

TyG 指数及其联合指数、相对脂肪质量指数对围绝经期女性非酒精性脂肪肝的诊断价值

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摘要:目的 探讨甘油三酯葡萄糖(triglyceride glucose, TyG)指数、TyG-腰围(TyG-waist circumference, TyG-WC)、TyG-腰围身高比(TyG-waist to height ratio, TyG-WHtR)、TyG-身体质量指数(TyG-body mass index, TyG-BMI)以及相对脂肪质量(relative fat mass, RFM)指数对围绝经期女性非酒精性脂肪肝(nonalcoholic fatty liver disease, NAFLD)的诊断价值。方法 选取 2022 年 3 月—2024 年 11 月就诊于北京积水潭医院贵州医院的围绝经期女性 448 名, 根据胸部/腹部 CT 结果分为 NAFLD 组($n=61$)和对照组($n=387$)。收集年龄、身高、体重、腰围、收缩压、舒张压、血常规、血生化、空腹血糖等资料, 计算身体质量指数(body mass index, BMI)、腰围身高比(waist to height ratio, WHtR)、TyG、TyG-WC、TyG-WHtR、TyG-BMI 以及 RFM 指数, 采用独立样本 t 检验或 Mann-Whitney U 检验比较两组各指标的差异, 采用多因素 logistic 回归分析 NAFLD 的独立危险因素, 构建受试者工作特征(receiver operating characteristic, ROC)曲线, 分析 TyG 指数及其联合指数、RFM 指数对 NAFLD 的诊断价值。结果 围绝经期女性 NAFLD 组和对照组的体重、BMI、腰围、WHtR、收缩压、舒张压、血红蛋白、甘油三酯、高密度脂蛋白、空腹血糖、TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 差异具有统计学意义($P<0.05$); 多因素 logistic 回归分析结果显示, TyG($OR=2.860, 95\%CI=1.900 \sim 4.305$)、TyG-WC($OR=1.011, 95\%CI: 1.008 \sim 1.014$)、TyG-WHtR ($OR=3.491, 95\%CI: 2.077 \sim 5.868$)、TyG-BMI ($OR=1.018, 95\%CI: 1.009 \sim 1.028$)、RFM($OR=1.172, 95\%CI: 1.074 \sim 1.279$)均是围绝经期女性 NAFLD 的独立危险因素($P<0.001$); ROC 曲线显示, TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 诊断围绝经期女性 NAFLD 的 ROC 曲线下面积分别为 0.779 ($95\%CI: 0.719 \sim 0.839$)、0.814 ($95\%CI: 0.769 \sim 0.859$)、0.804 ($95\%CI: 0.758 \sim 0.851$)、0.795 ($95\%CI: 0.746 \sim 0.844$)、0.735 ($95\%CI: 0.675 \sim 0.794$), 最佳截断值分别为 8.888、687.312、4.385、215.743、37.104; 曲线下面积值: TyG 相关指数>TyG>RFM, TyG 相关指数中以 TyG-WC 和 TyG-WHtR 的曲线下面积值最大(尤以 TyG-WC 最大), 均大于 TyG-BMI。结论 TyG 指数及其联合指数、RFM 指数均是围绝经期女性 NAFLD 的良好诊断指标, 其中 TyG 联合指数的诊断价值大于 TyG 指数和 RFM 指数, TyG 联合指数中以 TyG-WC 和 TyG-WHtR 的诊断价值最大(尤以 TyG-WC 最大)。本研究结果为围绝经期女性 NAFLD 的早期诊断和防治提供参考。

关键词: 非酒精性脂肪肝; TyG 指数; 相对脂肪质量指数; 围绝经期女性; 诊断价值

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The diagnostic value of the TyG index, its combined indices, and the relative fat mass index for nonalcoholic fatty liver disease in perimenopausal women

