·临床研究·

肺癌根治术后老年患者营养不良的影响因素及 Nomogram 预测模型的构建与评价

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【摘 要】 **目的** 探讨肺癌根治术后老年患者发生营养不良的影响因素,构建 Nomogram 风险预测模型,为临床早期采取干预措施提供参考。**方法** 选择2023年1月至2024年4月于山西省运城市中心医院行肺癌根治术、术后存在营养不良的124例老年肺癌患者为研究对象,按患者性别、年龄行频数匹配,再选择同期无营养不良的131例老年肺癌患者为研究对象,对患者进行问卷调查[营养风险筛查2002(NRS2002)量表、社会支持评定量表(SSRS)及家庭功能评定量表(FAD)]。采用SPSS 27.0统计软件进行数据分析。根据数据类型,分别采用 t 检验、χ^2 检验或 Ridit 分析进行组间比较。采用多因素 logistic 回归模型分析术后营养不良发生的影响因素。进一步构建 Nomogram 预测模型,以受试者工作特征(ROC)曲线、决策曲线(DCA)、校准曲线对预测模型的预测价值和临床效用进行评价。**结果** 共发放问卷255份,有效回收230份,有效回收率为90.20%。其中,营养不良组112例,无营养不良组118例。两组患者 NRS2002 评分、术后早期营养支持、总蛋白、白蛋白、血红蛋白、体质量指数(BMI)、年龄、第三腰骨骼肌指数(L3-SMI)、SSRS 评分及 FAD 评分比较,差异有统计学意义($P<0.05$)。多因素 logistic 回归分析显示,NRS2002 评分及年龄是老年肺癌患者肺癌根治术后发生营养不良的危险因素;术后早期营养支持、白蛋白、BMI、L3-SMI、SSRS 评分及 FAD 评分是其保护因素。构建 Nomogram 预测模型,ROC 曲线分析显示,此模型预测营养不良的曲线下面积(AUC)为0.885;DCA 及校准曲线分析显示,校准曲线和理想曲线拟合良好,根据模型进行风险评估具有良好的临床净收益。**结论** NRS2002 评分、年龄、术后早期营养支持、白蛋白、BMI、L3-SMI、SSRS 评分及 FAD 评分是肺癌根治术后老年患者营养不良的独立影响因素,基于上述指标构建 Nomogram 预测模型具有较好的预测效能及临床效用,可为临床预测术后营养不良风险提供参考。

【关键词】 老年人;肺癌根治术;营养不良;Nomogram 模型;预测价值
【中图分类号】 R459.3 【文献标志码】 A 【DOI】 10.11915/j.issn.1671-5403.2025.09.146

Influencing factors of malnutrition in elderly patients after radical surgery for lung cancer and construction and evaluation of a nomogram prediction model

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【**Abstract**】 **Objective** To explore the influencing factors of malnutrition in elderly patients after radical lung cancer surgery, and then construct a Nomogram risk prediction model to provide reference for early clinical intervention measures. **Methods** A total of 124 elderly lung cancer patients who underwent radical surgery in our hospital from January 2023 to April 2024 and were found to be malnourished postoperatively were enrolled in this study. Frequency matching was performed based on patient's gender and age, and another 131 elderly lung cancer patients without malnutrition during the same period were recruited. Questionnaires, including nutritional risk screening 2002 (NRS2002) scale, social support rating scale (SSRS) and family functioning assessment device (FAD), were employed to survey all the participants. SPSS statistics 27.0 was used for data analysis. Depending on data type, t test, χ^2 test or Ridit analysis was utilized for comparison between groups. Multivariate logistic regression analysis was conducted to identify the influencing factors of postoperative malnutrition. Subsequently, a Nomogram prediction model was constructed, and the predictive value and clinical utility of the prediction model were evaluated using receiver operating characteristic (ROC) curve, decision curve analysis (DCA), and calibration curves. **Results** A total of 255 questionnaires were distributed, and 230 were validly recovered, with an effective recovery rate of 90.20%. Among them, there were 112 cases in the malnourished group and 118 cases in the non-malnourished group.

