

三酰甘油-葡萄糖指数及其衍生指数与老年男性代谢相关脂肪性肝病的相关性分析

康娟¹, 刘文徽², 常青², 庄颖洁^{2*}

¹解放军总医院第二医学中心门诊部急诊医学科/国家老年疾病临床研究中心, 北京 100853; ²解放军总医院第二医学中心消化内科/国家老年疾病临床医学研究中心, 北京 100853

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[摘要] **目的** 探讨三酰甘油-葡萄糖(TyG)指数及其衍生指数三酰甘油-葡萄糖-体重指数(TyG-BMI)与老年男性人群代谢相关脂肪性肝病(MAFLD)患病风险之间的相关性。**方法** 选取2021年1—12月于解放军总医院第二医学中心门诊行年度体检的2290例老年男性, 分为MAFLD组($n=1322$)与非MAFLD组($n=968$)。筛选MAFLD患病的混杂因素, 采用多因素logistic回归分析TyG指数及TyG-BMI与MAFLD患病风险的相关性, 并绘制受试者工作特征(ROC)曲线探讨其对老年男性MAFLD患病风险的预测价值。**结果** 2290例体检者年龄(74.3 ± 10.1)岁, 体重指数(BMI)为(24.63 ± 2.70) kg/m²。MAFLD组BMI、 γ -谷氨酰转氨酶(γ -GT)、谷丙转氨酶(ALT)、谷草转氨酶(AST)、血肌酐(Scr)、促甲状腺激素(TSH)、游离三碘甲状腺原氨酸(FT_3)、吸烟、饮酒率, 以及高血压、糖尿病、高尿酸血症、高甘油三酯(TG)血症、低高密度脂蛋白胆固醇(HDL-C)血症、甲状腺结节、胆系结石等的患病率明显高于非MAFLD组($P<0.05$), 年龄低于非MAFLD组($P=0.003$)。调整混杂因素后, 多因素logistic回归分析显示, 按TyG指数四分位数分组的 Q_1 组、 Q_2 组、 Q_3 组患MAFLD的风险分别是 Q_4 组的1.667倍(95%CI 1.257~2.236, $P<0.001$)、2.004倍(95%CI 1.482~2.710, $P<0.001$)、5.420倍(95%CI 3.266~8.995, $P<0.001$); 按TyG-BMI四分位数分组的 Q_1 组、 Q_2 组、 Q_3 组患MAFLD的风险分别是 Q_4 组的2.215倍(95%CI 1.549~3.167, $P<0.001$)、2.809倍(95%CI 1.723~4.580, $P<0.001$)、2.513倍(95%CI 1.253~5.040, $P=0.009$)。TyG指数及TyG-BMI预测老年男性MAFLD的ROC曲线下面积(AUC)分别为0.717(95%CI 0.696~0.738)、0.840(95%CI 0.823~0.856), 最佳截断值分别为8.63、205.20; 在无高脂血症及糖尿病的老年男性中, TyG指数与TyG-BMI预测MAFLD的AUC分别为0.653(95%CI 0.622~0.684)、0.840(95%CI 0.818~0.862), 最佳截断值分别为8.42、202.66。TyG-BMI预测MAFLD的AUC、准确率、特异度、敏感度、阳性预测值、阴性预测值均高于TyG指数。**结论** TyG指数及TyG-BMI高水平状态与老年男性MAFLD患病风险升高相关。TyG指数及TyG-BMI对老年男性MAFLD患病均有一定的预测价值, 而TyG-BMI较TyG指数的预测价值更优。

[关键词] 非酒精性脂肪性肝病; 三酰甘油; 葡萄糖; 体重指数; ROC曲线

Association between triglyceride glucose index and its related derivative index and metabolic associated fatty liver disease in the elderly men

Kang Juan¹, Liu Wen-Hui², Chang Qing², Zhuang Ying-Jie^{2*}

¹Department of Emergency Medicine, Outpatient Department of the Second Medical Center/National Clinical Research Center for Geriatric Diseases, ²Department of Gastroenterology, the Second Medical Center/National Clinical Research Center for Geriatric Diseases, Chinese PLA General Hospital, Beijing 100853, China

*Corresponding author, E-mail: zhuangyj1201@163.com

[Abstract] **Objective** To explore the association between triglyceride glucose (TyG) index and TyG-body mass index (TyG-BMI) and the prevalence of metabolic associated fatty liver disease (MAFLD) in the elderly men. **Methods** Totally 2290 elderly

[作者简介] 康娟, 医学学士, 主要从事慢性肝病方面的临床研究

[通信作者] 庄颖洁, E-mail: zhuangyj1201@163.com

men were selected from January to December in 2021 in the Second Medical Center of Chinese PLA General Hospital, and divided into MAFLD group ($n=1322$) and non-MAFLD group ($n=968$). Multivariate logistic regression was used to analyze the association between TyG index, TyG-BMI and MAFLD. The receiver operating characteristic (ROC) curve was drawn to explore the predictive value of TyG index and TyG-BMI with MAFLD in the elderly men. **Results** Two thousand two hundred and ninety elderly men were (74.3 ± 10.1) years old, and an average BMI of (24.63 ± 2.70) kg/m^2 . BMI, γ -glutamyl transaminase (γ -GT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), serum creatinine (Scr), thyroid stimulating hormone (TSH), free triiodothyronine (FT_3), the rate of smoking and drinking, and the prevalence of hypertension, diabetes, hyperuricemia, high triglyceride (TG), low high density lipoprotein cholesterol (HDL-C), hyperuricemia, thyroid nodules and cholelithiasis were all significantly higher in non-MAFLD group than those in MAFLD group ($P<0.05$), while the age of MAFLD group was lower than that of non-MAFLD group ($P=0.003$). Multivariate logistic regression analysis showed that the risk of MAFLD in patients of TyG quartile groups Q_2 , Q_3 , Q_4 was 1.667 (95%CI 1.257-2.236, $P<0.001$), 2.004 (95%CI 1.482-2.710, $P<0.001$) and 5.420 (95%CI 3.266-8.995, $P<0.001$) times higher than that of TyG Q_1 , respectively. The risk of MAFLD in patients of TyG-BMI Q_2 , Q_3 , Q_4 was 2.215 (95%CI 1.549-3.167, $P<0.001$), 2.809 (95%CI 1.723-4.580, $P<0.001$) and 2.513 (95%CI 1.253-5.040, $P=0.009$) times higher than that of TyG-BMI Q_1 , respectively. The ROC curve showed that areas under the curve (AUC) of MAFLD predicted by TyG index and TyG-BMI were 0.717 (95%CI 0.696-0.738) and 0.840 (95%CI 0.823-0.856), and the best cut-off values were 8.63 and 205.20, respectively. Moreover, the ROC curve showed that AUC of MAFLD in the elderly men without hyperlipidemia or diabetes predicted by TyG index and TyG-BMI were 0.653 (95%CI 0.622-0.684) and 0.840 (95%CI 0.818-0.862), and the best cut-off values were 8.42 and 202.66, respectively. In addition, AUC, accuracy, specificity, sensitivity, positive predictive value and negative predictive value predicted by TyG-BMI were higher than those by TyG index. **Conclusions** TyG index and TyG-BMI are significantly associated with MAFLD in the elderly men. Both TyG index and TyG-BMI have certain predictive value for the prevalence of MAFLD in the elderly men, and TyG-BMI may be better.