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Abstract: Objective To investigate the diagnostic value of triglyceride-glucose (TyG) index and its combination with waist circumference (TyG-WC), waist-to-height ratio (TyG-WHtR), body mass index (TyG-BMI) and relative fat mass (RFM) index for nonalcoholic fatty liver disease (NAFLD) in perimenopausal women. **Methods** A total of 448 perimenopausal women who visited the Guizhou Hospital of Beijing Jishuitan Hospital from March 2022 to November 2024 were selected. They were divided into the NAFLD group ($n=61$) and the control group ($n=387$) based on the results of chest or abdominal CT. The data of age, height, weight, waist circumference (WC), systolic blood pressure, diastolic blood pressure, blood routine, blood biochemistry, fasting blood glucose, etc. were collected. The body mass index (BMI), waist-to-height ratio (WHtR), TyG, TyG-WC, TyG-WHtR, TyG-BMI and RFM index were calculated. According to the results of chest or abdominal CT, the

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women were divided into NAFLD group and control group. The differences of each index between the two groups were compared by independent sample *t* test or Mann-Whitney *U* test. The independent risk factors for NAFLD were analyzed by multivariable logistic regression. Receiver operating characteristic (ROC) curve was used to analyze the diagnostic value of TyG index, its combined indices and RFM index for NAFLD. **Results** There were statistically significant differences ($P<0.05$) in weight, BMI, WC, WHtR, systolic blood pressure, diastolic blood pressure, hemoglobin, triglycerides, high-density lipoprotein, fasting blood glucose, TyG, TyG-WC, TyG-WHtR, TyG-BMI, and RFM between the NAFLD group and the control group of perimenopausal women. The results of multivariable logistic regression analysis showed that TyG ($OR=2.860$, 95% *CI*: 1.900–4.305), TyG-WC ($OR=1.011$, 95% *CI*: 1.008–1.014), TyG-WHtR ($OR=3.491$, 95% *CI*: 2.077–5.868), TyG-BMI ($OR=1.018$, 95% *CI*: 1.009–1.028), and RFM ($OR=1.172$, 95% *CI*: 1.074–1.279) were all independent risk factors for NAFLD in perimenopausal women ($P<0.001$). The ROC curve showed that the areas under the ROC curve (AUC) for diagnosing NAFLD in perimenopausal women by TyG, TyG-WC, TyG-WHtR, TyG-BMI, and RFM were 0.779 (95% *CI*: 0.719–0.839), 0.814 (95% *CI*: 0.769–0.859), 0.804 (95% *CI*: 0.758–0.851), 0.795 (95% *CI*: 0.746–0.844), and 0.735 (95% *CI*: 0.675–0.794), respectively, and the optimal cut-off values were 8.888, 687.312, 4.385, 215.743, and 37.104. The AUC values followed the order TyG-related indices > TyG > RFM, and among the TyG-related indices, the AUC values of TyG-WC and TyG-WHtR were the largest (especially TyG-WC), both of which were greater than those of TyG-BMI. **Conclusion** The TyG index and its combined indices, as well as the RFM index, are all good diagnostic indicators for NAFLD in perimenopausal women. Among them, the diagnostic value of the TyG combined indices is greater than that of the TyG index and the RFM index. Among the TyG combined indices, TyG-WC and TyG-WHtR showed the greatest diagnostic value, especially TyG-WC. The results of this study provide a reference for the early diagnosis, prevention, and treatment of NAFLD in perimenopausal women.

Keywords: Nonalcoholic fatty liver disease; Triglyceride-glucose (TyG) index; Relative fat mass (RFM) index; Perimenopausal women; Diagnostic value