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Statistical differences were observed between the two groups in terms of NRS2002 scores, early postoperative nutritional support, total protein, albumin, hemoglobin, body mass index (BMI), age, L3 skeletal muscle index (L3-SMI), SSRS score, and FAD score (P<0.05). Multivariate logistic regression analysis revealed that NRS2002 score and age were risk factors for malnutrition in elderly patients after radical surgery of lung cancer, while early postoperative nutritional support, albumin, BMI, L3-SMI, and SSRS and FAD scores were protective factors. ROC analysis showed that the area under the curve (AUC) of this Nomogram prediction model for predicting malnutrition was 0.885. DCA and calibration curve analysis showed that the calibration curve fitted well with the ideal curve, and risk assessment based on the model had good clinical net benefit. **Conclusion** NRS2002 score, age, early postoperative nutritional support, albumin, BMI, L3-SMI, and SSRS and FAD scores are independent influencing factors for malnutrition in elderly patients after radical surgery for lung cancer. Our constructed Nomogram prediction model based on these indicators exhibits good predictive performance and clinical utility, providing a reference for predicting postoperative malnutrition risk in clinical practice.

【Key words】 aged; radical resection of lung cancer; malnutrition; Nomogram model; predictive value

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肺癌居全球肿瘤发病率首位,病死率高,根治手术是其重要干预手段[1]。营养不良指蛋白质等营养摄入不足或消耗增加导致机体营养素失衡的病理状态,临床以消瘦、免疫力下降等为主要表现。老年患者由于身体机能较差,肺癌根治术后营养不良发生风险较高,由此造成患者出现术后恢复慢、并发症发生率增加等状况[2]。早期预测术后是否发生营养不良,并积极制定个性化应对措施,对行肺癌根治术的老年患者极为重要。既往研究显示,营养风险筛查2002(nutritional risk screening 2002, NRS2002)评分等对肺癌非手术患者营养不良状况具有一定的评估价值[3]。目前已有关于老年患者发生营养不良的风险因素及行为干预的研究,但风险因素覆盖不全,因此本研究纳入更多指标,以分析肺癌根治术后老年患者发生营养不良的影响因素。

1 对象与方法

1.1 研究对象

选择2023年1月至2024年4月于山西省运城市中心医院行肺癌根治术、术后存在营养不良的124例老年肺癌患者为研究对象。按性别、年龄(±3岁)行频数匹配,再选取同期无营养不良的131例老年肺癌患者为研究对象。纳入标准:(1)符合原发性肺癌诊断标准[4];(2)首次确诊,行肺癌根治手术。排除标准:(1)合并其他恶性肿瘤;(2)合并严重感染性疾病;(3)合并自身免疫缺陷及循环系统疾病;(4)合并严重精神、行为障碍;(5)术后未进行病理检查;(6)其他重要器官损伤。脱落标准:(1)自行退出本研究;(2)失联或意外死亡。患者及家属对研究方案知情且签署知情同意书。本研究已通过本院医学伦理委员会批准(YXLL2024163)。

1.2 方法

1.2.1 资料收集 以查阅医院电子病历信息、调查问卷形式收集患者资料,包括性别、年龄、体质量指数(body mass index, BMI)、婚姻状况、居住地、吸烟史、饮酒史、糖尿病、高血压、病理类型、临床分期、手术方式、NRS2002评分、家庭功能评定量表(family assessment device, FAD)评分、社会支持评定量表(social support rating scale, SSRS)评分、总蛋白、白蛋白、血红蛋白、手术时间、第三腰骨骼肌指数(L3 skeletal muscle index, L3-SMI)、术后早期营养支持等。

1.2.2 营养状态判定标准[5] 术后3个月,根据营养不良诊断标准进行营养状态判定。营养不良需符合以下至少1项:(1)BMI<18.5 kg/m^2;(2)三头肌皮褶厚度:女性<20 mm,男性<10 mm;(3)上臂肌围(arm muscle circumference, AMC)<正常值90%(AMC正常范围:女性20.9~25.5 cm,男性22.8~27.8 cm);(4)白蛋白<35 g/L;(5)前白蛋白<200 mg/L。

1.3 统计学处理

采用SPSS 27.0统计软件进行数据分析。计量资料以均数±标准差($\bar{x}\pm s$)表示,组间比较采用t检验。计数资料以例数(百分率)表示,组间比较采用χ^2检验。等级资料采用Ridit分析。采用多因素logistic回归模型分析术后营养不良发生的影响因素,构建发生营养不良的Nomogram风险预测模型,采用受试者工作特征(receiver operating characteristic, ROC)曲线、决策曲线(decision curve analysis, DCA)及校准曲线评价该模型的预测效能。P<0.05为差异有统计学意义。

