

• 临床研究 •

大血管闭塞性急性缺血性卒中患者血管内治疗术后预后不良预测模型的构建及价值分析

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[摘要] 目的: 构建大血管闭塞性急性缺血性卒中(large vessel occlusion-acute ischemic stroke, LVO-AIS)患者血管内治疗(endovascular treatment, EVT)术后90 d预后不良的预测模型并探讨其预测价值。方法: 回顾性选取2020年1月—2023年12月驻马店市中心医院诊治的LVO-AIS患者200例, 依据预后情况分别纳入预后良好组(112例)和预后不良组(88例), 比较2组临床资料及治疗相关指标, 采用Lasso-Logistic回归分析LVO-AIS患者EVT术后90 d预后不良的影响因素, 构建预测模型, 以列线图进行可视化呈现, 采用校正曲线、受试者工作特征(receiver operating characteristic, ROC)曲线评价模型的预测准确性和预测价值, 并进行外部验证。结果: 与预后良好组相比, 预后不良组合并高血压比例、入院时美国国立卫生研究院卒中量表(National Institutes of Health stroke scale, NIHSS)评分、入院时中性粒细胞与淋巴细胞比值(neutrophil-to-lymphocyte ratio, NLR)、闭塞血管数量 ≥ 2 支比例较高, 入院时Alberta卒中项目早期CT(Alberta stroke program early CT, ASPECT)评分较低($P < 0.05$); 预后不良组发病至手术时间、发病至再通时间长于预后良好组, 改良脑梗死溶栓分级(modified thrombolysis in cerebral infarction, mTICI) $\geq 2b$ 级的比例低于预后良好组($P < 0.05$); 高血压、入院时NIHSS评分、入院时NLR、入院时ASPECT评分、发病至再通时间、mTICI分级是预后的独立影响因素($P < 0.05$); 基于各指标构建的联合模型预测LVO-AIS患者EVT术后90 d预后不良的曲线下面积(area under curve, AUC)为0.900, 预测价值较高, 经外部验证进一步表明, 该模型具有可靠的预测价值。结论: 高血压、入院时NIHSS评分、入院时NLR、入院时ASPECT评分、发病至再通时间、mTICI分级与LVO-AIS患者预后有关, 基于各指标构建的联合模型可为患者EVT术后90 d预后预测提供参考, 并以此指导临床治疗。

[关键词] 缺血性卒中; 急性前循环闭塞; 血管内治疗术; 临床因素; 治疗相关指标; 预后; 预测模型

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Construction and value analysis of a predictive model for poor prognosis after endovascular treatment in patients with large vessel occlusion-acute ischemic stroke

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[Abstract] **Objective:** To construct a predictive model for poor 90-day prognosis after endovascular treatment (EVT) in patients with large vessel occlusion-acute ischemic stroke (LVO-AIS) and to explore its predictive value. **Methods:** Two hundred patients with LVO-AIS diagnosed and treated in Zhumadian Central Hospital from January 2020 to December 2023 were retrospectively selected. According to the prognosis, the patients were divided into a good prognosis group (112 cases) and a poor prognosis group (88 cases). The clinical data and treatment-related indicators of the two groups were compared. Lasso-Logistic regression was used to analyze the influencing factors of poor 90-day prognosis after EVT in patients with LVO-AIS. The prediction model was constructed and visualized by nomogram. The prediction accuracy and predictive value of the prediction model were evaluated by calibration curve and receiver operating characteristic (ROC) curve, and external validation was performed. **Results:** Compared with the good prognosis group, the proportion of hypertension, the National Institutes of Health stroke scale (NIHSS) score at admission, the neutrophil-to-lymphocyte ratio (NLR) at admission, and the number of occluded vessels ≥ 2 were higher in the poor prognosis group. The Alberta stroke program

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early CT(ASPECT) score was lower at admission ($P < 0.05$). The time from onset to operation and the time from onset to recanalization in the poor prognosis group were longer than those in the good prognosis group, and the proportion of modified thrombolysis in cerebral infarction(mTICI) grade $\geq 2b$ in the poor prognosis group was lower than that in the good prognosis group ($P < 0.05$). Hypertension, NIHSS score at admission, NLR at admission, ASPECT score at admission, time from onset to recanalization, and mTICI grade were independent prognostic factors ($P < 0.05$). The AUC of the combined model based on each index to predict the poor 90-day prognosis after EVT of LVO-AIS patients was 0.900, and the predictive value was high. The external validation further showed that the model had reliable predictive value. **Conclusion:** Hypertension, NIHSS score at admission, NLR at admission, ASPECTS score at admission, time from onset to reperfusion, and mTICI classification are related to the prognosis of patients with LVO-AIS. The combined model constructed based on these indicators can provide a reference for predicting the 90-day prognosis of patients after EVT, and guide clinical treatment accordingly.