非酒精性脂肪肝(non-alcoholic fatty liver disease, NAFLD)是全球最常见的慢性肝病,现已取代病毒性肝炎成为我国第一大慢性肝病^[1],其特征是肝细胞中甘油三酯的过度沉积,排除过量饮酒和其他肝病原因,可以从单纯的肝脏脂肪变性发展为 NAFLD,进而发展为肝纤维化、肝硬化,甚至肝癌,严重威胁人们的身体健康,并带来了一定的经济负担,NAFLD 与肥胖诱发的胰岛素抵抗有关,发病率逐年增加^[2]。TyG (triglyceride glucose, TyG) 指数由空腹甘油三酯和空腹血糖计算得来, TyG 指数及其联合指数已被证明可用于评估胰岛素抵抗^[3-4],成为反映人体成分和健康状况的重要参数;相对脂肪质量 (relative fat mass, RFM)指数是一种新型肥胖指标,由身高、腰围计算得来,能准确反映全身的体脂分布,已被用于临床评估身体成分^[5-6]。TyG 指数及其联合指数、RFM 指数均与多种代谢性疾病相关,而与 NAFLD 的关联研究较少。

围绝经期女性卵巢功能减退,雌激素分泌减少、代谢失衡,增加了线粒体功能障碍、细胞衰老、对损伤的免疫反应下降以及抗氧化和氧化应激之间的失衡,影响了肝脏功能并介导肝病的发展,此外,围绝经期腹部和内脏脂肪的增加以及肌肉质量和数量的减少,引起胰岛素抵抗加剧和脂质代谢受损^[7-8],导致 NAFLD 的患病风险增加,并促进肝纤维化的加速进展^[9-10],因此,对于围绝经期女性这一高风险人群,NAFLD 的早期筛查、诊断和干预至关重要。然而,围绝经期女性

这一人群更可能会被忽视,既往关于 TyG 指数及其联合指数与 NAFLD 的关联研究主要基于普通人群^[11-13]、非肥胖人群^[14-16],少数研究基于医务人员群体^[17]、老年人群^[18]、青少年人群^[19]等,RFM 指数与 NAFLD 的关联研究主要基于普通人群^[20-22]、普通和病态肥胖患者^[23],而基于围绝经期女性人群的研究目前国内外均未见报道,本研究选取了围绝经期女性这一特殊高风险人群,探讨 TyG 指数及其联合指数、RFM 指数对围绝经期女性 NAFLD 的诊断价值,有助于围绝经期女性 NAFLD 的早期预防、诊断和治疗。

1 资料与方法

1.1 研究对象 回顾性收集 2022 年 3 月—2024 年 11 月就诊于北京积水潭医院贵州医院(贵州省骨科医院)的围绝经期女性 448 名,年龄 45~55 岁,根据胸部/腹部 CT 结果分为 NAFLD 组和对照组。本研究经贵州省骨科医院伦理委员会批准(伦理批号 20220437)。

纳入标准:年龄 45~55 岁的围绝经期女性,临床资料、实验室检查及胸部/腹部 CT 检查结果等完整。**排除标准:**(1) 饮酒折合的乙醇量 ≥ 140 g/周;(2) 患病毒性肝炎、药物性肝损伤、胆汁淤积性肝损伤、免疫性肝病或者其它可导致继发性脂肪肝的疾病;(3) 合并急性或慢性感染、脑血管意外、恶性肿瘤等;(4) 合并严重的心脏、肾脏或其他疾病。

1.2 研究方法 收集患者以下临床资料:(1) 年龄、

身高、体重、腰围、收缩压、舒张压;(2)血常规和血生化:包括血红蛋白、血小板计数、直接胆红素、间接胆红素、总胆固醇、甘油三酯、高密度脂蛋白、低密度脂蛋白;(3)空腹血糖;(4)胸部/腹部 CT:测量肝脏和脾脏 CT 值,确定是否有 NAFLD;