2 结 果

2.1 两组患者临床资料

本研究共发放问卷255份,截至调查问卷回收完成,有效回收230份,有效回收率为90.20%。其中,营养不良组112例,无营养不良组118例。两组患者NRS2002评分、术后早期营养支持、总蛋白、白蛋白、血红蛋白、BMI、年龄、L3-SMI、SSRS及FAD评分比较,差异有统计学意义(P<0.05;表1)。

表 1 两组患者临床资料比较

Table 1 Comparison of clinical data between two groups

Item	Malnourished group(n=112)	Non-malnourished group(n=118)	$t/u/\chi^2$	P value
Gender[n(%)]			0.369	0.543
Male	62(55.36)	70(59.32)		
Female	50(44.64)	48(40.68)		
Marital status[n(%)]			0.405	0.525
Married	92(82.14)	93(78.81)		
Unmarried/divorced/widowed	20(17.86)	25(21.19)		
Place of residence[n(%)]			0.383	0.536
Rural	52(46.43)	50(42.37)		
Urban	60(53.57)	68(57.63)		
Smoking[n(%)]	39(34.82)	45(38.14)	0.272	0.602
Alcohol drinking[n(%)]	46(41.07)	53(44.92)	0.346	0.556
Diabetes mellitus[n(%)]	43(38.39)	41(34.75)	0.330	0.566
Hypertension[n(%)]	51(45.54)	58(49.15)	0.301	0.583
Pathological type[n(%)]			0.515	0.773
Adenocarcinoma	72(64.29)	80(67.80)		
Squamous carcinoma	31(27.68)	31(26.27)		
Other	9(8.03)	7(5.93)		
Clinical stage[n(%)]			0.541	0.589
Phase Ⅰ	41(36.61)	47(39.83)		
Phase Ⅱ	49(43.75)	51(43.22)		
Phase Ⅲ	22(19.64)	20(16.95)		
Mode of operation[n(%)]			0.519	0.471
Thoracoscopic segmental resection	46(41.07)	43(36.44)		
Thoracoscopic lobectomy	66(58.93)	75(63.56)		
NRS2002[n(%)]			10.494	0.001
<3 points	72(64.29)	98(83.05)		
≥3 points	40(35.71)	20(16.95)		
Early postoperative nutritional support[n(%)]	77(68.75)	97(82.20)	5.646	0.017
Total protein(g/L, $\bar{x}\pm s$)	56.35±5.00	64.78±7.25	10.310	<0.001
Albumin(g/L, $\bar{x}\pm s$)	31.29±3.62	38.65±3.18	16.347	<0.001
Hemoglobin(g/L, $\bar{x}\pm s$)	103.25±16.85	117.69±19.54	6.011	<0.001
Operation time(min, $\bar{x}\pm s$)	141.35±24.52	136.89±20.12	1.504	0.134
BMI(kg/m^2, $\bar{x}\pm s$)	21.02±1.18	23.65±1.25	16.414	<0.001
Age(years, $\bar{x}\pm s$)	69.54±3.25	65.21±2.11	11.916	<0.001
L 3-SMI(cm^2/m^2, $\bar{x}\pm s$)	38.96±3.57	51.24±5.32	20.651	<0.001
SSRS(points, $\bar{x}\pm s$)	21.32±3.24	33.58±4.10	25.228	<0.001
FAD(points, $\bar{x}\pm s$)	2.65±0.69	3.24±0.72	6.346	<0.001

NRS2002: nutritional risk screening 2002; BMI: body mass index; L 3-SMI: L3 skeletal muscle index; SSRS: social support rating scale; FAD: family assessment device.

2.2 肺癌根治术后老年患者营养不良的多因素 logistic 回归分析

将单因素分析中有意义的变量作为自变量，行多重共线性检验。结果发现，上述自变量的容忍度>0.1，方差膨胀因子均与 1 接近，不存在共线性，可进入 logistic 回归分析(表 2)。经上述分析差异有统计学意义的因素有：NRS2002 评分(<3 分=0，≥3 分=1)、术后早期营养支持(无=0，有=1)及总蛋白、白蛋白、血红蛋白、BMI、年龄、L3-SMI、SSRS 评分、FAD 评分(均原值输入)，将肺癌根治术后老年患者无营养不良组(赋值 0)和营养不良组(赋值 1)作为因变量，纳入多因素 logistic 回归方程，结果显示，NRS2002 评分及年龄是肺癌根治术后老年患者营养不良的危险因素；术后早期营养支持、白蛋白、BMI、L 3-SMI、SSRS 评分及 FAD 评分是肺癌根治术后老年患者营养不良的保护因素(P<0.05；表 3)。

