的工具。

1 对象与方法

1.1 研究对象

本研究已通过本院伦理委员会审批(伦理审批号:2021-zj-24)。样本量计算根据logistic回归样本量的

EPV(events per variable)原则,EPV=10,最终共纳入研究因素9个,故需要肺部感染患者至少90例,参考李宏^[9]文献中肺部感染发生率29.09%,总样本量 $90 \div 0.29 \approx 310$ 例。为增加结果稳健性,综合考虑后,最终纳入2022年1月—2024年1月期间在院内治疗的350例脑梗死患者进入研究,将其作为建模集。按照建模集与验证集7:3比例,同时选择2024年2月—2024年12月期间在院内治疗的150例脑梗死患者作为验证集。纳入标准:(1)符合脑梗死诊断标准^[10],为恢复期;(2)耐受针灸治疗,治疗期间无中断;(3)年龄18~80岁;(4)具备完整临床资料。排除标准:(1)针灸治疗前已合并肺部感染;(2)合并恶性肿瘤或血液病;(3)合并严重脏器功能不全;(4)针灸治疗中断。

1.2 诊断标准

结局指标为脑梗死患者1个月内是否发生肺部感染,以患者首次接受针灸治疗的时间点作为观察起点,持续观察针灸干预后的1个月。肺部感染诊断基于临床症状、血常规检查及影像学检查,发病7d内符合以下标准中的3项即可诊断:(1)新发咳嗽、咳痰,或原有症状加重;(2)痰培养检出致病菌;(3)双肺存在不同程度肺实质体征,和(或)伴干湿啰音;(4)白细胞计数升高且体温 $\geq 37.5^{\circ}\text{C}$;(5)影像学检查表现肺部感染征象。

1.3 研究方法

搜集患者资料,包括病原菌分布情况、性别、年龄、体质量指数(body mass index, BMI)、高血压、糖尿病、高血脂、冠心病、吸烟、饮酒;病程、梗死范围、梗死部位、吞咽功能障碍[进食评估问卷调查工具-10(eating assessment tool-10, EAT-10)]、侵入性操作(气管插管、气管切开等);美国国立卫生研究院卒中量表(national institute of health stroke scale, NIHSS)评分^[11]、格拉斯哥昏迷量表(glasgow coma scale, GCS)评分^[12];C反应蛋白

(c-reactive protein, CRP)、空腹血糖、白蛋白、前白蛋白、白细胞计数和血红蛋白;中医证型、行针手法、留针时间、治疗频率、针灸疗程、针灸介入时间、穴位选择。实验室指标及相关评分均在首次接受针灸治疗时检测或评估,本研究纳入的针灸治疗方案以通督调神针刺为主,根据患者病情辨证配合项针、夹脊针、腹针等,治疗周期不低于7 d。

1.4 统计学方法

SPSS26.0分析数据,计量资料进行正态性检验,符合正态分布的以 $\bar{x} \pm s$ 表示,组间比较采用 t 检验;不符合正态分布则表示为中位数(P_{25} , P_{75}),组间比较采用Mann-Whitney U检验;计数资料表示为例数(%),组间比较采用 χ^2 检验。使用R语言中glmnet包进行LASSO回归筛选重要变量,基于logistic多因素向后逐步回归法分析结果建立预测模型,rms包构建列线图并绘制受试者工作特征(receiver operator characteristic, ROC)曲线,曲线下面积(area under the curve, AUC)评估区分度,绘制校准曲线评价校准度,决策分析曲线(decision curve analysis, DCA)评价临床收益。 $P < 0.05$ 表示有统计学意义。

2 结果

2.1 肺部感染患者病原菌分布情况

建模集男性250例,女性100例,年龄(64.68 ± 11.56)岁,BMI(22.54 ± 2.18) kg/m²;验证集男性116例,女性34例,年龄(66.25 ± 11.76)岁,BMI(22.54 ± 2.16) kg/m²,两组在性别、年龄及BMI资料分布中差异无统计学意义($P > 0.05$)。肺部感染率为26.20%(131/500),发生肺部感染的患者中,建模集95例,验证集36例。共送检155份合格痰标本,检出147株病原菌,其中革兰阳性菌35株,革兰阴性菌100株,真菌12株,见表1。