[Key words] non-alcoholic fatty liver disease; triacylglycerol; glucose; body mass index; receiver operating characteristic curve

代谢相关脂肪性肝病 (metabolic associated fatty liver disease, MAFLD) 曾用名为非酒精性脂肪性肝病 (non-alcoholic fatty liver disease, NAFLD), 已经成为最流行的慢性肝脏疾病之一^[1-2], 影响着全球至少四分之一的成年人口^[3]。随着生活方式的改变, 近年来 MAFLD 的患病率呈明显上升趋势^[4]。研究发现, MAFLD 已逐渐成为肝硬化、终末期肝病及原发性肝癌的主要原因之一, 且已成为公共医疗保健的重大负担^[5]。

近年来, 三酰甘油-葡萄糖 (triglyceride-glucose, TyG) 指数及其衍生指数作为胰岛素抵抗 (insulin resistance, IR) 的理想替代指标逐渐兴起^[6-9]。与胰岛素抵抗指数 (homeostasis model assessment of insulin resistance, HOMA-IR)^[10] 比较, TyG 能以更简单、经济的方式确定 IR^[11-12]。既往研究发现, TyG 指数与 2 型糖尿病^[7,13-14]、高血压^[15]、冠状动脉疾病^[16-18] 有一定关联。研究发现, MAFLD/NAFLD 的发病与 IR 密切相关^[19]。另外, Er 等^[20] 研究发现, 应用 TyG 指数与体重指数 (body mass index, BMI) 的组合可以同时反映血脂、血糖及 BMI 等关键临床指标的信息, 且比单独的 TyG 指数更能反映 IR 的程度。本研究探讨老年男性人群中 TyG 指数及其衍生指数三酰甘油-葡萄糖-体重指数 (triglyceride-glucose-body mass index, TyG-BMI) 与 MAFLD 患病之间的相关性, 并比较 TyG 指数及 TyG-BMI 对老年男性 MAFLD 患病风险的

预测价值。

1 资料与方法

1.1 研究对象 选择 2021 年 1—12 月于解放军总医院第二医学中心门诊行年度体检的 2290 例老年男性。年龄 (74.3 ± 10.1) 岁, BMI (24.63 ± 2.70) kg/m^2 。纳入标准: (1) 男性; (2) 年龄 ≥ 60 岁; (3) 体检人群完成腹部超声或 CT 等影像学检查。排除标准: (1) 患有原发性肝癌、胆管细胞癌及巨大肝囊肿等重大肝脏疾病; (2) 重要数据缺失; (3) 无法配合本研究。本研究获解放军总医院医学伦理委员会审批 (S2023-213-01)。

1.2 诊断标准 MAFLD 的诊断根据《2020 APASL 代谢相关脂肪性肝病临床诊疗指南》^[21], 在明确肝脏脂肪变性基础上同时合并超重、肥胖、2 型糖尿病或代谢功能障碍即可诊断 MAFLD。代谢功能障碍为至少存在以下两项代谢风险异常: (1) 腰围: 男性 ≥ 90 cm, 女性 ≥ 80 cm; (2) 血压 $\geq 130/85$ mmHg (1 mmHg=0.133 kPa) 或正在使用降压药物治疗; (3) 三酰甘油 (triglyceride, TG) ≥ 1.70 mmol/L 或正在使用降脂药物治疗; (4) 高密度脂蛋白胆固醇 (high density lipoprotein cholesterol, HDL-C): 男性 < 1.0 mmol/L, 女性 < 1.3 mmol/L 或正在使用降脂药物治疗; (5) 空腹血糖 5.6~6.9 mmol/L 或餐后 2 h 血糖 7.8~11.0 mmol/L 或糖化血红蛋白 (hemoglobin A_{1c} , HbA_{1c}) 5.7%~6.4%;

(6)HOMA-IR \geq 2.5; (7)超敏C反应蛋白 $>$ 2 mg/L。由于缺乏胰岛素水平数据,因此本研究只考虑了其中6项代谢因素。另外,本研究中对于肝脏脂肪变性的诊断依赖于影像学依据,其中完全依赖超声诊断的962例,完全依赖CT诊断的24例,同时依赖超声及CT诊断的336例。根据是否患有MAFLD,将2290例研究对象分为MAFLD组(1322例)与非MAFLD组(968例)。