[Key words] ischemic stroke; acute anterior circulation occlusion; endovascular therapy; clinical factor; treatment-related indicator; prognosis; predictive model

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急性缺血性脑卒中是临床发病率、致死率均较高的脑血管疾病,目前在时间窗内的患者多采用静脉溶栓治疗^[1],但对于急性前循环闭塞的缺血性卒中(large vessel occlusion-acute ischemic stroke, LVO-AIS),溶栓治疗血管再通率较低,导致疗效欠佳。血管内治疗(endovascular treatment, EVT)术是目前公认的LVO-AIS患者有效恢复再灌注的最佳治疗方法^[2-3],但在临床实际应用过程中发现,仍有部分患者临床预后不理想^[4]。临床因素及治疗相关指标对患者预后有一定影响^[5-6]。治疗过程中,血管再通导致的再灌注损伤及炎症反应都会加重病情,患者自身情况也可能影响其对手术及药物的耐受,临床需依据相关因素调整治疗方案,尽可能降低患者预后不良风险^[7-8]。本研究采用回顾性方法,系统整合患者术前临床特征及术中治疗相关指标情况,并建立联合模型,旨在为临床早期有效筛查预后不良高风险患者、开展科学防治提供一定参考依据。

1 对象和方法

1.1 对象

选取驻马店市中心医院2020年1月—2023年12月诊治的200例LVO-AIS患者进行回顾性研究,于发病6h内完成磁共振血管成像或头+颈CT血管造影检查,发病6~24h完成CT灌注成像或磁共振灌注成像检查,确认颈内动脉、大脑中动脉M1段、M2段、大脑前动脉闭塞等相关大血管闭塞情况后,行EVT术。依据预后将患者分别纳入预后良好组、预后不良组。纳入标准:①急诊入院,经头部CT检

查确认不存在脑出血情况,且符合《中国急性缺血性脑卒中早期血管内介入诊疗指南2018》^[9]中LVO-AIS相关标准;②术前改良Rankin量表(improved Rankin scale, mRS)评分 < 2 分;③入院时美国国立卫生研究院卒中量表(NIH stroke scale, NIHSS)评分 > 5 分;④发病24h内行EVT术;⑤患者临床资料完整;⑥签署知情同意书。排除标准:①有活动性出血、出血倾向或存在凝血功能异常;②严重心、肺、肾等其他重要器官功能不全;③近3个月存在急慢性感染病史;④近6个月有免疫抑制剂、激素相关药物使用史;⑤血管炎、烟雾病等其他病因导致的脑卒中。本研究经驻马店市中心医院伦理研究委员会批准通过(伦理审批号:2023-02-KY006),患者均知情同意。

1.2 方法

1.2.1 资料收集

依据临床电子病历资料,统计患者年龄、性别、体重指数(body mass index, BMI)、合并症(糖尿病、高血压、房颤、冠心病、高脂血症)、吸烟史、入院时NIHSS评分、入院时Alberta卒中项目早期CT(Alberta stroke program early CT, ASPECT)评分、入院时中性粒细胞与淋巴细胞计数比值(neutrophil-to-lymphocyte ratio, NLR)、TOAST病因分型[大动脉粥样硬化(large artery atherosclerotic, LAA)、心源性栓塞(cardioembolism, CE)、小动脉闭塞(small artery occlusion, SAO)]、血管闭塞部位(颈内动脉、大脑中动脉M1段、颈内动脉+大脑中动脉M1段、大脑中动脉M1+大脑前动脉A2段)、血管闭塞数量;统计患者治疗相关指标,包括静脉溶栓比例、发病至手术

时间、发病至再通时间、穿刺至再通时间、球囊扩张/支架植入比例、取栓次数、改良脑梗死溶栓分级(modified thrombolysis in cerebral infarction, mTICI)、脑内出血(intracerebral hemorrhage, ICH)发生率、症状性脑内出血(symptomatic intracerebral hemorrhage, sICH)发生率、肺部感染率、下肢深静脉血栓形成率。其中, BMI=体重(kg)/身高²(m²), 入院时 NHISS 评分^[10]、ASPECT 评分^[11]依据相关标准进行评估。在患者入院时采集肘静脉血于抗凝管中, 采用全自动模块式血液体液分析仪(希森美康公司, 日本)检测中性粒细胞、淋巴细胞计数, 并计算 NLR 值。血管再灌注成功率依据 mTICI 分级^[12]进行, 如血流 mTICI 分级 $\geq 2b$ 级, 则定义为血管再灌注成功, 否则为血管再灌注失败。

1.2.2 EVT 术

依据患者自身情况及《中国急性缺血性脑卒中早期血管内介入诊疗指南 2018》^[9]相关标准制定合理的治疗方案。经 Solitaire FR 支架抽吸取栓后进行脑动脉造影, 若造影结果提示闭塞血管支数 >2 支, 则找出责任血管, 对狭窄性串联病变进行逆向取栓, 对栓塞闭塞串联病变则需抽吸近端血栓, 再处理远端闭塞血管, 若造影结果表明无法维持前向血流, 则再次进行取栓。依据实际情况决定取栓次数, 但总次数 ≤ 3 次。多次取栓后血管仍存在严重狭窄, 需应用球囊扩张/植入支架进行补救治疗。治疗结束后需进行数字减影血管造影检查, 若 mTICI $\geq 2b$ 级, 前向血流维持时间 >15 min, 则转入 ICU 进一步治疗, 若 mTICI 分级 $<2b$ 级, 则依照急性脑梗死进行治疗, 收缩压需 ≤ 180 mmHg。术后 24 h 需维持收缩压 100~140 mmHg, 血糖 <10 mmol/L, 脑动脉取栓治疗或桥接治疗 24 h 后复查头部 CT, 无出血则口服抗血小板聚集药物。接受单纯脑动脉取栓的患者在术后 24 h 内静脉泵入替罗非班, 24 h 后使用抗血小板聚集药物。接受静脉溶栓患者 24 h 内不使用抗血小板聚集药物, 未接受静脉溶栓患者需依据具体情况使用抗血小板聚集药物。术后发生 sICH 及 ICH 的患者, 需依据患者自身情况给予甘露醇或甘露果糖, 待出血吸收, 暂不使用抗血小板聚集药物; 术后并发肺部感染患者应接受抗感染治疗, 术后发生下肢静脉血栓患者进行抗凝治疗。