2.2 肺部感染的单因素分析

建模集感染组和非感染组中,年龄、高血压、糖尿病、EAT-10评分、侵入性操作、NIHSS评分、GCS评分、CRP、空腹血糖、白蛋白、前白蛋白、白细胞计数、血红蛋白、留针时间、治疗频率、针灸疗程以及针灸介入时间的资料分布差异有统计学意义($P < 0.05$),其余资料差异分布则均无统计学意义($P > 0.05$),见表2。

2.3 LASSO回归筛选结果

将表2中两组差异有统计学意义的17个变量纳入LASSO回归进行变量筛选,交叉验证确定最佳惩罚系数lambda(λ),取lambda.1se筛选出12个系数不为0的变量,即年龄、糖尿病、EAT-10评分、侵入性操作、NIHSS评分、白蛋白、前白蛋白、白细胞计数、血红蛋白、留针时

表 1 肺部感染患者病原菌分布情况
Table 1 Distribution of pathogens in patients with pulmonary infection

Pathogenic bacteria	Number of pathogenic strains	Proportion/%
Gram-positive bacteria	35	23.81
<i>Staphylococcus aureus</i>	19	12.93
<i>Staphylococcus epidermidis</i>	12	8.16
<i>Streptococcus</i>	2	1.36
<i>Enterococcus</i>	2	1.36
Gram-negative bacteria	100	68.03
<i>Klebsiella pneumoniae</i>	34	23.13
<i>Escherichia coli</i>	23	15.65
<i>Acinetobacter baumannii</i>	13	8.84
<i>Pseudomonas aeruginosa</i>	14	9.52
<i>Enterobacter cloacae</i>	7	4.76
Other	9	6.12
Fungus	12	8.16
<i>Candida albicans</i>	12	8.16
Total	147	100

间、针灸疗程、针灸介入时间。

2.4 肺部感染的多因素分析

以患者是否并发肺部感染作为因变量(感染=1,非感染=0),将LASSO回归筛选出的12个因素作为自变量(糖尿病有=1,无=0;侵入性操作是=1,否=0;留针时间30 min=1,40 min=0;针灸疗程<14 d=1,≥14 d=0;针灸介入时间发病后≤3 d=0,发病后>3 d=1,其余均以原值代入)进行多因素logistic回归方程分析,并采用向后法进行变量筛选。结果显示,年龄增加、EAT-10评分升高、有侵入性操作、NIHSS评分升高、白蛋白降低、前白蛋白降低、留针时间为30 min、针灸疗程<14 d以及发病后>3 d介入针灸治疗是针灸治疗后脑梗死患者肺部感染的危险因素($P < 0.05$),见表3。

2.5 构建列线图预测模型

基于表3中的9个因素,构建患者针灸治疗后发生肺部感染的风险预测列线图,见图1。

2.6 列线图模型评价与验证

绘制ROC曲线得到的建模集AUC为0.916(95%CI: 0.877 ~ 0.954),验证集AUC为0.923(95%CI: 0.874 ~ 0.973),表明模型具有较好区分能力,校准曲线显示预测结果与实际结果仅略微偏离,说明模型具有较好校准能力;Hosmer-Lemeshow检验 $P > 0.05$,说明拟合度较好(图2、图3)。DCA曲线结果显示,该模型有较高的临床收益(图4)。