1.3 研究方法 收集研究对象的临床资料包括年龄、性别、身高、体重、BMI、吸烟、饮酒、有无合并高血压、糖尿病、颈动脉硬化、甲状腺结节、胆系结石及血生化指标等。禁食至少8 h后抽取受试者静脉血,检测的血生化指标主要包括血肌酐(serum creatinine, Scr)、尿素氮(blood urea nitrogen, BUN)、总胆固醇(total cholesterol, TC)、TG、HDL-C、低密度脂蛋白胆固醇(low density lipoprotein cholesterol, LDL-C)、谷草转氨酶(aspartate aminotransferase, AST)、谷丙转氨酶(alanine aminotransferase, ALT)、 γ -谷氨酰氨基转移酶(γ -glutamyl transpeptidase, γ -GT)、总胆红素(total bilirubin, TBil)、直接胆红素(direct bilirubin, DBil)、空腹血糖(fast blood glucose, FBG)、HbA_{1c}、促甲状腺激素(thyroid stimulating hormone, TSH)、游离三碘甲腺原氨酸(free triiodothyronine, FT₃)、游离甲状腺素(free thyroxine, FT₄)等。高血压、糖尿病、血脂异常、高尿酸血症等疾病分别根据相关指南进行诊断^[22-25]。TyG指数及TyG-BMI的计算公式^[26]: TyG= \ln [TG(mg/dl)×FBG(mg/dl)/2]; TyG-BMI=TyG×BMI; BMI=体重(kg)/身高(m)²。基线TyG指数根据四分位数分组: Q₁组, TyG指数 \leq 8.33; Q₂组, 8.33<TyG指数 \leq 8.64; Q₃组, 8.64<TyG指数 \leq 8.99; Q₄组, TyG指数 $>$ 8.99。基线TyG-BMI根据四

分位数分组: Q₁组, TyG-BMI \leq 195.47; Q₂组, 195.47<TyG-BMI \leq 213.95; Q₃组, 213.95<TyG-BMI \leq 232.36; Q₄组, TyG-BMI $>$ 232.36。

采用二元logistic回归模型分析TyG指数及TyG-BMI与MAFLD患病风险的相关性,采用多因素分析调整混杂因素,并将TyG指数及TyG-BMI四分位数分组赋值后纳入logistic回归模型进行线性趋势检验。建立受试者工作特征(receiver operating characteristic, ROC)曲线,探讨TyG指数及TyG-BMI对老年男性患MAFLD的预测价值。根据约登指数(即敏感度+特异度-1)最大值确定最佳截断值,并采用Delong test检验计算曲线下面积(area under the curve, AUC)差异。

1.4 统计学处理 采用SPSS 26.0及R4.2.2软件进行统计学分析。符合正态分布的计量资料以 $\bar{x}\pm s$ 表示,组间比较采用独立样本 t 检验;非正态分布的计量资料以 $M(Q_1, Q_3)$ 表示,组间比较采用Mann-Whitney U 检验。计数资料以例(%)表示,组间比较采用Pearson χ^2 检验或Fisher确切概率法检验。 $P<0.05$ 为差异有统计学意义。

2 结果

2.1 非MAFLD组与MAFLD组临床资料比较 与非MAFLD组比较,MAFLD组年龄小($P<0.05$),BMI、 γ -GT、ALT、AST、Scr、TSH、FT₃水平明显升高($P<0.05$),吸烟、饮酒率及高血压、糖尿病、高尿酸血症、高TG血症、低HDL-C血症、甲状腺结节、胆系结石患病率也明显增高($P<0.05$),但两组TBil、DBil、BUN、FT₄水平及高TC血症、高LDL-C血症及颈动脉硬化患病率比较,差异均无统计学意义($P>0.05$,表1)。

2.2 不同亚组老年男性MAFLD患病情况比较 TyG

表1 非MAFLD组与MAFLD组临床资料比较

Tab.1 Comparison of clinical data between non MAFLD group and MAFLD group

指标	总体($n=2290$)	非MAFLD组($n=968$)	MAFLD组($n=1322$)	$t/\chi^2/Z$	P
年龄(岁, $\bar{x}\pm s$)	74.3 \pm 10.1	75.0 \pm 10.7	73.7 \pm 9.6	2.972	0.003
BMI (kg/m ² , $\bar{x}\pm s$)	24.63 \pm 2.70	23.00 \pm 2.39	25.82 \pm 2.26	-28.538	<0.001
吸烟[例(%)]				6.163	0.013
否	1917(83.7)	832(86.0)	1085(82.1)		
是	373(16.3)	136(14.0)	237(17.9)		
饮酒[例(%)]				14.143	<0.001
否	1258(54.9)	576(59.5)	682(51.6)		
是	1032(45.1)	392(40.5)	640(48.4)		
TBil(μ mol/L, $\bar{x}\pm s$)	13.62 \pm 5.44	13.41 \pm 5.14	13.78 \pm 5.65	-1.599	0.110
DBil(μ mol/L, $\bar{x}\pm s$)	5.22 \pm 1.71	5.18 \pm 1.67	5.25 \pm 1.75	-0.860	0.390
γ -GT[U/L, $M(Q_1, Q_3)$]	22.50(17.00, 31.00)	20.00(15.00, 27.00)	25.00(18.00, 35.00)	10.657	<0.001
ALT[U/L, $M(Q_1, Q_3)$]	17.00(13.00, 23.00)	15.20(12.00, 20.08)	18.30(14.08, 24.60)	9.805	<0.001

(续表)

