美国心脏病学院基金会 / 美国超声心动图学会 / 美国心脏病协会 / 美国核素心脏病学会 / 美国心力衰竭学会 / 美国心律学会 / 美国心血管造影和介入学会 / 美国重症医学会 / 国际心血管 CT 学会 / 美国心脏核磁共振成像协会

# 超声心动图的适用标准

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缩略词：

ACS 急性冠脉综合症

APC 心房期前收缩

CABG 冠状动脉旁路移植术

CAD 冠状动脉硬化性心脏病

CMR 心血管核磁共振

CRT 心脏再同步化治疗

CT 计算机断层显像

ECG 心电图

HF 心力衰竭

ICD 埋藏式心脏除颤器

LBBB 左束支传导阻滞

LV 左心室

MET 估计运动代谢当量

MI 心肌梗死

PCI 经皮冠状动脉介入术

RNI 放射性核素显像

SPECT MPI 单光子发射计算机断层心肌灌注显像

STEMI ST 段抬高型心肌梗死

SVT 室上型心动过速

TEE 经食管超声显像

TIA 一过性脑缺血发作

TIMI 心肌梗死溶栓治疗

TTE 经胸超声显像

NSTEMI/NSTEMI 不稳定型心绞痛（译者添加）/非 ST 段抬高型心肌梗死

VPC 室性期前收缩

VT 室性心动过速

**摘要：**美国心脏病学院基金会（ACCF）与美国超声心动图学会（ASE）以及主要专科和亚专科学会合作，对经常行超声心动图检查的常见临床情况进行了回顾。本文件参考并更新了 2007 年原有的经胸和经食管超声心动图适用标准（1），2008 年原有的负荷超声心动图适用标准（2）。本修订版采纳了新的临床数据，反映了所用检查模态的变化，并阐明了原始标准中存在遗漏或描述欠清楚的部分。

本适应症（临床场合）来自常用或预期将运用，以及当前临床实践指南和原先适用标准（AUC）的履行结果。本文件中，202 个适应症是由一个多学科的写作小组开发的，分别由一个独立的技术小组从 1 到 9 分进行评判，合理（7-9 分），不确定（4-6 分），以及不合理（1-3 分）。

97 个适应症被定为合理，34 个被定为不确定，71 个被定为不合理。一般而言，当临床情况发生变化或者超声结果预期会改变病人的处理，此时用超声进行初步诊断就被定为合理。当临床情况没有发生变化，或者检查结果不可能改变患者的处理时，作常规超声检查就被视为不合理/不确定。

超声心动图的 AUC 有可能会影响医生的决策，医疗保健服务和报销政策。此外，认识不确定的临床情况有助于识别那一些能从未来的研究中获益的领域。

**前言：**

为了使影像技术的合理使用满足高质量的护理需求，ACCF 为选定患者的适应症制定了一套流程，规范心血管成像的合理使用。

AUC 的颁布反映了 ACCF 正在努力对临床各种情况进行分析和系统性创新，审查和分类，使诊断性检查和手术能被医师用于心血管病患者的护理。这套流程是基于目前对各种检查方法技术能力的理解。尽管它不可能对临床广泛多样性疾病作全面的解读，但这些适应症可以涵盖目前临床实践遇到的大多数情况中常见的场景。鉴于他们表达的信息范围十分广泛，这些适应症并不直接对应于国际疾病分类系统的第九次修订版本，因为这些代码不包括例如症状等临床信息。

ACCF 认为，仔细地汇集广泛的临床经验和现有的循证信息将有助于指导更有效和公平地分配心血管影像中的医疗资源。AUC 的最终目标是要以一种经济有效的方式，改善患者的护理和健康预后，但并非要忽视临床决策中模棱两可的实质。因此，AUC 不应被视为可以替代合理的临床判断和实践经验。

ACCF 的 AUC 自身也在不断更新。在当前的更新中，技术小组成员被要求以独立的方式评价超声心动图的适应症，而不考虑先前颁布的经胸超声心动图（TTE）和经食管超声心动图（TEE）（1）和负荷超声心动图（2）以及 ACCF 先前对影像诊断模态的评分。例如心脏放射性核素显像（RNI）（3）和心脏计算机断层显像（CT）（4）。鉴于这个过程中的更新和演变，读者被告知，在过去几年不同时间，各种方法个自的适用评级可能无法反映不同检查方法的适应症的比较性应用，因为评级可能会随着时间的推移有所不同。目前正在对多种影像技术的适用性进行比较，以评价各种临床场合每一种检查方法的相对适用度。

我们感谢技术小组及其主席 Steven Bailey，MD，FACC，FSCAI，FAHA，这是一个具有广泛技能和见解的专业团队，他们深思熟虑地探讨了超声心动图各种适应症的特点。我们还要感谢 27 位对适应症草案进行仔细审查的人员，包括由 Michael Wolk, MD, MACC, Rory Weiner, MD, 领导的 AUC 专案组原班人马和 ACC 工作人员, John C. Lewin, MD, Joseph Allen, Starr Webb, Jenissa Haidari, Lea Binder，以他们非常娴熟的技能在本文件生成过程中提供的支持。

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**1 引言：**

本报告阐述了 TTE，TEE 和负荷超声心动图的适用性。心血管影像技术的改进，以及无创性诊断工具和心血管病治疗选择的扩展，使心血管影像需求剧增。随着超声心动图领域与其它影像方法和治疗方法的不断发展，医疗保健界需要了解如何将这项技术最好地融入临床日常护理中。

ACCF 和合作单位先前发表的所有关于 AUC 的出版物，正反映了他们对心血管病手术和诊断方法的适用性进行批判性和系统性地创新，审查和分类所进行的努力。ACCF 认识到及时修订这些标准的重要性，以便为心血管病领域提供最准确的适应症。在理解适应症的评级表之前，了解本文的背景和观点非常重要。本文是参考了 2007 年 ACCF 有关经胸和经食管超声心动图的 AUC（1）和 2008 年 ACCF 有关负荷超声心动图的 AUC（2）修订而成。合理的超声心动图检查是指那些可能有助于改善患者临床预后的超声心动图检查，重要的是，不恰当地使用超声心动图可能对患者有潜在危害并且会给医疗保健系统带来不必要的成本。

**2 方法：**

本文所包含的适应症涵盖了广泛的心血管病体征和症状，以及心血管病可能性的临床判断。在每个主要的疾病分类中，使用标准化方法来获取大多数临床情况，而不会使适应症列表过多。该方法针对可能的超声心动图使用环境设立 5 个临床场合：1）用于初步诊断; 2）不论症状如何，指导治疗或处理; 3）评价临床状态或心脏的变化; 4）在临床情况无变化的情况下作早期随访; 5）在临床状态无变化的情况下作晚期随访。某些特殊的临床场合可以通过其它有针对性的适应症得到解决。

这些适应症由超声心动图专家和其它领域的专家构建，并根据工作组之间的讨论，独立评审员和技术小组的反馈进行修改。在可能的情况下，适应症被映射到相关的临床指南和重点出版物/参考文献（在线附录）。

适应症修订过程中的一个重点是协调各种非侵入性方法的适应症，以便在可行的情况下，适应症的措辞与其它 AUC（3）相似。尽管有几种临床场合在这个修订的超声心动图 AUC 中不能涵盖，但是新的适应症和适应症表格还是被建立了。一旦适应症修订完成，就会接受 AUC 专案组原班人马和代表了心血管病

领域各方面专科和初级保健 27 位外部评委的审核，然后才能定稿。

对所选用的临床适用症分级方法，在先前出版的《ACCF 对评估心血管成像适用性的建议》中有过详细描述（5）。简单说来，这个过程结合循证医学和实践经验，让技术小组参与改良的 Delphi 训练。自从最初关于 TTE/TEE（1）和负荷超声心动图（2）的文件和方法方面的论文（5）发表以来，已经建立了几个重要的流程，以进一步提高设立评分方法的严谨性。其中包括在进行评分之前，召集在影像学和临床护理方面具有不同专业知识的人组成的一个正式写作小组，将适应症在外围流通，以确保技术小组在专家意见和实践领域之间适当平衡，建立标准化的评分系统，并为促进小组互动，在会议上面对面确定正式任务。

技术小组首先独立对适应症进行评分。然后，小组召开会议，对每一个适应症面对面讨论。在这个会议上，小组成员提供他们的评分及同行在不了解对方结果的情况下得到的评分。会后，小组成员被要求独立提供每个适应症最终的评分。

虽然未向专家组成员提供明确的费用信息，以便帮助他们确定其合理使用评级，但隐匿费用信息被视为评价其合理使用的附加因素。在对这些标准进行评分时，要求技术小组对该检查的每个适应症是否合理、不确定或不合理作出判断，并提供合理使用定义如下：

**合理的影像学检查是这样一种检查，通过结合临床判断，这一个适应症所预期的信息增量，有足够大的范围超出预期的负面后果*，这样的适应症通常就被认为是可接受的和合理的。**

*负面结果包括检查的风险（如辐射或造影剂过敏），以及检查结果不佳对下一步治疗的影响，如延误诊断（假阴性）或误诊（假阳性）。

技术小组对各项适应症评分如下：

评分 7-9

做这个检查的适应症是合理的（通常是可接受且有充分理由做这个检查）。

评分 4-6

适应症不确定（一般情况下，检查也许可被接受且适应症也许有一定的理由）。不确定还意味着需要更多的研究和/或患者信息来对适应症的明确性进行分类。

评分 1-3

检查的适应症是不合理的（检查通常不被接受且没有理由做这项检查）

将这些分数分为 3 个适用级别有些随意，即然为数字就应有连续性。此外，对于特定临床情况，临床意见存在多样性，这样，适用评分处于中间水平应被标记为“不确定”，因为危重患者或研究的数据可能缺失或不一致。这种评分方法应能促使该领域尽可能进行确切的研究调查。随着更多数据被收集，以及这个标准履行后信息的积累，预计 AUC 报告将持续被修订。

为了防止评分过程中出现偏差，技术小组特意组合了几个超声心动图专家。虽然专家能提供重要的临床和技术见解，但可能有一种自然倾向，即将其专业中适应症的评分比非专科医生更高。此外，还应注意向技术小组提供客观、无偏见的信息，包括指南和关键的参考资料。

根据 BIOMED 规则，小组由 14 至 16 位成员组成，通过 RAND 分析（6）确定小组成员意见的一致性。因此，适应症被定义为一致，表示仅 4 个或更少小组成员的评级落在 3 个区域包括中位数在内的外面。

不一致表示至少有 5 位专家的评级在合理和不合理之下。无论最终的中位数得分如何，任何有分歧的适应症都被归类为不确定。既不符合一致也不符合不一致的适应症属于第三类，无标签类。

## 3. 一般假设

在制定住院和门诊成年病人 TTE / TEE 和负荷超声心动图的临床适应症时，写作小组为避免解释上出现任何不一致，考虑到了许多特定假设。

1. TTE 和 TEE 的检查和报告包括二维/M 型超声显像、彩色血流多普勒和频谱多普勒，是 TTE/TEE（7-9）综合评价心脏结构和血流动力学的重要组成部分。负荷超声心动图应至少包括静息和负荷状态下的二维超声显像，如果需要进行血流动力学检查，还必须包括多普勒（10）。
2. 所有标准超声技术对于图像采集，包括静息状态下的标准成像和负荷超声成像（10）适用于每一种适应症，并且与公开发表的文献具有类似的敏感性和特异性。造影使用的选择和检查假定与实践指南一致（11）。
3. 检查由熟练掌握超声技术的合格人员完成和解释（12,13）。

4. 尤其是与其它心血管病影像检查相比，超声心动图潜在的适应症范围相当大。因此，这些适应症有时有目的地广泛涵盖一些心血管病症状和体征，以便有序的帮助医生对存在的心血管病作出最佳判断。此外，本文件中可能有未涉及到的临床情况。
5. 有资质的临床医师已完成了完整的临床病史采集和体格检查，从而可以假定患者的临床状态正如适应症中的描述（例如，无症状患者，在充分询问后，确定是无症状）。
6. 如果检查的理由有一个以上，则应归类到最合理的适应症。
7. 在合理运用检查的同时应考虑隐含的成本。
8. 对每一个适应症，评级应根据定义合理使用超声心动图，而不是根据该检查是否优于其它方法。不应为了每一个适应症，决定执行该诊断检查的假设。也不应考虑任何检查方法的本地可用性或技术性问题，或以任何方式尝试将两种检查方法相互比较。
9. 当没有足够的临床数据可用于明确分类，或对该指征的合理性存在实质性分歧时，应归于“不确定”组。“不确定”不应作为拒绝报销的理由。
10. 以超声心动图作常规或监测的适应症，是指已经过了某一段时间，该检查正在被考虑进行“定期”随访。只是预期临床决策或治疗发生改变，该检查就不应被安排。
11. 除非本文另有特别说明，人工瓣膜和自身瓣膜应一起考虑。瓣膜狭窄或反流严重程度的定义见临床指南（14，15）。
12. 一般来说，当 TTE 图像不理想不能获得最佳诊断时，可以假设 TEE 是最适合作为 TTE 的辅助或后续检查。本文件中的表 8 可作为首选 TEE 检查的适应症，但并不仅限于此。
13. 术中 TEE 是心血管超声的一项重要应用。然而，该检查不在本文范围内，因此不作说明。
14. 对于所有负荷影像学检查，能够运动的患者，负荷的模式被假设为运动试验（例如，平板、踏车）。对于不能运动的患者，则假设给予多巴酚丁胺超声负荷试验。需要特定形式负荷试验的适应症（如需要血液动力学信息时），检查时都会这样标记。

15. 负荷超声检查过程中多普勒血液动力学，应包括右心和左心血液动力学评价（如跨瓣压差、肺动脉压、二尖瓣反流严重程度）。
16. 非心脏外科手术的围手术期评价的适应症是根据 ACC/AHA 非心脏外科手术围手术期心血管评价和护理的指南（16）建立的。如果患者有疑似心源性体征/症状时，临床场景应被考虑为有症状类（如适应症 1），而不是围手术期。
17. 就如其它手术一样，由于冠状动脉疾病与手术风险相关，因此器官移植前需要进行冠状动脉疾病（CAD）评价。一般而言，在血管外科手术类别中，CAD 在肾病终末期的糖尿病患者中很常见，实体器官移植应要被考虑到。

## 4.定义

这里列举了贯穿全文中使用的适用症术语的定义。附录 A 列举了附加的定义。这些定义在适应症评分前已提供给技术小组讨论。

1. 等同缺血的症状：胸痛综合征、类似心绞痛的表现或缺血性心电图异常：医师感觉到的任何临床发现都与 CAD 一致。这些发现的实例包括但并不限于胸痛、胸部紧缩感、胸部烧灼痛、肩痛、心悸、下颌痛、新出现的心电图异常，或其它提示 CAD 的症状/表现。被认为与 CAD 相关的非胸痛症状（如呼吸困难或运动耐量下降/恶化），也可被视为缺血表现。
2. 总体 CAD 风险：假设临床医师使用当前的标准方法评价总体风险，如国家心脏、肺和血液病研究所（National Heart, Lung, and Blood Institute）关于成人高胆固醇的检测、评价和治疗（成人治疗小组 III[ATP III]）（18）或类似的国家指南。

绝对风险定义为在给定的时间段内发生的 CAD 概率。ATP III 报告定义的绝对风险是未来 10 年发生 CAD 的概率。冠心病风险是指 10 年内发生任何硬终点心脏事件（如心肌梗死或冠心病死亡）的风险。然而，考虑到总体绝对风险评分可能在某些人群（如女性、年轻男性）中会有误差，因此必须应用临床判断来确定此类亚群的风险阈值。

- **低总体 CAD 风险**

低于年龄定义的平均风险水平。一般说来，低风险定义为 10 年绝对 CAD 风险<10%。然而，在女性和年轻男性中，低风险定义为 10 年绝对 CAD 风险

<6%。

- **中总体 CAD 风险**

达到年龄定义的平均风险水平。一般来说，中等风险定义为 10 年绝对 CAD 风险为 10%至 20%。在女性和年轻男性中，扩展为 6%至 20%是合适的。

- **高总体 CAD 风险**

高于根据年龄定义的平均风险水平。一般来说，高风险定义为 10 年绝对 CAD 风险大于 20%。CAD 的等危症（如糖尿病、外周动脉疾病）也被定义为高风险。

3. 冠心病的预测概率：有症状的（等同缺血的症状）患者：一旦医生确定症状可能与冠心病相关，即应评价冠心病的预测概率。有许多风险计算方法（19，20）可用于计算这种概率。临床医生应该熟悉那些与他们经常遇到的人群有关的计算方法。在对适应症进行评分时，以下概率应当从各种验证的方法计算。

极低预测概率：CAD 的预测概率<5%

低预测概率：CAD 的预测概率在 5%-10%之间

中预测概率：CAD 的预测概率在 10-90%之间

高预测概率：CAD 的预测概率>90%

ACC/AHA 有关慢性稳定型心绞痛指南（21）推荐的方法，是用于计算预测概率的一个实例，是对先前发表的文献综述（22）的一个改良。请参阅表 A 和附录 A 中有关心绞痛的定义。值得注意的是，病史或心电图检查结果（例如，陈旧性心肌梗死）可能会影响预测概率，尽管表 A 中未考虑这些因素。同样，虽然未纳入计算方法中，其它 CAD 危险因素也会影响 CAD 的预测可能性。详细的计算图表包括陈旧性心肌梗死病史、心电图 Q 波和 ST、T 波改变、糖尿病、吸烟和高胆固醇血症（23）的影响。

表 A，根据年龄、性别及症状*预测 CAD 的概率

| 年龄（年） | 性别 | 典型/明确的心绞痛 | 不典型/可能的心绞痛 | 非心绞痛样胸痛 | 无症状 |
|---|---|---|---|---|---|
| **<39** | 男 | 中 | 中 | 低 | 极低 |
| | 女 | 中 | 极低 | 极低 | 极低 |
| **40-49** | 男 | 高 | 中 | 中 | 低 |
| | 女 | 中 | 低 | 极低 | 极低 |
| **50-59** | 男 | 高 | 中 | 中 | 低 |
| | 女 | 中 | 中 | 低 | 极低 |
| **>60** | 男 | 高 | 中 | 中 | 低 |
| | 女 | 高 | 中 | 中 | 低 |

高：>90%预测概率，中：预测概率在 10-90%之间，低，预测概率在 5-10%之间，极低：预测概率<5%

*根据 ACC/AHA 运动试验指南修改，反映所有年龄段。

## 5.评级结果

超声心动图的适应症最终评分结果见表 1 至 18。最终得分反映了 15 位技术小组成员评分的中位数，并根据合理（平均分 7 至 9）、不确定（平均分 4 至 6）和不合理（平均分 1 至 3）分为 3 类。表 19 至表 21 示根据适用类别得到的适应症。

定义为合理或不合理的适应症差异较小，意见一致性分别为 92%和 90%，体现了方法第 2 部分中定义的一致性。对定义为不确定的适应症，评分的变异性较大（一致性低），仅 21%与先前定义一致。两个适应症，即 182 和 189，专家组意见分歧被分布到两个极端。然而，这两个适应症的中位评分已经落在不确定的类别中，因此不需要改变来反映分歧。在所有类别中，40 个适应症不能得到一致的意见；但是，得分并没有太大的差异（定义为不一致），因而并不需要改变最终评分。

所有适应症图表（流程图）都被在线包括在附录中。

各类别适应症选择流程图见图 1-6。

## 6.超声心动图适用标准（按适应症）

**表 1，TTE 对心脏结构和功能的一般评价**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **疑似心脏病因——TTE 的一般检查** | |
| **1** | • 可能与疑似心脏病因有关的症状或情况，包括但不限于胸痛、呼吸困难、心悸、TIA、脑卒中或周围血管栓塞事件 | A（9） |
| **2** | • 以往有过心脏疾病或心脏结构异常的检查，包括但不限于 X 线胸片、负荷超声心动图、心电图和生物标志物的基础报告 | A（9） |
| | **TTE 评价心律失常** | |
| **3** | • 偶发 APCs 或偶发 VPCs，无其它心脏病依据 | I（2） |
| **4** | • 频发 VPCs 或运动诱发的 VPCs | A（8） |
| **5** | • 持续或非持续性房颤，SVT 或 VT | A（9） |
| **6** | • 无症状的孤立性窦性心动过缓 | I（2） |
| | **TTE 评价头晕/先兆晕厥/晕厥** | |
| **7** | • 临床症状或体征与已知可导致头晕/先兆晕厥/晕厥的心脏病诊断息息相关（包括但不局限于主动脉瓣狭窄、肥厚型心肌病或心力衰竭） | A（9） |
| **8** | • 头晕/先兆晕厥，不伴有其它心血管病的症状或体征 | I（3） |
| **9** | • 晕厥不伴有其它心血管病的症状或体征 | A（7） |
| | **TTE 评价心室功能** | |
| **10** | • 无心血管病的症状或体征者心室功能初步评价（如普查） | I（2） |
| **11** | • 已知有 CAD 但临床情况或心脏检查无变化者心室功能的常规监测 | I（3） |
| **12** | • 以往左心室功能检查（如超声心动图、左心室造影、CT、SPECT MPI、CMR）显示正常，临床情况或心脏体检无变化者左室功能的评价。 | I（1） |
| | **围手术期 TTE 的评价** | |
| **13** | • 无心血管病症状和体征者常规行围手术期心室功能评价 | I（2） |
| **14** | • 非心脏实体器官移植术前，对心脏结构和功能作常规围手术期评价 | U（6） |
| | **TTE 评价肺高压** | |
| **15** | • 对疑似肺高压患者的评价，包括右心室功能的评价和测定肺动脉压 | A（9） |
| **16** | • 已知肺动脉高压，但临床情况或心脏体检无变化者作常规监测（<1 y） | I（3） |
| **17** | • 已知肺动脉高压，但临床情况或心脏体检无变化者作常规监测（≥ 1 y） | A（7） |
| **18** | • 已知肺动脉高压，但临床情况或心脏体检发生变化或需要指导治疗者的重新评价 | A（9） |

A 合理适应症，I 不合理适应症，U 不确定

**表 2，TTE 对急性期心血管病的评价**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **TTE 评价低血压或血液动力学不稳定** | |
| **19** | • 不肯定或疑似心脏病因的低血压或血液动力学不稳定 | A（9） |
| **20** | • 评价危重病人的血容量状态 | U（5） |
| | **TTE 评价心肌缺血/梗死** | |
| **21** | • 急性胸痛疑似心肌梗死但静息状态 ECG 无法诊断，在胸痛时进行检查 | A（9） |
| **22** | • 评价无胸痛者但有等同缺血的其它特征或 MI 发病的实验室标志物阳性 | A（8） |
| **23** | • 疑似心肌缺血/心肌梗死的并发症，包括但不局限于急性二尖瓣反流、室间隔穿孔、心肌游离壁破裂/心包填塞、休克、右心受累、心力衰竭或血栓形成 | A（9） |
| | **TTE 评价 ACS 后心室功能** | |
| **24** | • ACS 后心室功能的初步评价 | A（9） |
| **25** | • 在 ACS 恢复期重新评价心室功能，检查结果能够指导治疗时 | A（9） |
| | **TTE 评价呼吸衰竭** | |
| **26** | • 原因不明的呼吸衰竭或低氧血症 | A（8） |
| **27** | • 已确定为非心脏原因引起的呼吸衰竭或低氧血症 | U（5） |
| | **TTE 评价肺栓塞** | |
| **28** | • 疑似肺栓塞旨在明确诊断 | I（2） |
| **29** | • 已知急性肺栓塞需要指导治疗（如血栓切除及溶栓） | A（8） |
| **30** | • 患者有肺栓塞既往史，右心功能、肺动脉压正常的常规监测 | I（1） |
| **31** | • 肺栓塞溶栓或血栓切除术后，重新评价右心功能及/或肺动脉压的变化 | A（7） |
| | **TEE 评价心脏外伤** | |
| **32** | • 严重的减速伤或胸部外伤，可能或疑似瓣膜损伤，心包积液或心脏损伤 | A（9） |
| **33** | • 常规评价轻微胸部损伤不伴有心电图改变及生物标志物升高 | I（2） |