根据以下公式计算身体质量指数 (body mass index, BMI)、腰围身高比 (waist to height ratio, WHtR)、TyG 指数、TyG-WC 指数、TyG-WHtR 指数、TyG-BMI 以及 RFM 指数。

$$\text{BMI} = \frac{\text{体重(kg)}}{\text{身高(m)}^2},$$

$$\text{WHtR} = \frac{\text{腰围(m)}}{\text{身高(m)}};$$

$$\text{TyG} = \ln[\text{甘油三酯(mg/dl)} \times \text{空腹血糖(mg/dl)} / 2]$$

其中甘油三酯:1 mmol/L=88.545 mg/dl,空腹血糖 1 mmol/L=18 mg/dl;

$$\text{TyG-WC} = \text{TyG} \times \text{WC},$$

$$\text{TyG-WHtR} = \text{TyG} \times \text{WHtR},$$

$$\text{TyG-BMI} = \text{TyG} \times \text{BMI};$$

$$\text{RFM} = 76 - [20 \times \text{身高(cm)} / \text{WC(cm)}]。$$

其中,WC为腰围。

NAFLD 评估标准^[1]:胸部 CT 或腹部 CT 上,肝脏 CT 值/脾脏 CT 值比值<1 诊断为脂肪肝。

1.3 统计学分析 使用 SPSS 25.0 软件进行统计分

析,所有计量资料采用 Shapiro-Wilk 检验方法进行正态性检验,符合正态分布,以均数±标准差($\bar{x} \pm s$)表示,采用独立样本 *t* 检验进行两组间比较;不符合正态分布,以 $[M(P_{25}, P_{75})]$ 表示,采用 Mann-Whitney *U* 检验进行两组间比较;将单因素分析中具有统计学意义且不存在共线性的因素作为自变量,以是否患有 NAFLD 作为因变量,进行多因素 logistic 回归分析。构建受试者工作特征(receiver operating characteristic, ROC)曲线,分析 TyG 指数及其联合指数、RFM 指数对 NAFLD 的诊断价值,并基于最大约登指数确定截断值;检验水准 $\alpha=0.05$ 。

2 结 果

2.1 两组一般资料及各项指标比较 本研究共入选 448 名研究对象,中位年龄 50.0(47.0,53.0)岁,其中有 NAFLD 患者 61 名(NAFLD 组),无 NAFLD 者 387 名(对照组),NAFLD 的患病率为 13.62%(61/448)。

NAFLD 组和对照组在体重、BMI、腰围、WHtR、收缩压、舒张压、血红蛋白、甘油三酯、高密度脂蛋白、空腹血糖、TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 上差异具有统计学意义($P<0.05$),两组年龄、身高、血小板计数、直接胆红素、间接胆红素、总胆固醇、低密度脂蛋白比较差异均无统计学意义($P>0.05$)。见表 1。

表 1 两组一般资料及各项指标比较 $[M(P_{25}, P_{75}), (\bar{x} \pm s)]$

Table 1 Comparison of general information and various indicators between the two groups $[M(P_{25}, P_{75}), (\bar{x} \pm s)]$

指标	对照组(<i>n</i> =387)	NAFLD 组(<i>n</i> =61)	Z/t 值	P 值
年龄(岁)	50.00(47.00,53.00)	50.00(46.50,53.00)	-0.791	0.429
身高(cm)*	155.115±5.511	155.082±5.607	0.044	0.965
体重(kg)	57.00(52.00,62.00)	62.200(57.200,67.650)	-5.205	<0.001
BMI(kg/m ²)	23.626(21.745,25.744)	26.029(24.460,28.107)	-5.705	<0.001
WC(cm)	78.00(73.00,84.00)	84.00(80.5,90.00)	-6.171	<0.001
WHtR	0.502(0.472,0.538)	0.542(0.517,0.574)	-5.898	<0.001
收缩压(mm Hg)	120.00(110.00,132.00)	135.00(119.00,145.00)	-4.569	<0.001
舒张压(mm Hg)	73.00(66.00,82.00)	81.00(74.50,89.50)	-4.566	<0.001
血红蛋白(g/L)	137.00(131.00,143.00)	141.00(134.50,147.00)	-2.890	0.004
血小板计数(10 ⁹ /L)	223.00(191.00,261.00)	222.00(191.50,248.00)	-0.494	0.622
直接胆红素(μmol/L)	3.700(2.990,4.910)	3.800(2.900,4.900)	-0.152	0.879
间接胆红素(μmol/L)	5.800(4.100,8.000)	5.300(3.955,7.450)	-0.422	0.673
总胆固醇(mmol/L)	4.890(4.380,5.550)	4.850(4.250,5.555)	-0.517	0.605
甘油三酯(mmol/L)	1.280(0.910,1.780)	2.150(1.560,3.675)	-6.675	<0.001
高密度脂蛋白(mmol/L)	1.440(1.230,1.700)	1.190(1.030,1.315)	-5.883	<0.001
低密度脂蛋白(mmol/L)	2.960(2.550,3.450)	2.900(2.220,3.575)	-1.137	0.256
空腹血糖(mmol/L)	4.810(4.540,5.110)	5.220(4.805,5.810)	-4.565	<0.001
TyG	8.505(8.121,8.849)	9.158(8.745,9.761)	-6.996	<0.001
TyG-WC	665.331(606.023,727.729)	786.222(714.841,827.743)	-7.888	<0.001
TyG-WHtR	4.285(3.915,4.715)	4.931(4.608,5.449)	-7.638	<0.001
TyG-BMI	201.017(181.145,227.374)	239.982(218.681,261.810)	-7.404	<0.001
RFM*	36.229±3.875	39.324±3.104	-5.944	<0.001