指标	总体(n=2290)	非MAFLD组(n=968)	MAFLD组(n=1322)	t/ χ^2 /Z	P
AST[U/L, M(Q ₁ , Q ₃)]	19.10(16.78, 23.00)	19.00(16.40, 22.00)	19.40(17.00, 23.00)	2.180	0.029
BUN(mmol/L, $\bar{x}\pm s$)	6.02±1.75	6.00±1.78	6.03±1.73	-0.453	0.651
Scr(μ mol/L, $\bar{x}\pm s$)	84.60±21.17	83.28±19.74	85.57±22.12	-2.558	0.011
TSH[μ U/mL, M(Q ₁ , Q ₃)]	2.15(1.55, 3.13)	2.08(1.49, 3.11)	2.18(1.60, 3.16)	1.993	0.046
FT ₃ (pmol/L, $\bar{x}\pm s$)	4.74±0.59	4.70±0.59	4.77±0.60	-2.864	0.004
FT ₄ (pmol/L, $\bar{x}\pm s$)	16.36±2.46	16.46±2.41	16.28±2.49	1.662	0.097
高血压[例(%)]				20.622	<0.001
否	1407(61.4)	647(66.8)	760(57.5)		
是	883(38.6)	321(33.2)	562(42.5)		
糖尿病[例(%)]				49.805	<0.001
否	1977(86.3)	893(92.3)	1084(82.0)		
是	313(13.7)	75(7.7)	238(18.0)		
高尿酸血症[例(%)]				37.347	<0.001
否	1869(81.6)	846(87.4)	1023(77.4)		
是	421(18.4)	122(12.6)	299(22.6)		
高TC血症[例(%)]				2.965	0.085
否	2163(94.5)	905(93.5)	1258(95.2)		
是	127(5.5)	63(6.5)	64(4.8)		
高TG血症[例(%)]				151.039	<0.001
否	1744(76.2)	861(88.9)	883(66.8)		
是	546(23.8)	107(11.1)	439(33.2)		
高LDL-C血症[例(%)]				1.688	0.194
否	1940(84.7)	809(83.6)	1131(85.6)		
是	350(15.3)	159(16.4)	191(14.4)		
低HDL-C血症[例(%)]				61.828	<0.001
否	1946(85.0)	889(91.8)	1057(80.0)		
是	344(15.0)	79(8.2)	265(20.0)		
颈动脉硬化[例(%)]				3.360	0.067
否	449(19.6)	207(21.4)	242(18.3)		
是	1841(80.4)	761(78.6)	1080(81.7)		
甲状腺结节[例(%)]				6.956	0.008
否	423(18.5)	203(21.0)	220(16.6)		
是	1867(81.5)	765(79.0)	1102(83.4)		
胆系结石[例(%)]				6.852	0.009
否	1859(81.2)	810(83.7)	1049(79.3)		
是	431(18.8)	158(16.3)	273(20.7)		
TyG指数	8.67±0.49	8.47±0.43	8.83±0.48	18.877	<0.001
TyG-BMI	214.00±29.09	194.99±24.61	227.92±23.74	32.291	<0.001

BMI. 体重指数; TBil. 总胆红素; DBil. 直接胆红素; γ -GT. γ -谷氨酰转氨酶; ALT. 谷丙转氨酶; AST. 谷草转氨酶; BUN. 尿素氮; Scr. 肌酐; TSH. 促甲状腺激素; FT₃. 血清游离三碘甲状腺原氨酸; FT₄. 血清游离甲状腺素; TC. 总胆固醇; TG. 三酰甘油; LDL-C. 低密度脂蛋白胆固醇; HDL-C. 高密度脂蛋白胆固醇; TyG. 三酰甘油-葡萄糖; TyG-BMI. 三酰甘油-葡萄糖-体重指数; MAFLD. 代谢相关脂肪性肝病

指数Q₄组中MAFLD的患病率(35.9%), 明显高于Q₁组(14.4%)、Q₂组(22.5%)及Q₃组(27.2%), 差异有统计学意义(P<0.001)。TyG-BMI Q₄组中MAFLD的患病率为(38.7%), 明显高于Q₁组(6.6%)、Q₂组(22.3%)及Q₃组(32.4%), 差异有统计学意义(P<0.001, 表2)。

2.3 TyG指数及TyG-BMI与老年男性MAFLD患病的相关性 分别以TyG指数及TyG-BMI为自变量, 以MAFLD为因变量, 采用logistic回归模型分析TyG指数及TyG-BMI与老年男性MAFLD患病的关系。分别以TyG指数及TyG-BMI的第1个四分位组(Q₁)作

表2 不同TyG指数及TyG-BMI亚组老年男性MAFLD患病率比较[例(%)]

Tab.2 Comparison of MAFLD prevalence among elderly men in different TyG index and TyG-BMI subgroups [n(%)]

亚组	非MAFLD组 (n=968)	MAFLD组 (n=1322)	χ^2	P
TyG指数			297.540	<0.001
Q ₁	381(39.4)	191(14.4)		
Q ₂	270(27.9)	297(22.5)		
Q ₃	218(22.5)	359(27.2)		
Q ₄	99(10.2)	475(35.9)		
TyG-BMI			737.276	<0.001
Q ₁	485(50.1)	87(6.6)		
Q ₂	278(28.7)	295(22.3)		
Q ₃	145(15.0)	428(32.4)		
Q ₄	60(6.2)	512(38.7)		

TyG.三酰甘油-葡萄糖; TyG-BMI.三酰甘油-葡萄糖-体重指数; MAFLD.代谢相关脂肪性肝病

为参照。经模型3校正后, TyG指数Q₂组患MAFLD风险是Q₁组的1.667倍(95%CI 1.257~2.236, P<0.001), TyG指数Q₃组患MAFLD风险是Q₁组的2.004倍(95%CI 1.482~2.710, P<0.001), TyG指数Q₄组患MAFLD风险是Q₁组的5.420倍(95%CI 3.266~8.995, P<0.001), 且MAFLD患病风险随TyG指数四分位数

增加而增加(趋势性检验P<0.001)。经模型3校正后, TyG-BMI Q₂组患MAFLD风险是Q₁组的2.215倍(95%CI 1.549~3.167, P<0.001), TyG-BMI Q₃组患MAFLD风险是Q₁组的2.809倍(95%CI 1.723~4.580, P<0.001), TyG-BMI Q₄组患MAFLD风险是Q₁组的2.513倍(95%CI 1.253~5.040, P=0.009), 且MAFLD患病风险随TyG-BMI四分位数增加而增加(趋势性检验P=0.004, 表3)。

2.4 TyG指数及TyG-BMI对老年男性患MAFLD的预测价值 TyG指数及TyG-BMI预测老年男性患MAFLD的AUC分别为0.717(95%CI 0.696~0.738)、0.840(95%CI 0.823~0.856), 最佳截断值分别为8.63、205.20(图1)。TyG-BMI预测MAFLD的AUC、准确率、特异度、敏感度、阳性预测值、阴性预测值均优于TyG指数(表4)。

2.5 TyG指数及TyG-BMI在无高脂血症及糖尿病老年男性中对MAFLD患病风险的预测价值 因TyG指数及TyG-BMI是基于三酰甘油及葡萄糖计算, 故本研究进一步在无高脂血症及糖尿病的老年男性人群中分析TyG指数及TyG-BMI对MAFLD患病风险的预测价值。TyG指数及TyG-BMI的AUC分别为0.653(95%CI 0.622~0.684)、0.840(95%CI 0.818~0.862), 最