A 合理适应症，I 不合理适应症，U 不确定

**表 3，TTE 评价瓣膜功能**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **TTE 评价心脏杂音或附加音** | |
| **34** | • 疑似瓣膜性或结构性心脏病的初步评价 | A（9） |
| **35** | • 对无瓣膜性或结构性心脏病症状和体征的患者作初步评价 | I（2） |
| **36** | • 对以往超声心动图证实无瓣膜疾病，临床情况或 | I（1） |

| | | | |
|---|---|---|---|
| | | 心脏检查无变化者作重新评价 | |
| **37** | • | 对已知有心脏瓣膜病，临床情况或心脏体检发生变化或需要指导治疗的患者作再评价 | A（9） |
| | | **TTE 评价自身瓣膜狭窄** | |
| **38** | • | 对轻度瓣膜狭窄且临床情况或心脏体检无变化的患者作常规随访（<3 年） | I（3） |
| **39** | • | 对轻度瓣膜狭窄且临床情况或心脏体检无变化的患者作常规随访（≥3 年） | A（7） |
| **40** | • | 对中重度瓣膜狭窄且临床情况或心脏体检无变化的患者作常规随访（<1 年） | I（3） |
| **41** | • | 对中重度瓣膜狭窄且临床情况或心脏体检无变化的患者作常规随访（≥1 年） | A（8） |
| | | **TTE 评价自身瓣膜反流** | |
| **42** | • | 轻微瓣膜反流的常规监测 | I（1） |
| **43** | • | 对轻度瓣膜反流且临床情况或心脏体检无变化的患者作常规随访（<3 年） | I（2） |
| **44** | • | 对轻度瓣膜反流且临床情况或心脏体检无变化的患者作常规随访（≥3 年） | U（4） |
| **45** | • | 对中重度瓣膜反流且临床情况或心脏体检无变化的患者作常规随访（<1 年） | U（6） |
| **46** | • | 对中重度瓣膜反流且临床情况或心脏体检无变化的患者作常规随访（≥1 年） | A（8） |
| | | **TTE 评价人工瓣膜** | |
| **47** | • | 人工瓣膜术后为建立基础对照作初步评价 | A（9） |
| **48** | • | 对无已知或疑似功能失调的人工瓣作常规随访（置入后<3 年） | I（3） |
| **49** | • | 对无已知或疑似功能失调的人工瓣作常规随访（置入后≥3 年） | A（7） |
| **50** | • | 对疑似人工瓣功能失调或临床情状或心脏体检发生变化的人工瓣进行评价 | A（9） |
| **51** | • | 对已知人工瓣功能失调的患者，需改变或指导治疗的再评价 | A（9） |
| | | **TTE 评价感染性心内膜炎（自身或人工瓣膜）** | |
| **52** | • | 初步评价血培养阳性或有新出现的杂音，疑似感染性心内膜炎的患者 | A（9） |
| **53** | • | 一过性发热，无菌血症或新出现的杂音 | I（2） |
| **54** | • | 一过性菌血症，具有通常不与感染性心内膜炎和/或记录在册的非血管内感染源相关的病原体 | I（3） |
| **55** | • | 对感染性心内膜炎处于高风险进展状态或并发症或临床状态或心脏体检发生变化的患者作重新评价 | A（9） |
| **56** | • | 在不考虑改变治疗方案的情况下，对无并发症的感染性心内膜炎进行常规检查 | I（2） |

A 合理适应症，I 不合理适应症，U 不确定

**表 4，TTE 评价心内、心外结构及心腔**

| 适应症 | | | 合理性评分（1-9） |
|---|---|---|---|
| **57** | • | 疑似心脏肿块 | A（9） |
| **58** | • | 疑似源于心血管的栓塞 | A（9） |
| **59** | • | 疑似心包疾病 | A（9） |
| **60** | • | 对无临床情况改变的少量心包积液作常规监测 | I（2） |
| **61** | • | 对已知的心包积液，需要指导治疗而作再评价 | A（8） |
| **62** | • | 经皮非冠状动脉心脏手术的指导，包括但不限于心包穿刺、室间隔消融或右心室活检 | A（9） |

A 合理适应症，I 不合理适应症，U 不确定

**表 5 TTE 评价主动脉疾病**

| 适应症 | | | 合理性评分（1-9） |
|---|---|---|---|
| **63** | • | 对已知或疑似的结缔组织病或易患主动脉瘤或主动脉夹层分离的遗传性疾病（如 Marfan 综合征）的患者，评价升主动脉。 | A（9） |
| **64** | • | 对已知的升主动脉扩张或具主动脉夹层分离病史的患者，为建立基线扩张率或扩张率过高作再评价 | A（9） |
| **65** | • | 对已知的升主动脉扩张或具主动脉夹层分离病史的患者，伴有临床情况或心脏体检发生变化，或检查结果也许会改变治疗或处理者的再评价 | A（9） |
| **66** | • | 对已知的升主动脉扩张或具主动脉夹层分离病史的患者，临床情况或心脏体检无变化或不改变治疗的结果的患者作再评价。 | I（3） |

A 合理适应症，I 不合理适应症，U 不确定

**表 6，TTE 评价高血压、心力衰竭、或心肌病**

| 适应症 | | | 合理性评分（1-9） |
|---|---|---|---|
| | | **TTE 评价高血压** | |
| **67** | • | 疑似高血压性心脏病的初步评价 | A（8） |
| **68** | • | 原发性高血压不伴有高血压性心脏病的症状和体征者的常规评价 | I（3） |
| **69** | • | 已知高血压性心脏病，临床情况或心脏体检无变化者 | U（4） |
| | | **TTE 评价心力衰竭** | |
| **70** | • | 根据症状、体征或检查异常确定或疑似心力衰竭（收缩或舒张型）者的初步评价 | A（9） |
| **71** | • | 对已知心力衰竭（收缩或舒张型）伴有临床情况或心脏体检改变，而药物或饮食没有明显改变者的再评价 | A（8） |

| | | |
|---|---|---|
| **72** | • 对已知心力衰竭（收缩或舒张型）伴有临床情况或心脏体检改变并且药物或饮食有明显变化者的再评价 | U（4） |
| **73** | • 为指导已知心力衰竭者的治疗作再评价 | A（9） |
| **74** | • 心力衰竭（收缩或舒张型）不伴有临床情况或心脏体检变化者的常规检查（<1 年） | I（2） |
| **75** | • 心力衰竭（收缩或舒张型）不伴有临床情况或心脏体检变化者的常规检查（≥1 年） | U（6） |
| | **TTE 评价医疗装置（包括起搏器、ICD 或 CRT）** | |
| **76** | • 在血管重建术和/或最佳药物治疗后进行初步评价或重新评价，以确定是否需要安装医疗装置和/或确定装置的优化设置 | A（9） |
| **77** | • CRT 植入后优化设置的初步评价 | U（6） |
| **78** | • 植入起搏器后出现症状，可能与起搏器并发症或起搏器设置不当有关 | A（8） |
| **79** | • 植入装置后临床情况或心脏体检无变化者的常规检查（<1 年） | I（1） |
| **80** | • 植入装置后临床情况或心脏体检无变化者的常规检查（≥1 年） | I（3） |
| | **TTE 评价心室辅助装置及心脏移植** | |
| **81** | • 决定心室辅助装置的候选资格 | A（9） |
| **82** | • 优化心室辅助装置的设置 | A（7） |
| **83** | • 重新评价提示心室辅助装置相关并发症的症状/体征 | A（9） |
| **84** | • 监测心脏移植的排异反应 | A（7） |
| **85** | • 评价潜在心脏供体的心脏结构与功能 | A（9） |
| | **TTE 评价心肌病** | |
| **86** | • 已知或疑似心肌病（如限制型、浸润型、扩张型、肥厚型、或遗传性心肌病）的初步评价 | A（9） |
| **87** | • 已知心肌病伴有临床情况或心脏体检变化或需要指导治疗的重新评价 | A（9） |
| **88** | • 已知心肌病未发生临床情况或心脏体检变化的常规随访（<1 年） | I（2） |
| **89** | • 已知心肌病不伴有临床情况或心脏体检变化的常规随访（≥1 年） | U（5） |
| **90** | • 遗传性心肌病患者一级亲属心脏结构和功能的普查 | A（9） |
| **91** | • 接受心脏毒性药物治疗者的基础评价及连续再评价 | A（9） |

A 合理适应症，I 不合理适应症，U 不确定

**表 7，TTE 评价成人先天性心脏病**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| **92** | • 已知或疑似成人先天性心脏病的初步评价 | A（9） |
| **93** | • 已知成人先天性心脏病伴有临床情况或心脏体检变 | A（9） |

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|---|---|---|
| | 化 | |
| **94** | • 已知成人先天性心脏病需要再评价指导治疗 | A（9） |
| **95** | • 成人先天性心脏病完全纠治术后的常规检查（<2 年）<br>• 无残余结构或血流动力学异常<br>• 无临床情况或心脏体检变化 | I（3） |
| **96** | 成人先天性心脏病完全纠治术后的常规检查（≥2 年）<br>• 无残余结构或血流动力学异常<br>• 无临床情况或心脏体检变化 | U（6） |
| **97** | 成人先天性心脏病未得到完全纠治或行姑息性治疗术后的常规检查（<1 年）<br>• 有残余结构或血流动力学异常<br>• 无临床情况或心脏体检变化 | U（5） |
| **98** | 成人先天性心脏病未得到完全纠治或行姑息性治疗术后的常规检查（≥1 年）<br>• 无残余结构或血流动力学异常<br>• 无临床情况或心脏体检变化 | A（8） |

A 合理适应症，I 不合理适应症，U 不确定

**表 8，TEE**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **TEE 作为初步或补充检查——一般应用** | |
| **99** | • TEE 使用在由于患者的心脏特征或相关结构显示不清，TTE 多半不能获得诊断 | A（8） |
| **100** | • TTE 预期能解决所有诊断和治疗问题时常规使用 TEE | I（1） |
| **101** | • 当预期治疗发生改变，间隔一段时间后重新评价先前 TEE 检查结果的变化（如抗凝后血栓的消退、抗生素治疗后赘生物的消退）。 | A（8） |
| **102** | • 预期治疗未发生改变，间隔一段时间后对先前 TEE 检查结果的监测（如抗凝后血栓的消退、抗生素治疗后赘生物的消退） | I（2） |
| **103** | • 需要指导经皮非冠状动脉心脏介入治疗，包括但不限于放置封堵器、射频消融术和经皮瓣膜手术 | A（9） |
| **104** | • 疑似急性主动脉病变，包括但不限于夹层分离/贯通伤 | A（9） |
| **105** | • 常规评价肺静脉隔离术后无症状患者的肺静脉情况 | I（3） |
| | **TEE 作为初步或补充检查——瓣膜疾病** | |
| **106** | • 评价瓣膜的结构和功能，以估计介入治疗的可行性并协助手术规划 | A（9） |
| **107** | • 诊断预期概率较低的感染性心内膜炎（例如短暂发热、已知的其他感染源，或血培养阴性/非典型的心内膜炎病原体） | I（3） |
| **108** | • 诊断中度或高度预期概率的感染性心内膜炎（如葡萄球菌菌血症、真菌血症、人工心脏瓣膜或心内辅助装 | A（9） |

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| | | **TEE 作为初步或补充检查——栓塞事件** | |
| **109** | • | 评价心血管源性栓塞，未明确为非心源性 | A（7） |
| **110** | • | 评价心血管源性栓塞，先前已经明确为非心源性 | U（5） |
| **111** | • | 评价心血管源性栓塞，已知为心源性栓塞，但并不会根据 TEE 检查结果改变处理 | I（1） |
| | | **TEE 作为初步检查——房颤/房扑** | |
| **112** | • | 评价有助于抗凝、心脏复律和/或射频消融的临床决策 | A（9） |
| **113** | • | 已决定抗凝不进行心脏复律者的评价 | I（2） |

A 合理适应症，I 不合理适应症，U 不确定

**表 9 负荷超声心动图对 CAD 的检测/风险评价：有症状或心肌缺血**

| 适应症 | | | 合理性评估（1-9） |
|---|---|---|---|
| | | **负荷超声心动图评价心肌缺血（非急性）** | |
| **114** | • | CAD 预测概率低<br>ECG 明确且能运动 | I（3） |
| **115** | • | CAD 预测概率低<br>ECG 不明确或不能运动 | A（7） |
| **116** | • | CAD 预测概率中等<br>ECG 明确且能运动 | A（7） |
| **117** | • | CAD 预测概率中等<br>ECG 不明确或不能运动 | A（9） |
| **118** | • | CAD 预测概率高<br>不管 ECG 解释和能否运动 | A（7） |
| | | **负荷超声心动图评价急性胸痛** | |
| **119** | • | ACS 可能<br>ECG：没有缺血改变或伴 CLBBB 或心室起搏节律<br>TIMI 评级为低风险<br>肌钙蛋白阴性 | A（7） |
| **120** | • | ACS 可能<br>ECG：没有缺血改变或伴 CLBBB 或心室起搏节律<br>TIMI 评级为低风险<br>峰值肌钙蛋白：临界，模棱两可，轻微升高 | A（7） |
| **121** | • | ACS 可能<br>ECG：没有缺血改变或伴 CLBBB 或心室起搏节律<br>TIMI 评级为高风险<br>肌钙蛋白阴性 | A（7） |
| **122** | • | ACS 可能<br>ECG：没有缺血改变或伴 CLBBB 或心室起搏节律<br>TIMI 评级为高风险<br>肌钙蛋白：临界，模棱两可，轻微升高 | A（7） |
| **123** | • | 明确的 ACS | I（1） |

A 合理适应症，I 不合理适应症，U 不确定

**表 10，负荷超声心动图评价 CAD/风险：无症状（无缺血相关的症状）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **负荷超声心动图评价一般人群** | |
| **124** | • 低整体 CAD 风险 | I（1） |
| **125** | • 中等整体 CAD 风险<br>• ECG 可明确 | I（2） |
| **126** | • 中等整体 CAD 风险<br>• ECG 不能明确 | U（5） |
| **127** | • 高整体 CAD 风险 | U（5） |

A 合理适应症，I 不合理适应症，U 不确定

**表 11，负荷超声心动图对 CAD 的评价/风险评估：患者有明确患病但无症状（无缺血相关的症状）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **负荷超声心动图评价首次发病或新诊断的心力衰竭或左室收缩功能不全** | |
| **128** | • 以往未做过 CAD 检查，也不准备行冠脉造影 | A（7） |
| | **负荷超声心动图评价心律失常** | |
| **129** | • 持续性 VT | A（7） |
| **130** | • 频发 PVCs，运动诱发 VT，或非持续性 VT | A（7） |
| **131** | • 偶发 PVCs | I（3） |
| **132** | • 新起病的房颤 | U（6） |
| | **负荷超声心动图评价晕厥** | |
| **133** | • 低整体 CAD 风险 | I（3） |
| **134** | • 中或高整体 CAD 风险 | A（7） |
| | **负荷超声心动图评价肌钙蛋白升高** | |
| **135** | • 肌钙蛋白升高不伴有症状或 ACS 的其它证据 | A（7） |

A 合理适应症，I 不合理适应症，U 不确定

**表 12，先前有检查结果的负荷超声心动图评价**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **无症状：负荷超声心动图评价先前检查有亚临床疾病证据的患者** | |
| **136** | • 冠脉钙化 Agatston 评分<100 | I（2） |
| **137** | • 低中度整体 CAD 风险<br>• 冠脉钙化评分 100-400 之间 | U（5） |
| **138** | • 高整体 CAD 风险<br>• 冠脉钙化评分 100-400 之间 | U（6） |
| **139** | • 冠脉钙化评分>400 | A（7） |
| **140** | • 颈动脉内膜厚度（≥0.9mm 和/或有突入动脉管腔的 | U（5） |

| | | |
|---|---|---|
| | 斑块） | |
| | **负荷超声心动图评价冠状动脉造影（侵入或非侵入）** | |
| **141** | • 冠状动脉狭窄的显著性不明显 | A（8） |
| | **负荷超声心动图评价无症状或症状稳定者，以往负荷影像学检查正常** | |
| **142** | • 低整体 CAD 风险<br>• 最近一次负荷影像学检查<2 年 | I（1） |
| **143** | • 低整体 CAD 风险<br>• 最近一次负荷影像学检查≥2 年 | I（2） |
| **144** | • 中和高整体 CAD 风险<br>• 最近一次负荷影像学检查<2 年 | I（2） |
| **145** | • 中及高整体 CAD 风险<br>• 最近一次负荷影像学检查≥2 年 | U（4） |
| | **负荷超声心动图评价无症状或症状稳定者，以往冠脉造影或负荷影像学检查异常未行血管重建术治疗** | |
| **146** | • 冠脉造影已知冠心病或以往负荷影像学检查异常<br>• 最近一次负荷影像学检查<2 年 | I（3） |
| **147** | • 冠脉造影已知冠心病或以往负荷影像学检查异常<br>• 最近一次负荷影像学检查≥2 年 | U（5） |
| | **负荷超声心动图评价活动平板负荷 ECG** | |
| **148** | • 活动平板负荷 ECG 评分（如 Duke）处于低危 | I（1） |
| **149** | • 活动平板负荷 ECG 评分（如 Duke）处于中危 | A（7） |
| **150** | • 活动平板负荷 ECG 评分（如 Duke）处于高危 | A（7） |
| | **负荷超声心动图评价新出现症状或症状恶化者** | |
| **151** | • 冠脉造影异常或以往负荷影像学检查异常 | A（7） |
| **152** | • 冠脉造影正常或以往负荷影像学检查正常 | U（6） |
| | **负荷超声心动图评价以往非侵入性检查** | |
| **153** | • 负荷试验结果模凌两可、临界或与临床不一致，堵塞性 CAD 仍不确定 | A（8） |

A 合理适应症，I 不合理适应症，U 不确定

**表 13，负荷超声心动图用于风险评价：无心脏病者非心脏手术围手术期评价**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **负荷超声心动图评价低风险外科手术** | |
| **154** | • 围手术期的风险评价 | I（1） |
| | **负荷超声心动图评价中等风险外科手术** | |
| **155** | • 中至高等运动代谢当量（≥4METs） | I（3） |
| **156** | • 无临床危险因素 | I（2） |
| **157** | • ≥1 个临床危险因素<br>• 运动代谢当量差或不明（<4METs） | U（6） |
| **158** | • 正常的心导管检查、非侵入性检查或血管再通手术<1 年，无症状 | I（1） |
| | **负荷超声心动图评价血管外科手术** | |

| | | |
|---|---|---|
| **159** | • 中和高运动代谢当量（≥4METs） | I（3） |
| **160** | • 无临床危险因素 | I（2） |
| **161** | • ≥1 个临床危险因素<br>• 运动代谢当量差或不明（<4METs） | A（7） |
| **162** | • 正常的心导管检查、非侵入性检查或血管再通手术<1 年，无症状 | I（2） |

A 合理适应症，I 不合理适应症，U 不确定

**表 14，负荷超声心动图用于风险评价：ACS 发病 3 个月内**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **负荷超声心动图评价 STEMI** | |
| **163** | • 直接 PCI，完全再血管化<br>• 无复发症状 | I（2） |
| **164** | • 血流动力学稳定，胸痛症状未复发或无心力衰竭体征<br>• 评价可诱导的缺血<br>• 自事件发生以来，未行冠状动脉造影 | A（7） |
| **165** | • 血流动力学不稳定，心源性休克征象，或机械并发症 | I（1） |
| | **负荷超声心动图评价 UA/USTEMI** | |
| **166** | • 血流动力学稳定，胸痛症状未复发或无心力衰竭体征<br>• 评价可诱导的缺血<br>• 自事件发生以来，未行冠状动脉造影检查 | A（8） |
| | **负荷超声心动图评价 ACS—再血管化后（PCI 或 CABG）无症状** | |
| **167** | • 出院前充分再血管化患者的评价 | I（1） |
| | **负荷超声心动图评价心脏康复** | |
| **168** | • 心脏康复开始前（作为一个独立的适应症） | I（3） |

A 合理适应症，I 不合理适应症，U 不确定

**表 15，负荷超声心动图用于风险评价：再血管化后（PCI 或 CABG）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **负荷超声心动图评价有症状者** | |
| **169** | • 等同缺血的症状 | A（8） |
| | **负荷超声心动图评价无症状者** | |
| **170** | • 未完全再血管化<br>• 额外血管重建术可行 | A（7） |
| **171** | • CABG 术后<5 年 | I（2） |
| **172** | • CABG 术后≥5 年 | U（6） |
| **173** | • PCI 术后<2 年 | I（2） |
| **174** | • PCI 术后≥2 年 | U（5） |

| | | |
|---|---|---|
| **负荷超声心动图评价心脏康复** | | |
| **175** | • 开始心脏康复前初步评价（作为 1 个独立的适应症） | I（3） |

A 合理适应症，I 不合理适应症，U 不确定

**表 16，负荷超声心动图评价存活心肌/缺血**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| **负荷超声心动图评价缺血性心肌病/存活心肌** | | |
| **176** | • 已知中度或重度左心功能不全<br>• 适合血管重建术的患者<br>• 仅用多巴酚丁胺负荷试验 | A（8） |