表 2 肺部感染的单因素分析

Table 2 Univariate analysis of pulmonary infection

Project	Infection group (<i>n</i> = 95)	Non-infected group (<i>n</i> = 255)	$\chi^2/t/z$	<i>P</i>
Gender/case (%)			1.670	0.196
Man	63 (66.32)	187 (73.33)		
Woman	32 (33.68)	68 (26.67)		
Age/yr.	67.76 ± 11.52	63.54 ± 11.38	3.075	0.002
BMI/(kg/m ²), $\bar{x} \pm s$	22.43 ± 2.15	22.58 ± 2.19	0.199	0.842
Hypertension/case (%)	33 (34.74)	59 (23.14)	4.806	0.028
Diabetes/case (%)	44 (46.32)	82 (32.16)	6.022	0.014
Hyperlipidemia/case (%)	23 (24.21)	53 (20.78)	0.478	0.489
Coronary heart disease/case (%)	18 (18.95)	42 (16.47)	0.299	0.585
Smoking/case (%)	36 (37.89)	87 (34.12)	0.433	0.510
Alcohol consumption/case (%)	38 (40.00)	91 (35.69)	0.553	0.457
Course of disease/year, $\bar{x} \pm s$	3.12 ± 1.08	3.17 ± 1.14	0.370	0.712
Infarction range/case (%)			0.182	0.670
≥ 3 cm ³	41 (43.16)	117 (45.88)		
< 3 cm ³	54 (56.84)	138 (54.12)		
Infarction site/case (%)			3.437	0.329
Pre-split pre-cycle	32 (33.68)	97 (38.04)		
Complete precirculation	27 (28.42)	79 (30.98)		
Posterior circulation	22 (23.16)	58 (22.75)		
Occurring frequently	14 (14.74)	21 (8.24)		
EAT-10 score/point, $\bar{x} \pm s$	20.35 ± 4.38	18.28 ± 3.12	4.899	< 0.001
Invasive operation/case (%)	54 (56.84)	103 (40.39)	7.572	0.006
NIHSS score/point, $\bar{x} \pm s$	11.52 ± 2.16	9.14 ± 1.37	12.197	< 0.001
GCS score/point, $\bar{x} \pm s$	7.18 ± 1.29	7.58 ± 1.36	-2.461	0.014
CRP/mg/L, $\bar{x} \pm s$	66.81 (49.61, 95.11)	46.87 (29.08, 70.63)	-1.531	0.026
Fasting blood glucose/(mmol/L), $\bar{x} \pm s$	5.85 ± 1.08	5.63 ± 0.74	2.169	0.031
Albumin/(g/L), $\bar{x} \pm s$	36.14 ± 4.23	38.64 ± 4.53	-4.670	< 0.001
Prealbumin/(mg/L), $\bar{x} \pm s$	211.35 ± 64.54	248.76 ± 77.61	-4.188	< 0.001
White blood cell count/(×10 ⁹ L ⁻¹), $\bar{x} \pm s$	6.36 ± 1.83	5.85 ± 1.73	2.455	0.015
Hemoglobin/(g/L), $\bar{x} \pm s$	131.05 ± 14.63	134.68 ± 13.61	-2.173	0.030
TCM syndrome types/case (%)			1.464	0.962
Syndrome of hyperactivity of wind, phlegm and fire	23 (24.21)	57 (22.35)		
Syndrome of wind-fire disturbance	13 (13.68)	40 (15.69)		
Syndrome of phlegm-heat in fu-organs	10 (10.53)	32 (12.55)		
Syndrome of wind-phlegm and blood stasis	12 (12.63)	38 (14.90)		
Syndrome of phlegm-dampness affecting the spirit,	8 (8.42)	23 (9.02)		
Qi deficiency and blood stasis syndrome	18 (18.95)	41 (16.08)		
Yin deficiency and wind-driven syndrome	11 (11.58)	24 (9.41)		
Manipulation of needling/case (%)			0.977	0.614
Pingbu Pingxie method	68 (71.58)	193 (75.69)		
Interpolation method	14 (14.74)	28 (10.98)		
Twisting method	13 (13.68)	34 (13.33)		
Time of needle retention/case (%)			7.680	0.006
30 min	67 (70.53)	138 (54.12)		
40 min	28 (29.47)	117 (45.88)		
Frequency of treatment/case (%)			5.054	0.025
6 times/week	63 (66.32)	199 (78.04)		
7 times/week	32 (33.68)	56 (21.96)		
Acupuncture treatment course/case (%)			6.524	0.011
< 14 d	71 (74.74)	153 (60.00)		
≥ 14 d	24 (25.26)	102 (40.00)		
Acupuncture intervention time/case (%)			8.682	0.013
3 d or less after onset	22 (23.16)	102 (40.00)		
4-7 d after onset	54 (56.84)	116 (45.49)		
8-15 d after onset	19 (20.00)	37 (14.51)		
Acupoint selection/case (%)			0.232	0.891
Du meridian was dominant	73 (76.84)	202 (79.22)		
Mainly scalp acupuncture	12 (12.63)	29 (11.37)		
Yangming meridian was dominant	10 (10.53)	24 (9.41)		

BMI: body mass index; EAT-10: eating assessment tool-10; NIHSS: national institute of health stroke scale; GCS: glasgow coma scale; CRP: C-reactive protein.