表3 TyG指数及TyG-BMI与老年男性MAFLD患病的相关性

Tab.3 Association between TyG index and TyG-BMI and MAFLD in the elderly men

亚组	模型1		模型2		模型3	
	OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
TyG指数						
Q ₁	1		1		1	
Q ₂	2.194(1.727~2.788)	<0.001	1.755(1.325~2.324)	<0.001	1.667(1.257~2.236)	<0.001
Q ₃	3.285(2.579~4.184)	<0.001	2.285(1.716~3.042)	<0.001	2.004(1.482~2.710)	<0.001
Q ₄	9.571(7.251~12.634)	<0.001	7.427(5.389~10.237)	<0.001	5.420(3.266~8.995)	<0.001
趋势性检验P值		<0.001		<0.001		<0.001
TyG-BMI						
Q ₁	1		1		1	
Q ₂	5.916(4.467~7.834)	<0.001	3.494(2.511~4.862)	<0.001	2.215(1.549~3.167)	<0.001
Q ₃	16.455(12.241~22.121)	<0.001	6.746(4.445~10.239)	<0.001	2.809(1.723~4.580)	<0.001
Q ₄	47.571(33.470~67.612)	<0.001	12.899(7.426~22.407)	<0.001	2.513(1.253~5.040)	0.009
趋势性检验P值		<0.001		<0.001		0.004

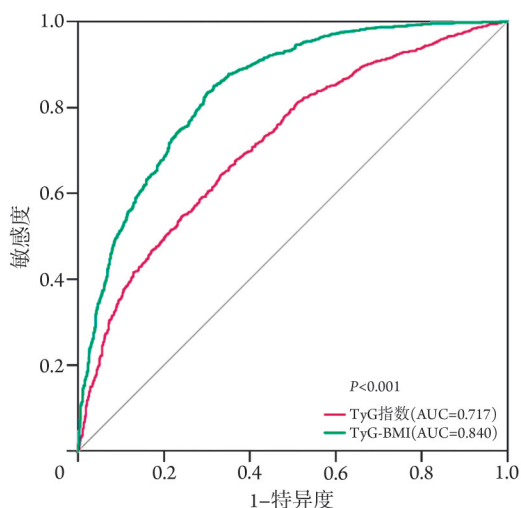
TyG.三酰甘油-葡萄糖; TyG-BMI.三酰甘油-葡萄糖-体重指数; MAFLD.代谢相关脂肪性肝病; 模型1未校正各因素; 模型2校正了年龄、BMI、吸烟及饮酒; 模型3在模型2基础上继续校正了 γ -GT、ALT、AST、Scr、TSH、FT₃、高血压、糖尿病、高尿酸血症、高TG血症、低HDL-C血症、甲状腺结节及胆系结石等对结局可能存在影响的协变量

表4 TyG指数及TyG-BMI对老年男性MAFLD的预测价值

Tab.4 Predictive value of TyG index and TyG-BMI for MAFLD in the elderly men

指数	AUC	95%CI	准确率(%)	敏感度(%)	特异度(%)	阳性预测值(%)	阴性预测值(%)
TyG指数	0.717	0.696~0.738	65	64	67	73	58
TyG-BMI	0.840	0.823~0.856	78	85	68	79	77

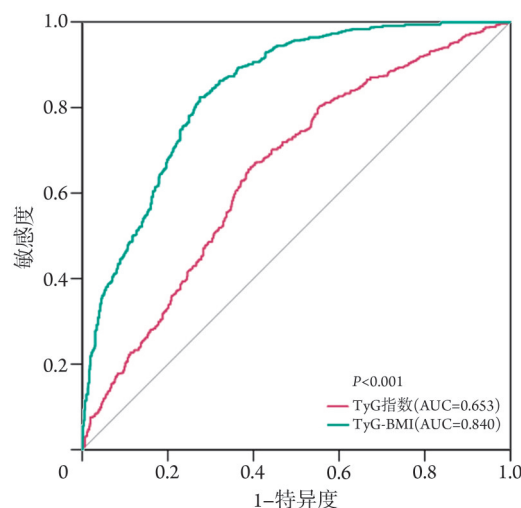
TyG.三酰甘油-葡萄糖; TyG-BMI.三酰甘油-葡萄糖-体重指数; MAFLD.代谢相关脂肪性肝病; AUC.受试者工作特征曲线下面积



TyG. 三酰甘油-葡萄糖; TyG-BMI. 三酰甘油-葡萄糖-体重指数; MAFLD. 代谢相关脂肪性肝病; ROC. 受试者工作特征; AUC. ROC曲线下面积

图1 TyG指数及TyG-BMI预测老年男性MAFLD患病风险的ROC曲线

Fig. 1 ROC curves of TyG index and TyG-BMI for predicting MAFLD in the elderly men



TyG. 三酰甘油-葡萄糖; TyG-BMI. 三酰甘油-葡萄糖-体重指数; MAFLD. 代谢相关脂肪性肝病; ROC. 受试者工作特征; AUC. ROC曲线下面积

图2 TyG指数及TyG-BMI在无高脂血症及糖尿病的老年男性中预测MAFLD的ROC曲线

Fig. 2 ROC curves of TyG index and TyG-BMI for predicting MAFLD in the elderly men without hyperlipidemia or diabetes

佳截断值分别为 8.42、202.66(图 2)。TyG-BMI 预测 MAFLD 的 AUC、准确率、特异度、敏感度、阳性预

测值、阴性预测值仍优于 TyG 指数(表 5)。

表 5 TyG 指数及 TyG-BMI 在无高脂血症及糖尿病的老年男性中对 MAFLD 的预测价值

Tab.5 Predictive value of TyG index and TyG-BMI for MAFLD in the elderly men without hyperlipidemia or diabetes

指数	AUC	95%CI	准确率(%)	敏感度(%)	特异度(%)	阳性预测值(%)	阴性预测值(%)
TyG 指数	0.653	0.622-0.684	63	66	61	60	67
TyG-BMI	0.840	0.818-0.862	77	82	73	73	82

