·综述·

冠状动脉钙化积分、心肌灌注显像及其联合应用的临床价值

薛倩倩 姚稚明

【摘要】 冠状动脉钙化积分(CACS)、心肌灌注显像(MPI)在冠心病的危险度分层、诊疗、预后评价中均有较高价值；两者的联合能给临床提供更多的信息。SPECT/CT 能使两者同时显示。出于辐射剂量的考虑，低剂量非门控 CT 已经被用于 CACS。该文综述了 CACS、MPI 及其联合应用的临床价值。

【关键词】 冠状动脉硬化；冠状动脉狭窄；心肌灌注显像；冠心病

The clinic application of coronary artery calcification scores and myocardial perfusion imaging and the combination

XUE Qian-qian, YAO Zhi-ming. Department of Nuclear Medicine, Beijing Hospital(Peking University Fifth Hospital), Beijing 100730, China

Corresponding author: YAO Zhi-ming, Email: yao.zhiming@163.com

【**Abstract**】 Coronary artery calcification score and myocardial perfusion imaging play important role in the diagnosis, risk stratification, prognosis of coronary heart disease. With the emerging of fusion imaging, the combination of CACS and MPI provides more information to the physician. Out of consideration for radiological dose, low-dose non-gated CT has been used to quantitate the coronary artery calcification. This review focuses on the clinical application of coronary artery calcification score, myocardial perfusion imaging and the combination.

【**Key words**】 Coronary arteriosclerosis; Coronary stenosis; Myocardial perfusion imaging; Coronary artery disease

心血管疾病是引起人类死亡的首要病因，据世界卫生组织统计，2008 年，约 1730 万人死于心血管疾病，占全球死亡总人数的 30%；其中约 730 万人死于冠心病[1]。准确评估危险因素识别高危人群，进行干预以减少心血管事件的发生率至关重要。目前常用的危险度评估方法有传统危险因素评估、冠状动脉钙化积分(coronary artery calcification score，CACS)、心肌灌注显像(myocardial perfusion imaging，MPI)等。PET/CT、SPECT/CT 能同时显示病变解剖与功能改变。为降低辐射剂量，低剂量非门控 CT 已被用于定量冠状动脉钙化(coronary artery calcification，CAC)。本文主要介绍 CACS、MPI 及其联合的临床应用价值。

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作者单位：100730，卫生部北京医院（北京大学第五临床医学院)核医学科

通信作者：姚稚明(Email：yao.zhiming@163.com)

1 CAC

1.1 CAC 对心血管疾病的预测

CAC 是冠状动脉粥样硬化的特异性标志，可反映斑块的存在、分布和负荷情况。斑块负荷重预示心血管疾病发生率高[2]，因此对 CAC 进行定性、定量可以评估心血管疾病的发生率。定量 CAC 常用 Agatston 等[3]提出的计算方法：以+130 HU，面积≥1 mm 代表钙化灶；钙化积分=钙化面积×钙化灶峰值积分(130~199 HU 为 1 分，200~299 HU 为 2 分，300~399 HU 为 3 分，≥400 HU 为 4 分)。它的预测作用比传统危险因素的预测作用高 7 倍[4]。研究表明在无症状人群中，定量 CAC 可及时发现心血管疾病的高危人群[5-7]，尤其对年轻无症状的男性[8]；CACS 是预测冠心病突发事件重要、有效和独立的因素。在有症状的人群中，CACS 是严重冠状动脉疾病的独立预测因子[9]。使用 CACS 计算所得的动脉年龄计算 Framingham 积分比使用真实年龄计算

Framingham 积分更能准确地预测短期心血管疾病的发生率[10]。无论患者有无症状，无 CAC 预示着未来 2~5 年内出现心血管疾病的可能性小[11-12]。与 Framingham 风险评分(Framingham risk score，FRS)相比，CACS 可更好地预测冠心病患者的病死率，与传统危险因素评估方法联合能提高对冠心病的诊断价值。Shaw 等[13]的研究表明，对中等风险因素且最不容易做出处理决策的人群，高 CACS 能够明显提高对心血管疾病的预测能力。另有研究显示，CACS 对亚临床动脉粥样硬化患者(特别是对FRS评为中等危险的患者)可提供有用的信息[14]。