表 2 患者营养不良影响因素的多重共线性检验

Table 2 Multiple covariance test for factors affecting malnutrition in patients

Variable		TOL	VIF
X_1	NRS2002 rating	0.796	1.218
X_2	Early postoperative nutritional support	0.812	1.147
X_3	Total protein	0.658	1.532
X_4	Albumin	0.749	1.336
X_5	Hemoglobin	0.663	1.601
X_6	BMI	0.569	1.718
X_7	Age	0.718	1.410
X_8	L 3-SMI	0.932	1.032
X_9	SSRS	0.754	1.310
X_{10}	FAD	0.629	1.632

NRS2002: nutritional risk screening 2002; BMI: body mass index; L 3-SMI: L3 skeletal muscle index; SSRS: social support rating scale; FAD: family assessment device.

表3 患者营养不良的多因素 logistic 回归分析

Table 3 Multifactorial logistic regression analysis of malnutrition in patients

Variable	β	*SE*	*Wald* χ^2	*OR*	95%*CI*		*P* value
					Upper limit	Lower limit	
Constant	−2.574	0.518	26.325	−	−	−	<0.001
NRS2002	1.714	0.358	22.924	5.552	2.262	13.625	<0.001
Early postoperative nutritional support	−0.825	0.326	6.407	0.438	0.235	0.817	<0.05
Albumin	−0.686	0.233	8.665	0.504	0.365	0.695	<0.001
BMI	−0.967	0.143	45.744	0.380	0.201	0.719	<0.001
Age	1.513	0.295	26.293	4.539	3.257	6.325	<0.001
L 3-SMI	−0.902	0.319	8.003	0.406	0.236	0.697	<0.001
SSRS	−0.532	0.214	6.177	0.588	0.408	0.846	<0.05
FAD	−1.074	0.363	8.750	0.342	0.135	0.865	<0.001

NRS2002: nutritional risk screening 2002; BMI: body mass index; L3-SMI: L3 skeletal muscle index; SSRS: social support rating scale; FAD: family assessment device.

2.3 Nomogram 预测模型的构建与验证

将多因素 logistic 回归分析中筛选出的影响因素纳入 Nomogram 预测模型，以 R3.6.3 软件构建营养不良个体化 Nomogram 预测模型（图 1）。绘制 Nomogram 预测模型预测肺癌根治术后老年患者营养不良的 ROC 曲线，由结果得知，此模型预测老年患者营养不良的曲线下面积（area under the curve，AUC）为 0.885（95%*CI* 0.843～0.927）。详见图 2。以 7∶3的比例选取本院肺癌根治术后老年患者99 例作为外部验证组，对肺癌根治术后老年患者营养不良Nomogram 预测模型进行评价及外部验证，其中营养不良 48 例，无营养不良 51 例。设置因变量无营养不良组和营养不良组，自变量为构建 Nomogram 预测模型风险总分进行 DCA 及校准曲线分析，结果显示，校准曲线和理想曲线拟合良好，训练集 Hosmer-Lemeshow 拟合优度检验 χ^2 = 8.659，*P*=0.578，验证集 χ^2 = 11.249，*P* = 0.436，提示 Nomogram 预测模型具有良好的校准能力（图 3）。DCA 曲线显示根据模型进行风险评估可获取良好临床净收益（图 4）。

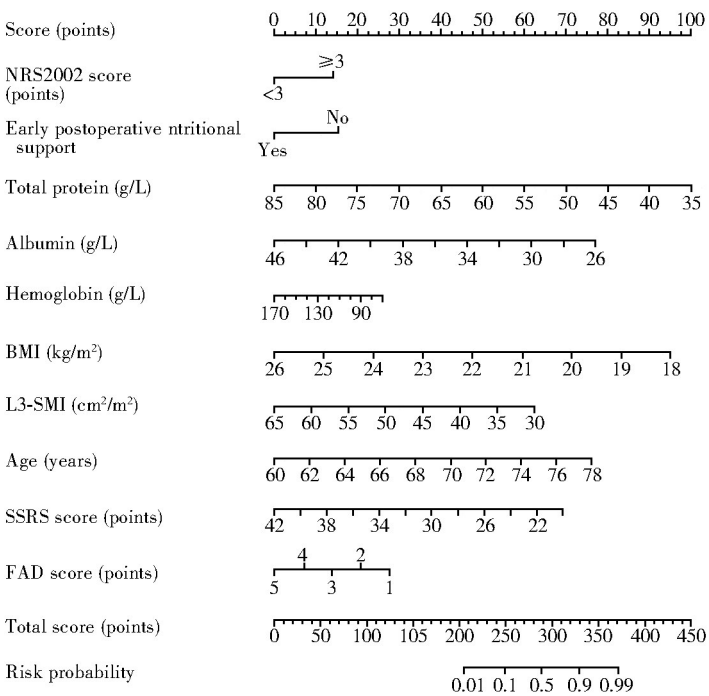


图1 Nomogram 预测模型

Figure 1 Nomogram prediction model

NRS2002: nutritional risk screening 2002; BMI: body mass index; L3-SMI: L3 skeletal muscle index; SSRS: social support rating scale; FAD: family assessment device.