A 合理适应症，I 不合理适应症，U 不确定

**表 17，负荷超声心动图用于血液动力学评价（包括负荷过程中多普勒超声）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| **负荷超声心动图评价慢性瓣膜病—无症状** | | |
| **177** | • 轻度二尖瓣狭窄 | I（2） |
| **178** | • 中度二尖瓣狭窄 | U（5） |
| **179** | • 重度二尖瓣狭窄 | A（7） |
| **180** | • 轻度主动脉瓣狭窄 | I（3） |
| **181** | • 中度主动脉瓣狭窄 | U（6） |
| **182** | • 重度主动脉瓣狭窄 | U（5） |
| **183** | • 轻度二尖瓣反流 | I（2） |
| **184** | • 中度二尖瓣反流 | U（5） |
| **185** | • 重度二尖瓣反流<br>• 左室大小及功能未达到外科手术标准 | A（7） |
| **186** | • 轻度主动脉瓣反流 | I（2） |
| **187** | • 中度主动脉瓣反流 | U（5） |
| **188** | • 重度主动脉瓣反流<br>• 左室大小及功能未达到外科手术标准 | A（7） |
| **负荷超声心动图评价慢性瓣膜病—有症状** | | |
| **189** | • 轻度二尖瓣狭窄 | U（5） |
| **190** | • 中度二尖瓣狭窄 | A（7） |
| **191** | • 重度二尖瓣狭窄 | I（3） |
| **192** | • 重度主动脉瓣狭窄 | I（1） |
| **193** | • 评价不明确的主动脉瓣狭窄<br>• 有低心排量或左室收缩功能不全的证据（低压差主动脉瓣狭窄）<br>• 仅用多巴酚丁胺负荷试验 | A（8） |
| **194** | • 轻度二尖瓣反流 | U（4） |
| **195** | • 中度二尖瓣反流 | A（7） |
| **196** | • 重度二尖瓣反流 | I（3） |

| | | |
|---|---|---|
| | • 左室明显增大或左室收缩功能不全 | |
| | **负荷超声心动图评价急性瓣膜疾病** | |
| **197** | • 急性中度或重度二尖瓣或主动脉瓣反流 | I（3） |
| | **肺动脉高压与负荷超声心动图** | |
| **198** | • 疑似肺动脉高压<br>• 静息状态超声检查估测的右室收缩压正常或处于升高的临界 | U（5） |
| **199** | • 常规评价已知静息状态下肺动脉高压 | I（3） |
| **200** | • 再评价运动诱导的肺高压，用以判断治疗反应 | U（5） |

A 合理适应症，I 不合理适应症，U 不确定

**表 18，超声造影的使用在 TTE/TEE 或负荷超声心动图中**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| **201** | • 常规应用造影<br>• 不做造影也能显示心室所有节段 | I（1） |
| **202** | • 选择性使用造影<br>• 不做造影左室≥2 个相邻节段不能显示 | A（8） |

A 合理适应症，I 不合理适应症，U 不确定

**7. 超声心动图的适用标准（根据适用评分）**

**表 19，合理的适应症（中位数评分 7-9）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **TTE 对疑似心脏病患者的心脏结构和功能作常规评价——一般检查** | |
| **1** | • 症状或临床情况疑似心脏病，包括但不限于胸痛、呼吸急促、心悸、TIA、脑卒中、或外周血管栓塞事件 | A（9） |
| **2** | • 以往检查有心脏病或心脏结构异常，包括但不限于 X 线胸片、负荷超声心动图、心电图或心脏标志物的基线检查结果 | A（9） |
| | **TTE 用于心脏结构和功能性心律失常的一般评价** | |
| **4** | • 频发 VPCs 或运动诱导的 VPCs | **A（8）** |
| **5** | • 持续或非持续性房颤，SVT，或 VT | A（9） |
| | **TTE 对头晕/先兆晕厥/晕厥者心脏结构及功能的一般评价** | |
| **7** | • 临床症状或体征与已知可导致头晕/先兆晕厥/晕厥心脏病诊断一致（包括但不局限于主动脉瓣狭窄、肥厚性心肌病或心力衰竭） | A（9） |
| **9** | • 不伴有其它心血管病症状或体征的晕厥 | **A（7）** |
| | **TTE 对肺高压者心脏结构和功能的一般评价** | |
| **15** | • 疑似肺高压的评价，包括右心室功能的评价和肺动脉压 | **A（9）** |

| | | | |
|---|---|---|---|
| | | 的估测 | |
| **17** | • | 无临床情况或心脏体检变化，对已知肺高压者作常规监测（≥1 y） | A（7） |
| **18** | • | 如果临床情况或心脏体检发生变化或需要指导治疗，对已知肺高压者重新评价 | **A（9）** |
| | | **TTE 对急性低血压和血液动力学不稳定者的心血管评价** | |
| **19** | • | 原因不明或疑似心源性低血压或血液动力学不稳定 | **A（9）** |
| | | **TTE 对急性心肌缺血/梗死的心血管评价** | |
| **21** | • | 急性胸痛疑似心肌梗死和不能诊断的 ECG，在胸痛时行静息状态超声心动图检查 | **A（9）** |
| **22** | • | 评价无胸痛但有等同缺血的其它特点或提示 MI 起病的实验室标志物阳性 | A（8） |
| **23** | • | 疑似心肌缺血/梗死的并发症，包括但不局限于急性二尖瓣反流、室间隔穿孔、游离壁破裂/心包填塞、休克、右心功能受损、心力衰竭，或血栓 | **A（9）** |
| | | **TTE 在 ACS 后急需评价心室功能的心血管评价，** | |
| **24** | • | ACS 后心室功能的初步评价 | **A（9）** |
| **25** | • | 在 ACS 恢复期，当检查结果能够指导治疗时重新评价心室功能 | A（9） |
| | | **TTE 在急性呼吸衰竭中的心血管评价** | |
| **26** | • | 原因不明的呼吸衰竭或低氧血症 | A（8） |
| | | **TTE 在急性肺栓塞中的心血管评价** | |
| **29** | • | 已知急性肺栓塞，为要指导治疗（如血栓切除及溶栓） | A（8） |
| **31** | • | 肺栓塞溶栓或血栓切除术后，重新评价右心功能和/或肺动脉压的变化 | **A（7）** |
| | | **TTE 在急性心脏外伤中的心血管评价** | |
| **32** | • | 严重的减速伤或胸部外伤，可能或疑似瓣膜损伤，心包积液或心脏损伤 | **A（9）** |
| | | **TTE 对心脏杂音或附加音者瓣膜功能的评价** | |
| **34** | • | 有理由怀疑瓣膜病或结构性心脏病的初步评价 | **A（9）** |
| **37** | • | 已知心脏瓣膜病，临床情况或心脏体检变化或需要指导治疗的再评价 | A（9） |
| | | **TTE 对自身瓣膜狭窄者瓣膜功能的评价** | |
| **39** | • | 轻度瓣膜狭窄伴临床情况或心脏体检无变化者的常规检查（≥3 年） | A（7） |
| **41** | • | 中度或重度瓣膜狭窄伴临床情况或心脏体检无变化者的常规检查（≥1 年） | **A（8）** |
| **46** | • | 中度或重度瓣膜反流伴临床情况或心脏体检无变化者的常规检查（≥1 年） | A（8） |
| | | **TTE 评价人工瓣的瓣膜功能** | |
| **47** | • | 人工瓣置换术后的初步评价，为建立基础对照 | A（9） |
| **49** | • | 人工瓣常规随访（置换术后≥3 年），无已知或疑似的人工瓣功能失调 | **A（7）** |
| **50** | • | 对疑似功能失调或临床情况或心脏体检发生变化的人工 | A（9） |

| | | | |
|---|---|---|---|
| | | 瓣进行评价 | |
| **51** | • | 已知人工瓣功能失调，需改变或指导治疗而作再评价 | **A（9）** |
| | | **TTE 评价感染性心内膜炎的瓣膜功能（自身或人工瓣膜）** | |
| **52** | • | 血培养阳性或有新出现的杂音，疑似感染性心内膜炎的初步评价 | **A（9）** |
| **55** | • | 重新评价感染性心内膜炎伴有病情发展或高并发症风险或伴有临床情况或心脏体检的变化 | A（9） |
| | | **TTE 对心内和心外结构以及心腔的评价** | |
| **57** | • | 疑似心脏肿块 | A（9） |
| **58** | • | 疑似心血管源性栓塞 | **A（9）** |
| **59** | • | 疑似心包疾病 | A（9） |
| **61** | • | 为了指导处理和治疗对已知的心包积液作再评价 | **A（8）** |
| **62** | • | 指导经皮非冠状动脉心脏手术，包括但不限于心包穿刺、室间隔消融或右心室活检 | A（9） |
| | | **TTE 评价主动脉疾病** | |
| **63** | • | 在已知或疑似结缔组织病或易患主动脉瘤或主动脉夹层分离的遗传性疾病（如 Marfan 综合征）者评价升主动脉 | A（9） |
| **64** | • | 为了建立扩张率的基线对照或确定扩张率过度，对已知有升主动脉扩张或主动脉夹层分离病史的患者作再评价 | **A（9）** |
| **65** | • | 已知升主动脉扩张或有主动脉夹层分离的病史，伴有临床情况或心脏体检改变或检查结果可能改变治疗方案时作再评价 | A（9） |
| | | **TTE 对高血压、心力衰竭或高血压心脏病的评价** | |
| **67** | • | 对疑似高血压性心脏病的初步评价 | A（8） |
| | | **TTE 对高血压、心力衰竭或心肌病性心力衰竭的评价** | |
| **70** | • | 根据症状、体征或异常的化验结果，对已知或疑似心力衰竭（收缩或舒张型）者作初步评价 | A（9） |
| **71** | • | 当临床情况或心脏体检发生改变，而用药或饮食没有明显改变，对已知心力衰竭（收缩或舒张型）者的再评价 | **A（8）** |
| **73** | • | 为了指导治疗，对已知心力衰竭者的再评价 | A（9） |
| | | **TTE 对高血压、心力衰竭或心脏植入装置（包括起搏器、ICD、或 CRT）的评价** | |
| **76** | • | 在血管重建和/或最佳药物治疗后，为了确定起搏器治疗的候选资格和/或最佳设置，进行初步或重新评价 | A（9） |
| **78** | • | 起搏器植入术后出现的症状，疑似与起搏器的并发症或起搏器设置不当有关 | **A（8）** |
| | | **TTE 对高血压、心力衰竭或心肌病心室辅助装置和心脏移植的评价** | |
| **81** | • | 决定心室辅助装置的候选资格 | **A（9）** |
| **82** | • | 优化心室辅助装置的设置 | A（7） |
| **83** | • | 对症状/体征提示与心室辅助装置并发症相关者的再评价 | **A（9）** |
| **84** | • | 监测心脏移植者的排斥反应 | A（7） |

| | | | |
|---|---|---|---|
| **85** | • | 对潜在心脏供体的心脏结构和功能的评价 | **A（9）** |
| | | **TTE 对高血压、心力衰竭或心肌病的评价** | |
| **86** | • | 对已知或疑似心肌病（如限制型、浸润型、扩张型、肥厚型、或遗传性心肌病）的初步评价 | **A（9）** |
| **87** | • | 对已知的心肌病，伴有临床情况或心脏体检变化或需要指导治疗时的再评价 | A（9） |
| **90** | • | 对遗传性心肌病的一级亲属作心脏结构和功能的普查 | **A（9）** |
| **91** | • | 对接受心脏毒性药物治疗者的基础和连续再评价 | A（9） |
| | | **TTE 对成人先天性心脏病的评价** | |
| **92** | • | 对已知或疑似成人先天性心脏病者的初步评价 | A（9） |
| **93** | • | 对已知成人先天性心脏病伴有临床情况或心脏体检变化 | **A（9）** |
| **94** | • | 为了指导治疗，对已知成人先天性心脏病的再评价 | A（9） |
| **98** | • | 对未完全修复或姑息治疗的成人先天性心脏病作常规随访（≥1 年） | **A（8）** |
| | ✧ | 无残余结构或血液动力学异常 | |
| | ✧ | 无临床情况或心脏体检变化 | |
| | | **TEE 作为初次或补充检查——一般应用** | |
| **99** | • | 由于患者的心脏特征或相关结构显示不满意，TTE 多半不能诊断，使用 TEE | **A（8）** |
| **101** | • | 先前 TEE 的检查结果，经过一段时间治疗后预期发生改变，需要重新评价（如抗凝后血栓的消失、抗生素治疗后赘生物的消失） | A（8） |
| **103** | • | 在经皮非冠状动脉心脏介入手术期间的指导，包括但不限于放置封堵器、射频消融术和经皮瓣膜手术 | **A（9）** |
| **104** | • | 疑似急性主动脉病变，包括但不限于夹层分离/贯通伤 | A（9） |
| | | **TEE 作为初次或补充检查——瓣膜病** | |
| **106** | • | 为了解介入手术的可行性，帮助规划手术方案，对瓣膜的结构和功能进行评价 | A（9） |
| **108** | • | 中度或高度怀疑感染性心内膜炎（如葡萄球菌血症、真菌血症、人工心脏瓣膜或心内装置的感染） | **A（9）** |
| | | **TEE 作为初次或补充检查——栓塞事件** | |
| **109** | • | 心血管源性栓塞的评价，不确定为非心脏来源 | **A（7）** |
| | | **TEE 作为初次检查——房颤/房扑** | |
| **112** | • | 为帮助抗凝、心脏复律和/或射频消融作临床决策的评价 | **A（9）** |
| | | **负荷超声心动图检出 CAD/风险评价：有症状或等同缺血的症状（非急性）** | |
| **115** | • | 低 CAD 预测概率 | **A（7）** |
| | • | ECG 不明确或不能运动 | |
| **116** | • | 中等 CAD 预测概率 | A（7） |
| | • | ECG 明确且能运动 | |
| **117** | • | 中等 CAD 预测概率 | **A（9）** |
| | • | ECG 不明确或不能运动 | |
| **118** | • | 高 CAD 预测概率 | A（7） |
| | • | 不管 ECG 解释和运动能力 | |

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|---|---|---|
| | **负荷超声心动图评价 CAD/风险：有症状或等同缺血的急性胸痛** | |
| **119** | • 可能的 ACS<br>• ECG：没有缺血改变或伴 CLBBB 或电起搏心室律<br>• TIMI 评级为低风险<br>• 肌钙蛋白阴性 | A（7） |
| **120** | • 可能的 ACS<br>• ECG：没有缺血改变或伴 CLBBB 或电起搏心室律<br>• TIMI 评级为低风险<br>• 峰值肌钙蛋白：临界，模棱两可，轻微升高 | **A（7）** |
| **121** | • 可能的 ACS<br>• ECG：没有缺血改变或伴 CLBBB 或电起搏心室律<br>• TIMI 评级为高风险<br>• 肌钙蛋白阴性 | A（7） |
| **122** | • 可能的 ACS<br>• ECG：没有缺血改变或伴 CLBBB 或电起搏心室律<br>• TIMI 评级为高风险<br>• 峰值肌钙蛋白：临界，模棱两可，轻微升高 | **A（7）** |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血的症状），但有初发或新诊断的心力衰竭或左室收缩功能不全** | |
| **128** | • 以往无 CAD 评价并且没有行冠脉造影的计划 | **A（7）** |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血的症状）但有明确的心律失常** | |
| **129** | • 持续性 VT | **A（7）** |
| **130** | • 频发 PVCs，运动诱发的 VT 或非持续性 VT | A（7） |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血的症状）但有明确的晕厥** | |
| **134** | • 中度或高度整体 CAD 风险 | A（7） |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血的症状）但有明确的肌钙蛋白升高** | |
| **135** | • 肌钙蛋白升高不伴有症状或无 ACS 的附加证据 | A（7） |
| | **在先前检查无症状之后行负荷超声心动图：先前亚临床疾病的证据** | |
| **139** | • 冠脉钙化 Agatston 评分>400 | A（7） |
| | **冠状动脉造影（侵入或非侵入性）后行负荷超声心动图** | |
| **141** | • 冠状动脉狭窄的显著性不明确 | A（8） |
| | **活动平板心电图后行负荷超声心动图** | |
| **149** | • 活动平板评级中度危险（如 Duke） | A（7） |
| **150** | • 活动平板评分高度危险（如 Duke） | **A（7）** |
| | **先前检查有新发现或症状恶化后行负荷超声心动图** | |
| **151** | • 冠脉造影异常或以往负荷影像学检查异常 | **A（7）** |
| | **先前非侵入性检查后行负荷超声心动图** | |
| **153** | • 先前的负荷试验结果模凌两可、临界或相互矛盾，阻塞性 CAD 仍不确定 | **A（8）** |

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| | **负荷超声心动图对风险的评价：非心脏外科手术、无活动性心脏情况的血管外科手术围手术期评价** | |
| **161** | • ≥1 个临床危险因素<br>• 心脏运动代谢当量差或不明（<4METs） | **A（7）** |
| | **负荷超声心动图对风险评价：ACS STEMI 在 3 个月内** | |
| **164** | • 血液动力学稳定，胸痛症状无复发或无心力衰竭体征<br>• 为评价可诱导的缺血<br>• 发病以来，未行过冠状动脉造影 | **A（7）** |
| | **负荷超声心动图对风险评价：ACS UA/NSTEMI 在 3 个月内** | |
| **166** | • 血液动力学稳定，胸痛无复发或无心力衰竭体征<br>• 为评价可诱导的缺血<br>• 发病以来，未做过冠状动脉造影 | **A（8）** |
| | **负荷超声心动图对风险评价：血管重建术后（PCI 或 CABG）有症状** | |
| **169** | • 等同于缺血的症状 | **A（8）** |
| | **负荷超声心动图对风险评价：血管重建术后（PCI 或 CABG）无症状** | |
| **170** | • 未完全再血管化<br>• 额外的血管重建术可行 | **A（7）** |
| | **负荷超声心动图对心肌存活性/缺血性心肌病的评价** | |
| **176** | • 已知的中度或重度左心功能不全<br>• 能接受血管重建术<br>• 仅用多巴酚丁胺负荷试验 | **A（8）** |
| | **负荷超声心动图评价慢性瓣膜病的血液动力学（包括负荷过程中行多普勒超声）——无症状** | |
| **179** | • 重度二尖瓣狭窄 | **A（7）** |
| **185** | • 重度二尖瓣反流<br>• 左室大小及功能未达到外科手术标准 | A（7） |
| **188** | • 重度主动脉瓣反流<br>• 左室大小及功能未达到外科手术标准 | **A（7）** |
| | **负荷超声心动图评价慢性瓣膜病的血液动力学（包括负荷过程中的多普勒超声）—有症状** | |
| **190** | • 中度二尖瓣狭窄 | **A（7）** |
| **193** | • 主动脉瓣狭窄不明确的评价<br>• 有心排量低或左室收缩功能不全的证据（低压差主动脉瓣狭窄）<br>• 仅用多巴酚丁胺负荷试验 | A（8） |
| **195** | • 中度二尖瓣反流 | **A（7）** |
| | **在 TTE/TEE 或负荷超声心动图中使用造影** | |
| **202** | • 选择地使用造影<br>• 相邻≥2 个左室节段非造影不能显示 | **A（8）** |

A 合理适应症，I 不合理适应症，U 不确定

**表 20，不确定适应症（中位数分数 4-6）**

| 适应症 | | 合理性评分（1-9） |
|---|---|---|
| | **TTE 对围手术期患者心脏结构及功能的一般评价** | |
| **14** | • 非心脏实体器官移植术前，对心脏结构和功能作围手术期常规评价 | **U（6）** |
| | **TTE 对急性低血压及血液动力学不稳定者的心血管评价** | |
| **20** | • 危重病人血容量状态的评价 | **U（5）** |
| | **TTE 对呼吸衰竭者的心血管评价** | |
| **27** | • 已明确为非心脏原因的呼吸衰竭或低氧血症 | **U（5）** |
| | **TTE 评价自身瓣膜反流者瓣膜的功能** | |
| **44** | • 轻度瓣膜反流伴临床情况或心脏体检无变化者的常规随访（≥3 年） | **U（4）** |
| **45** | • 中重度瓣膜反流伴临床情况或心脏体检无变化者的常规检查（<1 年） | **U（6）** |
| | **TTE 对高血压、心力衰竭或高血压心脏病的评价** | |
| **69** | • 已知高血压性心脏病，临床情况或心脏体检无变化者的再评价 | **U（4）** |
| | **TTE 对高血压、心力衰竭或心肌病性心力衰竭的评价** | |
| **72** | • 对已知心力衰竭（收缩或舒张型）伴临床情况或心脏体检改变和用药或饮食有明显改变者的再评价 | **U（4）** |
| **75** | • 心力衰竭（收缩或舒张型）不伴有临床情况或心脏体检变化的常规检查（≥1 年） | **U（6）** |
| | **TTE 对高血压、心力衰竭或心肌病心脏植入装置（包括起搏器、ICD、或 CRT）的评价** | |
| **77** | • CRT 植入后优化设置的初步评价 | **U（6）** |
| | **TTE 对高血压、心力衰竭或心肌病的评价** | |
| **89** | • 临床情况或心脏体检无变化，已知心肌病的常规检查（≥1 年） | **U（5）** |
| | **TTE 对成人先天性心脏病的评价** | |
| **96** | • 完全纠治的成人先天性心脏病的常规检查（≥2 年）<br>✧ 无残余结构或血液动力学异常<br>✧ 无临床情况或心脏体检变化 | **U（6）** |
| **97** | • 未完全纠治或姑息手术的成人先天性心脏病的常规检查（<1 年）<br>✧ 有残余结构或血液动力学异常<br>✧ 无临床情况或心脏体检变化 | **U（5）** |
| | **TEE 作为初次或补充检查——栓塞事件** | |
| **110** | • 对心血管源性栓塞的评价，伴以往明确的非心脏来源 | **U（5）** |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血症状）的一般人群** | |
| **126** | • 中等整体 CAD 风险<br>• ECG 不明确 | **U（5）** |
| **127** | • 高整体 CAD 风险 | **U（5）** |
| | **负荷超声心动图评价 CAD/风险：无症状（无等同缺血的** | |

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|---|---|---|
| | **症状）但有明确心律失常的患者** | |
| **132** | • 新起病的房颤 | **U（6）** |
| | **以往检查无症状之后的负荷超声心动图：先前亚临床疾病的证据** | |
| **137** | • 低或中度整体 CAD 风险<br>• 冠脉钙化 Agaston 评分 100-400 | **U（5）** |
| **138** | • 高整体 CAD 风险<br>• 冠脉钙化 Agaston 评分 100-400 | **U（6）** |
| **140** | • 颈动脉内膜异常增厚（≥0.9mm 和/或有突入动脉管腔的斑块） | **U（5）** |
| | **先前无症状或症状稳定者，以往负荷影像学检查正常之后的负荷超声心动图，** | |
| **145** | • 中及高度整体 CAD 风险<br>• 最近一次负荷影像学检查≥2 年 | **U（4）** |
| | **先前无症状或症状稳定者，以往冠脉造影或负荷影像学检查异常，未行血管重建手术之后的负荷超声心动图** | |
| **147** | • 冠脉造影证实的冠心病或以往负荷影像学检查异常<br>• 最近一次负荷影像学检查≥2 年 | **U（5）** |
| | **新出现症状或症状恶化之后的负荷超声心动图** | |
| **152** | • 冠脉造影正常或以往负荷影像学检查正常 | **U（6）** |
| | **负荷超声心动图对风险评价：非心脏外科手术，无活动性心脏情况，中等手术风险的围手术期评价** | |
| **157** | • ≥1 个临床危险因素<br>• 心脏运动代谢当量差或不明（<4METs） | **U（6）** |
| | **负荷超声心动图对风险的评价：血管重建术（PCI 或 CABG）后——无症状** | |
| **172** | • CABG 术后≥5 年 | **U（6）** |
| **174** | • PCI 术后≥2 年 | **U（5）** |
| | **负荷超声心动图对慢性瓣膜病的血液动力学评价（包括负荷过程中多普勒超声检查）——无症状** | |
| **178** | • 中度二尖瓣狭窄 | **U（5）** |
| **181** | • 中度主动脉瓣狭窄 | **U（6）** |
| **182** | • 重度主动脉瓣狭窄 | **U（5）** |
| **184** | • 中度二尖瓣反流 | **U（5）** |
| **187** | • 中度主动脉瓣反流 | **U（5）** |
| | **负荷超声心动图对慢性瓣膜病的血液动力学评价（包括负荷过程中多普勒超声检查）——有症状** | |
| **189** | • 轻度二尖瓣狭窄 | **U（5）** |
| **194** | • 轻度二尖瓣反流 | **U（4）** |
| | **负荷超声心动图对肺高压的血流动力学评价（包括负荷过程中多普勒超声检查）** | |
| **198** | • 疑似肺高压<br>• 静息状态超声检查提示右室收缩压正常或临界升高 | **U（5）** |
| **200** | • 为了评价对治疗的反应，对运动诱发肺高压的患者作 | **U（5）** |

