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MAR与ACS患者冠脉病变严重程度的相关性研究

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摘　要

目的：探讨单核细胞/白蛋白比值(monocyte-to-albumin ratio, MAR)与急性冠脉综合征(acute coronary syndrome, ACS)患者冠脉病变严重程度的相关性，并评估其辅助分层评估的价值。方法：纳入4234例ACS患者，根据Gensini评分中位数将患者分为严重与非严重冠脉病变组。采用Spearman相关分析及单因素和多因素Logistic回归模型探讨MAR与冠脉病变严重程度的关系，并通过受试者工作特征(ROC)曲线评估MAR单独及联合传统危险因素对严重冠脉病变的预测效能。结果：严重冠脉病变组MAR水平显著高于非严重组(11.81 vs. 9.64, $P < 0.001$)，且MAR四分位数越高，Gensini评分越高(P for trend < 0.001)。多因素Logistic回归显示，MAR最高四分位组(Q4)的冠脉病变风险较Q1增加56% (OR = 1.562, 95% CI: 1.280~1.907, $P < 0.001$)。ROC分析表明，MAR联合传统危险因素可显著提升预测效能(AUC = 0.663 vs. 0.624, $P < 0.001$)。结论：MAR水平与ACS患者冠脉病变严重程度呈独立正相关，且联合传统危险因素后可提高严重冠脉病变的识别能力，提示其在临床辅助分层评估中具有潜在应用价值。

关键词

急性冠脉综合征，单核细胞/白蛋白比值，冠脉病变严重程度，Gensini评分

Association between Monocyte-to-Albumin Ratio and Severity of Coronary Artery Disease in Patients with Acute Coronary Syndrome

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Abstract

Objective: To investigate the association between the monocyte-to-albumin ratio (MAR) and the severity of coronary artery disease (CAD) in patients with acute coronary syndrome (ACS), and to evaluate its potential value in assisting risk stratification. Methods: A total of 4234 ACS patients were enrolled. Patients were divided into severe and non-severe CAD groups based on the median Gensini score. Spearman correlation analysis and univariate and multivariate logistic regression models were used to explore the relationship between MAR and CAD severity. The predictive value of MAR alone and in combination with traditional risk factors for severe CAD was assessed using receiver operating characteristic (ROC) curve analysis. Results: MAR levels were significantly higher in the severe CAD group compared with the non-severe group (11.81 vs. 9.64, *P* < 0.001), and higher MAR quartiles were associated with higher Gensini scores (*P* for trend < 0.001). Multivariate logistic regression analysis showed that patients in the highest MAR quartile (Q4) had a 56% increased risk of severe CAD compared with those in the lowest quartile (Q1) (OR = 1.562, 95% CI: 1.280~1.907, *P* < 0.001). ROC analysis demonstrated that combining MAR with traditional risk factors significantly improved predictive performance (AUC = 0.663 vs. 0.624, *P* < 0.001). Conclusion: MAR is independently and positively associated with the severity of CAD in ACS patients. Incorporating MAR with traditional risk factors may enhance the identification of severe CAD, suggesting its potential value in clinical risk stratification.

Keywords

Acute Coronary Syndrome, Monocyte-to-Albumin Ratio, Severity of Coronary Artery Disease, Gensini Score

1. 引言

急性冠脉综合征(acute coronary syndrome, ACS)是动脉粥样硬化斑块破裂或侵蚀引发的临床急症，其病理机制涉及炎症激活、氧化应激及代谢紊乱等多重因素，已成为全球死亡和疾病负担的重要原因[1]-[3]。近年来，炎症与代谢失衡在 ACS 中的作用备受关注[4]-[7]：单核细胞通过浸润血管壁、促进斑块不稳定性和血栓形成，参与 ACS 的发病[8]；而低白蛋白血症则反映全身炎症状态和氧化应激失衡，可能加剧内皮功能障碍[9]。已有研究提示单核细胞计数升高与冠状动脉钙化评分相关[10]，低白蛋白血症是心血管事件的独立预测因子[11]，而单核细胞/白蛋白比值(Monocyte-to-Albumin Ratio, MAR)被证实可作为经皮冠状动脉介入治疗患者长期死亡率的独立预测因子，其升高与全因死亡率和心脏死亡率显著相关[12]。然而，目前研究多聚焦于预后或稳定型冠心病，关于 MAR 能否更敏感地反映 ACS 患者冠脉解剖学病变严重程度，尚未系统研究。因此，本研究旨在探讨 MAR 与 ACS 患者冠脉病变严重程度的相关性，并评估其与传统心血管危险因素联合的预测效能。