注:*为 *t* 值。

2.2 TyG 指数及其联合指数、RFM 指数与围绝经期女性 NAFLD 的 logistic 回归分析 以是否患有 NAFLD 为因变量, TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 作为自变量, 进行 logistic 回归分析。校正混杂因素前, 单因素 logistic 回归分析显示, TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 均是 NAFLD 的危险因素; 由于 TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 之间存在共线性, 所以分别进行多因素 logistic 回归分析, 即每个指标对应 1 个模型, 总共建立 5 个模型, 将单因素分析中具有统计学意义的变量去除存在共线性的变量后加入回归方程进行校正, 5 个模型分别为: 模型 1 代入 RFM, 校正变量为收缩

压、舒张压、血红蛋白、甘油三脂、高密度脂蛋白、空腹血糖、BMI; 模型 2 代入 TyG, 校正变量为收缩压、舒张压、血红蛋白、高密度脂蛋白、BMI、腰围; 模型 3 代入 TyG-WC, 校正变量为收缩压、舒张压、血红蛋白、高密度脂蛋白、BMI; 模型 4 代入 TyG-WHtR, 校正变量为收缩压、舒张压、血红蛋白、高密度脂蛋白、BMI; 模型 5 代入 TyG-BMI, 校正变量为收缩压、舒张压、血红蛋白、高密度脂蛋白、腰围。校正混杂因素后 TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 仍具有统计学意义 ($P < 0.05$), 表明 TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 均是非酒精性脂肪肝的独立危险因素。见表 2。

表 2 TyG 指数及其联合指数、RFM 指数与围绝经期女性 NAFLD 的 logistic 回归分析

Table 2 Logistic regression analysis of the association of the TyG index, its combined indices, and the RFM index with NAFLD in perimenopausal women

变量	β	s_x	Wald 值	OR 值(95%CI)	P 值
粗关联 TyG	1.256	0.197	40.693	3.512(2.387 ~ 5.165)	<0.001
校正后关联 TyG	1.051	0.209	25.364	2.860(1.900 ~ 4.305)	<0.001
粗关联 TyG-WC	0.011	0.002	50.457	1.011(1.008 ~ 1.014)	<0.001
校正后关联 TyG-WC	0.011	0.002	47.454	1.011(1.008 ~ 1.014)	<0.001
粗关联 TyG-WHtR	1.579	0.229	47.713	4.849(3.098 ~ 7.588)	<0.001
校正后关联 TyG-WHtR	1.250	0.265	22.272	3.491(2.077 ~ 5.868)	<0.001
粗关联 TyG-BMI	0.027	0.004	43.955	1.027(1.019 ~ 1.035)	<0.001
校正后关联 TyG-BMI	0.018	0.005	13.948	1.018(1.009 ~ 1.028)	<0.001
粗关联 RFM	0.220	0.040	29.678	1.247(1.152 ~ 1.349)	<0.001
校正后关联 RFM	0.159	0.045	12.657	1.172(1.074 ~ 1.279)	<0.001