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| | 再评价 |

A 合理适应症，I 不合理适应症，U 不确定

**表 21，不合理适应症（平均分 1-3）**

| 适应症 | | | 合理性评分（1-9） |
|---|---|---|---|
| | | **TTE 对心律失常者心脏结构及功能的常规评价** | |
| **3** | • | 偶发 APCs 或偶发 VPCs，无其他心脏病证据 | I（2） |
| **6** | • | 无症状孤立性窦性心动过缓 | I（2） |
| | | **TTE 对头晕/先兆晕厥/晕厥者心脏结构及功能的一般评价** | |
| **8** | • | 头晕/先兆晕厥，不伴有其它心血管病的症状或体征 | I（3） |
| | | **TTE 对心脏结构和心室功能的一般评价** | |
| **10** | • | 对无心血管病症状或体征者的心室功能（如普查）作初步评价 | I（2） |
| **11** | • | 对已知的 CAD 不伴有临床情况或心脏体检变化的患者作心室功能的常规检查 | I（3） |
| **12** | • | 对以往左室功能检查（如超声心动图、左心室造影、CT、SPECT MPI、CMR）正常，不伴有临床情况或心脏体检变化者作左室功能评价 | I（1） |
| | | **TTE 对围手术期患者的心脏结构和功能作一般评价** | |
| **13** | • | 对无心血管病症状和体征者作围手术期心室功能的常规评价 | I（2） |
| | | **TTE 对肺高压者的心脏结构和功能作一般检查** | |
| **16** | • | 对已知的肺高压不伴有临床情况或心脏体检变化的患者作常规检查（<1 y), | I（3） |
| | | **TTE 对急性肺栓塞的心血管评价** | |
| **28** | • | 为了明确诊断对疑似肺栓塞患者的检查 | I（2） |
| **30** | • | 既往有肺栓塞史，右心功能、肺动脉压正常者的常规检查 | I（1） |
| | | **TTE 对急性心脏外伤的心血管评价** | |
| **33** | • | 轻微胸部损伤不伴有心电图改变及生物标志物升高者的常规检查 | I（2） |
| | | **TTE 对心脏杂音或附加音的瓣膜功能评价** | |
| **35** | • | 对无瓣膜病或结构性心脏病症状和体征的初步评价 | I（2） |
| **36** | • | 对以往超声检查证实无瓣膜病不伴有临床情况或心脏体检变化者的再评价 | I（1） |
| | | **TTE 对自身瓣膜狭窄瓣膜功能的评价** | |
| **38** | • | 对轻度瓣膜狭窄、临床情况或心脏体检无变化患者的常规检查（<3 年） | I（3） |
| **40** | • | 对中度或重度瓣膜狭窄伴临床情况或心脏体检无变化患者的常规检查（<1 年） | I（3） |
| | | **TTE 评价自身瓣膜反流者的瓣膜功能** | |
| **42** | • | 轻微瓣膜反流的常规检查 | I（1） |
| **43** | • | 轻度瓣膜反流伴临床情况或心脏体检无变化者的常规 | I（2） |

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|---|---|---|
| | 检查（<3 年） | |
| | **TTE 对人工瓣膜功能的评价** | |
| **48** | • 对无或疑似人工瓣功能失调的患者作常规检查（置换后<3 年） | I（3） |
| | **TTE 评价感染性心内膜炎的瓣膜（自身或人工瓣）功能** | |
| **53** | • 短暂发热，无菌血症或新出现的杂音 | I（2） |
| **54** | • 短暂菌血症，病原体与典型的感染性心内膜炎无关，和/或已知有非血管内的感染源 | I（3） |
| **56** | • 在不考虑改变治疗方案的情况下，对无并发症的感染性心内膜炎作常规检查 | I（2） |
| | **TTE 评价心内和心外结构及心腔** | |
| **60** | • 对少量心包积液无临床情况改变的患者作常规检查 | I（2） |
| | **TTE 对主动脉疾病的评价** | |
| **66** | • 已知升主动脉扩张或具有主动脉夹层分离病史，不伴有临床情况或心脏体检变化或结果不改变治疗方案时的再评价 | I（3） |
| | **TTE 对高血压、心力衰竭或高血压性心脏病的评价** | |
| **68** | • 对无高血压性心脏病症状和体征的原发性高血压作常规评价 | I（3） |
| | **TTE 对高血压、心力衰竭或心肌病性心力衰竭的评价** | |
| **74** | • 心力衰竭（收缩或舒张型）伴临床情况或心脏检查无变化时的常规监测（<1 年） | I（2） |
| | **TTE 对高血压、心力衰竭或心脏植入装置（包括起搏器、ICD、或 CRT）的评价** | |
| **79** | • 心脏植入装置后临床情况或心脏体检无变化的常规检查（< 1 年） | I（1） |
| **80** | • 心脏植入后临床情况或心脏体检无变化的常规检查（≥ 1 年） | I（3） |
| | **TTE 对高血压、心力衰竭或心肌病的评价** | |
| **88** | • 已知心肌病不伴有临床情况或心脏体检变化的常规检查（<1 年） | I（2） |
| | **TTE 对成人先天性心脏病的评价** | |
| **95** | • 已得到完全纠治的成人先天性心脏病作常规检查（<2 年）<br>• 无残余结构或血液动力学异常<br>• 无临床情况或心脏体检变化 | I（3） |
| | **TEE 作为初次或补充检查——一般应用** | |
| **100** | • TTE 预期能解决所有诊断和治疗问题时，常规使用 TEE | I（1） |
| **102** | • 为先前 TEE 发现间隔一段时间后的变化作再检查，预期治疗不发生改变（如抗凝后血栓的消退、抗生素治疗后赘生物的消退） | I（2） |
| **105** | • 肺静脉隔离术后无症状患者，常规评价肺静脉状况 | I（3） |
| | **TEE 作为初次或补充检查——瓣膜疾病** | |
| **107** | • 预期诊断感染性心内膜炎的概率较低（例如：短暂发热、 | I（3） |

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|---|---|---|
| | 已知的其它感染源，或血培养阴性/不典型心内膜炎病原体） | |
| | **TEE 作为初次或补充检查——栓塞事件** | |
| **111** | • 心血管源性栓塞的评价，已知心脏来源，但并不会根据 TEE 结果改变治疗方案 | I（1） |
| | **TEE 作为初次检查——房颤/房扑** | |
| **113** | • 已经决定抗凝不准备进行心脏复律者的评价 | I（2） |
| | **负荷超声心动图评价 CAD/风险：对有症状或等同缺血症状的评价（非急性）** | |
| **114** | • 低 CAD 预测概率<br>• ECG 明确，能够运动 | I（3） |
| | **负荷超声心动图评价 CAD/风险：对有症状或等同缺血症状的急性胸痛** | |
| **123** | • 明确的 ACS | I（1） |
| | **负荷超声心动图评价 CAD/风险：对无症状（无等同缺血的症状）的一般人群** | |
| **124** | • 低整体 CAD 风险 | I（1） |
| **125** | • 中度整体 CAD 风险<br>• ECG 明确 | I（2） |
| | **负荷超声心动图评价 CAD/风险：对无症状（无缺等同血的症状）但有明确心律失常并发症的人群** | |
| **131** | • 偶发 PVCs | I（3） |
| | **负荷超声心动图评价 CAD/风险：对无症状（无等同缺血的症状）但有明确晕厥的人群** | |
| **133** | • 低整体 CAD 风险 | I（3） |
| | **对以往检查提示有亚临床疾病的无症状患者作负荷超声心动图** | |
| **136** | • 冠脉钙化 Agatston 评分<100 | I（2） |
| | **以往负荷影像学检查正常，无症状或症状稳定者作负荷超声心动图** | |
| **142** | • 低整体 CAD 风险<br>• 最近一次负荷影像学检查<2 年 | I（1） |
| **143** | • 低整体 CAD 风险<br>• 最近一次负荷影像学检查≥2 年 | I（2） |
| **144** | • 中度及高度整体 CAD 风险<br>• 最近一次负荷影像学检查<2 年 | I（2） |
| | **以往冠脉造影或负荷影像学检查异常，未行血管重建手术，无症状或症状稳定者作负荷超声心动图** | |
| **146** | • 已知冠心病，冠脉造影或以往负荷影像学检查均异常<br>• 最近一次负荷影像学检查<2 年 | I（3） |
| | **活动平板心电图之后行负荷超声心动图** | |
| **148** | • 活动平板心电图 Agaston 评级为低危（如 Duke） | I（1） |
| | **负荷超声心动图对风险的评价：非心脏外科手术，无活动性心脏情况，低手术风险的围手术期评价** | |

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|---|---|---|
| **154** | • 围手术期的风险评价 | I（1） |
| | **负荷超声心动图评价风险：非心脏外科手术，无活动性心脏情况，中等手术风险的围手术期评价** | |
| **155** | • 中等以上运动代谢当量（≥4METs） | I（3） |
| **156** | • 无临床危险因素 | I（2） |
| **158** | • 心导管检查和非侵入性检查正常或血管重建术<1 年，无症状 | I（1） |
| | **负荷超声心动图对风险的评价：对非心脏外科手术，无活动性心脏表现的血管外科手术的围手术期评价** | |
| **159** | • 中等以上心脏运动代谢当量（≥4METs） | I（3） |
| **160** | • 无临床危险因素 | I（2） |
| **162** | • 心导管检查和非侵入性检查，或以往血管重建术后正常，无症状<1 年 | I（2） |
| | **负荷超声心动图对风险的评价：在 ACS STEMI3 个月内** | |
| **163** | • 直接 PCI 术完全再血管化<br>• 无复发症状 | I（2） |
| **165** | • 血液动力学不稳定，有心源性休克体征，或机械并发症 | I（1） |
| | **负荷超声心动图对风险的评价：ACS3 个月内，ACS——血管重建术后（PCI 或 CABG）无症状** | |
| **167** | • 充分再血管化患者出院前复查 | I（1） |
| | **负荷超声心动图对风险的评价：ACS 心脏康复 3 个月内** | |
| **168** | • 在开始心脏康复前（作为一个独立的适应症） | I（3） |
| | **负荷超声心动图对风险的评价：血管重建术后（PCI 或 CABG）无症状** | |
| **171** | • CABG 术后<5 年 | I（2） |
| **173** | • PCI 术后<2 年 | I（2） |
| | **负荷超声心动图对风险的评价：血管重建术后（PCI 或 CABG）心脏康复** | |
| **175** | • 开始心脏康复前（作为一个独立的适应症） | I（3） |
| | **负荷超声心动图对慢性瓣膜病的血液动力学的评价（包括负荷过程中多普勒超声检查）——无症状** | |
| **177** | • 轻度二尖瓣狭窄 | I（2） |
| **180** | • 轻度主动脉瓣狭窄 | I（3） |
| **183** | • 轻度二尖瓣反流 | I（2） |
| **186** | • 轻度主动脉瓣反流 | I（2） |
| | **负荷超声心动图对慢性瓣膜病的血液动力学评价（包括负荷过程中多普勒超声检查）——有症状** | |
| **191** | • 重度二尖瓣狭窄 | I（3） |
| **192** | • 重度主动脉瓣狭窄 | I（1） |
| **196** | • 重度二尖瓣反流<br>• 重度左室扩大或左室收缩功能不全 | I（3） |
| **197** | • 急性中度或重度二尖瓣或主动脉瓣反流 | I（3） |
| | **负荷超声心动图对肺高压的血液动力学评价（包括负荷过程中多普勒超声检查）** | |

| | | |
|---|---|---|
| **199** | • 对已知静息状态下肺高压的患者作常规评价 | I（3） |
| | **造影在 TTE/TEE 或负荷超声心动图中的应用** | |
| **201** | • 造影的常规应用<br>• 没有造影，左室所有节段都能显示 | I（1） |

A 合理适应症，I 不合理适应症，U 不确定

**8.讨论**

本适用标准结合目前已有的循证医学证据与专家意见来定义患者的亚组，评价某一特定临床场合下，对这部分患者进行检查或者手术操作是否有净获益或者风险，从而决定该项检查（在本文中指超声心动图）的合理性。该指南的目的旨在指导手术操作的合理使用，也就是避免过度使用或使用不足，从而改善患者预后，提供更合理的医疗服务和医疗卫生支出。

本文件是对经胸和经食管超声心动图（1）和负荷超声心动图原始 AUC（2）的修订与组合。这个修订本采纳了过渡期的临床数据和近期发表的标准文献提供的见解，对上一版中遗漏或不明确的部分进行了说明。此外，自从上一版本颁布后，一些研究评价了这些适用标准在临床实践中的应用，而这些研究结果也被整合进来，并将在此进行简要陈述。

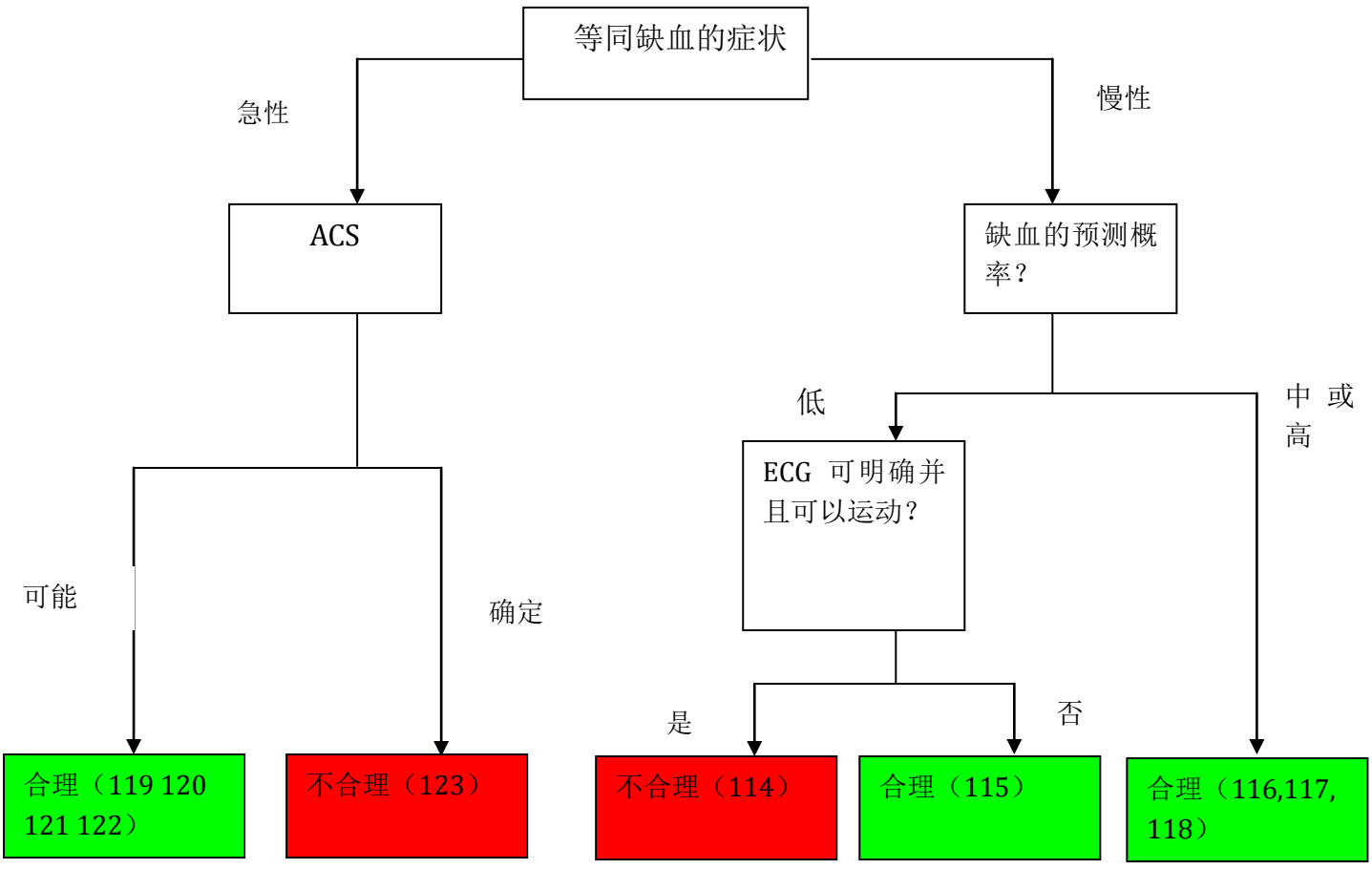


**图 1，负荷超声评价 CAD/风险：症状或者等同缺血的症状**

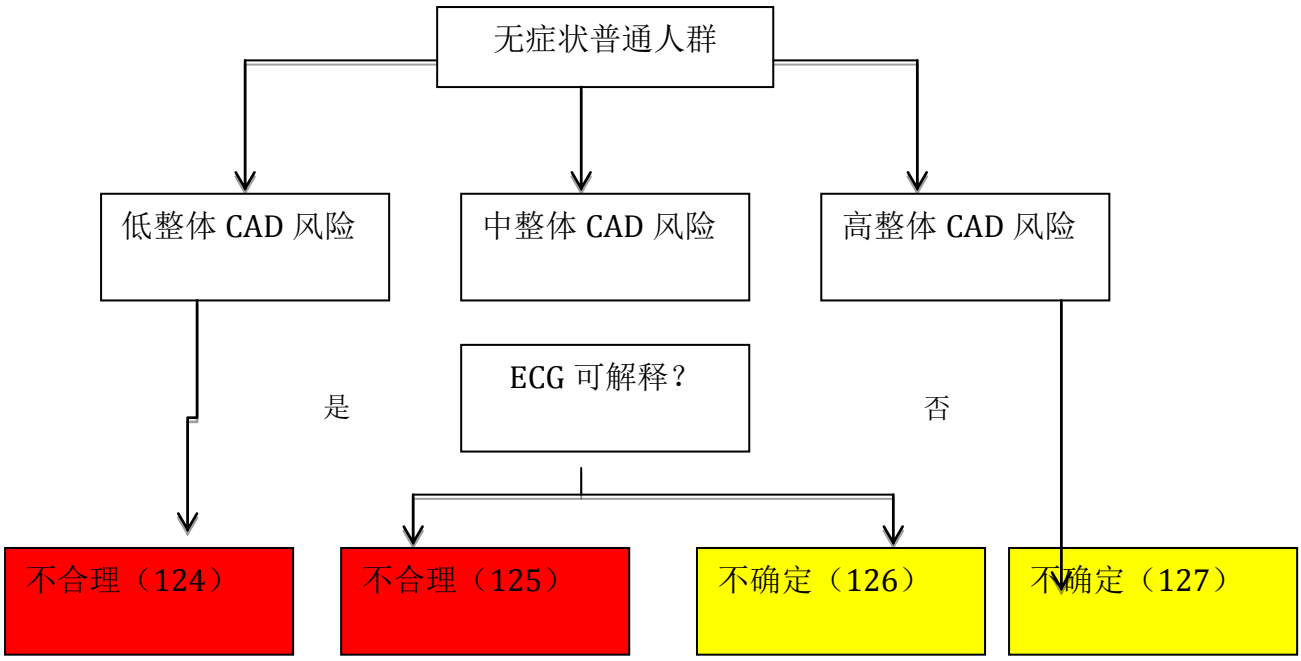
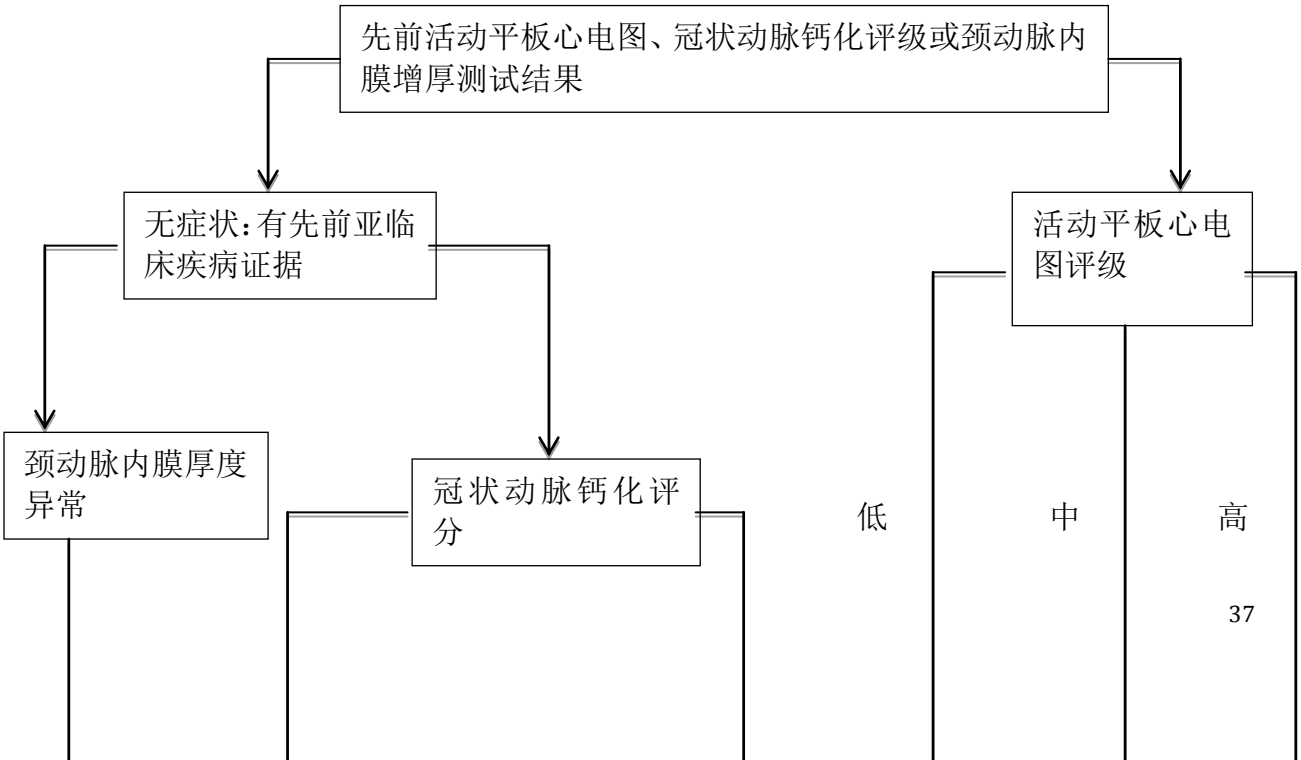