2. 资料与方法

2.1. 研究对象

选取2022年1月~2024年4月在山东第一医科大学附属中心医院心血管内科住院并行经皮冠状动脉造影的患者。纳入标准：年龄 < 18岁；符合《2023 ESC急性冠状动脉综合征管理指南》[2]诊断标准的ACS患者；病历资料完整。排除标准：既往冠状动脉造影检查后行经皮冠状动脉介入治疗及冠状动脉旁路移植术者；伴有严重风湿性心脏病、瓣膜病、心肌病或严重心肺疾病者；诊断有恶性肿瘤、严重肝肾功能不全等系统性疾病者；妊娠或哺乳期妇女；临床资料或冠状动脉造影结果不完整者。本研究经山东第一医科大学附属中心医院伦理委员会批准(批准号：No.2021-206-03)，所有参与者均已签署知情同意书。

2.2. 临床数据及实验室检查结果收集

通过电子病历系统收集患者的一般临床资料，包括年龄、性别、身高、体重、血压、吸烟史、饮酒史及既往病史等。同时，记录血脂、血液学指标等实验室检查结果。吸烟史定义为当前吸烟者，即每日或偶尔使用烟草制品者[13]。饮酒史定义为每周酒精摄入量超过14单位(男性)或7单位(女性)，其中1单位相当于14 g纯酒精[14]。糖尿病诊断标准包括空腹血糖 ≥ 7.0 mmol/L、糖化血红蛋白 ≥ 6.5%，或随机血糖 ≥ 11.1 mmol/L且伴典型糖尿病症状，或既往已确诊并接受降糖治疗[15]。高血压定义为未服药时收缩压 ≥ 140 mmHg和/或舒张压 ≥ 90 mmHg，或已确诊并接受降压治疗[16]。体重指数(Body Mass Index, BMI)按标准公式计算：体重(kg)/身高$(m)^2$。MAR计算公式为：单核细胞计数(10^9/L) × 1000/白蛋白(g/L)。

2.3. 冠状动脉病变严重程度评价

采用Gensini评分系统和病变血管支数两种方法评估冠状动脉病变严重程度。Gensini评分根据美国心脏协会标准计算[17] [18]，该评分系统包含两个组成部分：(1) 狭窄程度评分(1%~25%：1分，26%~50%：2分，51%~75%：4分，76%~90%：8分，91%~99%：16分，完全闭塞：32分)；(2) 病变部位权重系数(如左主干5倍，左前降支近段2.5倍)。最终评分为各病变评分与相应权重系数的乘积之和。

2.4. 统计方法

统计分析采用R语言(Version 4.3.3)进行。计量资料经Shapiro-Wilk检验评估正态性，正态分布数据以 $\bar{x} \pm s$ 表示，两组间比较采用独立样本t检验。非正态分布数据以M (Q1, Q3)表示，组间比较采用Mann-Whitney U检验。计数资料以n (%)表示，组间比较采用卡方检验或Fisher确切概率法。采用Spearman相关分析评估MAR与冠状动脉狭窄程度(Gensini评分)的相关性。单因素分析筛选变量后，纳入多因素Logistic回归分析，评估MAR是否为冠脉病变严重程度的独立预测因子。通过方差膨胀因子(variance inflation factor, VIF)评估多重共线性，VIF < 5提示共线性。构建受试者工作特征曲线(receiver operating characteristic curve, ROC)，计算曲线下面积(area under curve, AUC)，并采用DeLong检验比较不同模型的AUC差异性。所有统计检验均为双侧检验，$P < 0.05$视为具有统计学意义。

3. 结果

3.1. ACS患者的整体特征与严重冠脉病变分组比较

本研究共纳入4234例的ACS患者，根据Gensini评分中位数分为非严重冠脉病变组和严重冠脉病变组。整体患者平均年龄65.19 ± 10.54岁，男性占60.63%，合并高血压、糖尿病比例较高。与非严重病变组相比，严重冠脉病变组男性、糖尿病、吸烟及饮酒比例更高(均$P < 0.001$)。此外，严重病变组单核细胞计数和MAR更高，白蛋白水平更低。严重病变组还表现出更高的心肌损伤标志物(NT-proBNP、肌钙蛋