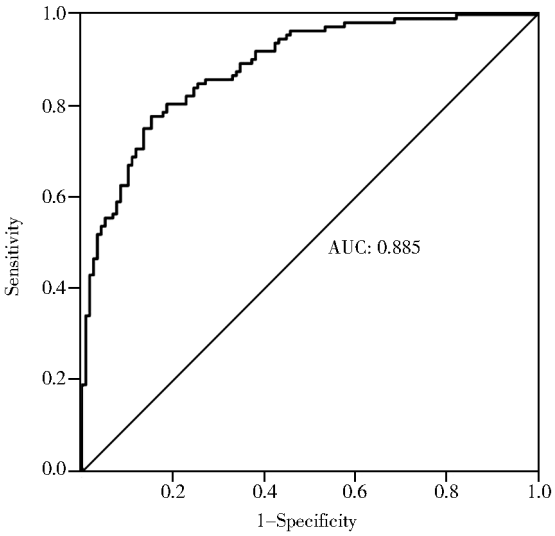


图 2 ROC 曲线验证

Figure 2 ROC curve verification

ROC: receiver operating characteristic.

3 讨 论

本研究结果显示，NRS2002 评分及年龄是肺癌根治术后老年患者营养不良的危险因素，术后早期营养支持、白蛋白、BMI、L3-SMI、SSRS 评分及 FAD 评分是其保护因素，临床医师应重点关注上述因素。NRS2002 量表为营养筛查工具，通过患者近期体质量变化、年龄、疾病等与营养支持的关系进行综合评分，可较准确判断是否存在营养风险，更突出患者营养状态与治疗结局的关系[6]。本研究中营养不良组平均年龄较高，与许静涌等[7]研究结果相似。究其原因，随年龄增长，机体代谢功能及器官代偿恢复功能逐渐下降，且味觉老化、活动力较弱等使老年人进食减少，增加了营养不良风险[8]，与陈丽如等[9]研究观点一致。肺癌根治术创伤大，营养物质合成减少，肌肉蛋白分解增加，而术后营养支持可尽早提供较全面的营养制剂，

