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心力衰竭风险分层中肥胖指标的研究进展与临床应用展望

王　鑫[1]，任景怡[2*]

[1]中国医学科学院，北京协和医学院，中日友好医院(中日友好临床医学研究所)，北京
[2]中日友好医院心衰中心，北京

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摘　要

心力衰竭(HF)的精准风险分层是改善患者预后的关键。传统体重指数(BMI)因无法区分脂肪与肌肉，评估价值有限。目前研究重点已转向能反映脂肪分布、身体成分及代谢状态的多元指标，包括中心性肥胖测量指标、影像学及生物电阻抗评估的身体成分参数、以及复合代谢指标。这些指标在预测心衰发生、发展及预后方面展现出重要价值。本文旨在系统盘点用于心力衰竭风险分层的各类肥胖指标，综述其研究进展并探讨临床应用方向。

关键词

心力衰竭，风险评估，肥胖指标，身体成分，内脏脂肪

Research Advances and Clinical Application Perspectives of Obesity Indicators in Heart Failure Risk Stratification

Xin Wang[1], Jingyi Ren[2*]

[1]China-Japan Friendship Hospital (Institute of Clinical Medical Sciences), Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing
[2]Heart Failure Center, China-Japan Friendship Hospital, Beijing

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[*]通讯作者。

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Abstract

Accurate risk stratification in heart failure (HF) is crucial for improving patient outcomes. The traditional body mass index (BMI) has limited predictive value as it cannot distinguish between fat and muscle mass. Current research focus has shifted toward multivariate indicators that reflect fat distribution, body composition, and metabolic status, including measures of central obesity, body composition parameters assessed via imaging techniques and bioelectrical impedance analysis, as well as composite metabolic indices. These indicators have demonstrated significant value in predicting the onset, progression, and prognosis of HF. This review aims to systematically summarize various obesity-related indicators used in HF risk stratification, outline recent research advances, and discuss their potential clinical applications.

Keywords

Heart Failure, Risk Assessment, Obesity Indicators, Body Composition, Visceral Adipose Tissue

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1. 引言

心力衰竭(heart failure, HF)是心血管疾病终末阶段的主要表现形式，其发病率与死亡率居高不下，已成为全球性的重大公共卫生负担[1]。肥胖作为 HF 明确且可干预的独立危险因素，其传统衡量指标体重指数(body mass index, BMI)衰风险评估中存在显著局限，既无法区分脂肪与肌肉，也无法反映脂肪分布与代谢活性的异质性[2] [3]。因此，探索并整合能够更精确评估肥胖相关风险的新型指标，已成为当前临床研究与实践的热点[4]。本文旨在系统性地盘点当前可用于 HF 风险分层的各类肥胖指标，重点聚焦于指标的计算方法及其在预测 HF 发生、发展及预后方面的现有研究发现，以期为临床工作者提供一个清晰、实用的参考工具。

2. 传统与改良型人体测量学指标

以 BMI 为代表的传统人体测量指标因简便易得而广泛应用，但其在 HF 风险评估中的价值需被重新审视。BMI 的计算公式 = 体重(kg)/身高(m) [2]。Khan 等人的研究评估了 BMI 与终生心血管疾病风险的关系，提供了 BMI 作为长期风险预测因子的宏观视角[5]。然而，BMI 无法区分脂肪与去脂体重，这直接导致了“肥胖悖论”的观察现象，即在已确诊的 HF 患者中，较高 BMI 有时与较好的生存率相关[6]。这一现象促使研究者寻求更能反映脂肪分布的中心性肥胖的改良指标。

中心性肥胖指标，如腰围(Waist Circumference, WC)、腰臀比(Waist-to-Hip Ratio, WHR)、腰高比(Waist-to-Height Ratio, WHtR)和中国内脏脂肪指数(Visceral Adiposity Index, VAI)，因其与内脏脂肪蓄积密切相关而被广泛研究。WHR 的计算公式 = WC/臀围；WHtR = WC/身高；VAI (男性) = [WC/(39.68 + (1.88 × BMI))] × (TG/1.03) × (1.31/HDL-C)，VAI (女性) = [WC/(36.58 + (1.89 × BMI))] × (TG/0.81) × (1.52/HDL-C)。Streng 等在慢性 HF 患者中的研究发现，较高的 WHR 与全因死亡率独立相关，其预测效力优于 BMI [7]。Ichikawa 等人在一项长达 13 年的日本人群随访研究中系统比较了多种人体测量指标，证实 WC 和 WHR 对预测包括 HF 在内的首发心血管事件具有重要价值[8]。Wu 等人的研究进一步扩展了简单指标的