表 3 肺部感染的多因素分析
Table 3 Multivariate analysis of pulmonary infection

Factor	β	SE	Wald χ^2	P	OR	95% CI
Age	0.042	0.016	6.596	0.010	1.043	1.010 ~ 1.077
EAT-10 score	0.223	0.053	17.37	< 0.001	1.249	1.125 ~ 1.387
Invasive operation	0.999	0.360	7.679	0.006	2.715	1.340 ~ 5.501
NIHSS score	0.907	0.122	55.508	< 0.001	2.477	1.951 ~ 3.144
Albumin	-0.156	0.043	13.214	< 0.001	0.856	0.786 ~ 0.931
Prealbumin	-0.008	0.003	10.687	0.001	0.992	0.987 ~ 0.997
Needle retention time	0.891	0.385	5.347	0.021	2.439	1.146 ~ 5.191
Acupuncture treatment course	0.901	0.386	5.463	0.019	2.463	1.157 ~ 5.243
Acupuncture intervention time	0.978	0.410	5.687	0.017	2.660	1.190 ~ 5.942
Constant	-13.01	2.657	23.978	< 0.001	< 0.001	

All abbreviations are explained in the first footnote to Table 2.

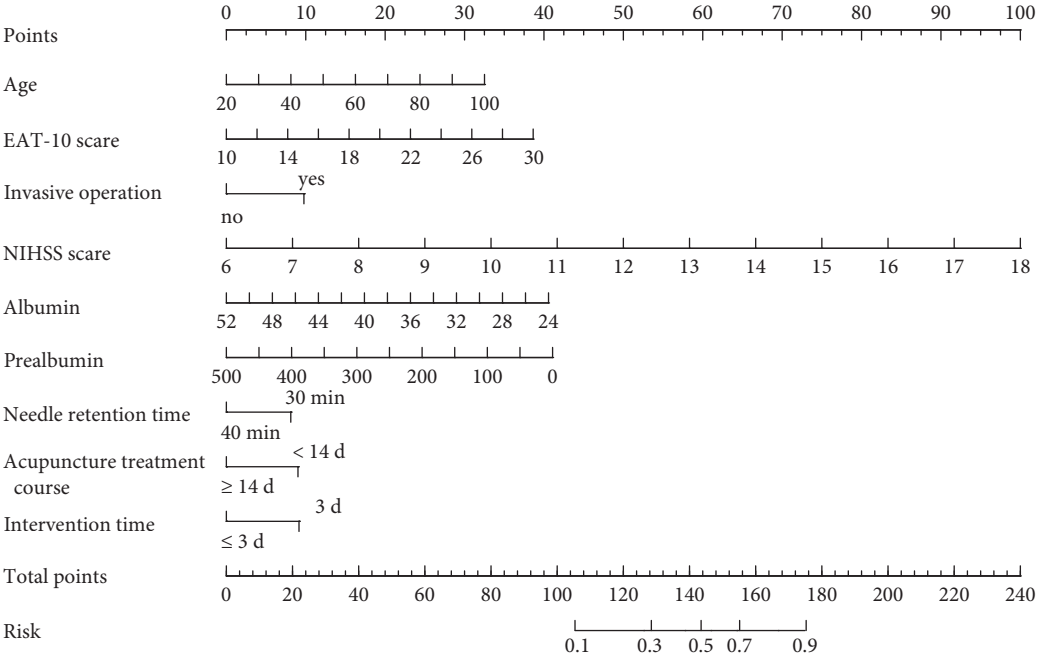


图 1 针灸治疗后肺部感染风险预测列线图

Fig 1 Line chart of lung infection risk prediction after acupuncture treatment

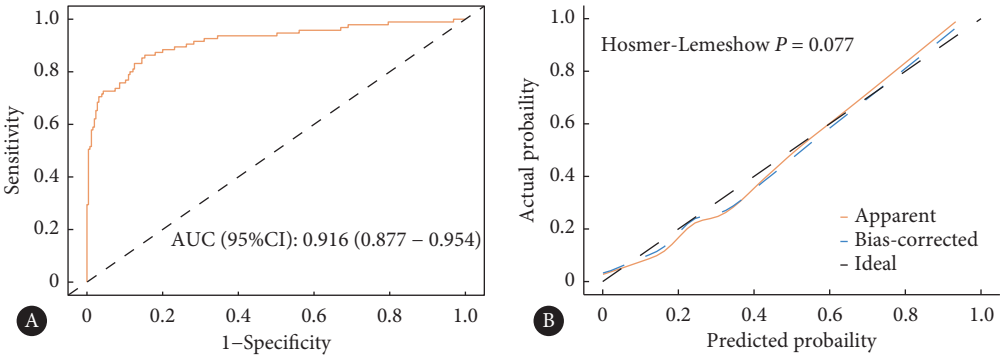


图 2 建模集ROC曲线 (A) 及校准曲线 (B)