1.2 CAC 与冠状动脉狭窄

无 CAC 说明冠状动脉严重狭窄的可能性较小，但并不意味着动脉粥样硬化斑块不存在。Gottlieb 等[15]对 72 例无 CAC 的患者进行冠状动脉造影发现，有 14 例患者存在至少 1 支冠状动脉狭窄，狭窄程度>50%；在未见钙化的 383 支血管中有 47 支狭窄，狭窄程度>50%。通常动脉钙化越严重动脉发生狭窄的可能性就越大，但两者之间没有很好的相关性。Kitamura 等[16]认为 CAC 与动脉狭窄的严重程度明显相关；Mitsutake 等[17]的研究也表明 CAC 与动脉狭窄的程度密切相关。但 Gottlieb 等[15]研究的64 支完全闭塞的血管中有 13 支未见钙化；也有研究表明冠状动脉造影未见狭窄的血管有时钙化也很严重[18]。总之，CAC 与动脉狭窄之间有一定的相关性，但不呈正相关；钙化情况在一定程度上反映着冠状动脉狭窄的程度。

2 MPI

从 20 世纪 70 年代早期开始，核显像就在冠心病诊断和危险度分层中发挥着重要作用[19]。MPI 可反映心肌的血流灌注量和心肌细胞的活性，其在临床上主要用于冠心病的诊断、危险度分层、疗效评估和预后判断等。

2.1 MPI 对冠心病的诊断

MPI 直接反映病变血管供血心肌的血流状况，可明确缺血与否、缺血范围与程度和心肌存活与否。通过对已经发表的文章的分析发现，负荷 SPECT MPI 诊断冠心病的灵敏度约 87%(71%~97%)，特异度约 73%(36%~100%)[20]；一篇对 8964 例患者的 Meta 分析的文献也支持以上数据，灵敏度平均约 86%，特异度平均约 74%[21]。特异度相对较低主要是由于周围软组织的衰减所致。门控 MPI(gated MPI，GMPI)可以直接观看心肌的运动情况，在一定程度上提高了 MPI 诊断冠心病的特异度，尤其在女性患者中其特异度高达 92%(非 GMPI 的诊断特异度为 84%)[22]。最近研究发现，即使冠状动脉没有明显狭窄的患者其负荷 MPI 也可能为异常[23]，这可能是由于心肌微循环障碍引起的，因此 MPI 异常而冠状动脉正常的患者并非都是假阳性。PET MPI 在诊断冠心病上拥有更高的灵敏度(90%)和特异度(89%)[24]，PET 对心室间隔也有更高的空间和时间分辨率。

2.2 MPI 对发生心血管疾病的危险度分层

MPI 对患者心血管疾病的发生率进行评估，进而进行危险度分层、评估预后，从而指导临床诊疗措施。MPI 对心血管疾病有很高的阴性预测价值，负荷 SPECT MPI 阴性的患者发生心血管疾病的可能性很低，约 0.6%/年[25]；MPI 阴性的患者一般不需要进行其他的检查或介入治疗，可以安全地进行单纯的药物治疗[26]。MPI 异常者心血管疾病的发生率较高，约 7.4%/年[25]；因此，高危 MPI 患者需行冠状动脉造影以了解冠状动脉狭窄程度，确定是否需要实施血运重建术以及联合改变危险因子等综合治疗方法。平板运动 Duke 评分对预测心血管疾病有很大的价值，但对于评为中危的患者，其心血管疾病的发生率及进行何种治疗措施仍存在较大争议[27]。针对这些患者，MPI 有更高的临床应用价值，若 MPI 正常则其心血管疾病的发生率约 0.4%/年；若 MPI 评为高危则其心血管疾病的发生率则高达 8.9%/年[28]。美国心脏病学会/美国心脏协会/美国核心脏病学会所制定的相关指南中均强调应把核素心肌显像作为冠状动脉造影的“把门人”，以提高造影的阳性率、制定合理的治疗方案、大幅度降低医疗费用。但与冠状动脉造影相比，MPI 在评价阻塞性冠心病的程度时的灵敏度较低，尤其对于多支血管病变的患者。Berman 等[29]报道，在 101 个冠状动脉左主干狭窄>50%的患者中，SPECT 根据中重度灌注缺损评为高危的患者仅占 59%，15%的患者显示为无明显灌注缺损。