2.3 TyG 指数及其联合指数、RFM 指数对围绝经期女性 NAFLD 的诊断价值分析 ROC 曲线结果显示, TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 诊断围绝经期女性 NAFLD 的 ROC 曲线下面积(area under the curve,AUC) 分别为 0.779、0.814、0.804、0.795、0.735, 最佳截断值分别为 8.888、687.312、4.385、215.743、

37.104, 敏感度分别为 70.5%、93.4%、91.8%、82.0%、78.7%, 特异度分别为 77.0%、61.5%、58.4%、68.2%、60.7%; AUC 值: TyG 相关指数 > TyG > RFM, TyG 相关指数中以 TyG-WC 和 TyG-WHtR 的 AUC 值最大(尤以 TyG-WC 最大), 均大于 TyG-BMI。见表 3、图 1。

表 3 TyG 指数及其联合指数、RFM 指数对围绝经期女性 NAFLD 的诊断价值

Table 3 Diagnostic value of the TyG index, its combined indices, and the RFM index for NAFLD in perimenopausal women

变量	AUC(95%CI)	P 值	最佳截断值	约登指数	敏感度(%)	特异度(%)
TyG	0.779(0.719 ~ 0.839)	<0.001	8.888	0.475	70.5	77.0
TyG-WC	0.814(0.769 ~ 0.859)	<0.001	687.312	0.549	93.4	61.5
TyG-WHtR	0.804(0.758 ~ 0.851)	<0.001	4.385	0.502	91.8	58.4
TyG-BMI	0.795(0.746 ~ 0.844)	<0.001	215.743	0.502	82.0	68.2
RFM	0.735(0.675 ~ 0.794)	<0.001	37.104	0.394	78.7	60.7

3 讨论

NAFLD 是全球最常见的慢性肝病, 全球成人患病率已达 38%, 并呈持续增长趋势^[24-25]。NAFLD 是一种慢性多系统疾病, 与胰岛素抵抗和相关代谢紊乱有

关, 可导致肝硬化、肝衰竭、肝癌等, 也与心血管疾病、慢性肾脏病、糖尿病、肿瘤等肝外并发症相关^[25-26]。围绝经期女性由于雌激素分泌减少, 导致脂肪组织重新分布(腹部和内脏脂肪增加)、胰岛素抵抗增加、肝脏脂肪摄取增加和肝脏载脂蛋白表达减少等, 更容易发

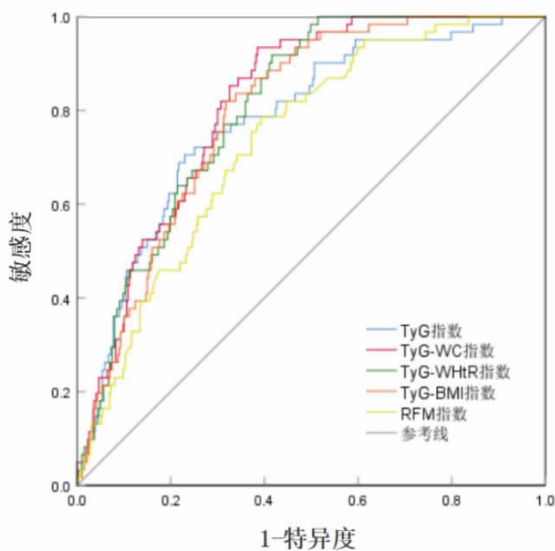


图1 TyG指数及其联合指数、RFM指数诊断围绝经期女性NAFLD的ROC曲线

Figure 1 ROC curves of the TyG index, its combined index, and the RFM index for diagnosing NAFLD in perimenopausal women