Fig 2 ROC curve (A) and calibration curve (B) of modeling set

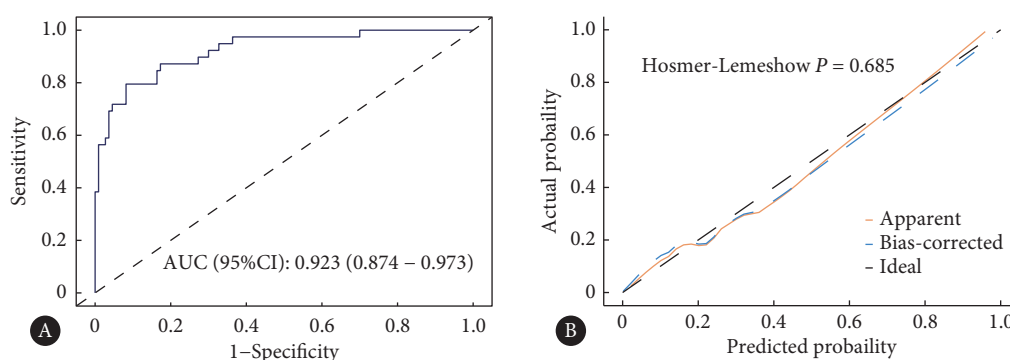


图 3 验证集ROC曲线 (A) 及校准曲线 (B)

Fig 3 ROC curve (A) and calibration curve (B) of verification set

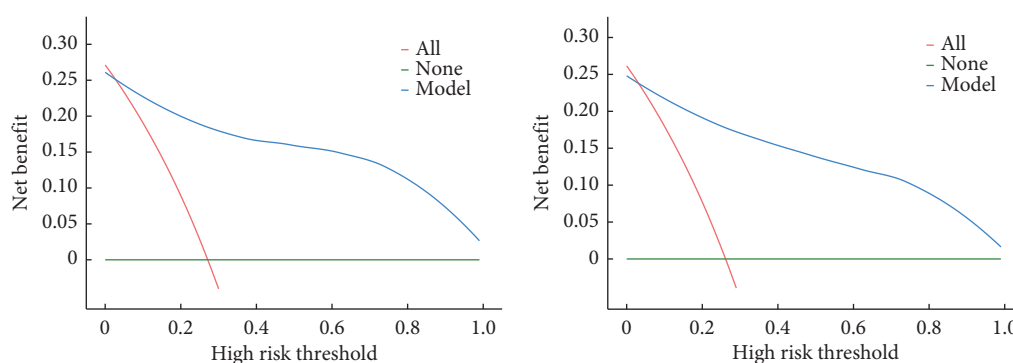


图 4 建模集 (A) 和验证集 (B) 的DCA曲线

Fig 4 DCA curves of modeling set (A) and verification set (B)

2.7 列线图模型临床应用

假设某一接受针灸治疗的脑梗死患者, 年龄60岁, EAT-10评分22分, NIHSS评分10分, 白蛋白35 g/L, 前白蛋白200 mg/L, 留针时间为40 min, 针灸疗程12 d, 发病后5 d介入针灸治疗, 对应分值分别为16分、23分、32分、23分、24分、0分、8分、7分, 则总分133分, 对应肺部感染风险约为35%。根据模型预测结果, 此时可通过优化针灸治疗方案、营养支持治疗、吞咽功能障碍干预等方式针对性降低患者感染的风险因素, 进而降低肺部感染风险。

3 讨论

针对脑梗死患者, 相关指南建议临床尽早开展微生物培养与药物敏感性试验, 并依据结果选用抗菌药物^[13]。本研究搜集到的资料显示, 肺部感染的脑梗死患者检出血病原菌以革兰阴性菌为主, 与Mohapatra等^[14]的研究结果相符。其分布特征可能与梗死后脑损伤引发的免疫功能减退及机体机能障碍导致易感性增加相关, 同时患者因侵入性操作及合并慢性疾病等因素, 均升高原本定植于消化道的革兰阴性菌肺部移位风险。鉴于肺炎克雷伯菌、大肠埃希菌等革兰阴性菌在脑梗死恢复期患者中占