范畴，发现颈围、WHtR 以及基于中国人群数据计算的 VAI 均与新发 HF 风险显著相关，为临床提供了更多简便易行的评估工具[9]。

此外，一些研究探索了将 BMI 与其他简单指标结合以提升预测能力的方法。Kamiya 等人提出了臂围作为 BMI 补充指标的角色，发现臂围在心力衰竭患者风险分层中具有独立的预后价值[10]。有研究针对射血分数轻度降低或射血分数保留的 HF 患者，系统评估了 BMI、WC 等多种肥胖相关人体测量学指标与 HF 住院、心血管死亡的关联，为这类人群的指标选择提供了实证依据[11]。

3. 身体成分与脂肪分布特异性指标

随着生物电阻抗分析和影像学技术的发展，对肥胖的评估进入了量化身体成分与脂肪分布的新阶段。这些指标的核心在于区分脂肪质量、非脂肪质量以及脂肪的分布部位。

生物电阻抗分析可估算体脂率、去脂体重、相位角等参数。相位角(phase angle, PhA)是生物电阻抗分析中反映细胞膜完整性与细胞活力的电学参数，其数值高低直接指示细胞健康状况，是评估营养状况、疾病预后及代谢活力的重要功能性指标。Thomas 等人和 Mendonça 等人的研究均证实，PhA 是 HF 患者全因死亡率的独立预测因子[12] [13]。

Konishi 等人和 Uchida 等人强调了骨骼肌质量本身对 HF 患者预后的重要影响[14] [15]，研究表明，肌肉减少症是心衰不良预后的一个关键且可评估的因素。更深入的研究聚焦于肌肉质量的“质”而非仅“量”。研究发现，大腿肌肉的脂肪浸润是新发 HF 的危险因素[16]。Salmons 等在肥胖相关的射血分数保留的心衰(Heart Failure with Preserved Ejection Fraction, HFpEF)患者中，证实了通过 PhA 评估的骨骼肌质量与患者的心肺功能之间存在显著相关性[17]。这些研究共同指向“少肌性肥胖”这一高危表型。Billingsley 等发现，在 HFpEF 患者中，合并少肌性肥胖者比单纯肥胖者的心肺功能更差[18]。值得注意的是，基于人体测量学参数推导的肌肉质量估算指标，已被证实是 HF 患者全因死亡风险的独立预测因子。更深入的分析表明，这种预测关系具有性别特异性，在不同性别的患者中可能存在不同的风险阈值或关联强度[19] [20]。

在脂肪分布方面，特定区域的异位脂肪沉积受到高度关注。内脏脂肪面积通常通过计算机断层扫描(computed tomography, CT)和磁共振成像(magnetic resonance imaging, MRI)定量。在 HFpEF 患者中，内脏脂肪增多与肾功能恶化风险增加、心脏交感神经功能受损相关[21] [22]。值得注意的是，内脏脂肪的病理生理作用在女性 HFpEF 患者中表现得尤为突出，与更严重的血流动力学异常和临床结局独立相关，这提示性别是脂肪分布与心衰表型关联中的一个关键修饰因素[23]。此外，一项大型队列研究证实，通过 CT 测量的心包脂肪体积是新发心力衰竭的独立危险因素[24]。Antoniades 等人则综述了血管周围脂肪组织作为炎症来源和潜在治疗靶点的价值[25]。有研究认为，内脏脂肪等特定脂肪库的堆积不仅与 HFpEF 发病风险独立相关，也是预测该患者群体全因死亡率的重要因素[26] [27]。