3 MPI 和 CACS 联合应用

融合显像随着 SPECT/CT、PET/CT 的问世而兴起，影像学技术从单一向多元化模式发展。CT 对

心脏和冠状动脉的解剖结构的高分辨率显像能够诊断亚临床动脉粥样硬化，MPI 可显示心肌血流和代谢的异常改变。这两种互补型检查方法的联合应用能提供更多诊断、预后信息[30-32]。MPI 诊断亚临床冠状动脉粥样硬化的灵敏度较低，与 CACS 的联合应用能为危险度分层提供更多的信息，尤其是对于 MPI 正常的患者。大量的研究表明，MPI 正常的患者中有约 1/3 的患者的 CACS>400[33-36]。传统评分为中危的患者，若其 CACS>400，那么该患者将会被重新评为高危患者，从而改变诊疗措施[37]，以降低其心血管疾病的发生率。对于无症状的患者，有研究表明，MPI 异常率、心血管疾病发生率都随 CACS 的增高而增高；MPI 正常的患者，其发生心血管疾病的相对风险亦随 CACS 的增高而增加[38]。一项对有症状患者的研究表明，MPI 异常的患者 CACS 显著高于 MPI 正常者[39]。通过对冠状动脉造影结果的回顾性分析发现，当 CACS>709 时，可以发现 MPI 漏诊的冠状动脉疾病。另有研究表明，当 CACS<100 时，负荷 MPI 异常的可能性较低(≤2%)；冠状动脉狭窄超过 50%的可能性<3%，CACS 可以作为有创性冠状动脉造影及负荷 MPI 前的筛查方法，从而降低患者因检查所受的辐射剂量[40-41]。但也有研究发现 CACS 与 MPI 之间无直接相关性[42]。

CACS 联合 MPI 不仅能提供冠状动脉结构改变的信息，还能提供心肌血流和代谢改变的信息，比 CACS 联合 FRS 方法可提供更多的心肌功能和代谢信息，对临床治疗方案的选择及预后评估都具有重要作用。关于这两种方法联合在临床中的综合应用价值、长期患者所得利益以及医疗资源节约等方面的优劣势，还没有相关研究。

4 低剂量 CT 与 CAC

SPECT/CT、PET/CT 可同时显示冠状动脉解剖结构改变与心肌病理生理改变，如 MPI 与冠状动脉造影、CACS，但是联合显像会增加辐射剂量。行 MPI 时，会通过低剂量非门控 CT 获得衰减校正图像，能否利用低剂量衰减校正 CT 来定量 CAC，以降低患者的辐射剂量成为新的研究方向。有研究表明，Agatston 积分适用于低剂量非门控 CT 扫描图像[43]；另有研究显示，低剂量非门控 CT 两次扫描之间对患者进行的危险度分层有较好的一致性[44]。Einstein 等[45]通过对衰减校正 CT 图像视觉定量 CAC，并与标准 Agatston 积分对比分析发现：视觉定量 CACS 与标准 Agatston 积分有较高的一致性。另有研究表明，衰减校正 CT 图像可以运用 Agatston 积分，而且选用 CT 阈值为 50 时，衰减校正 CT 计算的钙化积分与标准钙化积分有较高的一致性[46]。应用 SPECT/CT、PET/CT 的衰减校正低剂量 CT 图像定量 CAC 并综合 MPI 不仅能为临床提供更为准确的风险评估信息，还可以降低辐射剂量，更有利于需要随诊的患者。

5 总结

CACS、MPI 对冠心病的诊疗、预后评估、治疗疗效评估和危险度评估有较高的应用价值。SPECT/CT 融合技术的不断发展，能同时获得 MPI 与 CACS；低剂量衰减校正 CT 已被用于定量 CAC，患者行心肌核素显像可同时获得 CACS 和 MPI，且没有增加辐射剂量。随着科学技术的发展，一次检查获得更多信息将拥有更高的临床应用价值。

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