1.2.3 预后评估

于患者行 EVT 术后 90 d, 依据 mRS 评分^[13]进行预后评估。0 分: 患者无症状; 1 分: 患者无明显残疾, 能够完成所有日常活动; 2 分: 患者轻度残疾, 但

能够处理个人事务; 3 分: 患者轻度残疾, 日常活动需要一些帮助, 但不需要持续护理; 4 分: 患者中重度残疾, 需要他人帮助以满足日常需求, 无法独立生活; 5 分: 重度残疾, 并需要持续护理; 6 分: 患者死亡。将 mRS 评分 ≥ 3 分患者纳入预后不良组, 将 mRS 评分 ≤ 2 分患者纳入预后良好组。

1.3 统计学方法

采用 SPSS22.0 进行统计学分析, 计量资料以均数 \pm 标准差($\bar{x} \pm s$)表示, 采用两独立样本 *t* 检验, 计数资料以例数(百分比)[*n*(%)]表示, 行 χ^2 检验或 Fisher 确切概率法; 采用多因素 Logistic 回归分析影响因素, 采用方差膨胀因子诊断多重共线性, 当方差膨胀因子 ≥ 10 时, 则提示存在多重共线性, 需基于变量间的临床关联性和单因素分析结果, 选择性删除与其他变量理论关联最强或在模型中导致系数估计最不稳定的变量; 绘制受试者工作特征(receiver operating characteristic, ROC)曲线后, 通过计算曲线下面积(area under curve, AUC)值验证模型的预测价值。 $P < 0.05$ 为差异有统计学意义。

2 结果

2.1 分组情况及 2 组临床资料比较

200 例 LVO-AIS 患者中 90 d 预后良好(mRS ≤ 2 分) 112 例, 预后不良(mRS ≥ 3 分) 88 例。2 组年龄、性别、糖尿病、高脂血症、房颤、冠心病、吸烟史、TOAST 病因分型、血管闭塞部位、闭塞血管数量 ≥ 2 支比例比较, 差异均无统计学意义(P 均 >0.05); 与预后良好组相比, 预后不良组合并高血压比例、入院时 NHISS 评分、入院时 NLR、闭塞血管数量 ≥ 2 支比例较高, 入院时 ASPECT 评分较低(P 均 <0.05 , 表 1)。

2.2 2 组治疗相关指标比较

预后不良组发病至手术时间、发病至再通时间长于预后良好组, mTICI 分级 $\geq 2b$ 级比例低于预后良好组($P < 0.05$); 2 组取栓次数及静脉溶栓、穿刺至再通时间、sICH、ICH、球囊扩张/植入支架比例、肺部感染、下肢深静脉血栓形成发生率比较, 差异均无统计学意义(P 均 >0.05 , 表 2)。

2.3 LVO-AIS 患者 EVT 术后 90 d 预后的影响因素

以 LVO-AIS 患者 EVT 术后 90 d 预后为因变量(预后不良=1, 预后良好=0), 以高血压(有=1, 无=0)、入院时 NHISS 评分、入院时 NLR、入院时 ASPECT 评分、闭塞血管数量(<2 支=0, ≥ 2 支=1)、发病至手术时间、发病至再通时间、mTICI 分级($<2b$ 级=1, $\geq 2b$ 级=0)等 8 个因素为自变量, Lasso 回归分析筛选出

表1 2组临床资料比较

Table 1 Comparison of clinical characteristics between the two groups

Characteristic	Poor prognosis group(n=88)	Good prognosis group(n=112)	t/χ^2	P
Age(years, $\bar{x} \pm s$)	44.15 ± 3.61	43.39 ± 3.18	1.580	0.116
Sex[n(%)]			0.531	0.466
Male	54(61.36)	63(56.25)		
Female	34(38.64)	49(43.75)		
BMI(kg/m ² , $\bar{x} \pm s$)	23.16 ± 1.35	22.89 ± 1.22	1.482	0.140
Complication[n(%)]				
Hypertension	69(78.41)	40(35.71)	36.225	< 0.001
Diabetes	11(12.50)	15(13.39)	0.035	0.852
Hyperlipidemia	25(28.41)	28(25.00)	0.294	0.588
Atrial fibrillation	58(65.91)	70(62.50)	0.249	0.618
Coronary heart disease	21(23.86)	22(19.64)	0.520	0.471
Smoking history[n(%)]	28(31.82)	31(27.68)	0.406	0.524
NHSS scores at admission($\bar{x} \pm s$)	13.17 ± 2.28	11.40 ± 2.06	5.754	< 0.001
ASPECTS scores at admission($\bar{x} \pm s$)	6.83 ± 0.71	6.02 ± 0.57	8.950	< 0.001
NLR at admission($\bar{x} \pm s$)	3.03 ± 0.64	2.51 ± 0.49	6.508	< 0.001
TOAST etiological classification[n(%)]			0.026	0.987
LAA	43(48.86)	56(50.00)		
CE	33(37.50)	41(36.61)		
SAO	12(13.64)	15(13.39)		
Vascular occlusion site[n(%)]			1.329	0.856
Internal carotid artery	31(35.23)	43(38.39)		
Internal carotid artery + middle cerebral artery M1 segment	18(20.45)	25(22.32)		
Internal carotid artery + middle cerebral artery M1 + anterior cerebral artery	15(17.05)	17(15.18)		
Middle cerebral artery M1 segment	14(15.91)	19(16.96)		
Middle cerebral artery M1 + anterior cerebral artery A2 segment	10(11.36)	8(7.14)		
Number of occluded vessels ≥ 2 [n(%)]	43(48.86)	28(25.00)	12.256	0.001