白 T)、空腹血糖及肝功能异常(ALT、AST 升高)，同时 HDL-C 和 eGFR 较低(均 $P<0.05$)。两组间年龄、LVEF 及血小板计数无统计学差异(均 $P>0.05$)。见表 1。

Table 1. Comparison of clinical characteristics in acute coronary syndrome patients with severe vs. non-severe coronary lesions
表 1. 急性冠脉综合征患者严重冠脉病变的临床特征比较

变量	整体(n = 4234)	非严重病变组(n = 2101)	严重病变组(n = 2133)	*P* 值
年龄(岁)	65.19 ± 10.54	65.16 ± 9.94	65.22 ± 11.09	0.437
男性，n (%)	2567 (60.63%)	1115 (53.07%)	1452 (68.07%)	<0.001
BMI (kg/m^2)	25.66 ± 3.48	25.77 ± 3.50	25.56 ± 3.45	0.031
收缩压(mmHg)	136.39 ± 20.02	137.46 ± 19.28	135.33 ± 20.66	0.002
舒张压(mmHg)	81.59 ± 12.82	82.19 ± 12.44	81.01 ± 13.16	0.003
高血压，n (%)	2820 (66.60%)	1395 (66.40%)	1425 (66.81%)	0.802
糖尿病，n (%)	1853 (43.76%)	794 (37.79%)	1059 (49.65%)	<0.001
目前吸烟，n (%)	973 (22.98%)	387 (18.42%)	586 (27.47%)	<0.001
目前饮酒，n (%)	1160 (27.40%)	498 (23.70%)	662 (31.04%)	<0.001
Gensini 评分	29.00 (10.00, 66.00)	10.00 (5.00, 18.00)	65.00 (44.00, 92.00)	<0.001
LVEF (%)	60.51 ± 7.98	60.35 ± 8.17	60.68 ± 7.79	0.310
NT-proBNP (ng/L)	182.43 (82.81, 733.00)	130.00 (70.00, 318.99)	344.41 (107.82, 1306.32)	<0.001
肌钙蛋白 T (ng/L)	11.84 (6.71, 59.87)	8.26 (5.51, 13.31)	27.40 (9.55, 416.60)	<0.001
白细胞计数(10^9/L)	6.74 ± 2.37	6.20 ± 1.94	7.27 ± 2.62	<0.001
血小板计数(10^9/L)	218.65 ± 58.85	218.00 ± 57.86	219.28 ± 59.82	0.644
单核细胞计数(10^9/L)	0.44 ± 0.18	0.40 ± 0.14	0.47 ± 0.20	<0.001
白蛋白(g/L)	41.24 ± 3.95	41.81 ± 3.71	40.69 ± 4.10	<0.001
MAR	10.74 ± 4.88	9.64 ± 3.81	11.81 ± 5.54	<0.001
空腹血糖(mmol/L)	6.17 ± 2.29	5.83 ± 1.92	6.51 ± 2.56	<0.001
糖化血红蛋白(%)	6.65 ± 1.38	6.44 ± 1.22	6.85 ± 1.50	<0.001
总胆固醇(mmol/L)	4.45 ± 1.17	4.40 ± 1.12	4.49 ± 1.22	0.058
甘油三酯(mmol/L)	1.56 ± 1.33	1.54 ± 1.32	1.59 ± 1.34	0.017
HDL-C (mmol/L)	1.13 ± 0.30	1.18 ± 0.32	1.09 ± 0.27	<0.001
LDL-C (mmol/L)	2.60 ± 0.94	2.53 ± 0.89	2.66 ± 0.97	<0.001
eGFR (mL/min/1.73 m^2)	93.79 ± 16.61	94.76 ± 14.92	92.85 ± 18.07	0.008
ALT (U/L)	18.50 (13.10, 28.10)	17.00 (12.40, 24.90)	20.60 (14.00, 31.80)	<0.001
AST (U/L)	20.40 (16.30, 30.00)	18.90 (15.70, 23.90)	22.90 (17.10, 47.00)	<0.001