TyG. 三酰甘油-葡萄糖; TyG-BMI. 三酰甘油-葡萄糖-体重指数; MAFLD. 代谢相关脂肪性肝病; AUC. 受试者工作特征曲线下面积

3 讨 论

MAFLD 作为全球流行的慢性肝病, 随着社会老龄化进程的加快, 已经成为影响老年人健康的重要问题之一^[27-28]。目前对 TyG 指数及其相关衍生指数 TyG-BMI 与老年人群 MAFLD 患病风险的相关性报道较少。本研究以 2290 例老年男性为研究对象, 探讨 TyG 指数及 TyG-BMI 与 MAFLD 患病之间的相关性, 并探究该指数对 MAFLD 患病风险的预测价值。结果发现, 高水平的 TyG 指数及 TyG-BMI 均与老年男性 MAFLD 患病风险增加明显相关, 对老年男性 MAFLD 患病风险存在一定的预测价值, 且 TyG-BMI 较 TyG 指数预测价值更优。

本研究通过 logistic 回归分析发现, 在调整各种混杂因素后, 高水平的 TyG 指数及 TyG-BMI 均与老年男性 MAFLD 患病风险增加独立相关, 其机制可能与能量过剩、IR 抑制脂肪组织分解、增加肝脏新生脂肪生成导致游离脂肪酸增加, 从而使三酰甘油合

成增多^[29-32], 以及高甘油三酯血症促进游离脂肪酸向肝脏的运输, 并增加肝脏葡萄糖输出有关^[33-35]。

本研究 ROC 曲线分析显示, TyG 指数及 TyG-BMI 对于老年男性 MAFLD 患病均有良好的预测价值, 其 AUC 分别为 0.717、0.840。本研究进一步分析发现, 在无高脂血症及糖尿病的老年男性人群中, TyG 指数及 TyG-BMI 对 MAFLD 患病预测的 AUC 分别为 0.653、0.840, 与老年男性全人群相似, 尤其是 TyG-BMI 的结果是相对稳定的。此与 Xue 等^[36]基于 NHANES 数据库的研究结果相似, 该研究中 TyG-BMI 预测 MAFLD 的 AUC 为 0.822。Hu 等^[37]发现, TyG-BMI 在训练集及验证集中预测 NAFLD 的 AUC 分别为 0.888、0.884, 稍高于本研究, 可能是其研究训练集排除了 2 型糖尿病、服用任何药物及饮酒人群, 验证集受试者均为 LDL-C 正常范围的非肥胖患者, 与本研究人群的基线差异较大。Yang 等^[38]对中国西南部 7968 例成年人研究发现, 其 TyG 指数及 TyG-BMI 预测 MAFLD 的 AUC(分别为 0.795、0.884)高于

本研究。原因可能是该研究人群年龄仅(39.6±11.0)岁,明显低于本研究,而年龄对胰岛素的敏感度影响较大。Song等^[35]发现,TyG指数及TyG-BMI预测青少年NAFLD患病的最佳截断值为8.466、201.617。Zhang等^[39]发现20岁以上人群TyG指数预测NAFLD的临界值为8.5。Guo等^[40]发现成人TyG指数预测NAFLD的临界值为8.7。本研究中TyG指数及TyG-BMI预测老年男性MAFLD患病的最佳截断值分别为8.63、205.20,与上述研究结果基本一致。

肥胖是MAFLD发生及发展的重要因素^[41],研究表明BMI与MAFLD密切相关^[42-43]。因此,本研究发现TyG-BMI比单独应用TyG指数预测MAFLD的效能更优不难理解。Wang等^[44]也发现,TyG-BMI预测NAFLD的效能优于TyG指数,尤其是在年轻人、中年人及非肥胖人群中;Kim等^[45]发现,韩国普通人群TyG-BMI预测NAFLD的效能优于TyG指数及HOMA-IR;Sheng等^[46]在中国普通人群中及Song等^[47]在韩国青少年中的横断面研究也得出了一致的结果;Li等^[48]在中国2型糖尿病人群中也得出了相似的结果。

综上所述,TyG指数及TyG-BMI高水平状态与老年男性MAFLD患病风险增高相关。TyG指数及TyG-BMI对老年男性MAFLD患病均有一定的预测价值,而TyG-BMI较TyG指数预测价值更优。监测TyG指数及TyG-BMI有助于识别老年男性群体健康中原本被忽视的潜在风险,为MAFLD的早期防治提供了新思路。但本研究仍有一定的局限性:(1)本研究为单中心回顾性研究,代表性不足,且无法确定因果关系;(2)肝脏脂肪变性均依赖超声、CT等影像学结果,无病理学活检证据,虽然影像学检查在诊断肝脏脂肪变性方面也显示出较高的敏感度及特异度,但当肝脏脂肪变性程度<20%或在受试者BMI>40 kg/m²时,超声检测效能明显降低,CT也多用于中、重度肝脂肪变性^[49];(3)未能收集到臀围等数据,不能评估其他TyG指数相关衍生指标与老年男性MAFLD患病的相关性。今后仍需前瞻性、多中心临床研究以进一步探讨。