表2 2组治疗相关指标比较

Table 2 Comparison of treatment-related indicators between the two groups

Treatment-related indicator	Poor prognosis group(n=88)	Good prognosis group(n=112)	t/χ^2	P
Intravenous thrombolysis[n(%)]	35(39.77)	36(32.14)	1.253	0.263
Time from onset to operation(min, $\bar{x} \pm s$)	272.14 ± 30.59	249.88 ± 33.74	4.824	< 0.001
Time from onset to recanalization(min, $\bar{x} \pm s$)	342.07 ± 25.64	324.52 ± 21.27	5.290	< 0.001
Puncture to recanalization time(min, $\bar{x} \pm s$)	69.93 ± 13.31	67.64 ± 15.08	1.122	0.263
Thrombectomy[n(%)]			0.701	0.704
1 time	52(59.09)	71(63.39)		
2 times	30(34.09)	36(32.14)		
≥ 3 times	6(6.82)	5(4.46)		
Balloon dilatation or stent implantation[n(%)]	21(23.86)	23(20.54)	0.318	0.573
mTICI grade $\geq 2b$ [n(%)]	79(89.77)	110(98.21)	5.230	0.022
sICH[n(%)]	2(2.27)	0(0)	-	0.192
ICH[n(%)]	4(4.55)	3(2.68)	0.106	0.745
Pulmonary infection[n(%)]	3(3.41)	3(2.68)	0.014	0.907
Lower extremity deep venous thrombosis[n(%)]	2(2.27)	1(0.89)	0.044	0.833

高血压、入院时 NHSS 评分、入院时 NLR、入院时 ASPECT 评分、发病至再通时间、mTICI 分级 6 个因素，筛选过程见图 1。将 Lasso 回归分析筛选出的 6 个因素作为自变量纳入 Logistic 回归分析，高血

压、入院时 NHSS 评分、入院时 NLR、入院时 ASPECT 评分、发病至再通时间、mTICI 分级是患者预后的独立影响因素 ($P < 0.001$)，且不存在多重共线性(方差膨胀因子 < 10 ，表 4)。

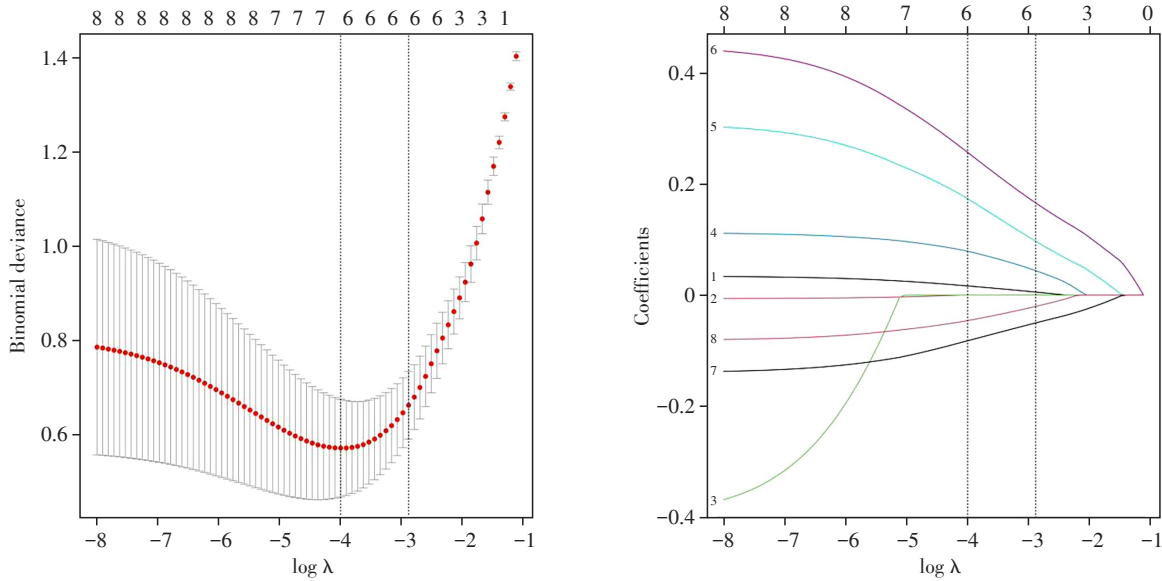


图1 Lasso 筛选过程图

Figure 1 Lasso screening process diagram

表4 LVO-AIS 患者EVT 术后 90 d 预后不良的影响因素

Table 4 Influencing factors of poor 90-day prognosis after EVT in LVO-AIS patients

Variable	β	SE	Wald χ^2	OR	95%CI	P
Hypertension	1.590	0.426	13.926	4.902	1.755-13.694	< 0.001
NIHSS score at admission	0.800	0.213	14.103	2.225	1.621-3.055	< 0.001
NLR at admission	0.628	0.195	10.382	1.874	1.338-2.626	< 0.001
ASPECTS score at admission	-0.788	0.201	15.372	0.445	0.271-0.763	< 0.001
Time from onset to recanalization	0.383	0.104	13.537	1.466	1.302-1.651	< 0.001
mTICI classification	1.806	0.451	16.039	6.087	2.034-18.217	< 0.001
Constant term	-0.910	0.230	15.148	-	-	< 0.001

2.4 预测模型的构建及价值评价

以 Lasso-Logistic 回归分析筛选出的 6 个独立预测因子(高血压、入院时 NHSS 评分、入院时 NLR、入院时 ASPECT 评分、发病至再通时间、mTICI 分级)构建预测模型，以列线图进行可视化呈现(图 2)。经 Losmer-Lemeshow 拟合优度检验显示，该预测模型的拟合度良好($\chi^2=6.174, P=0.203$)。校正曲线显示，该预测模型的校准度为 0.830，一致性指数为 0.814(图 3)。ROC 曲线显示，该预测模型预测 LVO-AIS 患者 EVT 术后 90 d 预后不良的 AUC 为 0.900 (95%CI: 0.859~0.941)，灵敏度为 85.23%，特异度为 80.36%，预测性能参数准确率、精确率、召回率、F1