3.2. 基于 MAR 四分位数分组的临床特征和趋势分析

根据 MAR 四分位数将患者分为四组(Q1~Q4)。随 MAR 升高，男性、吸烟、饮酒及糖尿病的比例递增(P for trend < 0.05)。心肌损伤标志物(NT-proBNP、肌钙蛋白 T)、炎症指标(白细胞、单核细胞计数)显

著上升，而白蛋白、HDL-C 和 eGFR 逐步下降(P for trend < 0.001)。此外，空腹血糖、糖化血红蛋白、甘油三酯随 MAR 升高递增，总胆固醇及 LDL-C 无一致趋势。年龄、BMI、LVEF 在各组间无差异(P > 0.05)。随着 MAR 升高，Gensini 评分呈线性递增趋势(P for trend < 0.001)。见表 2。

Table 2. Clinical characteristics and trend analysis by quartiles of monocyte-to-albumin ratio (MAR)
表 2. 按单核细胞/白蛋白比值(MAR)四分位数分组的临床特征及趋势分析

变量	Q1 (n = 1059)	Q2 (n = 1061)	Q3 (n = 1057)	Q4 (n = 1057)	P 值	P for trend
年龄(岁)	64.87 ± 9.78	65.10 ± 9.98	65.53 ± 10.39	65.26 ± 11.88	0.538	0.272
男性，n (%)	488 (46.1%)	607 (57.2%)	697 (65.9%)	775 (73.3%)	<0.001	<0.001
BMI (kg/m^2)	25.56 ± 3.26	25.70 ± 3.54	25.79 ± 3.49	25.60 ± 3.61	0.447	0.667
收缩压(mmHg)	137.85 ± 19.66	137.65 ± 18.81	137.15 ± 19.56	132.91 ± 21.55	<0.001	<0.001
舒张压(mmHg)	81.97 ± 12.49	82.43 ± 12.13	81.66 ± 12.57	80.31 ± 13.93	0.001	0.001
高血压，n (%)	700 (66.1%)	709 (66.8%)	729 (69.0%)	682 (64.5%)	0.182	0.690
糖尿病，n (%)	443 (41.8%)	446 (42.0%)	473 (44.7%)	491 (46.5%)	0.093	0.015
目前吸烟，n (%)	151 (14.3%)	197 (18.6%)	279 (26.4%)	346 (32.7%)	<0.001	<0.001
目前饮酒，n (%)	219 (20.7%)	269 (25.4%)	314 (29.7%)	358 (33.9%)	<0.001	<0.001
Gensini 评分	20.00 (8.00, 50.00)	22.00 (9.00, 52.00)	31.00 (12.00, 67.00)	48.00 (20.00, 82.00)	<0.001	<0.001
LVEF (%)	60.41 ± 8.08	60.63 ± 8.06	60.66 ± 7.78	60.36 ± 8.01	0.75	0.910
NT-proBNP (ng/L)	138.08 (70.00, 361.70)	137.00 (70.24, 381.95)	187.41 (85.24, 827.25)	515.14 (125.79, 1758.21)	<0.001	<0.001
肌钙蛋白 T (ng/L)	8.28 (5.46, 14.68)	9.20 (5.96, 19.15)	13.27 (7.43, 74.00)	57.55 (11.20, 971.70)	<0.001	<0.001
白细胞计数(10^9/L)	5.24 ± 1.55	6.02 ± 1.40	6.84 ± 1.73	8.85 ± 2.82	<0.001	<0.001
血小板计数(10^9/L)	208.08 ± 53.68	214.71 ± 56.85	220.68 ± 57.44	231.15 ± 64.53	<0.001	<0.001
单核细胞计数(10^9/L)	0.26 ± 0.05	0.36 ± 0.04	0.45 ± 0.05	0.67 ± 0.18	<0.001	<0.001
白蛋白(g/L)	43.18 ± 3.57	41.77 ± 3.44	40.75 ± 3.56	39.27 ± 4.12	<0.001	<0.001
MAR	6.04 ± 1.20	8.67 ± 0.65	11.10 ± 0.84	17.14 ± 5.04	<0.001	<0.001
空腹血糖(mmol/L)	6.09 ± 2.04	6.03 ± 2.06	6.21 ± 2.35	6.36 ± 2.64	0.005	0.002
糖化血红蛋白(%)	6.51 ± 1.25	6.55 ± 1.27	6.69 ± 1.42	6.82 ± 1.54	<0.001	<0.001
总胆固醇(mmol/L)	4.57 ± 1.20	4.39 ± 1.12	4.40 ± 1.19	4.44 ± 1.17	0.002	0.018
甘油三酯(mmol/L)	1.46 ± 1.10	1.58 ± 1.21	1.57 ± 1.34	1.65 ± 1.61	0.014	0.003
HDL-C (mmol/L)	1.24 ± 0.33	1.15 ± 0.29	1.10 ± 0.28	1.06 ± 0.26	<0.001	<0.001
LDL-C (mmol/L)	2.67 ± 0.99	2.55 ± 0.91	2.58 ± 0.94	2.60 ± 0.90	0.018	0.162
eGFR (mL/min/1.73m^2)	95.24 ± 15.14	95.17 ± 15.07	93.27 ± 16.88	91.49 ± 18.80	<0.001	<0.001
ALT(U/L)	16.90 (12.50, 24.20)	17.30 (12.60, 24.70)	19.30 (13.20, 28.80)	22.20 (14.30, 37.30)	<0.001	<0.001
AST(U/L)	19.20 (16.10, 24.40)	19.00 (15.60, 24.30)	20.60 (16.30, 29.90)	27.40 (17.50, 78.00)	<0.001	<0.001