【参考文献】

- [1] Younossi Z, Tacke F, Arrese M, *et al.* Global perspectives on nonalcoholic fatty liver disease and nonalcoholic steatohepatitis[J]. *Hepatology*, 2019, 69(6): 2672-2682.
- [2] Wu WW, Li XW, Cui LH. The value of changes in diagnostic criteria for fatty liver in stratified management of cardiovascular risk[J]. *Med J Chin PLA*, 2021, 46(5): 486-491. [吴婉雯, 李晓伟, 崔立红. 脂肪肝诊断标准的变更对心血管疾病风险分层管理的价值分析[J]. *解放军医学杂志*, 2021, 46(5): 486-491.]
- [3] Younossi Z, Anstee QM, Marietti M, *et al.* Global burden of NAFLD and NASH: trends, predictions, risk factors and prevention[J]. *Nat Rev Gastroenterol Hepatol*, 2018, 15(1): 11-20.
- [4] Brar G, Tsukamoto H. Alcoholic and non-alcoholic steatohepatitis: global perspective and emerging science[J]. *J Gastroenterol*, 2019, 54(3): 218-225.
- [5] Shiha G, Korenjak M, Eskridge W, *et al.* Redefining fatty liver disease: an international patient perspective[J]. *Lancet Gastroenterol Hepatol*, 2021, 6(1): 73-79.
- [6] Du TT, Yuan G, Zhang MX, *et al.* Clinical usefulness of lipid ratios, visceral adiposity indicators, and the triglycerides and glucose index as risk markers of insulin resistance[J]. *Cardiovasc Diabetol*, 2014, 13: 146.
- [7] Navarro-González D, Sánchez-Íñigo L, Pastrana-Delgado J, *et al.* Triglyceride-glucose index (TyG index) in comparison with fasting plasma glucose improved diabetes prediction in patients with normal fasting glucose: The Vascular-Metabolic CUN cohort[J]. *Prev Med*, 2016, 86: 99-105.
- [8] Ramdas Nayak VK, Sathesh P, Shenoy MT, *et al.* Triglyceride glucose (TyG) index: a surrogate biomarker of insulin resistance[J]. *J Pak Med Assoc*, 2022, 72(5): 986-988.
- [9] Chen Y, Wang YT, Qian WJ, *et al.* Correlation of visceral fat area and sarcopenia in patient with type 2 diabetes[J]. *Med J Chin PLA*, 2020, 45(6): 651-656. [陈月, 王蕴婷, 钱文杰, 等. 2型糖尿病内脏脂肪面积与肌少症的相关性分析[J]. *解放军医学杂志*, 2020, 45(6): 651-656.]
- [10] Zhou L, Liao MY, Li X, *et al.* Changes of peroxiredoxin 6 level in patients with polycystic ovary syndrome and the relativity with glucose and lipid metabolism and sex hormone levels[J]. *Med J Chin PLA*, 2022, 47(3): 243-250. [周玲, 廖明钰, 李行, 等. PRDX6在多囊卵巢综合征患者中的表达变化及其与糖脂代谢、性激素水平的相关性分析[J]. *解放军医学杂志*, 2022, 47(3): 243-250.]
- [11] Vasques AC, Novaes FS, de Oliveira Mda S, *et al.* TyG index performs better than HOMA in a Brazilian population: a hyperglycemic clamp validated study[J]. *Diabetes Res Clin Pract*, 2011, 93(3): e98-e100.
- [12] Son DH, Lee HS, Lee YJ, *et al.* Comparison of triglyceride-glucose index and HOMA-IR for predicting prevalence and incidence of metabolic syndrome[J]. *Nutr Metab Cardiovasc Dis*, 2022, 32(3): 596-604.
- [13] Zhang M, Wang BY, Liu Y, *et al.* Cumulative increased risk of incident type 2 diabetes mellitus with increasing triglyceride glucose index in normal-weight people: the Rural Chinese Cohort Study[J]. *Cardiovasc Diabetol*, 2017, 16(1): 30.
- [14] Lee DY, Lee ES, Kim JH, *et al.* Predictive value of triglyceride glucose index for the risk of incident diabetes: a 4-year retrospective longitudinal study[J]. *PLoS One*, 2016, 11(9): e0163465.
- [15] Jian S, Su-Mei N, Xue C, *et al.* Association and interaction between triglyceride-glucose index and obesity on risk of hypertension in middle-aged and elderly adults[J]. *Clin Exp Hypertens*, 2017, 39(8): 732-739.
- [16] Mao Q, Zhou DL, Li YM, *et al.* The triglyceride-glucose index predicts coronary artery disease severity and cardiovascular outcomes in patients with non-ST-segment elevation acute coronary syndrome[J]. *Dis Markers*, 2019, 2019: 6891537.
- [17] Lee SB, Ahn CW, Lee BK, *et al.* Association between triglyceride glucose index and arterial stiffness in Korean adults[J]. *Cardiovasc*