生NAFLD^[9,27]。研究表明,围绝经期导致NAFLD的发生风险增加约2.4倍^[10],并促进肝纤维化的加速进展,因此,对于围绝经期女性这一高风险人群,NAFLD的早期筛查、诊断和干预极其重要;NAFLD的诊断金标准是肝组织活检,具有侵入性且价格昂贵,存在一定的健康风险和经济成本,因此,寻找NAFLD的早期诊断指标至关重要。本研究选取围绝经期女性这一特殊高风险人群,探讨TyG指数及其联合指数(TyG-WC、TyG-WHtR、TyG-BMI)、RFM指数对围绝经期女性NAFLD的诊断价值,旨在找到围绝经期女性NAFLD最佳的早期诊断指标,达到提前筛查和诊断NAFLD的目的。

本研究结果显示,围绝经期女性NAFLD组的TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM均高于对照组,差异具有统计学意义。校正混杂因素后,多因素logistic回归分析结果显示,TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM均是围绝经期女性NAFLD的独立危险因素。ROC曲线分析结果显示,TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM的AUC均>0.7,提示各指标对围绝经期女性NAFLD均具有良好的诊断价值,诊断价值:TyG联合指数>TyG>RFM,TyG联合指数中以TyG-WC和TyG-WHtR的诊断价值最大(尤以TyG-WC最大),均大于TyG-BMI。关于TyG指数及其联合指数对NAFLD预测和诊断价值的研究中,既往多项研究基于普通人群^[12-13,28]、非肥胖人群^[14-16]、医务人员群体^[17]等,表明TyG指数及其联合指数对NAFLD具有一定的预测和诊断价值,较高的TyG指数及其联合指数可能与

NAFLD的风险增加相关,其中部分基于医务人员群体^[17]和普通人群^[13,28]的研究表明,TyG联合指数的预测/诊断价值大于TyG指数本身以及其他肥胖、血脂相关指标,我们的研究基于围绝经期女性人群,也得出了一致的结果,进一步证实了TyG联合肥胖指标(腰围、WHtR、BMI)比单独的TyG指数更具有诊断价值。而TyG各个联合指数对NAFLD预测/诊断价值的比较,研究结果目前还存在争议,如Sheng G等^[28]研究基于普通人群,结果表明女性人群中46~60岁年龄段TyG-WHtR的预测价值大于TyG-BMI和TyG-WC,10~30岁年龄段TyG-WC和TyG-WHtR的预测价值大于TyG-BMI,31~45岁和大于60岁两个年龄段TyG-BMI的预测价值大于TyG-WC和TyG-WHtR。Song S等^[13]研究基于韩国普通人群,结果表明对NAFLD的预测价值:TyG-WC>TyG-BMI;Wang X等^[15]研究基于日本非肥胖人群,结果表明对NAFLD的预测价值:TyG-WC>TyG-BMI>TyG-WHtR;Song K等^[19]基于韩国10~19岁青少年人群,结果表明对NAFLD的预测价值:TyG-WC>TyG-WHtR>TyG-BMI。以上关于TyG各个联合指数对NAFLD预测/诊断价值的比较研究结果存在一定差异,原因可能与研究人群的来源、分布、年龄和种族等有关,我们的研究基于围绝经期女性人群,结果显示,TyG联合指数中以TyG-WC和TyG-WHtR的诊断价值最大(尤以TyG-WC最大),均大于TyG-BMI,这可能与围绝经期女性的特殊性有关:围绝经期女性雌激素分泌减少,脂肪组织重新分布,导致腹部和内脏脂肪增加,腹围增加,主要引起腹型肥胖,而腰围和WHtR是腹型肥胖指标,更能反映腹部和内脏脂肪沉积,BMI是全身性肥胖指标,只反映皮下脂肪,而不能反映脂肪的分布^[29-30],此外,腹部内脏脂肪被认为是一个复杂且高度活跃的内分泌器官,通过释放激素和细胞因子,在炎症和代谢过程中发挥重要作用^[31],与皮下脂肪相比,腹部内脏脂肪的增加与胰岛素抵抗和代谢功能障碍(包括肝脏脂肪变性)更相关^[32-34],以上可能是对围绝经期女性NAFLD的诊断价值TyG-WC和TyG-WHtR大于TyG-BMI的原因。