3.3. MAR 与 Gensini 评分的相关性

采用 Spearman 相关分析评估 MAR 与 Gensini 评分的关系，结果显示二者呈正相关(ρ = 0.231, P < 0.001)，见图 1。

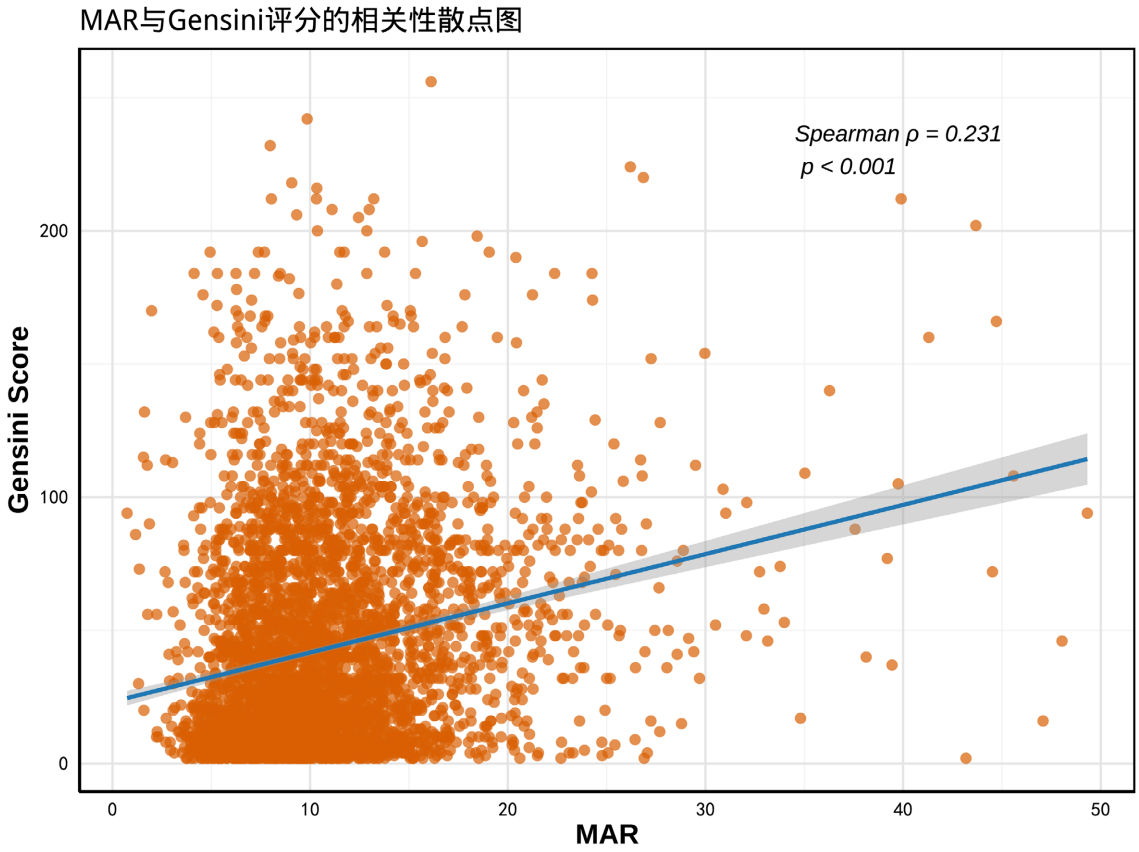

Figure 1. Scatter plot of Spearman correlation between MAR and Gensini score
图 1. MAR 与 Gensini 评分的 Spearman 相关性散点图