值分别为 82.50%、77.32%、85.23%、81.08 分，提示该预测模型的预测价值较高(图 4)。

2.5 预测模型预测价值的外部验证

另选取本院 2024 年 1 月—2025 年 1 月就诊的 87 例 LVO-AIS 患者作为外部验证集，均行 EVT 术治疗，随访 90 d，预后良好 52 例，预后不良 35 例。ROC 曲线显示，预测模型在外部数据集中预测 EVT 术后 90 d 预后不良的 AUC 为 0.899 (95% CI: 0.858~0.941)，灵敏度为 82.86%，特异度为 80.77%，预测性能参数准确率、精确率、召回率、F1 值分别为 81.61%、74.36%、82.86%、78.38 分，证实该预测模型具有可靠的预测价值(图 5)。

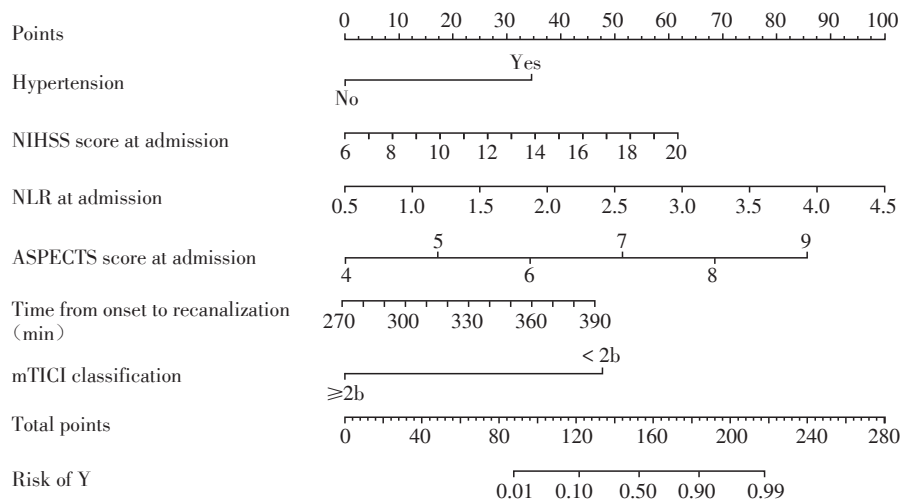


图2 预测模型的列线图

Figure 2 The nomogram of the prediction model

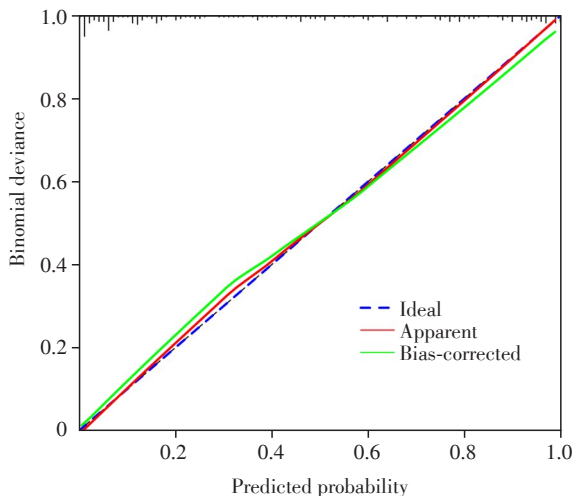


图3 预测模型的校正曲线

Figure 3 The calibration curve of the prediction model

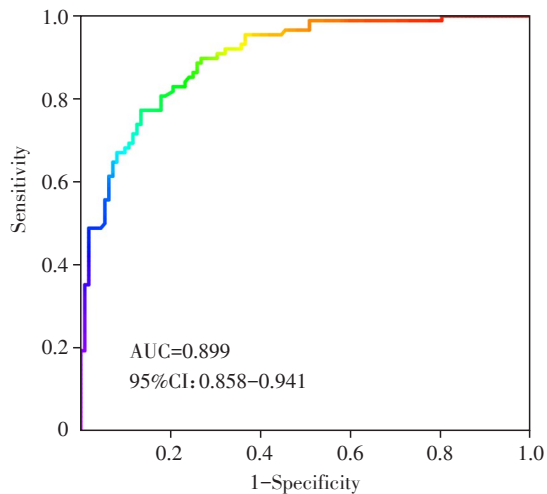


图5 外部验证的ROC曲线

Figure 5 Externally validated ROC curve

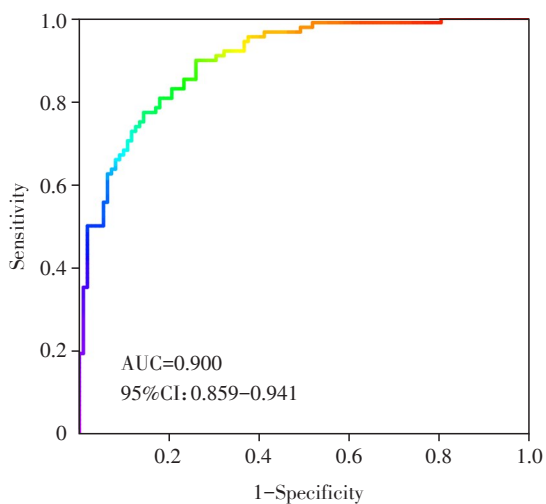


图4 预测模型的ROC曲线

Figure 4 The ROC curve of the prediction model

3 讨论

随着医疗技术的不断发展, EVT术对LVO-AIS患者血管再通率可达60%左右^[14], 是目前LVO-AIS的首选治疗方式, 但血管成功再通的LVO-AIS患者在EVT术治疗90 d后仍会出现功能恢复不佳, 影响患者预后^[15]。早期预测LVO-AIS患者EVT术后预后情况, 并在此基础上合理干预患者病情, 可在一定程度上降低预后不良发生率, 减轻患者家属及医保费用负担。