关于RFM指数的研究,研究表明RFM可以预测心力衰竭^[35]、糖尿病^[36-37]、严重肝病^[38]和代谢综合征^[39],而关于RFM指数与NAFLD的关联研究较少,且它们之间的关系仍然存在争议。Machado MV等^[23]基于普通人群和病态肥胖的葡萄牙人, Lee MS等^[20]基于台湾普通人群,他们的研究发现,RFM与NAFLD的发生风险和NAFLD的严重程度之间没有关联。Cao C等^[21]基于日本普通人群,结果表明,当女性RFM指数低于34.95、男性低于23.40时,RFM与NAFLD的发

生风险呈显著正相关,将 RFM 维持在较低水平可能有利于降低 NAFLD 的风险;Shen W 等^[22]基于中国普通人群的研究,结果表明,RFM 与 NAFLD 的发生风险显著相关,可作为临床上 NAFLD 的预测指标;以上研究基于不同的人群,研究结果存在差异,我们的研究基于围绝经期女性这一特殊人群,结果表明 RFM 指数对 NAFLD 具有良好的诊断价值,RFM 作为新兴、简单且低成本的人体测量指数,与各种肥胖疾病相关,并显示出与腹型肥胖的高度相关性^[40],如上文所述,围绝经期女性雌激素分泌减少,脂肪组织重新分布,容易导致腹型肥胖,而腹部内脏脂肪在炎症和代谢过程中发挥重要作用,与胰岛素抵抗和代谢功能障碍(包括肝脏脂肪变性)相关^[32-34]。本研究结果表明 RFM 对围绝经期女性 NAFLD 具有良好的诊断价值,未来需继续扩大样本量,进行多中心、前瞻性的研究,进一步说明 RFM 指数与围绝经期女性 NAFLD 之间的关联。

综上所述,本研究结果表明,TyG、TyG-WC、TyG-WHtR、TyG-BMI、RFM 指数均是围绝经期女性 NAFLD 的良好诊断指标,其中 TyG 联合指数的诊断价值大于 TyG 指数和 RFM 指数,TyG 联合指数中以 TyG-WC 和 TyG-WHtR 的诊断价值最大(尤以 TyG-WC 最大),提示临床上重点关注 TyG 联合指数,尤其是 TyG-WC 和 TyG-WHtR 指数,有助于围绝经期女性 NAFLD 的早期诊断以及后期 NAFLD 的进展情况。本研究结果为围绝经期女性 NAFLD 的早期诊断提供参考。

本研究存在一定的局限性:第一,本研究样本单一,为单中心、横断面研究,无法作出因果推论,且没有进行 TyG 指数及其联合指数、RFM 指数与 NAFLD 严重程度的相关性分析;第二,由于围绝经期女性人群的特殊性,仅参照相关文献以年龄界定围绝经期,未结合月经史与性激素水平,存在选择偏倚,也未开展绝经状态亚组分析,可能会对研究结果产生一定影响,未来研究将结合月经状态、绝经年限、性激素水平等进行研究;第三,本研究中以 CT 诊断 NAFLD,并非诊断的金标准,与肝活检结果存在一定偏差;第四,本研究未纳入绝经年限、激素替代治疗史、生育史等混杂因素,此外,膳食、体力活动、吸烟、饮酒等这些都是重要的混杂因素,但由于本研究为回顾性研究,这些数据不可及,存在缺失,没有将其进行混杂控制,是本研究的局限性,未来将收集并控制这些混杂因素进行进一步的研究;第五,本研究未开展外部验证,模型的外推性有限。今后研究将改善以上局限性,并扩大样本量,进行多中心、前瞻性的研究。

利益冲突声明 本研究不存在任何利益冲突

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