比较高的特点, 临床应重点关注此类病原菌耐药检测并合理选用抗菌药物。

3.1 患者特征与疾病因素

本研究发现, 年龄越大、EAT-10和NIHSS评分越高、有侵入性操作、白蛋白和前白蛋白水平降低的脑梗死患者肺部感染风险更高。分析原因: 生理机能衰退与疾病病理特征的叠加效应导致老年患者抗感染能力下降, 肺组织弹性减退、咳嗽反射减弱及免疫屏障退化等共同因素致使患者痰液廓清能力下降并增加呼吸道定植菌易感性^[15]。研究指出^[16], 老年人T细胞功能下降和中性粒细胞趋化能力减弱是导致病原体清除效率降低的根本原因。EAT-10评分与NIHSS评分升高通过直接损伤机体防御机制、加剧病理生理紊乱增加患者肺部感染风险, 前者反映吞咽功能障碍严重, 可能增加患者唾液与食物残渣误吸频率, 口咽部定植的病原菌直接侵入肺实质引发感染^[17]; 后者则提示脑损伤范围扩大, 可能抑制延髓咳嗽中枢、降低呼吸肌肌力导致排痰障碍, 并引发神经源性炎症反应、破坏肺血管屏障完整性, 为细菌定植提供炎症微环境^[18]。微生物-肠-肺轴理论认为, 重度神经损伤可通过激活迷走神经通路诱导淋巴细胞凋亡, 间接加剧感染风险^[19]。气管切开、插管等侵入性操作会破坏气道过滤功

能,使病原菌侵入肺实质并降低黏膜纤毛清除效率,若操作不规范则进一步损伤气道黏膜,形成操作-生理缺陷-感染的级联风险效应^[20]。白蛋白和前白蛋白反映机体营养状态与免疫功能,二者水平降低不仅营养储备减少,还导致免疫防御缺陷,使淋巴细胞活性下降、抗体产生减少、吞噬细胞功能受损,机体更易受到细菌或病毒侵袭。Lv^[21]及Qiu等^[22]学者研究中,二者下降均可导致黏膜屏障破坏、免疫细胞凋亡增加及促炎因子释放失衡,增加肺部感染风险。

3.2 针灸治疗干预因素

本研究发现,留针时间更长、针灸疗程 ≥ 14 d以及针灸介入时间越早的脑梗死患者肺部感染风险更低。多项研究证实^[23-24],针灸在抗细胞凋亡、拮抗兴奋性氨基酸细胞毒性、减轻炎症反应等方面均展现出显著疗效,这与针灸通过持续刺激穴位产生的整体调节效应密切相关。延长留针时间可更充分激活穴位信号传导,增强对神经系统的调节作用,抑制促炎因子过度表达,进而增强机体抗感染能力^[25]。针灸疗程与疾病风险关系体现了累积治疗效应,多次刺激治疗可持续调节下丘脑-垂体-肾上腺轴,改善患者机体应激状态并降低易感性。并在动物实验中发现^[26],连续针灸可显著增加CD4⁺ T细胞比例,增强Th1型免疫应答。早期针灸治疗符合中医治未病理念,脑梗死后72 h内为神经炎症高峰期,此时介入针灸可通过脑-肺轴机制抑制小胶质细胞过度激活,减少炎症因子对肺血管屏障的破坏,同时改善微循环并减轻全身应激反应,有利于维持白蛋白、前白蛋白等营养指标稳定,进而增强免疫防御功能。诸多研究证实^[27-28],针灸可通过优化CIS缺血区脑组织血液循环及能量代谢维护脑功能完整性。另一方面,针灸能够活化脑部不同区域并调节相关信号通路,进而推动缺血半暗带血管新生进程。并在徐健钦等^[29]研究中,提高针刺频率可增强治疗效果并缩短起效时间;孟醒等^[30]学者亦指出,早治疗、针刺频次、针刺疗程等时间因素是针刺疗效的影响因素,本次研究结果可为制定标准化针灸方案提供依据。

综上所述,年龄、EAT-10评分、侵入性操作、NIHSS评分、白蛋白、前白蛋白、留针时间、针灸疗程以及针灸介入时间是脑梗死患者针灸治疗后并发肺部感染的影响因素,本研究构建的列线图模型通过量化针灸参数与感染风险的关联,有利于指导针灸方案个体化优化,并为针灸治疗的标准化提供循证工具。但本研究由于个体差异及针刺操作异质性较大,因此未纳入针刺深度、角度、手法强度、针灸组合疗法等针灸操作细节,可能遗漏潜在影响因素,同时样本来源可能存在单中心偏倚,未来可通过

多中心数据验证并整合针灸疗法的多维数据,更精准评估其对肺炎预防的积极作用,为标准化针灸方案提供循证依据。

* * *

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