LVO-AIS患者EVT术后预后受到多种因素影响, 但在本研究分析过程中, 发现部分因素并不能影响患者EVT术后预后。其中糖尿病、高脂血症、冠心病虽然均对动脉粥样硬化及心血管不良事件发生风险存在长期影响, 但对于血管再通后的LVO-

AIS患者,三者对血管的影响较小且更缓慢^[16]。吸烟史可增加患者脑卒中风险,但对急性期疾病的直接影响较小,其主要影响LVO-AIS发病过程^[17]。而对于血管闭塞部位及多血管闭塞情况,可通过EVT术对各闭塞血管进行再通,对术后患者恢复情况影响较小。

在对临床影响因素的研究中发现,高血压、入院时NIHSS评分、入院时NLR、闭塞血管数量、入院时ASPECT评分均会影响LVO-AIS患者预后,分析原因如下:高血压会导致血管损伤,可能诱发动脉粥样硬化及血管内皮功能障碍,临床认为,高血压是急性缺血性脑卒中发生、发展的危险因素之一^[18-19],尤其是长期高血压可能导致EVT术后发生远端栓塞,而控制LVO-AIS患者血压可在一定程度上预防EVT术后的出血转化,故高血压与患者EVT术后预后有关^[20]。然而,作为回顾性研究,本研究未能获取术前动态血压和术后高频连续血压监测数据,仅基于现有数据将高血压作为影响因素进行了初步分析,未来前瞻性研究应优先考虑系统地收集术前24 h动态血压监测数据及取栓术后至少24 h内血压波动情况,以精确量化血压变异性,并建立更优化的个体化术后血压管理目标。NIHSS评分通过评价患者意识水平、视野等情况来评估LVO-AIS患者神经功能缺损程度。有学者指出,神经功能缺损程度与患者体内血管堵塞程度有关,故可通过NIHSS评分评估患者病情程度及侧支循环情况,以预测患者预后^[21-22]。NLR值是临床常用炎性指标,可反映机体炎症水平状态,入院时NLR水平异常升高可能意味着LVO-AIS患者脑组织损伤较严重,导致临床预后较差^[23]。闭塞血管数量与患者病灶范围有关,本研究发现,闭塞血管数量影响患者预后,推测闭塞血管数量越多,梗死范围越大;但梗死范围并不只受闭塞血管数量影响,其侧支循环的代偿能力也是极为重要的调节因素之一,即使存在较多的血管闭塞,良好的侧支循环也可在一定程度上维持缺血区的血流灌注,限制梗死核心扩大,但如果主要闭塞血管的侧支代偿较差,也会因为血流中断导致大面积梗死,影响患者预后^[24]。在评估LVO-AIS患者预后的过程中,除了需要关注血管闭塞数量外,还应该结合侧支循环情况进行综合判断。ASPECT评分是基于CT检查中水分子成像进行的脑组织情况评分,可半定量评估脑梗死体积,并在一定程度上预测急性缺血性脑卒中患者早期神经功能恶化情况^[25-26]。ASPECT评分降低的患者侧支

循环代偿功能较差,其中侧支循环异常可能导致半暗带脑组织血供异常,并加剧组织缺血坏死程度,扩大病灶,造成预后不良风险升高^[27-28]。故临床应重点关注合并高血压,且入院时NIHSS评分、入院时NLR水平较高,闭塞血管数量较多,ASPECT评分异常降低的患者,早期评估患者病情,并制定针对性治疗方案,尽可能改善患者预后。

在患者术前术后治疗过程中,发现预后不良组发病至手术时间、发病至再通时间长于预后良好组,mTICI分级 $\geq 2b$ 级比例低于预后良好组。患者接受手术、血管再通时间越长,脑组织缺血缺氧的时间也越长,可诱导大量神经元死亡,加剧患者脑缺损^[29-30]。mTICI分级是评价患者脑血管再通情况的指标,而再通效果越好,提示脑组织供血恢复情况越好,患者mTICI分级越高^[31-32]。故缩短发病至手术时间、发病至再通时间、提高mTICI分级,可在一定程度上降低EVT术后患者预后不良的发生风险。在临床工作中,可基于上述相关指标优化救治流程,以在此基础上改善患者神经恢复情况、降低患者预后不良发生风险,保障患者生命健康安全。

本研究主要探讨了临床因素与治疗相关指标对预后的影响,但患者术后90 d预后情况受多种因素的影响,除了与上述因素有关外,还与取栓术后的长期管理与康复情况有关。规范的术后药物治疗是二级预防的基石,所有再通患者均需依据病因、病情等接受个性化抗凝或抗血小板治疗,以及高强度他汀治疗,以此稳定斑块、预防病情复发。同时,积极管理高血压、高血糖、心脏病等基础疾病对改善长期预后也至关重要。而早期、持续且系统的康复治疗是神经功能恢复的核心,通过有效康复训练可最大限度减少残疾对患者的影响,康复治疗的强度、开始时间和持续时间均为影响患者恢复程度的重要因素。同时,对并发症的预防、营养支持、患者社会心理状态及家庭支持程度也会在一定程度上影响患者预后。因此,成功的血管再通是前提,围手术期血压管理是保障,通过规范的二级预防和积极康复训练可实现患者长期功能独立。