3.4. 冠脉病变严重程度(Gensini 评分中位数二分类)的单因素 Logistic 回归分析

单因素 Logistic 回归分析显示，男性、糖尿病、吸烟、饮酒、NT-proBNP、肌钙蛋白 T、白细胞计数、单核细胞计数、MAR、空腹血糖、糖化血红蛋白、LDL-C、ALT、AST 的升高均与冠脉病变严重程度显著相关(P < 0.05)。而 BMI、收缩压/舒张压、白蛋白、HDL-C、eGFR 较高则与较低的 Gensini 评分相关(P < 0.05)。年龄、高血压、LVEF、血小板计数、甘油三酯与冠脉病变严重程度无显著相关性(P > 0.05)。见表 3。

Table 3. Univariate Logistic regression analysis for coronary artery disease severity
表 3. 冠脉病变严重程度的单因素 Logistic 回归分析结果

变量	Estimate	Std.Error	Z.value	*P*.value
年龄	0.0005	0.0029	0.1881	0.851
男性	0.6342	0.0638	9.9429	<0.001
BMI	−0.0179	0.0089	−2.0186	0.044

续表

收缩压	−0.0053	0.0015	−3.4561	0.001
舒张压	−0.0072	0.0024	−2.9937	0.003
高血压	0.0184	0.0652	0.2831	0.777
糖尿病	0.4843	0.0624	7.7558	<0.001
目前吸烟	0.5174	0.0743	6.9639	<0.001
目前饮酒	0.3706	0.0694	5.3369	<0.001
LVEF	0.0052	0.0039	1.3589	0.174
NT-proBNP	0.0003	0.0000	11.2386	<0.001
肌钙蛋白 T	0.0016	0.0001	13.1485	<0.001
白细胞计数	0.2147	0.0154	13.9813	<0.001
血小板计数	0.0004	0.0005	0.7091	0.478
单核细胞计数	2.6350	0.2012	13.0964	<0.001
白蛋白	−0.0734	0.0081	−9.0920	<0.001
MAR	0.1072	0.0077	13.8679	<0.001
空腹血糖	0.1413	0.0150	9.4366	<0.001
糖化血红蛋白	0.2314	0.0241	9.5850	<0.001
总胆固醇	0.0644	0.0264	2.4434	0.015
甘油三酯	0.0308	0.0237	1.3006	0.193
HDL-C	−1.1229	0.1086	−10.3371	<0.001
LDL-C	0.1484	0.0332	4.4715	<0.001
eGFR	−0.0070	0.0019	−3.7312	<0.001
ALT	0.0128	0.0017	7.3992	<0.001
AST	0.0179	0.0013	13.5422	<0.001

3.5. MAR 与冠脉病变严重程度的多因素 Logistic 回归分析

多因素 Logistic 回归分析结果显示，MAR 与较高的 Gensini 评分显著相关。在未调整模型中，MAR 四分位的 Q3、Q4 组相比 Q1 组具有更高的冠脉病变风险($P < 0.001$)。在模型 1 (调整年龄、性别)和模型 2 (进一步调整 BMI、血压、糖尿病、血脂、eGFR、AST、吸烟和饮酒)中，Q4 组仍保持显著相关性($P < 0.001$)。同时，MAR 作为连续变量时，在所有模型中均与较高的 Gensini 评分显著正相关($P < 0.001$)。见表 4。

Table 4. Multivariate Logistic regression analysis of MAR for coronary artery disease severity
表 4. MAR 与冠脉病变严重程度的多因素 Logistic 回归分析