图 2，负荷超声心动图评价 CAD/风险：无症状（无等同缺血的症状）



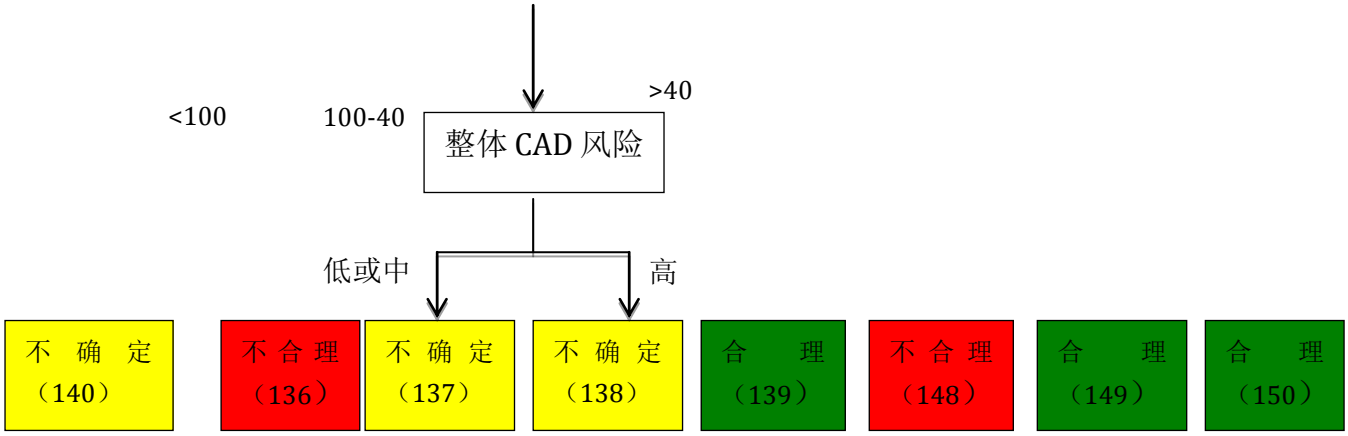



**图 3，根据以往活动平板 ECG、冠状动脉钙化评分、颈动脉内膜厚度的测试结果进行负荷超声检查的合理性。**

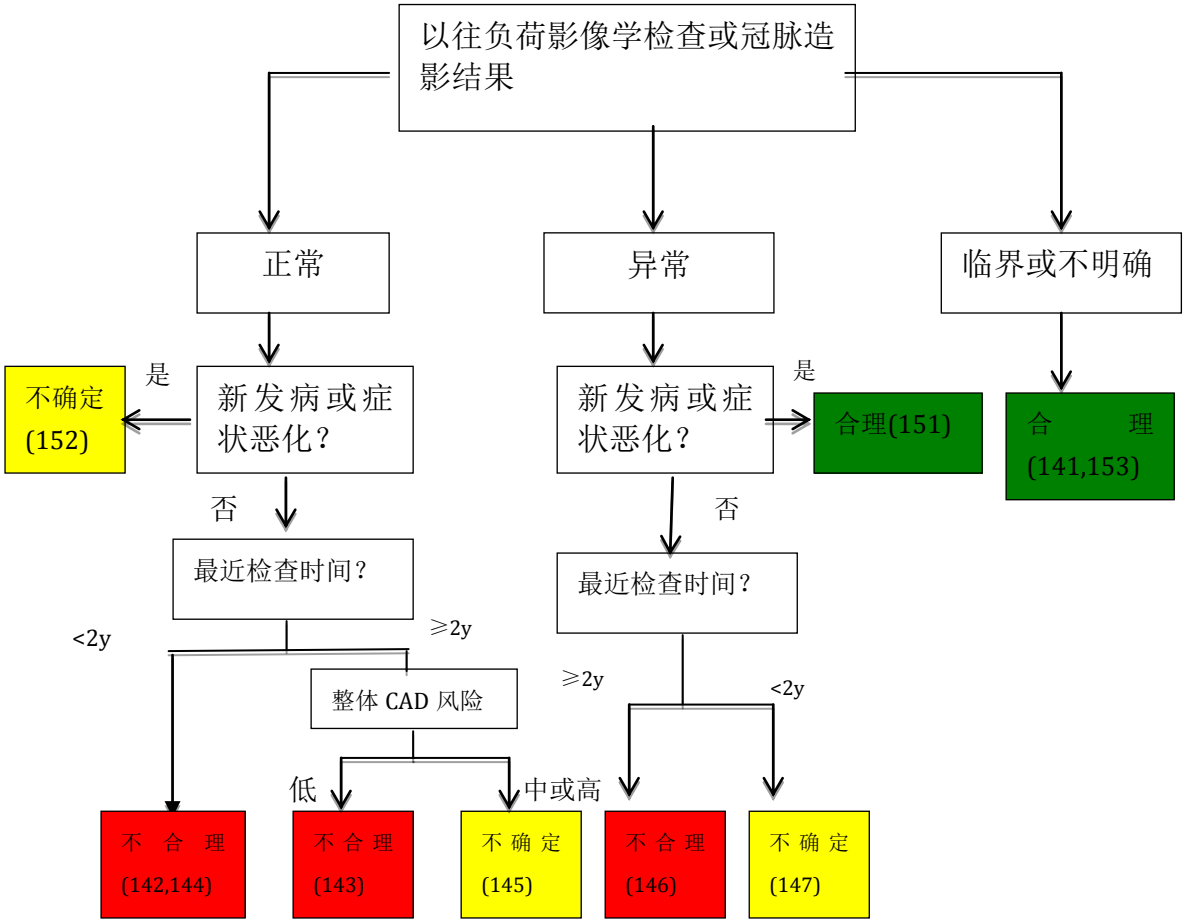


**图 4，根据以往负荷影像学检查或冠脉造影结果进行负荷超声检查**

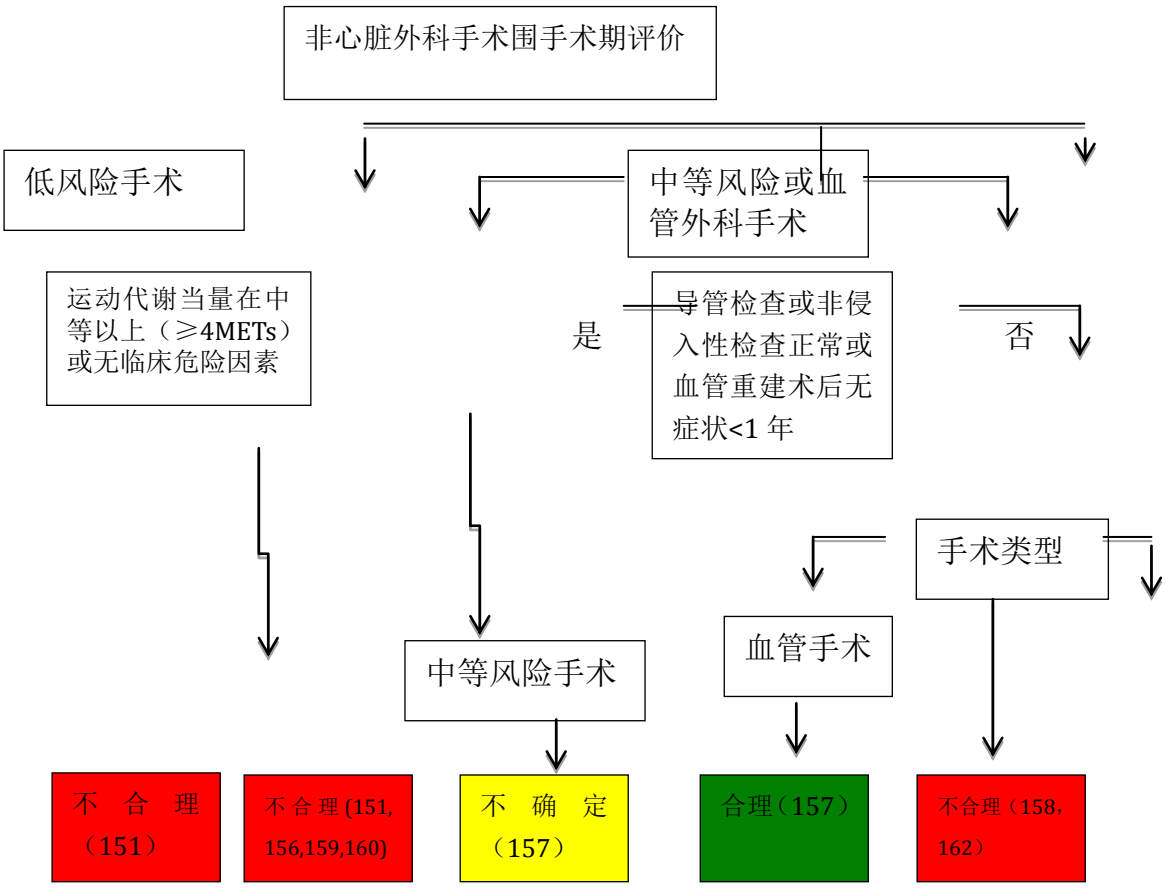
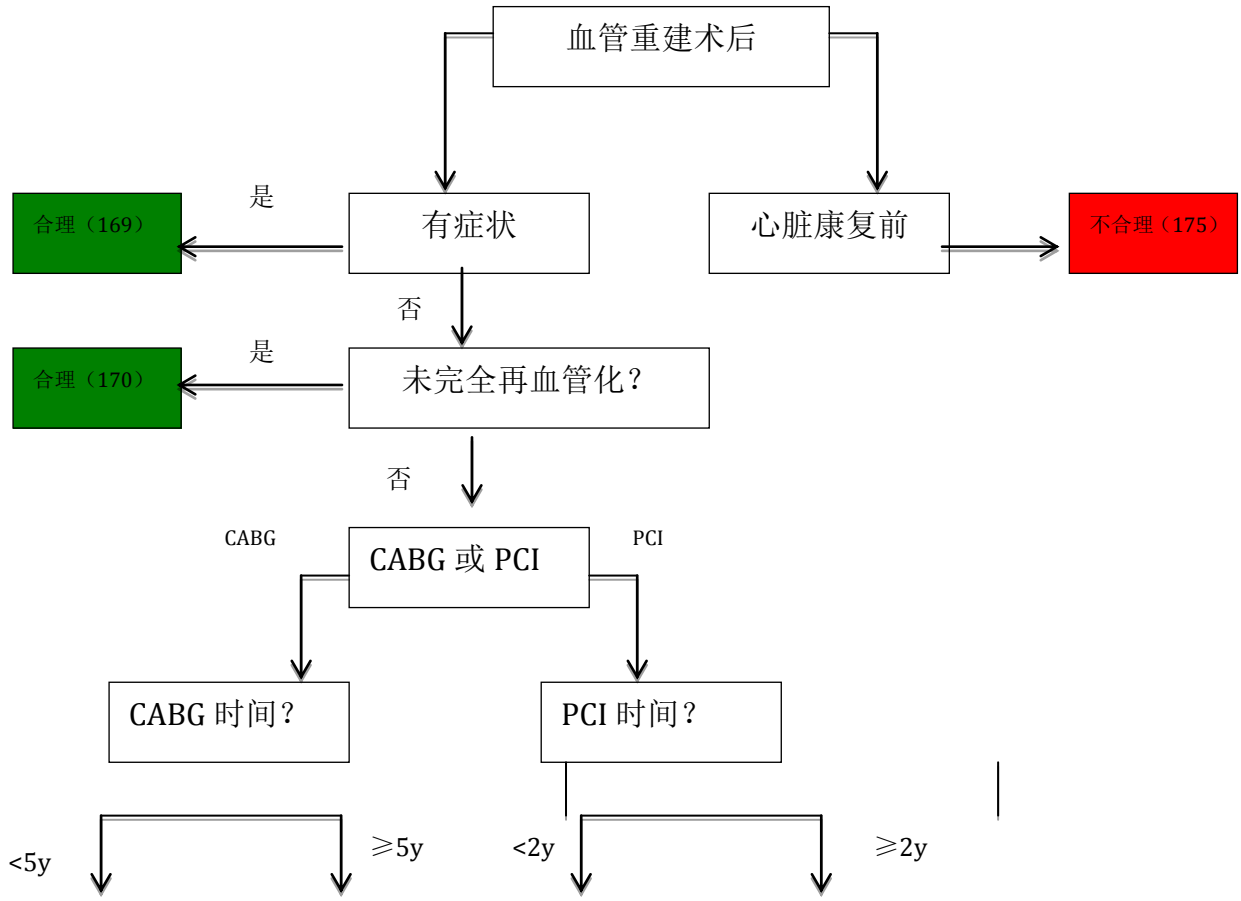



**图 5，负荷超声心动图对风险的评价——非心脏外科手术无活动性心脏情况的围手术期评价。**



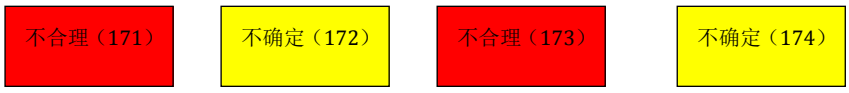



**图 6，负荷超声心动图对风险评价——血管重建术后（PCI 或 CABG）。**

**适用标准的实施**

2007 年版 AUC 在 TTE 上的应用已经在多个医疗学术中心（22,24-26），退伍军人（VA）医院(27)，和社区卫生中心（28,29）进行了评价。几个常见的问题值得注意。首先，大部分拥有 TTE 的临床场合都已经在 AUC 的框架下（有 11%到 16%的 TTE 检查没有归类）（24,27）。第二，在实施应用中，TTE 使用的适用和不适用的比例惊人地相似。在那些使用 AUC 作 TTE 的场合中（除了未归类的患者），绝大部分被评为合理（ 87%到 91%），而不合理使用 TTE 的比例始终很低（9%-13%）（24-27）。而一项门诊病人 TTE 的研究中（29），合理使用 TTE 的比例较低（74%），这可能是由于门诊未归类的检查比例较高所致，其他的研究也观察到类似的现象（24,26）。考虑到原始 AUC（1）版本中的许多适应症特别针对临床症状或者“临床情况的改变”来决定的，这可能可以解释为什么门诊患者中未归类 TTE 比例较高。

最常用的 TTE 合理使用适应症，包括症状疑似心脏病引起的初步评价，前期检查提示的心脏疾病，瓣膜疾病和心力衰竭的评价（24），这些适应症在此版本中依然保留（适应症 1，2 ，34，70）。扩展 AUC 的建议主要表现在：1）围手术期的评价（适应症 13, 14）；2）瓣膜病的随访期限（适应症 38-41， 43-49）；3）器械治疗的评价（适应症 76-83）；4）在某些专项护理或者“niche”项目中的评价（如实体器官移植）（适应症 14,84,85），以上这些情况都已经包含在当前的版本中。最后，反映门诊的临床场合（即，临床情况没有变化）的更多适应症也被采纳。

与评价 AUC 在 TEE 中应用的研究结果类似，即大部分可归类的 TEE 被定为合理的适应症（94%-97%），只有小部分没有被 AUC 归类（6%-9%）（30-32）。操作人员更多地参与作出 TEE 检查决定的这一事实，可能有助于解释 TEE 与 TTE 相比有更高的合理使用率。一开始 TEE 检查最常见的适应症是指导房颤或者房扑病人的抗凝治疗（适应症 112， 113）。本修正版的重点是改进评价栓塞心血管来源的适应症（适应症 109-111）。

很少有研究关注 AUC 在负荷超声心动图中的应用（33，34）。在一项研究中，19%的负荷超声心动图不能被 AUC 归类（33）。而能够归类的超声心动图中，仅 66%是合理的适应症。大部分未归类的检查主要集中在 2 个领域：围手术期风险评价和已有前次检查结果的再次风险评价。在另外一项研究中，88%（n=253）的负荷超声归于 AUC 中提到的适应症，而 12%（n=36）没有包括在 AUC 适应症中（34）。而归于 AUC 适应症的 253 个检查中，71%（n=180）是合理的，9%（n=23）是不确定的，20%（n=50）为不合理的。

实施研究的结果显示，在美国各个地区，不合理使用超声的比例相似。相比之下，其它资源利用的研究显示，资源利用模式存在地区间的差异（35）。最近的一项研究（36）表明，在使用中所观察到的地理差异的大部分原因，可归因于患者健康程度的地区性差异，AUC 实施的数据也支持这一结论，与保险申诉的数据不同，该数据内在地考虑到了临床的情况。AUC 的进一步应用也许有助于通过临床数据和补充保险申诉的数据，来剖析医疗服务的真实变化；当然，这还需要进一步的研究。

评价 AUC 在超声心动图中临床应用的研究表明，总的来说，大部分临床场合都可以按标准归类，并且大部分的应用都是为了合理的适应症而制定的。另外，这些研究确定了 AUC 应用中的差距，可能是由于前一版本中的遗漏和随后专业护理中的进展，这些在指导后续修订过程中都具有实质性意义。虽然有所改进，但是我们并不期望这个 AUC 文件可以广泛包含所有可能的临床场合。尽管实施研究的结果证明，先前的超声心动图 AUC 版本是成功的，但它也支持当前修订和更新标准的需要。

**修订版的其他特点**

除了纳入实施研究的结果以外，此修订版的其它方面也值得强调。首先，修订后的文件整合了 TTE，TEE 和负荷超声心动图，而之前的 TTE 和 TEE 的 AUC（1）与负荷超声心动图的 AUC 是分别独立颁布的（2）。这个适应症表格仍然分别关注每一种检查模态，例如，TTE，TEE 作为初步的检查(或者 TTE 诊断不明时用 TEE 作为辅助)和负荷超声心动图。但是最后的表格是个例外（表 18，适应症 201，202），其中包含了造影剂的使用，这适用于所有超声心动图模式。其次，创建了一个新的表格，包括成人先天性心脏病的适应症，因为成人心脏学

家更频繁接触到此类人群（表 7，适应症 92-98）（37）。值得注意的是，除了某些结扎或封堵的成年动脉导管未闭（适应症 95 和 96），大多数先天性心脏病有可能出现残存的解剖结构或者生理异常，因此，即使对许多没有症状病情稳定的患者，超声心动图仍被视为指导治疗决策而不只是常规监测。第三，扩充现有的表格，以便更全面地覆盖各种临床场合。第四，努力解决在修订或新的实践指南中新显现的临床情况，例如心脏瓣膜病（14），围手术期评价（16）和胸主动脉疾病的评价（38）。在版本修订过程中的目标是将适应症与相应的循证基础取得一致（见在线附录）。如果某些适应症没有得到随机临床试验或者其它相关的实践指南支持，那么尽可能从专家共识文件来确定该临床情况。最后，加入了更多与不断发展的治疗选择相关的适应症，如 CRT（适应症 76-78），或肺高压的治疗／随访（适应症 15-18）。

在此修订过程中一个重点是为了谐调所有无创伤性检查的适应症，使得适应症的措辞与其它 AUC 标准尽可能一致（3）。对于超声心动图来说，与其他文件谐调最主要体现在负荷超声这一部分。比如，表 13，非心脏外科手术的围手术期评价，借鉴了 RNI 文件中的表 4（3）。这应该有助于这个标准的临床应用并且协助未来的修订过程和未来可能的多模态显像 AUC 文件的开发。

和其它影像学检查一样，负荷超声心动图可以提供超出适应症主要目的以外的有用信息。此外，负荷超声没有电离辐射。然而，负荷超声的 AUC 并未被开发用于数算增加的信息或其它检查特点，这些特点超越体现个别适应症中固有的诊断需求。

在给各项适应症评定级别中，要求专家组在完成他们自己的评级时，不要与其它影像学检查比较。尽管如此，负荷超声心动图与 SPECT MPI 有类似的证据支持它们的使用。因此，并不奇怪对于类似的临床适应症，负荷超声心动图和负荷 RNI 的绝大多数最终评级是一致的。然而，本文报告的少数适应症，其最终评分与评级分类与之前发表的负荷 RNI 结果不同（3），特别是 4 个适应症（适应症 127，157，171,172）。值得注意的是，在这 4 个适应症中，有 3 个也出现在第一版的负荷超声 AUC 中（2），这 3 个适应症在本次修订中的评级相似，说明由不同成员组成的两个技术小组的评级一致。适应症 127 的评级差异，可能直接受到 DIAO 研究发表的影响（39），该研究在 RNI 评级时尚未发表。此外，尽管

最终评级与 RNI 不同，但是适应症 127 和 171 在当前超声心动图技术小组中的得分一致。因此，评级与 RNI 不同也许能反映 SPECT 的 AUC 出版以来的新内容和两个技术小组组合之间的差异。

读者也应该注意，分类总结可能会强调一些微小的差异。比方说，在中位分数附近的分级（4 和 3），很小的变化就可以影响合理性的分类（从不确定变为不合理）。适应症 157 就与此现象相关，在本文中被评为不确定（中位分数为 6 分），而在 RNI 中同一个适应症被评为合理（中位分数为 7 分）。这个分级差异的最主要的原因，是由于不同专家组成员之间评分的微小差异，包括成员的组成，临床的经验水平，或者对数据的不同理解。AUC 任务组已经仔细研究了专家组中的成员问题，并且尽一切可能，确保各技术组成员间的相似性。RAND 也已证明，由于不同专家对内容理解上的差别，也会导致最终评分的细微差异（6）。

如在“方法”部分所述，每一个主要疾病分类里，都会应用一个标准的方法来概括大部分临床场景，并避免适应症的列表过多。该方法主要是创建 5 大类的临床场景：1）用于初步诊断；2)指导患者的治疗或者处理，不管症状如何；3）评价临床情况或者心脏体检的变化；4）临床情况无变化者的早期随访；5）对于临床情况无变化患者的晚期随访。值得重视的是，很多心血管疾病有潜在的残余解剖或者生理学异常，因此超声心动图的随访和随访的时间点都应该依据病人的临床情况、残留异常的严重程度和风险来决定。因此，在临床情况正在发生变化或者正在考虑使用超声心动图来指导治疗决策的场合，超声心动图应被随时应用而非定时常规检查。对于已知或疑似残留解剖或生理异常的无症状或病情稳定的患者，对正在考虑更改治疗方案的患者，随访的时间应根据患者的个体因素来决定，而不是根据常规检查规定的时间点来确定。

总的来说，评级专家组对疾病的初步诊断，治疗指导和临床情况发生改变的所有适应症都给了合理的评价。评分为不确定或者不合理更可能是早期随访而不是晚期随访，特别是对无症状患者的最佳随访间期是不确定的适应症。在可能的情况下，与随访时间有关的适应症应尽可能遵循临床指南（14），尽管对于许多适应症而言，无症状患者最合适的随访时间间隔尚未确定。基于这个原因，也是为了方便临床，随访时间间隔的选择并不是一成不变的，而是给了一个大致的时间段。

尽管总的方法有广泛性和包容性，但还有几个特定的临床情况是要根据前面提到的实施研究结果确定的。以适应症 71 和 72 为例，这两个适应症的主要区别在于对失代偿性心力衰竭再评价的时间选择，到底是选择在用药或饮食没有骤然改变的情况下，还是在有骤然改变的情况下。当用药或者饮食有明显变化时，为了评价心脏功能，在安排重复影像学检查之前，要判断合理的药物治疗和监护是否可以为临床带来改善（25）。因此，适应症 72（药物或饮食的突然变化）被评为不确定，而适应症 71 则被评为不合理。另外一个重要的临床场合反映在适应症 76，“血管重建术和/或合理药物治疗后的初次或再次评价，以确定医疗装置治疗的候选资格和/或决定装置的最佳设置。”根据实施研究的结果（24），这些临床场合和在首版 AUC 中并没有很好地包括在内。然而，在血管重建术或者药物治疗一段时间后，再次评价左室射血分数，来决定医疗装置的候选资格，代表了一种标准的医疗护理（40），也是 TTE 的常规适应症。这种情况表现在适应症 76，被评为合理。