- Diabetol, 2018, 17(1): 41.
- [18] Lambrinoudaki I, Kazani MV, Armeni E, *et al.* The TyG index as a marker of subclinical atherosclerosis and arterial stiffness in lean and overweight postmenopausal women[J]. *Heart Lung Circ*, 2018, 27(6): 716-724.
- [19] Li MW, Chi XW, Wang Y, *et al.* Trends in insulin resistance: insights into mechanisms and therapeutic strategy[J]. *Signal Transduct Target Ther*, 2022, 7(1): 216.
- [20] Er LK, Wu S, Chou HH, *et al.* Triglyceride glucose-body mass index is a simple and clinically useful surrogate marker for insulin resistance in nondiabetic individuals[J]. *PLoS One*, 2016, 11(3): e0149731.
- [21] Eslam M, Sarin SK, Wong VWS, *et al.* The Asian Pacific Association for the Study of the Liver clinical practice guidelines for the diagnosis and management of metabolic associated fatty liver disease[J]. *Hepatol Int*, 2020, 14(6): 889-919.
- [22] Bureau of Disease Prevention and Control, National Health Commission of People's Republic of China, National Center for Cardiovascular Diseases, Chinese Academy of Medical Science & Peking Union Medical College, Fuwai Hospital, *et al.* National guideline for hypertension management in China (2019)[J]. *Chin J Cardiol*, 2020, 48(1): 10-46. [国家卫生健康委员会疾病预防控制局, 国家心血管病中心, 中国医学科学院阜外医院, 等. 中国高血压健康管理规范(2019)[J]. *中华心血管病杂志*, 2020, 48(1): 10-46.]
- [23] Chinese Diabetes Society. Guideline for the prevention and treatment of type 2 diabetes mellitus in China (2020 edition)[J]. *Chin J Diabetes Mellitus*, 2021, 13(4): 315-409. [中华医学会糖尿病学分会. 中国2型糖尿病防治指南(2020年版)[J]. *中华糖尿病杂志*, 2021, 13(4): 315-409.]
- [24] Zhao SP. Key points and comments on the 2016 Chinese guideline for the management of dyslipidemia in adults[J]. *Chin J Cardiol*, 2016, 44(10): 833-853. [赵水平. 《中国成人血脂异常防治指南(2016年修订版)》要点与解读[J]. *中华心血管病杂志*, 2016, 44(10): 827-829.]
- [25] Chinese Society of Endocrinology, Chinese Medical Association. Guideline for the diagnosis and management of hyperuricemia and gout in China (2019)[J]. *Chin J Endocrinol Metab*, 2020, 36(1): 1-13. [中华医学会内分泌学分会. 中国高尿酸血症与痛风诊疗指南(2019)[J]. *中华内分泌代谢杂志*, 2020, 36(1): 1-13.]
- [26] Simental-Mendía LE, Rodríguez-Morán M, Guerrero-Romero F. The product of fasting glucose and triglycerides as surrogate for identifying insulin resistance in apparently healthy subjects[J]. *Metab Syndr Relat Disord*, 2008, 6(4): 299-304.
- [27] Alqahtani SA, Schattenberg JM. NAFLD in the Elderly[J]. *Clin Interv Aging*, 2021, 16: 1633-1649.
- [28] Younossi ZM, Koenig AB, Abdelatif D, *et al.* Global epidemiology of nonalcoholic fatty liver disease-Meta-analytic assessment of prevalence, incidence, and outcomes[J]. *Hepatology*, 2016, 64(1): 73-84.
- [29] Sanyal AJ, Campbell-Sargent C, Mirshahi F, *et al.* Nonalcoholic steatohepatitis: association of insulin resistance and mitochondrial abnormalities[J]. *Gastroenterology*, 2001, 120(5): 1183-1192.
- [30] Donnelly KL, Smith CI, Schwarzenberg SJ, *et al.* Sources of fatty acids stored in liver and secreted via lipoproteins in patients with nonalcoholic fatty liver disease[J]. *J Clin Invest*, 2005, 115(5): 1343-1351.
- [31] Lambert JE, Ramos-Roman MA, Browning JD, *et al.* Increased de novo lipogenesis is a distinct characteristic of individuals with nonalcoholic fatty liver disease[J]. *Gastroenterology*, 2014, 146(3): 726-735.
- [32] Kitae A, Hashimoto Y, Hamaguchi M, *et al.* The triglyceride and glucose index is a predictor of incident nonalcoholic fatty liver disease: a population-based cohort study[J]. *Can J Gastroenterol Hepatol*, 2019, 2019: 5121574.
- [33] Kahn BB, Flier JS. Obesity and insulin resistance[J]. *J Clin Invest*, 2000, 106(4): 473-481.
- [34] Tirosh A, Shai I, Bitzur R, *et al.* Changes in triglyceride levels over time and risk of type 2 diabetes in young men[J]. *Diabetes Care*, 2008, 31(10): 2032-2037.
- [35] Song K, Lee HW, Choi HS, *et al.* Comparison of the modified TyG indices and other parameters to predict non-alcoholic fatty liver disease in youth[J]. *Biology(Basel)*, 2022, 11(5): 685.
- [36] Xue Y, Xu JH, Li M, *et al.* Potential screening indicators for early diagnosis of NAFLD/MAFLD and liver fibrosis: Triglyceride glucose index-related parameters[J]. *Front Endocrinol (Lausanne)*, 2022, 13: 951689.
- [37] Hu HF, Han Y, Cao CC, *et al.* The triglyceride glucose-body mass index: a non-invasive index that identifies non-alcoholic fatty liver disease in the general Japanese population[J]. *J Transl Med*, 2022, 20(1): 398.
- [38] Yang Z, Yu B, Wang ZH, *et al.* Comparison of the prognostic value of a comprehensive set of predictors in identifying risk of metabolic-associated fatty liver disease among employed adults[J]. *BMC Public Health*, 2023, 23(1): 584.
- [39] Zhang SJ, Du TT, Zhang JH, *et al.* The triglyceride and glucose index (TyG) is an effective biomarker to identify nonalcoholic fatty liver disease[J]. *Lipids Health Dis*, 2017, 16(1): 15.
- [40] Guo W, Lu J, Qin P, *et al.* The triglyceride-glucose index is associated with the severity of hepatic steatosis and the presence of liver fibrosis in non-alcoholic fatty liver disease: a cross-sectional study in Chinese adults[J]. *Lipids Health Dis*, 2020, 19(1): 218.
- [41] Li L, Liu DW, Yan HY, *et al.* Obesity is an independent risk factor for non-alcoholic fatty liver disease: evidence from a meta-analysis of 21 cohort studies[J]. *Obes Rev*, 2016, 17(6): 510-519.
- [42] Cuzmar V, Alberti G, Uauy R, *et al.* Early obesity: risk factor for fatty liver disease[J]. *J Pediatr Gastroenterol Nutr*, 2020, 70(1): 93-98.
- [43] Miyake T, Kumagi T, Hirooka M, *et al.* Body mass index is the most useful predictive factor for the onset of nonalcoholic fatty liver disease: a community-based retrospective longitudinal cohort study[J]. *J Gastroenterol*, 2013, 48(3): 413-422.
- [44] Wang RS, Dai LL, Zhong YJ, *et al.* Usefulness of the triglyceride glucose-body mass index in evaluating nonalcoholic fatty liver disease: insights from a general population[J]. *Lipids Health Dis*, 2021, 20(1): 77.
- [45] Kim HS, Cho YK, Kim EH, *et al.* Triglyceride glucose-waist circumference is superior to the homeostasis model assessment of insulin resistance in identifying nonalcoholic fatty liver disease in healthy subjects[J]. *J Clin Med*, 2021, 11(1): 41.
- [46] Sheng GT, Lu S, Xie QY, *et al.* The usefulness of obesity and lipid-related indices to predict the presence of Non-alcoholic fatty liver disease[J]. *Lipids Health Dis*, 2021, 20(1): 134.
- [47] Song K, Park G, Lee HS, *et al.* Comparison of the triglyceride glucose index and modified triglyceride glucose indices to predict nonalcoholic fatty liver disease in youths[J]. *J Pediatr*, 2022, 242:

- 79-85.e1.
- [48] Li N, Tan HW, Xie AX, *et al.* Value of the triglyceride glucose index combined with body mass index in identifying non-alcoholic fatty liver disease in patients with type 2 diabetes[J]. *BMC Endocr Disord*, 2022, 22(1): 101.
- [49] Hernaez R, Lazo M, Bonekamp S, *et al.* Diagnostic accuracy and reliability of ultrasonography for the detection of fatty liver: a meta-analysis[J]. *Hepatology*, 2011, 54(3): 1082-1090.

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