4. 复合型代谢与肥胖整合指数

鉴于肥胖常与胰岛素抵抗、血脂异常等代谢障碍共存，结合多项临床常规检验指标构建的复合指数，在评估 HF 风险方面展现出独特优势。

甘油三酯–葡萄糖指数(triglyceride-glucose Index, TyG index)是当前研究的热点之一，其计算公式通常为 Ln[空腹甘油三酯(mg/dL) × 空腹血糖(mg/dL)/2]。有研究发现，TyG 指数对急性失代偿性 HF 患者的预后具有预测价值[28]。前瞻性队列研究进一步表明，累积的 TyG 指数暴露与新发 HF 风险呈显著正相关[29]。在此基础上有学者开发了衍生指标，如 TyG-体重调整腰围指数，该指数整合了 WC 信息，研究显示其具有超越传统 TyG 指数的增量预测价值，能改善心力衰竭的风险分层[30]。

心脏代谢指数(cardio-metabolic index, CMI) = [甘油三酯(mmol/L)/高密度脂蛋白(mmol/L)] × WHtR，它通过将血脂异常与中心性肥胖整合在一个公式中，旨在更全面地反映与胰岛素抵抗、代谢综合征和动脉粥样硬化相关的心血管疾病风险。有横断面研究发现，CMI 与美国成年人的充血性 HF 患病率相关[31]。

5. 前沿探索性指标与评估技术

除上述指标外，一些基于新技术或新视角的探索性指标也开始涌现。这些指标可能代表了未来的发展方向，但目前证据多处于早期阶段。

多模态成像技术为超越传统指标提供了可能。CT 和 MRI 等影像学方法能够精确量化包括内脏、心包和肌间在内的多个特定解剖部位的脂肪体积与面积，甚至能对代谢活性不同的脂肪类型，例如白色脂肪与棕色脂肪，进行区分。这些技术所实现的精确测量，使得在临床研究与实践中，可以更直接地探究特定脂肪库与心脏结构功能损害及代谢紊乱之间的具体关联，从而为实现肥胖相关心血管风险的更精准评估提供了关键工具[32]。有研究利用双能 X 线吸收测定法测量的身体成分数据系统分析了其与冠状动脉微血管功能障碍的关联，并进一步探讨了该指标对包括心力衰竭在内的未来心血管事件的预测价值[33]。

人工智能的应用为风险分层带来了新模式。Jeon 等人探索了一种利用人工智能算法从常规胸部 X 光片中自动推导充血指数，并结合临床参数对急性 HF 进行风险分层的新方法，展现了将传统检查与 AI 结合提升效率的潜力[34]。

在机制探索层面，有研究发现内脏脂肪中胰腺脂肪酶的脂解作用会恶化 HF，这提示脂肪组织的代谢活性本身可能成为未来的生物标志物或治疗靶点[35]。早期研究显示，较高的利钠肽水平与更有利的脂肪分布相关，暗示了神经内分泌系统与脂肪生物学之间的交互作用[36]。

6. 总结与展望

综上所述，现有可用于 HF 风险分层的肥胖指标已形成一个从简单到复杂、从宏观到微观的多元化体系[37]。研究的主要特点表现为从依赖单一的 BMI，全面转向强调脂肪分布、身体成分构成(肌肉与脂肪的比例与质量)以及代谢整合状态的综合评价[38]。当前的研究趋势在于不断开发和验证各种复合型指数，并积极探索影像学、人工智能等新技术在量化与评估中的应用。这对临床实践的启示在于，应根据医疗条件可行性与患者具体特征，分层级选用指标，建立实用化评估路径。

然而，现有研究在临床转化层面仍存不足：不同指标间缺乏直接比较，尚未形成基于场景的成本效益共识；多数指标的诊断切值在不同人群中未标准化，普适性受限；部分指标计算复杂或依赖设备，难以整合进临床工作流程；且指标动态变化与心力衰竭风险改善的前瞻性证据仍显薄弱。

基于现有进展与不足，未来的研究可进一步聚焦于临床整合与路径优化：例如对指标进行证据与操作层面的分级，并构建适用于不同医疗场景的选用流程；重点探讨在合并常见共病的 HF 人群中，不同肥胖指标的特异性关联；同时关注其动态监测价值，为肥胖指标作为治疗反应监测工具提供依据。

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