变量	未调整 OR (95% CI)	*P* 值	模型 1 OR (95% CI)	*P* 值	模型 2 OR (95% CI)	*P* 值
MAR 四分位						
Q1	Ref	-	Ref	-	Ref	-
Q2	1.125 (0.946~1.337)	0.183	1.059 (0.889~1.261)	0.524	1.014 (0.845~1.218)	0.880
Q3	1.644 (1.384~1.954)	<0.001	1.479 (1.242~1.764)	<0.001	1.178 (0.977~1.419)	0.085
Q4	3.101 (2.597~3.707)	<0.001	2.706 (2.258~3.247)	<0.001	1.562 (1.280~1.907)	<0.001
MAR (连续)	1.113 (1.097~1.130)	<0.001	1.101 (1.085~1.118)	<0.001	1.044 (1.027~1.062)	<0.001

3.6. MAR 对严重冠脉病变的预测价值分析

ROC 分析结果显示，MAR 单独预测严重冠脉病变的 AUC 为 0.626 (95% CI: 0.609~0.642)，传统风险因素模型的 AUC 为 0.624 (95% CI: 0.608~0.641)，二者差异无统计学意义($P = 0.908$)。当 MAR 与传统风险因素联合建模时，AUC 提升至 0.663 (95% CI: 0.647~0.679)，显著高于单独的 MAR 模型及传统风险因素模型($P < 0.001$)。这表明 MAR 可为传统风险预测模型提供额外的预测价值。见图 2 和表 5。

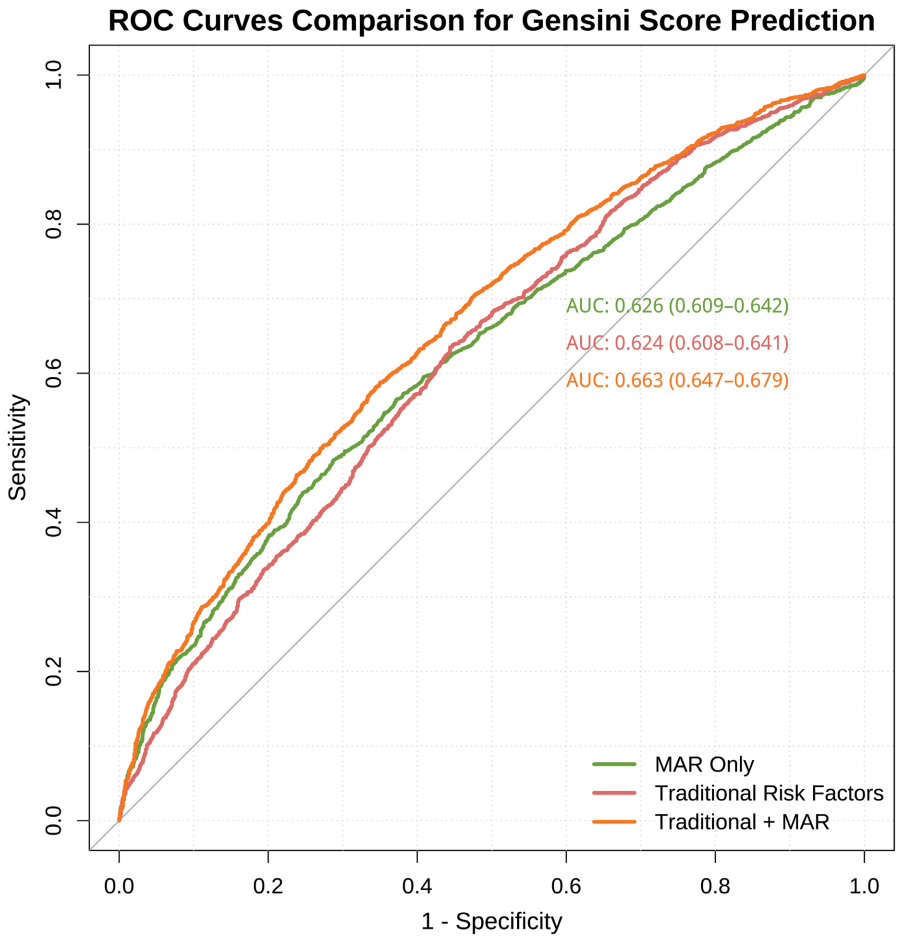

Figure 2. ROC curves for MAR in predicting severe coronary artery disease
图 2. MAR 预测严重冠脉病变的 ROC 曲线