本研究结果还显示,高血压、入院时NIHSS评分、入院时NLR、闭塞血管数量、入院时ASPECT评分、发病至手术时间、发病至再通时间、mTICI分级等8个因素均为患者预后的影响因素。基于上述研究,本研究创新性地通过Lasso回归对因子进行筛选,并以Logistic回归构建联合模型,结果显示,经Lasso筛选出的预测因子为高血压、入院时NIHSS评

分、入院时 NLR、入院时 ASPECT 评分、发病至再通时间、mTICI 分级, 基于 Logistic 构建的回归模型经价值评价和外部验证发现, 该模型拟合度良好, 且预测价值较高, 可为临床预测 LVO-AIS 患者 EVT 术后 90 d 预后提供参考。

综上所述, 临床因素高血压、入院时 NHISS 评分、入院时 NLR、入院时 ASPECT 评分及治疗相关指标发病至再通时间、mTICI 分级均与 LVO-AIS 患者 EVT 术后 90 d 预后有关, 基于各指标构建的 Logistic 回归模型具有较好的拟合度及预测价值, 可为临床预测 EVT 术后 90 d 预后提供参考。与其他研究相比, 本研究未局限于单一临床评分或使用血清学指标预测患者预后, 而是由患者自身病情出发, 选取相关影响因素预测预后, 希望未来能够开展前瞻性研究, 以协助本研究结果应用于临床。

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李圆圆负责研究设计、数据收集、数据分析、论文撰写全过程深度参与; 杨杨参与制定研究计划、论文撰写以及对整个研究工作负责; 李万春、冯文献负责数据分析指导及论文撰写指导; 康霞、李丹负责部分样本数据分析。

Author's Contributions:

LI Yuanyuan was deeply involved in the whole process of study design, data collection, data analysis, and paper writing; YANG Yang participated in research planning, paper writing, and oversaw the entire research work; LI Wanchun and FENG Wenxian were responsible for guidance of data analysis and paper writing; KANG Xia and LI Dan were responsible for part of sample data analysis.

参考文献

- [1] KAESMACHER J, CAVALCANTE F, KAPPELHOF M, et al. Time to treatment with intravenous thrombolysis before thrombectomy and functional outcomes in acute ischemic stroke: a meta-analysis [J]. *JAMA*, 2024, 331(9): 764-777
- [2] GAO F, TONG X, JIA B X, et al. Bailout intracranial angioplasty or stenting following thrombectomy for acute large vessel occlusion in China (ANGEL-REBOOT): a multicentre, open-label, blinded-endpoint, randomised controlled trial [J]. *Lancet Neurol*, 2024, 23(8): 797-806
- [3] SANTOS A C F F, COELHO L L S, CALDAS G C, et al. General anesthesia versus conscious sedation in mechanical thrombectomy for patients with acute ischemic stroke: systematic review and meta-analysis [J]. *Arq Neuropsiquiatr*, 2024, 82(4): 1-7
- [4] LAN X Y, LI D, CUI Y, et al. Proteomic analysis of jugular venous blood in acute large vessel occlusion stroke with futile recanalization [J]. *J Cereb Blood Flow Metab*, 2024, 44(5): 702-711
- [5] GALECIO-CASTILLO M, FAROOQUI M, GUERRERO W R, et al. Endovascular treatment of patients with acute ischemic stroke with tandem lesions presenting with low Alberta stroke program early computed tomography score [J]. *J Am Heart Assoc*, 2024, 13(22): e035977
- [6] JIANG P, ZHANG S, YU W T, et al. Late endovascular treatment for ischemic stroke with moderate to large infarct volume is associated with a better clinical prognosis [J]. *Curr Neurovasc Res*, 2025, 21(5): 564-573
- [7] SIEGLER J E, KONERU M, QURESHI M M, et al. CLEAR thrombectomy score: an index to estimate the probability of good functional outcome with or without endovascular treatment in the late window for anterior circulation occlusion [J]. *J Am Heart Assoc*, 2024, 13(14): e034948
- [8] CHENG X Q, CAI W, LI C Y, et al. Imaging-based brain frailty predicts unfavorable outcomes in acute ischemic stroke [J]. *J Am Heart Assoc*, 2025, 14(12): e039790
- [9] 中华医学会神经病学分会, 中华医学会神经病学分会脑血管病学组, 中华医学会神经病学分会神经血管介入协作组. 中国急性缺血性脑卒中早期血管内介入诊疗指南 2018 [J]. *中华神经科杂志*, 2018, 51(9): 683-691
The Neurology Branch of the Chinese Medical Association, the Cerebrovascular Disease Group of the Neurology Branch of the Chinese Medical Association, the Neurovascular Intervention Collaboration Group of the Neurology Branch of the Chinese Medical Association. Guidelines for early intravascular intervention diagnosis and treatment of acute ischemic stroke in China 2018 [J]. *Chinese Journal of Neurology*, 2018, 51(9): 683-691
- [10] BU J Y, HAN X F, WU Y K, et al. Correlation between asymmetrical vein sign of SWI and long-term clinical outcomes in patients with middle cerebral artery ischemic stroke [J]. *Jpn J Radiol*, 2024, 42(10): 1122-1129
- [11] KNOTT M, HOELTER P, HOCK S, et al. Can flat-detector CT after successful endovascular treatment predict long-term outcome in patients with large vessel occlusion? An Alberta stroke programme early CT score-based study [J]. *Neurol Sci*, 2023, 44(4): 1193-1200
- [12] ELAWADY S S, SAWAY B F, MATSUKAWA H, et al. Thrombectomy in stroke patients with low Alberta stroke program early computed tomography score: is modified