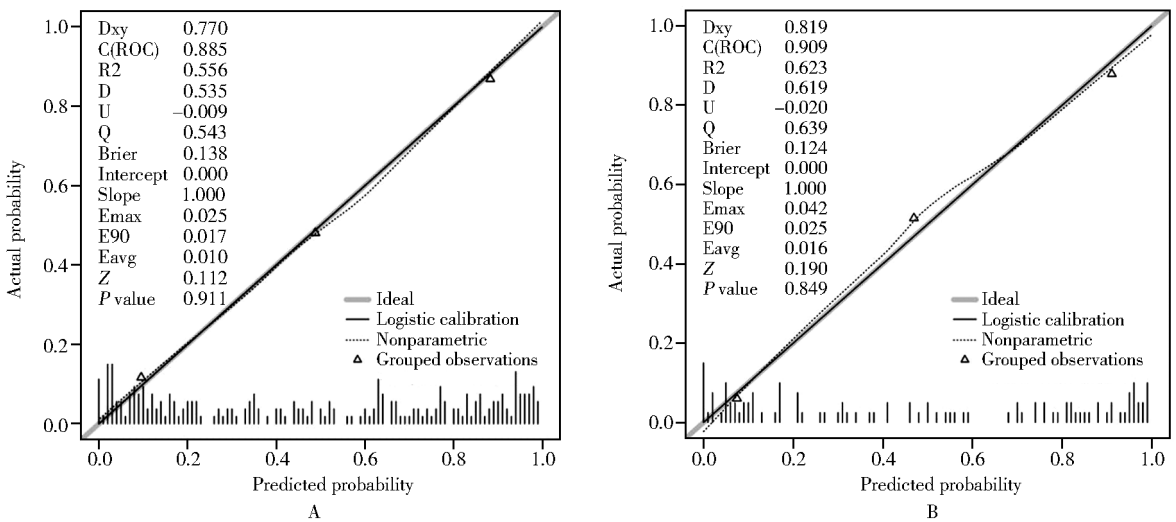


图 3 Nomogram 预测模型的校准曲线

Figure 3 Calibration curve of Nomogram prediction model

A: calibration curve for model building group; B: calibration curve of external validation group.Dxy: discrimination index; C: concordance index; ROC: receiver operating characteristic; R2: coefficient of determination; D: discrimination slope; U: unreliability index; Q: quality index; Emax: maximum calibration error; E90: 90th percentile calibration error; Eavg: average calibration error.

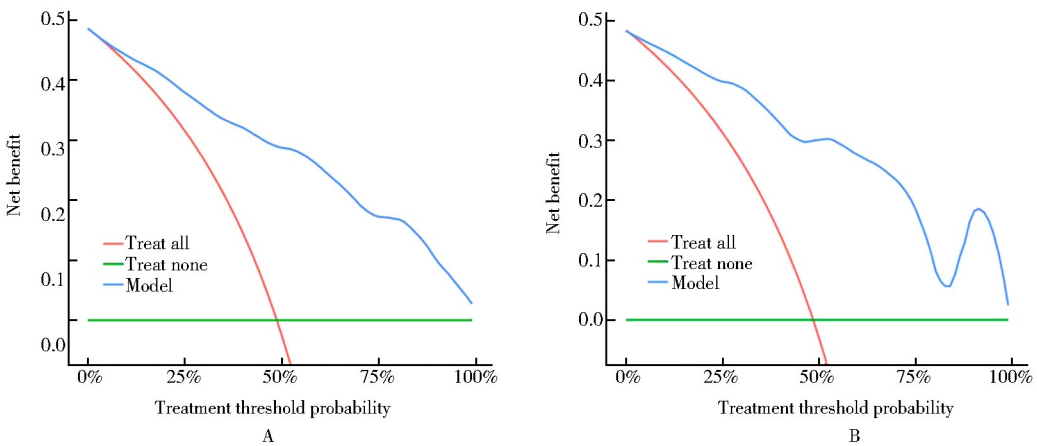


图 4 Nomogram 预测模型的 DCA 曲线

Figure 4 DCA curve of Nomogram prediction model

A: DCA curve of model building group; B: DCA curve of external validation group. DCA: decision curve analysis.

可增强机体免疫力、降低术后营养不良的发生率[10]。白蛋白可辅助评估营养状态及代谢功能,但由于半衰期较长,其评估营养不良的敏感度较低。蛋白质不足可导致免疫细胞减少、抵抗力下降、组织修复及抗感染能力减弱,患者对后续放、化疗耐受能力较差[11]。BMI是反映人体胖瘦程度、衡量总体营养状态的国际通用指标,其水平低于18.5 kg/m^{2}即可评定为营养不良[12]。肺癌可引发骨骼肌数量、质量病理性减少,L3-SMI可评估L3椎体旁肌肉质量,判断全身肌肉减少情况,为肿瘤患者整体营养与预后评估提供重要信息[13]。SSRS评分主要反映患者社会支持水平,FAD评分反映家庭支持度,而家庭、社会作为患者基础生活环境精神慰藉来源,若支持水平较低,可导致患者精神抑郁、食欲下降,进而加重营养不良[14,15]。

本研究进一步构建Nomogram预测模型,ROC分析显示,此模型预测营养不良的AUC为0.885,验证结果显示该模型具有良好的预测效能及临床净收益。建议临床关注老年肺癌患者术后生存质量,重视上述影响因素的变化,这有助于早期预测术后营养不良的发生风险,并可根据预测结果制定针对性营养支持方案,对保障患者营养状态、促进术后恢复、改善预后具有重要意义。

综上所述,NRS2002评分、年龄、术后早期营养支持、白蛋白、BMI、L3-SMI、SSRS评分及FAD评分是肺癌根治术后老年患者营养不良的独立影响因素,基于上述指标构建Nomogram预测模型具有较好的预测效能及临床净收益,可为临床早期预测术后营养不良提供参考。本研究仍存在一定不足,如根据多因素logistic回归分析结果拟合术后营养不良风险预测模型,结合相关截断值可判断营养不良发生风险,但未形成风险评估量表,难以实现风险分级管理,未来有待针对不同病情程度患者进行分层预警研究,以期为临床防治工作提供更多依据。

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