作为常见的临床场景，实施研究确定的其它专业领域，包括心动过缓（适应症 6）和新的亚组，TTE 对晕厥的评价（适应症 7-9）。此外，为了适应更多的临床场景和密切遵循最新的指南推荐（14），在心脏瓣膜病这个章节（静息 TTE/TEE 和负荷超声评价血液动力学）已经得到扩充。

尽管进行了大量的修订与扩充，被修订的超声心动图 AUC 还是无法涵盖所有潜在的临床场景。此外，实施研究中的某些被认为十分罕见或难以实践的建议，没有包含在本修订版中。如果有发现没有包含在此次版本中的某些临床场景比预期更加频繁，可以将其纳入未来的修订版本中。这也说明修订过程的更替特性。

另外，有几个一般类别在这里故意没有体现。比如，心脏外科手术中使用 TEE 就没有包含在此文件中。本文件未涉及更高度专业化的超声技术，如三维超声显像或者心包显像。此外，在假设部分第一段中，TTE，TEE 和负荷超声的 AUC 都是针对成年患者的，小儿超声的适应症未被包括。

**新的假设和定义**

除了增加新的临床适应症和澄清原来在 TTE/TEE（1）和负荷超声（2）AUC 中已经存在的适应症外，编写组也修订和添加了特殊的假设和定义。有几个主要的假设包括如下：首先，增加了在确定超声心动图的合理使用时，需要暗暗考虑

成本的假设。第二，新的假设对不确定适应症的分类，并澄清这样的评级不应作为不支付报销的理由。第三，新的假设表明，检查合理性的评分反映的是一种特定的检查对患者的合理性，而非是否优于其它形式的检查（如 RNI, CT）。因此，AUC 不应用来为有关检查的偏好管理政策提供临床支持。最后，假设澄清了常规或者监测的含义，这表示经过一段时间后的“定期”评价，而且不因为其它临床情况取消约定的检查。另外，其它更多的特定假设也被添加。其中包括需要将人工瓣和自体瓣膜一起考虑（除非另有说明）和用多普勒对左心和右心血液动力学的评价。此外，如果围手术期病人有心血管病的症状，就应被归类于有症状的适应症中（如适应症 1），而不是归类在围手术期的类别中。

与 RNI 的 AUC 相似（3），写作组修订了“胸痛综合征”的定义，采用了“等同缺血的症状”一词，这一词包括了胸痛综合征和被临床医师认为可能归因于 CAD 的临床症状和体征。在评价无症状患者的风险时，写作组还采用了整体风险评价这样一个概念(41)。本修订版得到了写作组，技术组和外部评阅人的支持并且与最近出版心脏 CT 的 AUC 相谐调（4）。

**局限性**

适应症评级为合理，不确定，不合理反映了评级这个时刻所涉及的知识体系。随着科学的发展和循证指南的颁布，可以预计，现在给予 1 分的某些适应症将来会有不同的适应症评级。虽然这反映了医学科学发展的必然特点，但它也许会在不同时间点上因为方法的不同，对类似的适应症评级产生显著差异。根据目前的循证依据和实践指南制定的适应症，尽管有迹象表明其内容有限，并且临床专业知识发挥了更大的作用，但是，这与医师促进绩效改善联盟（the Physician Consortium for Performance Improvement）认可的标准方法和原则是一致的（42）。此外，如前面已经提到过的，某些临床场景有意未包含在适应症中。未来的实施研究评价这个超声心动图 AUC 修订版时，可能会频繁发现有些情况没有被包含在这个版本中。与当前修订情况一样，实施研究的结果和建议有助于完善后续的 AUC 修订。

**用 AUC 改善医疗护理**

本报告中的 AUC 提供了特定临床情况下使用超声心动图的合理性评价，特

别是 1 至 202 条（原文 202 条中的 1 条，因为下文是复数，所以改为 1 至 202 条）临床适应症。这些标准预期将为临床医师，医疗机构和从事心血管影像方面的第三方支付者有用。希望 AUC 在各种情况下都具有价值，包括指导患者的个体化治疗，为护理人员提供教育，为心血管影像的政策提供决定。

AUC 是心血管影像质量管理链上的第一个环节(43)。在确保选择了合适的检查之后，影像质量的保证主要包括忠于图像采集的最佳实践，图像的理解和结果的交流，并将结果纳入临床护理。尽管 AUC 的发展和技术小组的评级只是质量管理链中的第一环，并且假设其它所涉及的质量标准都没有障碍，所有的因素对患者的优化护理都非常重要。

虽然这些标准旨在为护理决策提供指导，但是它们不能替代良好的临床判断与实践经验。写作组认识到，在临床实践中遇到的患者，可能不会完全在这些 AUC 中体现出来，或者与所显现的临床实际情况相比，也许无足轻重。此外，不确定的适应症常常需要医生的个体化判断和对患者深入的了解，来更好地决定在特定临床情况下选择一个检查的必要性。因此，不确定的适应症（4 至 6 分）不应被视为限制超声心动图对这些患者的使用。值得强调的是，技术组始终认为“不确定”仍属于保险报销的类别。

这些评级反映了重要的医学文献和专家共识，旨在评价在特定患者使用的合理性，以确定超声心动图的整体护理模式。在合理使用评级和临床医师认为最有利的推荐之间存在实质性差异的情况下，进一步考虑或采取措施（比如第二个方案），也许是合理的。此外，并非所有的医生或机构都 100%地认为超声心动图检查是合理的，这既不是预期也不可取。然而，尽管不现实，我们还是希望不合理的医嘱降为 0%。与整个护理模式相关，比如，如果合理与不确定的全国平均水平在 80%，而某个医生或医疗机构的不合理比例为 40%，那么进一步审查医疗护理模式也许是必要的也是有帮助的。需要认真研究用 AUC 来指导临床决策及其对患者预后和医疗保健质量 / 效率的影响。AUC 还可作为超声心动图的提供者和有关医师的教育工具。最近宣布的 AUC 纳入超声心动图实验室的认证要求将很快实施，这会促进 AUC 的使用（44）。然而，优化超声心动图使用最得益的机会是改善对患者个人的决策。AUC 成功用于临床实践是持续质量改进的重要方面。

附件 A，附加的超声心动图定义

1. 心绞痛

   典型心绞痛（定义）：定义为 1）胸骨后疼痛或不适，那是 2）由用力过度或情绪激动促发，和 3）休息和/或服用硝酸甘油可以缓解（45）。

   不典型心绞痛（可能）：胸痛或不适，缺乏典型心绞痛定义特征中的 1 条表现。

   非心绞痛性胸痛：胸痛或不适，仅符合 1 条或无典型心绞痛的表现。

2. 急性冠脉综合征（ACS）

   根据 ACC/AHA 关于 ST 段抬高型心肌梗死患者治疗指南的定义：ACS 患者的临床表现包括以下诊断范围的患者：不稳定型心绞痛、非 ST 段抬高型心肌梗死和 ST 段抬高型心肌梗死（46）。

3. 评价非心脏外科手术的围手术期风险

   判断围手术期风险的方法：见图 A1，“围手术期心脏评价的流程图”，摘自 ACCF/AHA 关于非心脏外科手术围手术期心血管病评价和护理指南（16）。根据这个流程图，一旦确定患者不需要紧急手术，临床医师必须明确患者的活动性心脏情况（见表 A1）和/或围手术期风险预测因子（见表 A2）。如果存在任何活动性心脏情况和/或主要风险预测因子，图 A1 建议考虑冠状动脉造影以及推迟或取消非心脏外科手术。一旦根据流程图对围手术期风险预测因子作出评价，就应根据患者的手术风险和功能状态来确定是否需要进行非侵入性检查。

4. 心肌梗死溶栓治疗（TIMI）的风险评级

   TIMI 危险评级（48）是一个简单的工具，包括 7 个风险指标组成（每个 1 分）。随着 TIMI 评分的增加，组合终点的发生率增高（总死亡率、新发生或反复发作的心肌梗死、或反复发作的严重心肌缺血需要在 14 天内紧急血管重建术）。这个方法是心血管事件和测试灵敏度的重要预测因子，并相对不受信息缺失的影响／不打折扣，例如前文提到的冠状动脉狭窄≥50%的观念。这个方法预测风险（odds ratio 译者添加）的截断值在 65 岁。

TIMI 风险评分取决于入院时 7 个变量的总和；下述每个变量 1 分：年龄≥65 岁，至少有 3 个冠心病的危险因素，以往证实冠状动脉狭窄≥50%，心电图见 ST 段变化，24 小时内至少有 2 次心绞痛发作，过去 7 天内服用阿司匹林，血清心脏生物标志物升高。

低危 TIMI 评分：TIMI 评分<2

高危 TIMI 评分：TIMI 评分≥2

5. 不确定的心电图改变

指静息状态下心电图 ST 段压低（≥0.1mV），完全性左束支传导阻滞，预激（W-P-W 综合征）或起搏心律。

6. 冠状动脉造影

冠状动脉造影是指侵入性心导管检查或已成熟的非侵入性冠状动脉成像方法，如冠状动脉 CT 血管造影。

表 A1，活动性心脏情况，应在非心脏外科手术前评价和治疗的患者

| 情况 | 举例 |
|---|---|
| **不稳定冠脉综合征** | 不稳定或严重心绞痛*（CCS III 级或 IV 级）† |
| | 近期心肌梗死‡ |
| **失代偿性 HF（NYHA 心功能 IV 级；恶化的或新起病的 HF）** | |
| **严重心律失常** | 高度房室传导阻滞 |
| | 莫氏 II 型房室传导阻滞 |
| | III 度房室传导阻滞 |
| | 有症状的室性心律失常 |
| | 室上性心动过速（包括房颤）伴未控制的心室率（静息时心率>100bpm） |
| | 有症状的心动过缓 |
| | 新出现的室性心动过速 |
| **严重的瓣膜病** | 重度主动脉瓣狭窄（平均跨瓣压差>40mmHg，瓣口面积<1.0cm$^2$，或有症状） |
| | 有症状的二尖瓣狭窄（活动后进行性呼吸困难加重，运动后先兆晕厥，或 HF） |

CCS 指加拿大心血管病协会；HF＝心力衰竭；HR＝心率；MI＝心肌梗死；和 NYHA＝纽约心脏学会心功能分级。

*根据 Campeau 定义（47）

†可以包括那些长期久坐患者中的“稳定型”心绞痛
‡美国心脏病学院国家数据库将近期 MI 定义为>7 天至≤1 个月（30 天之内）。
引自 Fleisher 等（16）。

表 A2，围手术期临床危险因素*

- **缺血性心脏病病史**
- **代偿性心力衰竭或以往心力衰竭病史**
- **脑血管病史**
- **糖尿病（需要用胰岛素治疗）**
- **肾功能不全（肌酐>2.0）**

*根据 2009 年 ACCF/AHA 的定义，将围手术期β 受体阻滞剂的更新纳入 ACCF/AHA2007 年围手术期心血管评价和非心脏外科手术护理的指南。注意这些并不是标准的冠心病危险因素。

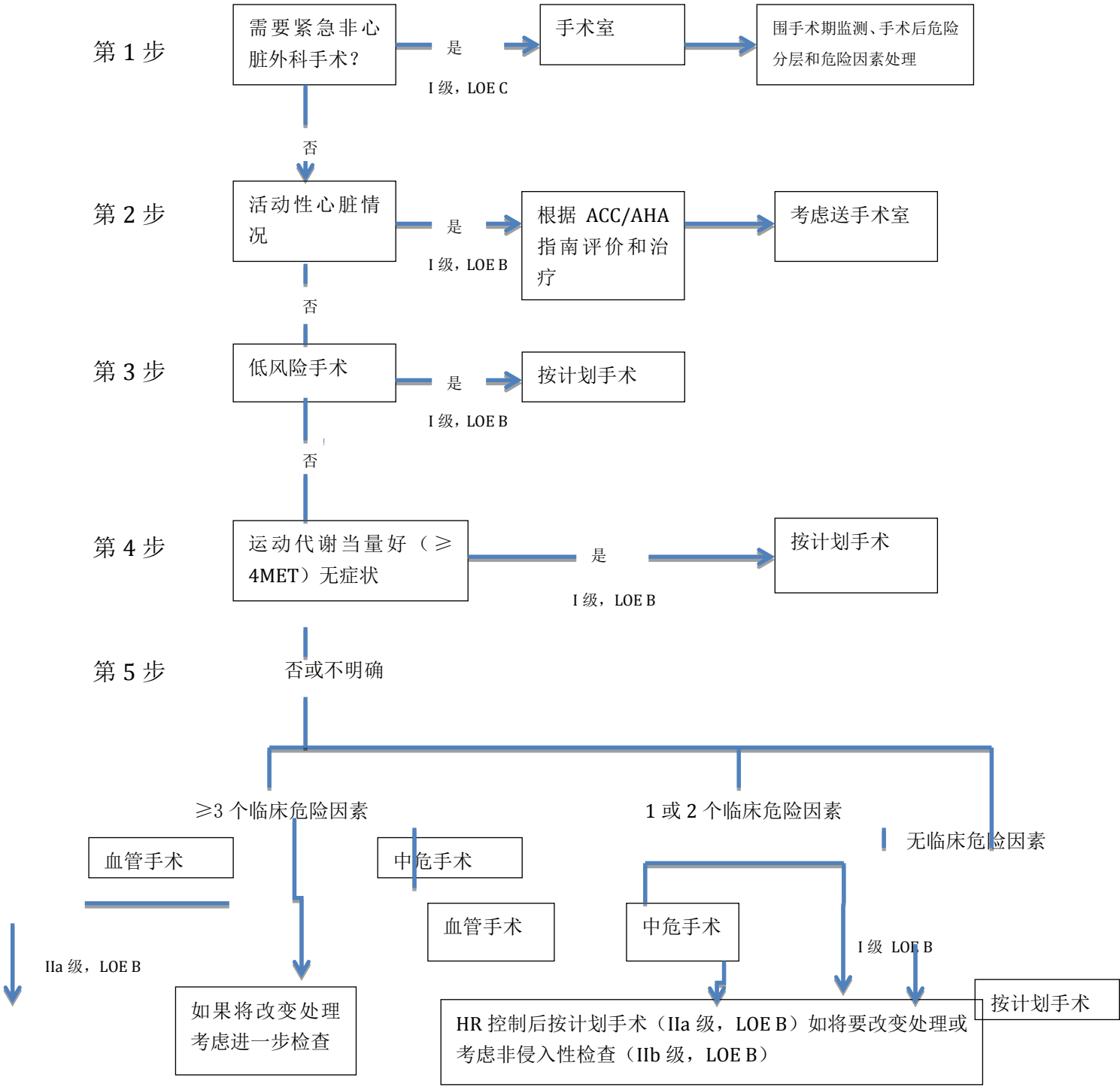



图 A1，围手术期心脏评价步进法
基于活动性临床情况，已知的心血管病，或年龄≥50 岁患者的心脏危险因素进行非心脏外科手术的心脏评价和护理的步骤。HR＝心率；LOE＝证据水平，MET＝运动代谢当量。
根据（16）修改

附录 B：附加的方法

有关技术小组的选择、适应症的产生、适应症概况和评级过程的说明见本文的方法部分。

**与行业和其他实体的关系**

参与本文件开发和审查及其单位和/或组织关系的人员名单见附录 C（略）。美国心脏病学院基金会及其合作组织，严格避免可能出现的，因技术小组成员外部关系或个人利益而可能产生的任何实际的、可察觉的或潜在的利益冲突。具体来说，要求所有小组成员提供可能被视为真实或潜在利益冲突所有关系的披露声明。这些声明由 AUC 专案工作组审查，并在面对面的会议上与技术小组所有成员进行讨论，必要时进行更新和审查。技术小组和监督工作组成员的披露表见附录 D（略）。此外，为确保完全透明、完整的披露信息（包括与本文无关的关系）可作为补充文件在线获取。

**文献复习**

要求技术小组成员在完成评级时，为每个适应症表格提供相关的参考文献（见在线附录）。

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# ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography

A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance American College of Chest Physicians

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## ABSTRACT

The American College of Cardiology Foundation (ACCF), in partnership with the American Society of Echocardiography (ASE) and along with key specialty and subspecialty societies, conducted a review of

**Abbreviations**

**ACS** = Acute coronary syndrome

**APC** = Atrial premature contraction

**CABG** = Coronary artery bypass grafting surgery

**CAD** = Coronary artery disease

**CMR** = Cardiovascular magnetic resonance

**CRT** = Cardiac resynchronization therapy

**CT** = Computed tomography

**ECG** = Electrocardiogram

**HF** = Heart failure

**ICD** = Implantable cardioverter-defibrillator

**LBBB** = Left bundle-branch block

**LV** = Left ventricular

**MET** = Estimated metabolic equivalents of exercise

**MI** = Myocardial infarction

**PCI** = Percutaneous coronary intervention

**RNI** = Radionuclide imaging

**SPECT MPI** = Single-photon emission computed tomography myocardial perfusion imaging

**STEMI** = ST-segment elevation myocardial infarction

**SVT** = Supraventricular tachycardia

**TEE** = Transesophageal echocardiogram

**TIA** = Transient ischemic attack

**TIMI** = Thrombolysis In Myocardial Infarction

**TTE** = Transthoracic echocardiogram

**NSTEMI/NSTEMI** = Unstable angina/non–ST-segment elevation myocardial infarction

**VPC** = Ventricular premature contraction

**VT** = Ventricular tachycardia

common clinical scenarios where echocardiography is frequently considered. This document combines and updates the original transthoracic and transesophageal echocardiography appropriateness criteria published in 2007 (1) and the original stress echocardiography appropriateness criteria published in 2008 (2). This revision reflects new clinical data, reflects changes in test utilization patterns, and clarifies echocardiography use where omissions or lack of clarity existed in the original criteria.

The indications (clinical scenarios) were derived from common applications or anticipated uses, as well as from current clinical practice guidelines and results of studies examining the implementation of the original appropriate use criteria (AUC). The 202 indications in this document were developed by a diverse writing group and scored by a separate independent technical panel on a scale of 1 to 9, to designate appropriate use (median 7 to 9), uncertain use (median 4 to 6), and inappropriate use (median 1 to 3).

Ninety-seven indications were rated as appropriate, 34 were rated as uncertain, and 71 were rated as inappropriate. In general, the use of echocardiography for initial diagnosis when there is a change in clinical status or when the results of the echocardiogram are anticipated to change patient management were rated appropriate. Routine testing when there was no change in clinical status or when results of testing were unlikely to modify management were more likely to be inappropriate than appropriate/uncertain.

The AUC for echocardiography have the potential to impact physician decision making, healthcare delivery, and reimbursement policy. Furthermore, recognition of uncertain clinical scenarios facilitates identification of areas that would benefit from future research.

## PREFACE

In an effort to respond to the need for the rational use of imaging services in the delivery of high-quality care, the ACCF has undertaken a process to determine the appropriate use of cardiovascular imaging for selected patient indications.

AUC publications reflect an ongoing effort by the ACCF to critically and systematically create, review, and categorize clinical situations where diagnostic tests and procedures are utilized by physicians caring for patients with cardiovascular diseases. The process is based on current understanding of the technical capabilities of the imaging modalities examined. Although impossible to be entirely comprehensive given the wide diversity of clinical disease, the indications are meant to identify common scenarios encompassing the majority of situations encountered in contemporary practice. Given the breadth of information they convey, the indications do not directly correspond to the Ninth Revision of the International Classification of Diseases system as these codes do not include clinical information, such as symptom status.

The ACCF believes that careful blending of a broad range of clinical experiences and available evidence-based information will help guide a more efficient and equitable allocation of healthcare resources in cardiovascular imaging. The ultimate objective of AUC is to improve patient care and health outcomes in a cost-effective manner, but it is not intended to ignore ambiguity and nuance intrinsic to clinical decision making. AUC thus should not be considered substitutes for sound clinical judgment and practice experience.

The ACCF AUC process itself is also evolving. In the current iteration, technical panel members were asked to rate indications for echocardiography in a manner independent and irrespective of the prior published ACCF ratings for transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) (1) and stress echocardiography (2) as well as the prior ACCF ratings for diagnostic imaging modalities such as cardiac radionuclide imaging (RNI) (3) and cardiac computed tomography (CT) (4). Given the iterative and evolving nature of the process, readers are counseled that comparison of individual appropriate use ratings among modalities rated at different times over the past several years may not reflect the comparative utility of the different modalities for an indication, as the ratings may vary over time. A comparative evaluation of the appropriate use of multiple imaging techniques is currently being undertaken to assess the relative strengths of each modality for various clinical scenarios.

We are grateful to the technical panel and its chair, Steven Bailey, MD, FACC, FSCAI, FAHA, a professional group with a wide range of skills and insights, for their thoughtful and thorough deliberation of the merits of echocardiography for various indications. We would also like to thank the 27 individuals who provided a careful review of the draft of indications, the parent AUC Task Force ably led by Michael Wolk, MD, MACC, Rory Weiner, MD, and the ACC staff, John C. Lewin, MD, Joseph Allen, Starr Webb, Jenissa Haidari, and Lea Binder for their exceptionally skilled support in the generation of this document.

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## 1. INTRODUCTION

This report addresses the appropriate use of TTE, TEE, and stress echocardiography. Improvements in cardiovascular imaging technology and an expanding armamentarium of noninvasive diagnostic tools and therapeutic options for cardiovascular disease have led to an increase in cardiovascular imaging. As the field of echocardiography continues to advance along with other imaging modalities and treatment options, the healthcare community needs to understand how to best incorporate this technology into daily clinical care.

All prior AUC publications from the ACCF and collaborating organizations reflect an ongoing effort to critically and systematically create, review, and categorize the appropriate use of cardiovascular procedures and diagnostic tests. The ACCF recognizes the importance of revising these criteria in a timely manner in order to provide the cardiovascular community with the most accurate indications. Understanding the background and scope of this document are important before interpreting the rating tables.

This document presents a combination and revision of the 2007 ACCF AUC for Transthoracic and Transesophageal Echocardiography (1) and the 2008 ACCF AUC for Stress Echocardiography (2). Appropriate echocardiograms are those that are likely to contribute to improving patients' clinical outcomes, and importantly, inappropriate use of echocardiography may be potentially harmful to patients and generate unwarranted costs to the healthcare system.

## 2. METHODS

The indications included in this publication cover a wide array of cardiovascular signs and symptoms as well as clinical judgments as to the likelihood of cardiovascular findings. Within each main disease category, a standardized approach was used to capture the majority of clinical scenarios without making the list of indications excessive. The approach was to create 5 broad clinical scenarios regarding the possible use of echocardiography: 1) for initial diagnosis; 2) to guide therapy or management, regardless of symptom status; 3) to evaluate a change in clinical status or cardiac exam; 4) for early follow-up without change in clinical status; and 5) for late follow-up without change in clinical status. Certain specific clinical scenarios were addressed with additional focused indications.

The indications were constructed by experts in echocardiography and in other fields and were modified on the basis of discussions among the task force and feedback from independent reviewers and the technical panel. Wherever possible, indications were mapped to relevant clinical guidelines and key publications/references (Online Appendix).