- thrombolysis in cerebral infarction (mTICI) 2c/3 superior to mTICI 2b? [J]. *J Stroke*, 2024, 26(1): 95–103
- [13] NOBELS-JANSSEN E, POSTMA E N, ABMA I L, et al. Inter-method reliability of the modified Rankin scale in patients with subarachnoid hemorrhage [J]. *J Neurol*, 2022, 269(5): 2734–2742
- [14] GALECIO - CASTILLO M, QUISPE - OROZCO D, FAROOQUI M, et al. Association between intraprocedural drops in blood pressure and infarct growth rate patterns after acute large - vessel occlusions [J]. *J Neurointerv Surg*, 2024, 16(12): 1275–1281
- [15] BHAYANA K, HANDSHOE J W, LI Y D, et al. Effect of stroke etiology on treatment-related outcomes in young adults with large vessel occlusion: results from a retrospective cohort study [J]. *J Stroke Cerebrovasc Dis*, 2024, 33(12): 108027
- [16] DE ISLA L P, VALLEJO-VAZ A J, WATTS G F, et al. Long-term sex differences in atherosclerotic cardiovascular disease in individuals with heterozygous familial hypercholesterolaemia in Spain: a study using data from SAFEHEART, a nationwide, multicentre, prospective cohort study [J]. *Lancet Diabetes Endocrinol*, 2024, 12(9): 643–652
- [17] HELGASON H, EIRIKSDOTTIR T, ULFARSSON M O, et al. Evaluation of large-scale proteomics for prediction of cardiovascular events [J]. *JAMA*, 2023, 330(8): 725–735
- [18] 毕美玲, 杨彦立. 硝苯地平控释片联合盐酸贝那普利片治疗老年高血压临床效果的研究进展 [J]. *临床误诊误治*, 2024, 37(19): 90–93
- BI M L, YANG Y L. Research progress on the clinical efficacy of nifedipine controlled-release tablets combined with benazepril hydrochloride tablets in the treatment of elderly hypertension [J]. *Clinical Misdiagnosis and Mistreatment*, 2024, 37(19): 90–93
- [19] SARZANI R, SPANNELLA F, DI PENTIMA C, et al. Molecular therapies in cardiovascular diseases: small interfering RNA in atherosclerosis, heart failure, and hypertension [J]. *Int J Mol Sci*, 2023, 25(1): 328
- [20] CHARCHAR F J, PRESTES P R, MILLS C, et al. Lifestyle management of hypertension: International Society of Hypertension position paper endorsed by the World Hypertension League and European Society of Hypertension [J]. *J Hypertens*, 2024, 42(1): 23–49
- [21] MATSUKAWA S, GO K, YANG T, et al. Low NIHSS score large vessel occlusion caused by infective endocarditis treated with thrombectomy [J]. *J Stroke Cerebrovasc Dis*, 2023, 32(2): 106915
- [22] WANG L Y, LI G S, HAO Y H, et al. Intravenous thrombolysis for mild stroke: NIHSS 3–5 versus NIHSS 0–2 [J]. *J Stroke Cerebrovasc Dis*, 2023, 32(5): 107070
- [23] ZHU B T, LIU Y X, LIU W W, et al. Association of neutrophil-to-lymphocyte ratio with all-cause and cardiovascular mortality in CVD patients with diabetes or pre-diabetes [J]. *Sci Rep*, 2024, 14(1): 24324
- [24] BEARD D J, BROWN L S, MORRIS G P, et al. Rapamycin treatment reduces brain pericyte constriction in ischemic stroke [J]. *Transl Stroke Res*, 2025, 16(4): 1185–1197
- [25] ALSBROOK D L, HEIFERMAN D M, DORNBOS D, et al. External validation of TICI-ASPECTS-glucose score as a predictive model for symptomatic intracranial hemorrhage following mechanical thrombectomy [J]. *J Stroke Cerebrovasc Dis*, 2022, 31(11): 106796
- [26] SARRAJ A, HASSAN A E, ABRAHAM M G, et al. Endovascular thrombectomy for large ischemic stroke across ischemic injury and penumbra profiles [J]. *JAMA*, 2024, 331(9): 750–763
- [27] PENSATO U, BOSSHART S L, STEBNER A, et al. Comparison of noncontrast computed tomography, multiphase computed tomography angiography, and computed tomography perfusion to assess infarct growth rate in acute stroke [J]. *Stroke*, 2025, 56(3): 657–666
- [28] WANG Y C, CHANG H, BAI P, et al. Evaluation of contralateral arterial flow compensation using transcranial Doppler in acute internal carotid artery occlusion and implications for neurological outcome [J]. *Sci Rep*, 2025, 15(1): 2998
- [29] TUDORACHE R, KOSSOROTOFF M, KERLEROUX B, et al. Determinants of timely access to recanalization treatments and outcomes in pediatric ischemic stroke [J]. *Stroke*, 2024, 55(11): 2716–2719
- [30] HA S H, RYU J C, BAE J H, et al. Early response to endovascular thrombectomy after stroke: early, late, and very late time windows [J]. *Cerebrovasc Dis*, 2023, 52(1): 28–35
- [31] WANG L R, LI B H, ZHANG Q, et al. Predictors of futile recanalization after endovascular treatment of acute ischemic stroke [J]. *BMC Neurol*, 2024, 24(1): 207
- [32] HOSHINO T, SATO S, KUSHI K, et al. Tortuosity of middle cerebral artery M1 segment and outcomes after mechanical thrombectomy [J]. *Interv Neuroradiol*, 2024, 30(2): 154–162

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