Table 5. ROC analysis results of three models
表 5. 三种模型的 ROC 分析结果

模型	AUC	95%置信区间	敏感度	特异度	比较	*P* 值
MAR 模型	0.626	(0.609, 0.642)	0.483	0.713	MAR vs 传统风险因素	0.908
传统风险因素模型	0.624	(0.608, 0.641)	0.635	0.556	MAR vs 组合模型	<0.001
组合模型(传统 + MAR)	0.663	(0.647, 0.679)	0.588	0.650	传统风险因素 vs 组合模型	<0.001

4. 讨论

本研究首次证实，MAR 与 ACS 患者冠脉病变严重程度呈独立正相关，且其预测效能可协同传统危

险因素。Spearman 相关分析显示，MAR 与 Gensini 评分呈显著正相关。严重冠脉病变组的 MAR 水平显著高于非严重组，且随 MAR 四分位数递增，Gensini 评分、心肌损伤标志物及炎症指标逐步恶化。多因素 Logistic 回归分析显示，MAR 最高四分位组(Q4)的冠脉病变风险较 Q1 增加 56%。此外，ROC 曲线分析显示，MAR 联合传统危险因素可显著提升对严重冠脉病变的预测效能。

动脉粥样硬化过程中，活化的单核细胞通过趋化因子募集至血管壁，分化为巨噬细胞并吞噬氧化低密度脂蛋白，形成泡沫细胞，导致斑块脂质核心扩大及纤维帽变薄[19]。这一过程与动脉粥样硬化斑块的不稳定性密切相关。本研究支持这一机制，发现单核细胞计数与 Gensini 评分正相关。此外，单核细胞亚型可能通过分泌基质金属蛋白酶，进一步削弱斑块稳定性。现有研究表明，中性粒细胞/淋巴细胞比值与冠脉病变严重程度呈正相关[20]，血小板/淋巴细胞比值和系统性免疫炎症指数也被证实可预测冠脉钙化及心血管事件风险[21]-[24]。白蛋白是血浆中主要的抗氧化分子，其水平降低可加剧氧化应激，促进内皮细胞凋亡[25]。在本研究中，严重病变组白蛋白水平较低。多项人群研究表明，血清白蛋白水平下降与动脉粥样硬化进展及心肌梗死风险显著相关[26]-[28]。此外，Kurtul 等人的研究发现，低白蛋白血症不仅是高 SYNTAX 评分的独立预测因子，还与院内死亡率升高相关[29]。

近年来，MAR 作为一种新型炎症－代谢联合标志物，同时反映炎症激活与代谢失衡，更贴近动脉粥样硬化的核心病理机制，其临床应用价值已在多个疾病领域得到证实。MAR 可独立预测经皮冠状动脉介入治疗患者的长期死亡率及主要心血管不良事件风险[12]；与自发性脑出血患者血肿扩大显著相关[30]；联合中性粒细胞百分比/血红蛋白比值可提高非小细胞肺癌早期诊断效能[31]；对乙肝病毒相关失代偿期肝硬化患者 30 天死亡率的预测能力与 MELD 评分相当[32]。然而，MAR 与 ACS 患者冠脉病变严重程度之间关系的研究尚较缺乏。本研究首次揭示 MAR 与 ACS 患者冠脉病变严重程度(Gensini 评分)呈独立正相关，且联合传统危险因素可显著提升预测效能。

本研究存在一定局限性。首先，作为回顾性横断面研究，我们仅揭示了 MAR 与 ACS 患者冠脉病变严重程度的相关性，无法确定因果关系，未来仍需前瞻性队列研究进一步验证。此外，本研究为单中心研究，样本量有限，且未进行长期随访，无法评估 MAR 对远期心血管事件的预测价值。尽管调整了多种协变量，仍可能存在未测量的混杂因素，如饮食、生活方式和遗传因素等。此外，尽管 ROC 曲线分析显示 MAR 联合传统危险因素能够提高预测效能，但其 AUC 值仅为 0.663，表明该模型的预测能力仍然有限，可能难以在临床实践中得到广泛应用。最后，由于本研究采用横断面设计，我们未能深入探讨 MAR 与冠脉病变严重程度之间关系的具体生物学机制。因此，未来需开展多中心、大样本量的前瞻性研究，并采用更精确的统计方法，以进一步验证本研究结果并评估其临床应用价值。

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