An important focus during the indication revision process was to harmonize the indications across noninvasive modalities, such that the wording of the indications are similar with other AUC (3) whenever it was feasible to do so. New indications as well as indication tables were created, although it remains likely that several clinical scenarios are not covered by these revised AUC for echocardiography. Once the revised indications were written, they were reviewed and critiqued by the parent AUC Task Force and by 27 external reviewers representing all cardiovascular specialties and primary care before being finalized.

A detailed description of the methods used for ranking the selected clinical indications is found in a previous publication, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging" (5). Briefly, this process combines evidence-based medicine and practice experience by engaging a technical panel in a modified Delphi exercise. Since the original TTE/TEE (1) and stress echocardiography (2) documents and methods paper (5) were published, several important processes have been put in place to further enhance the rigor of this process. They include convening a formal writing group with diverse expertise in imaging and clinical care, circulating the indications for external review prior to rating by the technical panel, ensuring appropriate balance of expertise and practice area of the technical panel, development of a standardized rating package, and establishment of formal roles for facilitating panel interaction at the face-to-face meeting.

The technical panel first rated indications independently. Then, the panel was convened for a face-to-face meeting for discussion of each indication. At this meeting, panel members were provided with their scores and a blinded summary of their peers' scores. After the meeting, panel members were then asked to independently provide their final scores for each indication.

Although panel members were not provided explicit cost information to help determine their appropriate use ratings, they were asked to implicitly consider cost as an additional factor in their evaluation of appropriate use. In rating these criteria, the technical panel was asked to assess whether the use of the test for each indication is appropriate, uncertain, or inappropriate, and was provided the following definition of appropriate use:

***An appropriate imaging study is one in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequence* by a sufficiently wide margin for a specific indication that the procedure is generally considered acceptable care and a reasonable approach for the indication.***

The technical panel scored each indication as follows:

Median Score 7 to 9

Appropriate test for specific indication (test **is** generally acceptable and **is** a reasonable approach for the indication).

Median Score 4 to 6

Uncertain for specific indication (test **may** be generally acceptable and **may** be a reasonable approach for the indication). Uncertainty also implies that more research and/or patient information is needed to classify the indication definitively.

Median Score 1 to 3

Inappropriate test for that indication (test **is not** generally acceptable and **is not** a reasonable approach for the indication).

The division of these scores into 3 levels of appropriateness is somewhat arbitrary, and the numeric designations should be viewed as a continuum. Further, there is diversity in clinical opinion for particular clinical scenarios, such that scores in the intermediate level of appropriate use should be labeled "uncertain," as critical patient or research data may be lacking or discordant. This designation should be a prompt to the field to carry out definitive

*Negative consequences include the risks of the procedure (i.e., radiation or contrast exposure) and the downstream impact of poor test performance such as delay in diagnosis (false-negatives) or inappropriate diagnosis (false-positives).

research investigations whenever possible. It is anticipated that the AUC reports will continue to be revised as further data are generated and information from the implementation of the criteria is accumulated.

To prevent bias in the scoring process, the technical panel was deliberately comprised of a minority of specialists in echocardiography. Specialists, although offering important clinical and technical insights, might have a natural tendency to rate the indications within their specialty as more appropriate than nonspecialists. In addition, care was taken in providing objective, nonbiased information, including guidelines and key references, to the technical panel.

The level of agreement among panelists as defined by RAND (6) was analyzed based on the BIOMED rule for a panel of 14 to 16 members. As such, agreement was defined as an indication where 4 or fewer panelists' ratings fell outside the 3-point region containing the median score.

Disagreement was defined as where at least 5 panelists' ratings fell in both the appropriate and the inappropriate categories. Any indication having disagreement was categorized as uncertain regardless of the final median score. Indications that met neither definition for agreement or disagreement are in a third, unlabeled category.

## 3. GENERAL ASSUMPTIONS

To prevent any inconsistencies in interpretation, specific assumptions were considered by the writing group in developing the indications and by the technical panel when rating the clinical indications for the appropriate use of inpatient and outpatient adult TTE/TEE and stress echocardiography.

1. A TTE and a TEE examination and report will include the use and interpretation of 2-dimensional/M-mode imaging, color flow Doppler, and spectral Doppler as important elements of a comprehensive TTE/TEE (7–9) evaluating relevant cardiac structures and hemodynamics. Stress echocardiography will include rest and stress 2-dimensional imaging at a minimum unless performed for hemodynamics, when Doppler must be included (10).
2. All standard echocardiographic techniques for image acquisition, including standard rest imaging and stress protocols (10), are available for each indication and have a sensitivity and specificity similar to those found in the published literature. Selection for and monitoring of contrast use is assumed to be in accord with practice guidelines (11).
3. The test is performed and interpreted by qualified individual(s) in a facility that is proficient in the echocardiographic technique (12,13).
4. The range of potential indications for echocardiography is quite large, particularly in comparison with other cardiovascular imaging tests. Thus, the indications are, at times, purposefully broad to cover an array of cardiovascular signs and symptoms as well as the ordering physician's best judgment as to the presence of cardiovascular abnormalities. Additionally, there are likely clinical scenarios that are not covered in this document.
5. A complete clinical history and physical exam has been completed by a qualified clinician such that the clinical status of the patient can be assumed to be valid as stated in the indication (e.g., an asymptomatic patient is truly asymptomatic for the condition in question and that sufficient questioning of the patient has been undertaken).
6. If the reason for a test can be assigned to more than 1 indication, it should be classified under the most appropriate indication.
7. Cost should be considered implicitly in the appropriate use determination.
8. For each indication, the rating should reflect whether the echocardiogram is reasonable for the patient according to the appropriate use definition, not whether the test is preferred over another modality. It should not be assumed that for each indication the decision to perform a diagnostic test has already been made. It also should not consider issues of local availability or skill for any modality or attempt in any way to compare 2 tests with each other.
9. The category of "uncertain" should be used when insufficient clinical data are available for a definitive categorization or there is substantial disagreement regarding the appropriateness of that indication. The designation of "uncertain" should not be used as grounds for denial of reimbursement.
10. Indications that describe routine or surveillance echocardiograms imply that the test is being considered for a "periodic" evaluation since a certain period of time has elapsed. The test is not being ordered due to the anticipation of changing clinical decision making or guiding therapy.
11. Prosthetic valves and native valves are to be considered together, except where specifically mentioned otherwise in this document. The severity of valve stenosis or regurgitation is defined in clinical guidelines (14,15).
12. In general, it is assumed that TEE is most appropriately used as an adjunct or subsequent test to TTE when indicated, such as when suboptimal TTE images preclude obtaining a diagnostic study. The indications for which TEE may reasonably be the test of first choice include, but are not limited to, the indications presented in Table 8 of this document.
13. Intraoperative TEE is an important use of cardiovascular ultrasound. However, this application is outside the scope of this document and thus is not addressed here.
14. For all stress imaging, the mode of stress testing is assumed to be exercise (e.g., treadmill, bicycle) for patients able to exercise. For patients unable to exercise, it is assumed that dobutamine is used for echocardiographic stress testing. Any indications requiring a specific mode of stress (e.g., when hemodynamic information is required) are labeled as such.
15. Doppler hemodynamic assessment during stress echocardiography includes both right and left heart hemodynamics (e.g., valvular gradients, pulmonary artery pressure, mitral regurgitation severity).
16. The indications for the perioperative evaluation for noncardiac surgery were modeled after the ACCF/AHA guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery (16). If a patient has signs/symptoms of suspected cardiac etiology, the clinical scenario should be considered in the symptomatic category (e.g., Indication 1) and not in the perioperative section.
17. As with other surgeries, the need for coronary artery disease (CAD) assessment prior to solid organ transplantation is related to patient and surgical risk. In general, solid organ transplantation should be considered in the vascular surgery category given that CAD is common in patients with diabetes mellitus who have end-stage renal disease.

## 4. DEFINITIONS

Definitions of terms used throughout the indication set are listed here. Additional definitions are listed in Appendix A. These definitions were provided to and discussed with the technical panel prior to ratings of indications.

1. **Ischemic Equivalent: Chest Pain Syndrome, Anginal Equivalent, or Ischemic Electrocardiographic Abnormalities:** Any constellation of clinical findings that the physician feels is consistent with CAD. Examples of such findings include, but are not limited to, chest pain, chest tightness, chest burning, shoulder pain, palpitations, jaw pain, new electrocardiographic abnormalities, or other symptoms/findings suggestive of CAD. Nonchest pain symptoms (e.g., dyspnea or reduced/worsening effort tolerance) that are thought to be consistent with CAD may also be considered to be an ischemic equivalent.
2. **Global CAD Risk:** It is assumed that clinicians will use current standard methods of global risk assessment such as those presented in the National

**Table A** Pretest probability of CAD by age, gender, and symptoms*

| Age (years) | Gender | Typical/Definite angina pectoris | Atypical/Probable angina pectoris | Nonanginal chest pain | Asymptomatic |
|---|---|---|---|---|---|
| <39 | Men | Intermediate | Intermediate | Low | Very low |
| | Women | Intermediate | Very low | Very low | Very low |
| 40–49 | Men | High | Intermediate | Intermediate | Low |
| | Women | Intermediate | Low | Very low | Very low |
| 50–59 | Men | High | Intermediate | Intermediate | Low |
| | Women | Intermediate | Intermediate | Low | Very low |
| >60 | Men | High | Intermediate | Intermediate | Low |
| | Women | High | Intermediate | Intermediate | Low |

**High:** >90% pretest probability; **Intermediate:** Between 10% and 90% pretest probability; **Low:** Between 5% and 10% pretest probability; **Very low:** <5% pretest probability.
*Modified from the ACC/AHA Exercise Testing Guidelines to reflect all age ranges.

Heart, Lung, and Blood Institute report on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III [ATP III]) (18) or similar national guidelines.

Absolute risk is defined as the probability of developing CAD over a given time period. The ATP III report specifies absolute risk for CAD over the next 10 years. CAD risk refers to 10-year risk for any hard cardiac event (e.g., myocardial infarction or CAD death). However, acknowledging that global absolute risk scores may be miscalibrated in certain populations (e.g., women, younger men), clinical judgment must be applied in assigning categorical risk thresholds in such subpopulations.

- **Low global CAD risk**

Defined by the age-specific risk level that is below average. In general, low risk will correlate with a 10-year absolute CAD risk <10%. However, in women and younger men, low risk may correlate with 10-year absolute CAD risk <6%.

- **Intermediate global CAD risk**

Defined by the age-specific risk level that is average. In general, moderate risk will correlate with a 10-year absolute CAD risk range of 10% to 20%. Among women and younger age men, an expanded intermediate risk range of 6% to 20% may be appropriate.

- **High global CAD risk**

Defined by the age-specific risk level that is above average. In general, high risk will correlate with a 10-year absolute CAD risk of >20%. CAD equivalents (e.g., diabetes mellitus, peripheral arterial disease) can also define high risk.

3. **Pretest Probability of CAD: Symptomatic (Ischemic Equivalent) Patients:** Once the physician determines that symptoms are present that may represent CAD, the pretest probability of CAD should be assessed. There are a number of risk algorithms (19,20) available that can be used to calculate this probability. Clinicians should be familiar with those algorithms that pertain to the populations they encounter most often. In scoring the indications, the following probabilities, as calculated from any of the various available validated algorithms, should be applied.
   - **Very low pretest probability:** <5% pretest probability of CAD
   - **Low pretest probability:** Between 5% and 10% pretest probability of CAD
   - **Intermediate pretest probability:** Between 10% and 90% pretest probability of CAD
   - **High pretest probability:** >90% pretest probability of CAD

The method recommended by the ACC/AHA guidelines for chronic stable angina (21) is provided as one example of a method used to calculate pretest probability and is a modification of a previously published literature review (22). Please refer to Table A and the definition of angina in Appendix A. It is important to note that other historical factors or electrocardiographic findings (e.g., prior infarction) can affect pretest probability, although these factors are not accounted for in Table A. Similarly, although not incorporated into the algorithm, other CAD risk factors may also affect pretest likelihood of CAD. Detailed nomograms are available that incorporate the effects of a history of prior infarction, electrocardiographic Q waves and ST- and T-wave changes, diabetes, smoking, and hypercholesterolemia(23).

## 5. RESULTS OF RATINGS

The final ratings for echocardiography are listed by indication in Tables 1 to 18. The final score reflects the median score of the 15 technical panel members and has been labeled according to the 3 appropriate use categories of appropriate (median 7 to 9), uncertain (median 4 to 6), and inappropriate (median 1 to 3). Tables 19 to 21 present the indications by the appropriate use categories.

There was less variation in ratings for the indications labeled as either appropriate or inappropriate, with 92% and 90%, respectively, showing agreement as defined in Methods Section 2. There was greater variability (less agreement) in the rating scores for indications defined as uncertain, with 21% showing agreement as defined previously. Two indications, 182 and 189, were distributed into each extreme such that the panel was classified as being in disagreement. However, the median scores for these indications were already placed in the uncertain category, so no changes were required to reflect disagreement. Across all categories, 40 indications did not meet the definition of agreement; however, the scores were not so divergent (as defined by disagreement) as to necessitate a change in the final score.

Visual representations (flow diagrams) for all indications are included in the Online Appendix.

Selected flow diagrams for several categories of indications are included here (Figs. 1 to 6).

## 6. ECHOCARDIOGRAPHY APPROPRIATE USE CRITERIA (BY INDICATION)

**Table 1** TTE for general evaluation of cardiac structure and function

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Suspected Cardiac Etiology—General With TTE** | |
| 1. | • Symptoms or conditions potentially related to suspected cardiac etiology including but not limited to chest pain, shortness of breath, palpitations, TIA, stroke, or peripheral embolic event | A (9) |
| 2. | • Prior testing that is concerning for heart disease or structural abnormality including but not limited to chest X-ray, baseline scout images for stress echocardiogram, ECG, or cardiac biomarkers | A (9) |
| | **Arrhythmias With TTE** | |
| 3. | • Infrequent APCs or infrequent VPCs without other evidence of heart disease | I (2) |
| 4. | • Frequent VPCs or exercise-induced VPCs | A (8) |
| 5. | • Sustained or nonsustained atrial fibrillation, SVT, or VT | A (9) |
| 6. | • Asymptomatic isolated sinus bradycardia | I (2) |
| | **Lightheadedness/Presyncope/Syncope With TTE** | |
| 7. | • Clinical symptoms or signs consistent with a cardiac diagnosis known to cause lightheadedness/ presyncope/syncope (including but not limited to aortic stenosis, hypertrophic cardiomyopathy, or HF) | A (9) |
| 8. | • Lightheadedness/presyncope when there are no other symptoms or signs of cardiovascular disease | I (3) |
| 9. | • Syncope when there are no other symptoms or signs of cardiovascular disease | A (7) |
| | **Evaluation of Ventricular Function With TTE** | |
| 10. | • Initial evaluation of ventricular function (e.g., screening) with no symptoms or signs of cardiovascular disease | I (2) |
| 11. | • Routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam | I (3) |
| 12. | • Evaluation of LV function with prior ventricular function evaluation showing normal function (e.g., prior echocardiogram, left ventriculogram, CT, SPECT MPI, CMR) in patients in whom there has been no change in clinical status or cardiac exam | I (1) |
| | **Perioperative Evaluation With TTE** | |
| 13. | • Routine perioperative evaluation of ventricular function with no symptoms or signs of cardiovascular disease | I (2) |
| 14. | • Routine perioperative evaluation of cardiac structure and function prior to noncardiac solid organ transplantation | U (6) |
| | **Pulmonary Hypertension With TTE** | |
| 15. | • Evaluation of suspected pulmonary hypertension including evaluation of right ventricular function and estimated pulmonary artery pressure | A (9) |
| 16. | • Routine surveillance (<1 y) of known pulmonary hypertension without change in clinical status or cardiac exam | I (3) |
| 17. | • Routine surveillance (≥1 y) of known pulmonary hypertension without change in clinical status or cardiac exam | A (7) |
| 18. | • Re-evaluation of known pulmonary hypertension if change in clinical status or cardiac exam or to guide therapy | A (9) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 2** TTE for cardiovascular evaluation in an acute setting

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Hypotension or Hemodynamic Instability With TTE** | |
| 19. | • Hypotension or hemodynamic instability of uncertain or suspected cardiac etiology | A (9) |
| 20. | • Assessment of volume status in a critically ill patient | U (5) |
| | **Myocardial Ischemia/Infarction With TTE** | |
| 21. | • Acute chest pain with suspected MI and nondiagnostic ECG when a resting echocardiogram can be performed during pain | A (9) |
| 22. | • Evaluation of a patient without chest pain but with other features of an ischemic equivalent or laboratory markers indicative of ongoing MI | A (8) |
| 23. | • Suspected complication of myocardial ischemia/infarction, including but not limited to acute mitral regurgitation, ventricular septal defect, free-wall rupture/tamponade, shock, right ventricular involvement, HF, or thrombus | A (9) |
| | **Evaluation of Ventricular Function after ACS With TTE** | |
| 24. | • Initial evaluation of ventricular function following ACS | A (9) |
| 25. | • Re-evaluation of ventricular function following ACS during recovery phase when results will guide therapy | A (9) |
| | **Respiratory Failure With TTE** | |
| 26. | • Respiratory failure or hypoxemia of uncertain etiology | A (8) |
| 27. | • Respiratory failure or hypoxemia when a noncardiac etiology of respiratory failure has been established | U (5) |

(*Continued*)

Table 2 (*Continued*)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Pulmonary Embolism With TTE** | |
| 28. | • Suspected pulmonary embolism in order to establish diagnosis | I (2) |
| 29. | • Known acute pulmonary embolism to guide therapy (e.g., thrombectomy and thrombolytics) | A (8) |
| 30. | • Routine surveillance of prior pulmonary embolism with normal right ventricular function and pulmonary artery systolic pressure | I (1) |
| 31. | • Re-evaluation of known pulmonary embolism after thrombolysis or thrombectomy for assessment of change in right ventricular function and/or pulmonary artery pressure | A (7) |
| | **Cardiac Trauma With TTE** | |
| 32. | • Severe deceleration injury or chest trauma when valve injury, pericardial effusion, or cardiac injury are possible or suspected | A (9) |
| 33. | • Routine evaluation in the setting of mild chest trauma with no electrocardiographic changes or biomarker elevation | I (2) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

Table 3 TTE for evaluation of valvular function

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Murmur or Click With TTE** | |
| 34. | • Initial evaluation when there is a reasonable suspicion of valvular or structural heart disease | A (9) |
| 35. | • Initial evaluation when there are no other symptoms or signs of valvular or structural heart disease | I (2) |
| 36. | • Re-evaluation in a patient without valvular disease on prior echocardiogram and no change in clinical status or cardiac exam | I (1) |
| 37. | • Re-evaluation of known valvular heart disease with a change in clinical status or cardiac exam or to guide therapy | A (9) |
| | **Native Valvular Stenosis With TTE** | |
| 38. | • Routine surveillance (<3 y) of mild valvular stenosis without a change in clinical status or cardiac exam | I (3) |
| 39. | • Routine surveillance (≥3 y) of mild valvular stenosis without a change in clinical status or cardiac exam | A (7) |
| 40. | • Routine surveillance (<1 y) of moderate or severe valvular stenosis without a change in clinical status or cardiac exam | I (3) |
| 41. | • Routine surveillance (≥1 y) of moderate or severe valvular stenosis without a change in clinical status or cardiac exam | A (8) |
| | **Native Valvular Regurgitation With TTE** | |
| 42. | • Routine surveillance of trace valvular regurgitation | I (1) |
| 43. | • Routine surveillance (<3 y) of mild valvular regurgitation without a change in clinical status or cardiac exam | I (2) |
| 44. | • Routine surveillance (≥3 y) of mild valvular regurgitation without a change in clinical status or cardiac exam | U (4) |
| 45. | • Routine surveillance (<1 y) of moderate or severe valvular regurgitation without a change in clinical status or cardiac exam | U (6) |
| 46. | • Routine surveillance (≥1 y) of moderate or severe valvular regurgitation without change in clinical status or cardiac exam | A (8) |
| | **Prosthetic Valves With TTE** | |
| 47. | • Initial postoperative evaluation of prosthetic valve for establishment of baseline | A (9) |
| 48. | • Routine surveillance (<3 y after valve implantation) of prosthetic valve if no known or suspected valve dysfunction | I (3) |
| 49. | • Routine surveillance (≥3 y after valve implantation) of prosthetic valve if no known or suspected valve dysfunction | A (7) |
| 50. | • Evaluation of prosthetic valve with suspected dysfunction or a change in clinical status or cardiac exam | A (9) |
| 51. | • Re-evaluation of known prosthetic valve dysfunction when it would change management or guide therapy | A (9) |
| | **Infective Endocarditis (Native or Prosthetic Valves) With TTE** | |
| 52. | • Initial evaluation of suspected infective endocarditis with positive blood cultures or a new murmur | A (9) |
| 53. | • Transient fever without evidence of bacteremia or a new murmur | I (2) |

(*Continued*)

**Table 3** (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 54. | • Transient bacteremia with a pathogen not typically associated with infective endocarditis and/or a documented nonendovascular source of infection | I (3) |
| 55. | • Re-evaluation of infective endocarditis at high risk for progression or complication or with a change in clinical status or cardiac exam | A (9) |
| 56. | • Routine surveillance of uncomplicated infective endocarditis when no change in management is contemplated | I (2) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 4** TTE for evaluation of intracardiac and extracardiac structures and chambers

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 57. | • Suspected cardiac mass | A (9) |
| 58. | • Suspected cardiovascular source of embolus | A (9) |
| 59. | • Suspected pericardial conditions | A (9) |
| 60. | • Routine surveillance of known small pericardial effusion with no change in clinical status | I (2) |
| 61. | • Re-evaluation of known pericardial effusion to guide management or therapy | A (8) |
| 62. | • Guidance of percutaneous noncoronary cardiac procedures including but not limited to pericardiocentesis, septal ablation, or right ventricular biopsy | A (9) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 5** TTE for evaluation of aortic disease

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 63. | • Evaluation of the ascending aorta in the setting of a known or suspected connective tissue disease or genetic condition that predisposes to aortic aneurysm or dissection (e.g., Marfan syndrome) | A (9) |
| 64. | • Re-evaluation of known ascending aortic dilation or history of aortic dissection to establish a baseline rate of expansion or when the rate of expansion is excessive | A (9) |
| 65. | • Re-evaluation of known ascending aortic dilation or history of aortic dissection with a change in clinical status or cardiac exam or when findings may alter management or therapy | A (9) |
| 66. | • Routine re-evaluation for surveillance of known ascending aortic dilation or history of aortic dissection without a change in clinical status or cardiac exam when findings would not change management or therapy | I (3) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 6** TTE for evaluation of hypertension, HF, or cardiomyopathy

| Indication | | Appropriate Use score (1–9) |
|---|---|---|
| | **Hypertension With TTE** | |
| 67. | • Initial evaluation of suspected hypertensive heart disease | A (8) |
| 68. | • Routine evaluation of systemic hypertension without symptoms or signs of hypertensive heart disease | I (3) |
| 69. | • Re-evaluation of known hypertensive heart disease without a change in clinical status or cardiac exam | U (4) |
| | **HF With TTE** | |
| 70. | • Initial evaluation of known or suspected HF (systolic or diastolic) based on symptoms, signs, or abnormal test results | A (9) |
| 71. | • Re-evaluation of known HF (systolic or diastolic) with a change in clinical status or cardiac exam without a clear precipitating change in medication or diet | A (8) |
| 72. | • Re-evaluation of known HF (systolic or diastolic) with a change in clinical status or cardiac exam with a clear precipitating change in medication or diet | U (4) |
| 73. | • Re-evaluation of known HF (systolic or diastolic) to guide therapy | A (9) |

(*Continued*)

**Table 6** (*Continued*)

| Indication | | Appropriate Use score (1–9) |
|---|---|---|
| 74. | • Routine surveillance (<1 y) of HF (systolic or diastolic) when there is no change in clinical status or cardiac exam | I (2) |
| 75. | • Routine surveillance (≥1 y) of HF (systolic or diastolic) when there is no change in clinical status or cardiac exam | U (6) |
| | **Device Evaluation (Including Pacemaker, ICD, or CRT) With TTE** | |
| 76. | • Initial evaluation or re-evaluation after revascularization and/or optimal medical therapy to determine candidacy for device therapy and/or to determine optimal choice of device | A (9) |
| 77. | • Initial evaluation for CRT device optimization after implantation | U (6) |
| 78. | • Known implanted pacing device with symptoms possibly due to device complication or suboptimal pacing device settings | A (8) |
| 79. | • Routine surveillance (<1 y) of implanted device without a change in clinical status or cardiac exam | I (1) |
| 80. | • Routine surveillance (≥1 y) of implanted device without a change in clinical status or cardiac exam | I (3) |
| | **Ventricular Assist Devices and Cardiac Transplantation With TTE** | |
| 81. | • To determine candidacy for ventricular assist device | A (9) |
| 82. | • Optimization of ventricular assist device settings | A (7) |
| 83. | • Re-evaluation for signs/symptoms suggestive of ventricular assist device-related complications | A (9) |
| 84. | • Monitoring for rejection in a cardiac transplant recipient | A (7) |
| 85. | • Cardiac structure and function evaluation in a potential heart donor | A (9) |
| | **Cardiomyopathies With TTE** | |
| 86. | • Initial evaluation of known or suspected cardiomyopathy (e.g., restrictive, infiltrative, dilated, hypertrophic, or genetic cardiomyopathy) | A (9) |
| 87. | • Re-evaluation of known cardiomyopathy with a change in clinical status or cardiac exam or to guide therapy | A (9) |
| 88. | • Routine surveillance (<1 y) of known cardiomyopathy without a change in clinical status or cardiac exam | I (2) |
| 89. | • Routine surveillance (≥1 y) of known cardiomyopathy without a change in clinical status or cardiac exam | U (5) |
| 90. | • Screening evaluation for structure and function in first-degree relatives of a patient with an inherited cardiomyopathy | A (9) |
| 91. | • Baseline and serial re-evaluations in a patient undergoing therapy with cardiotoxic agents | A (9) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 7** TTE for adult congenital heart disease

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| 92. | • Initial evaluation of known or suspected adult congenital heart disease | A (9) |
| 93. | • Known adult congenital heart disease with a change in clinical status or cardiac exam | A (9) |
| 94. | • Re-evaluation to guide therapy in known adult congenital heart disease | A (9) |
| 95. | • Routine surveillance (<2 y) of adult congenital heart disease following complete repair<br>◦ without a residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | I (3) |
| 96. | • Routine surveillance (≥2 y) of adult congenital heart disease following complete repair<br>◦ without residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | U (6) |
| 97. | • Routine surveillance (<1 y) of adult congenital heart disease following incomplete or palliative repair<br>◦ with residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | U (5) |
| 98. | • Routine surveillance (≥1 y) of adult congenital heart disease following incomplete or palliative repair<br>◦ with residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | A (8) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 8** TEE

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| | **TEE as Initial or Supplemental Test—General Uses** | |
| 99. | • Use of TEE when there is a high likelihood of a nondiagnostic TTE due to patient characteristics or inadequate visualization of relevant structures | A (8) |
| 100. | • Routine use of TEE when a diagnostic TTE is reasonably anticipated to resolve all diagnostic and management concerns | I (1) |
| 101. | • Re-evaluation of prior TEE finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) when a change in therapy is anticipated | A (8) |
| 102. | • Surveillance of prior TEE finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) when no change in therapy is anticipated | I (2) |
| 103. | • Guidance during percutaneous noncoronary cardiac interventions including but not limited to closure device placement, radiofrequency ablation, and percutaneous valve procedures | A (9) |
| 104. | • Suspected acute aortic pathology including but not limited to dissection/transsection | A (9) |
| 105. | • Routine assessment of pulmonary veins in an asymptomatic patient status post pulmonary vein isolation | I (3) |
| | **TEE as Initial or Supplemental Test—Valvular Disease** | |
| 106. | • Evaluation of valvular structure and function to assess suitability for, and assist in planning of, an intervention | A (9) |
| 107. | • To diagnose infective endocarditis with a low pretest probability (e.g., transient fever, known alternative source of infection, or negative blood cultures/atypical pathogen for endocarditis) | I (3) |
| 108. | • To diagnose infective endocarditis with a moderate or high pretest probability (e.g., staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device) | A (9) |
| | **TEE as Initial or Supplemental Test—Embolic Event** | |
| 109. | • Evaluation for cardiovascular source of embolus with no identified noncardiac source | A (7) |
| 110. | • Evaluation for cardiovascular source of embolus with a previously identified noncardiac source | U (5) |
| 111. | • Evaluation for cardiovascular source of embolus with a known cardiac source in which a TEE would not change management | I (1) |
| | **TEE as Initial Test—Atrial Fibrillation/Flutter** | |
| 112. | • Evaluation to facilitate clinical decision making with regard to anticoagulation, cardioversion, and/or radiofrequency ablation | A (9) |
| 113. | • Evaluation when a decision has been made to anticoagulate and not to perform cardioversion | I (2) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 9** Stress echocardiography for detection of CAD/Risk assessment: Symptomatic or ischemic equivalent

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| | **Evaluation of Ischemic Equivalent (Nonacute) With Stress Echocardiography** | |
| 114. | • Low pretest probability of CAD<br>• ECG interpretable and able to exercise | I (3) |
| 115. | • Low pretest probability of CAD<br>• ECG uninterpretable or unable to exercise | A (7) |
| 116. | • Intermediate pretest probability of CAD<br>• ECG interpretable and able to exercise | A (7) |
| 117. | • Intermediate pretest probability of CAD<br>• ECG uninterpretable or unable to exercise | A (9) |
| 118. | • High pretest probability of CAD<br>• Regardless of ECG interpretability and ability to exercise | A (7) |
| | **Acute Chest Pain With Stress Echocardiography** | |
| 119. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• Low-risk TIMI score<br>• Negative troponin levels | A (7) |

(*Continued*)

**Table 9** (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 120. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• Low-risk TIMI score<br>• Peak troponin: borderline, equivocal, minimally elevated | A (7) |
| 121. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• High-risk TIMI score<br>• Negative troponin levels | A (7) |
| 122. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• High-risk TIMI score<br>• Peak troponin: borderline, equivocal, minimally elevated | A (7) |
| 123. | • Definite ACS | I (1) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 10** Stress echocardiography for detection of CAD/Risk assessment: Asymptomatic (without ischemic equivalent)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| | **General Patient Populations With Stress Echocardiography** | |
| 124. | • Low global CAD risk | I (1) |
| 125. | • Intermediate global CAD risk<br>• ECG interpretable | I (2) |
| 126. | • Intermediate global CAD risk<br>• ECG uninterpretable | U (5) |
| 127. | • High global CAD risk | U (5) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 11** Stress echocardiography for detection of CAD/Risk assessment: Asymptomatic (without ischemic equivalent) in patient populations with defined comorbidities

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| | **New-Onset or Newly Diagnosed HF or LV Systolic Dysfunction With Stress Echocardiography** | |
| 128. | • No prior CAD evaluation and no planned coronary angiography | A (7) |
| | **Arrhythmias With Stress Echocardiography** | |
| 129. | • Sustained VT | A (7) |
| 130. | • Frequent PVCs, exercise induced VT, or nonsustained VT | A (7) |
| 131. | • Infrequent PVCs | I (3) |
| 132. | • New-onset atrial fibrillation | U (6) |
| | **Syncope With Stress Echocardiography** | |
| 133. | • Low global CAD risk | I (3) |
| 134. | • Intermediate or high global CAD risk | A (7) |
| | **Elevated Troponin With Stress Echocardiography** | |
| 135. | • Troponin elevation without symptoms or additional evidence of ACS | A (7) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 12** Stress echocardiography following prior test results

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Asymptomatic: Prior Evidence of Subclinical Disease With Stress Echocardiography** | |
| 136. | • Coronary calcium Agatston score <100 | I (2) |
| 137. | • Low to intermediate global CAD risk<br>• Coronary calcium Agatston score between 100 and 400 | U (5) |
| 138. | • High global CAD risk<br>• Coronary calcium Agatston score between 100 and 400 | U (6) |
| 139. | • Coronary calcium Agatston score >400 | A (7) |
| 140. | • Abnormal carotid intimal medial thickness (≥0.9 mm and/or the presence of plaque encroaching into the arterial lumen) | U (5) |
| | **Coronary Angiography (Invasive or Noninvasive) With Stress Echocardiography** | |
| 141. | • Coronary artery stenosis of unclear significance | A (8) |
| | **Asymptomatic or Stable Symptoms With Stress Echocardiography Normal Prior Stress Imaging Study** | |
| 142. | • Low global CAD risk<br>• Last stress imaging study <2 y ago | I (1) |
| 143. | • Low global CAD risk<br>• Last stress imaging study ≥2 y ago | I (2) |
| 144. | • Intermediate to high global CAD risk<br>• Last stress imaging study <2 y ago | I (2) |
| 145. | • Intermediate to high global CAD risk<br>• Last stress imaging study ≥2 y ago | U (4) |
| | **Asymptomatic or Stable Symptoms With Stress Echocardiography Abnormal Coronary Angiography or Abnormal Prior Stress Study No Prior Revascularization** | |
| 146. | • Known CAD on coronary angiography or prior abnormal stress imaging study<br>• Last stress imaging study <2 y ago | I (3) |
| 147. | • Known CAD on coronary angiography or prior abnormal stress imaging study<br>• Last stress imaging study ≥2 y ago | U (5) |
| | **Treadmill ECG Stress Test With Stress Echocardiography** | |
| 148. | • Low-risk treadmill score (e.g., Duke) | I (1) |
| 149. | • Intermediate-risk treadmill score (e.g., Duke) | A (7) |
| 150. | • High-risk treadmill score (e.g., Duke) | A (7) |
| | **New or Worsening Symptoms With Stress Echocardiography** | |
| 151. | • Abnormal coronary angiography or abnormal prior stress imaging study | A (7) |
| 152. | • Normal coronary angiography or normal prior stress imaging study | U (6) |
| | **Prior Noninvasive Evaluation With Stress Echocardiography** | |
| 153. | • Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern | A (8) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 13** Stress echocardiography for risk assessment: Perioperative evaluation for noncardiac surgery without active cardiac conditions

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Low-Risk Surgery With Stress Echocardiography** | |
| 154. | • Perioperative evaluation for risk assessment | I (1) |
| | **Intermediate-Risk Surgery With Stress Echocardiography** | |
| 155. | • Moderate to good functional capacity (≥4 METs) | I (3) |
| 156. | • No clinical risk factors | I (2) |
| 157. | • ≥1 clinical risk factor<br>• Poor or unknown functional capacity (<4 METs) | U (6) |
| 158. | • Asymptomatic <1 y post normal catheterization, noninvasive test, or previous revascularization | I (1) |
| | **Vascular Surgery With Stress Echocardiography** | |
| 159. | • Moderate to good functional capacity (≥4 METs) | I (3) |
| 160. | • No clinical risk factors | I (2) |
| 161. | • ≥1 clinical risk factor<br>• Poor or unknown functional capacity (<4 METs) | A (7) |
| 162. | • Asymptomatic <1 y post normal catheterization, noninvasive test, or previous revascularization | I (2) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 14** Stress echocardiography for risk assessment: Within 3 months of an ACS

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **STEMI With Stress Echocardiography** | |
| 163. | • Primary PCI with complete revascularization<br>• No recurrent symptoms | I (2) |
| 164. | • Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF<br>• To evaluate for inducible ischemia<br>• No prior coronary angiography since the index event | A (7) |
| 165. | • Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications | I (1) |
| | **UA/NSTEMI With Stress Echocardiography** | |
| 166. | • Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF<br>• To evaluate for inducible ischemia<br>• No prior coronary angiography since the index event | A (8) |
| | **ACS—Asymptomatic Postrevascularization (PCI or CABG) With Stress Echocardiography** | |
| 167. | • Prior to hospital discharge in a patient who has been adequately revascularized | I (1) |
| | **Cardiac Rehabilitation With Stress Echocardiography** | |
| 168. | • Prior to initiation of cardiac rehabilitation (as a stand-alone indication) | I (3) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 15** Stress echocardiography for risk assessment: Postrevascularization (PCI or CABG)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Symptomatic With Stress Echocardiography** | |
| 169. | • Ischemic equivalent | A (8) |
| | **Asymptomatic With Stress Echocardiography** | |
| 170. | • Incomplete revascularization<br>• Additional revascularization feasible | A (7) |
| 171. | • <5 y after CABG | I (2) |
| 172. | • ≥5 y after CABG | U (6) |
| 173. | • <2 y after PCI | I (2) |
| 174. | • ≥2 y after PCI | U (5) |
| | **Cardiac Rehabilitation With Stress Echocardiography** | |
| 175. | • Prior to initiation of cardiac rehabilitation (as a stand-alone indication) | I (3) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 16** Stress echocardiography for assessment of viability/ischemia

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Ischemic Cardiomyopathy/Assessment of Viability With Stress Echocardiography** | |
| 176. | • Known moderate or severe LV dysfunction<br>• Patient eligible for revascularization<br>• Use of dobutamine stress only | A (8) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 17** Stress echocardiography for hemodynamics (includes doppler during stress)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Chronic Valvular Disease—Asymptomatic With Stress Echocardiography** | |
| 177. | • Mild mitral stenosis | I (2) |
| 178. | • Moderate mitral stenosis | U (5) |
| 179. | • Severe mitral stenosis | A (7) |
| 180. | • Mild aortic stenosis | I (3) |
| 181. | • Moderate aortic stenosis | U (6) |
| 182. | • Severe aortic stenosis | U (5) |
| 183. | • Mild mitral regurgitation | I (2) |
| 184. | • Moderate mitral regurgitation | U (5) |
| 185. | • Severe mitral regurgitation<br>• LV size and function not meeting surgical criteria | A (7) |
| 186. | • Mild aortic regurgitation | I (2) |
| 187. | • Moderate aortic regurgitation | U (5) |
| 188. | • Severe aortic regurgitation<br>• LV size and function not meeting surgical criteria | A (7) |
| | **Chronic Valvular Disease—Symptomatic With Stress Echocardiography** | |
| 189. | • Mild mitral stenosis | U (5) |
| 190. | • Moderate mitral stenosis | A (7) |
| 191. | • Severe mitral stenosis | I (3) |
| 192. | • Severe aortic stenosis | I (1) |
| 193. | • Evaluation of equivocal aortic stenosis<br>• Evidence of low cardiac output or LV systolic dysfunction (“low gradient aortic stenosis”)<br>• Use of dobutamine only | A (8) |
| 194. | • Mild mitral regurgitation | U (4) |
| 195. | • Moderate mitral regurgitation | A (7) |
| 196. | • Severe mitral regurgitation<br>• Severe LV enlargement or LV systolic dysfunction | I (3) |
| | **Acute Valvular Disease With Stress Echocardiography** | |
| 197. | • Acute moderate or severe mitral or aortic regurgitation | I (3) |
| | **Pulmonary Hypertension With Stress Echocardiography** | |
| 198. | • Suspected pulmonary artery hypertension<br>• Normal or borderline elevated estimated right ventricular systolic pressure on resting echocardiographic study | U (5) |
| 199. | • Routine evaluation of patients with known resting pulmonary hypertension | I (3) |
| 200. | • Re-evaluation of patient with exercise-induced pulmonary hypertension to evaluate response to therapy | U (5) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

**Table 18** Contrast use in TTE/TEE or stress echocardiography

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| 201. | • Routine use of contrast<br>• All LV segments visualized on noncontrast images | I (1) |
| 202. | • Selective use of contrast<br>• ≥2 contiguous LV segments are not seen on noncontrast images | A (8) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

## 7. ECHOCARDIOGRAPHY APPROPRIATE USE CRITERIA (BY APPROPRIATE USE RATING)

**Table 19** Appropriate indications (median score 7–9)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **TTE for General Evaluation of Cardiac Structure and Function Suspected Cardiac Etiology—General** | |
| 1. | • Symptoms or conditions potentially related to suspected cardiac etiology including but not limited to chest pain, shortness of breath, palpitations, TIA, stroke, or peripheral embolic event | A (9) |
| 2. | • Prior testing that is concerning for heart disease or structural abnormality including but not limited to chest X-ray, baseline scout images for stress echocardiogram, ECG, or cardiac biomarkers | A (9) |
| | **TTE for General Evaluation of Cardiac Structure and Function Arrhythmias** | |
| 4. | • Frequent VPCs or exercise-induced VPCs | A (8) |
| 5. | • Sustained or nonsustained atrial fibrillation, SVT, or VT | A (9) |
| | **TTE for General Evaluation of Cardiac Structure and Function Lightheadedness/Presyncope/Syncope** | |
| 7. | • Clinical symptoms or signs consistent with a cardiac diagnosis known to cause lightheadedness/presyncope/syncope (including but not limited to aortic stenosis, hypertrophic cardiomyopathy, or HF) | A (9) |
| 9. | • Syncope when there are no other symptoms or signs of cardiovascular disease | A (7) |
| | **TTE for General Evaluation of Cardiac Structure and Function Pulmonary Hypertension** | |
| 15. | • Evaluation of suspected pulmonary hypertension including evaluation of right ventricular function and estimated pulmonary artery pressure | A (9) |
| 17. | • Routine surveillance (≥1 y) of known pulmonary hypertension without change in clinical status or cardiac exam | A (7) |
| 18. | • Re-evaluation of known pulmonary hypertension if change in clinical status or cardiac exam or to guide therapy | A (9) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Hypotension or Hemodynamic Instability** | |
| 19. | • Hypotension or hemodynamic instability of uncertain or suspected cardiac etiology | A (9) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Myocardial Ischemia/Infarction** | |
| 21. | • Acute chest pain with suspected MI and nondiagnostic ECG when a resting echocardiogram can be performed during pain | A (9) |
| 22. | • Evaluation of a patient without chest pain but with other features of an ischemic equivalent or laboratory markers indicative of ongoing MI | A (8) |
| 23. | • Suspected complication of myocardial ischemia/infarction, including but not limited to acute mitral regurgitation, ventricular septal defect, free-wall rupture/tamponade, shock, right ventricular involvement, HF, or thrombus | A (9) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Evaluation of Ventricular Function after ACS** | |
| 24. | • Initial evaluation of ventricular function following ACS | A (9) |
| 25. | • Re-evaluation of ventricular function following ACS during recovery phase when results will guide therapy | A (9) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Respiratory Failure** | |
| 26. | • Respiratory failure or hypoxemia of uncertain etiology | A (8) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Pulmonary Embolism** | |
| 29. | • Known acute pulmonary embolism to guide therapy (e.g., thrombectomy and thrombolytics) | A (8) |
| 31. | • Re-evaluation of known pulmonary embolism after thrombolysis or thrombectomy for assessment of change in right ventricular function and/or pulmonary artery pressure | A (7) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Cardiac Trauma** | |
| 32. | • Severe deceleration injury or chest trauma when valve injury, pericardial effusion, or cardiac injury are possible or suspected | A (9) |
| | **TTE for Evaluation of Valvular Function Murmur or Click** | |
| 34. | • Initial evaluation when there is a reasonable suspicion of valvular or structural heart disease | A (9) |
| 37. | • Re-evaluation of known valvular heart disease with a change in clinical status or cardiac exam or to guide therapy | A (9) |
| | **TTE for Evaluation of Valvular Function Native Valvular Stenosis** | |
| 39. | • Routine surveillance (≥3 y) of mild valvular stenosis without a change in clinical status or cardiac exam | A (7) |

(*Continued*)

Table 19 (*Continued*)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| 41. | • Routine surveillance (≥1 y) of moderate or severe valvular stenosis without a change in clinical status or cardiac exam | A (8) |
| 46. | • Routine surveillance (≥1 y) of moderate or severe valvular regurgitation without change in clinical status or cardiac exam | A (8) |
| | **TTE for Evaluation of Valvular Function Prosthetic Valves** | |
| 47. | • Initial postoperative evaluation of prosthetic valve for establishment of baseline | A (9) |
| 49. | • Routine surveillance (≥3 y after valve implantation) of prosthetic valve if no known or suspected valve dysfunction | A (7) |
| 50. | • Evaluation of prosthetic valve with suspected dysfunction or a change in clinical status or cardiac exam | A (9) |
| 51. | • Re-evaluation of known prosthetic valve dysfunction when it would change management or guide therapy | A (9) |
| | **TTE for Evaluation of Valvular Function Infective Endocarditis (Native or Prosthetic Valves)** | |
| 52. | • Initial evaluation of suspected infective endocarditis with positive blood cultures or a new murmur | A (9) |
| 55. | • Re-evaluation of infective endocarditis at high risk for progression or complication or with a change in clinical status or cardiac exam | A (9) |
| | **TTE for Evaluation of Intracardiac and Extracardiac Structures and Chambers** | |
| 57. | • Suspected cardiac mass | A (9) |
| 58. | • Suspected cardiovascular source of embolus | A (9) |
| 59. | • Suspected pericardial conditions | A (9) |
| 61. | • Re-evaluation of known pericardial effusion to guide management or therapy | A (8) |
| 62. | • Guidance of percutaneous noncoronary cardiac procedures including but not limited to pericardiocentesis, septal ablation, or right ventricular biopsy | A (9) |
| | **TTE for Evaluation of Aortic Disease** | |
| 63. | • Evaluation of the ascending aorta in the setting of a known or suspected connective tissue disease or genetic condition that predisposes to aortic aneurysm or dissection (e.g., Marfan syndrome) | A (9) |
| 64. | • Re-evaluation of known ascending aortic dilation or history of aortic dissection to establish a baseline rate of expansion or when the rate of expansion is excessive | A (9) |
| 65. | • Re-evaluation of known ascending aortic dilation or history of aortic dissection with a change in clinical status or cardiac exam or when findings may alter management or therapy | A (9) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Hypertension** | |
| 67. | • Initial evaluation of suspected hypertensive heart disease | A (8) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy HF** | |
| 70. | • Initial evaluation of known or suspected HF (systolic or diastolic) based on symptoms, signs, or abnormal test results | A (9) |
| 71. | • Re-evaluation of known HF (systolic or diastolic) with a change in clinical status or cardiac exam without a clear precipitating change in medication or diet | A (8) |
| 73. | • Re-evaluation of known HF (systolic or diastolic) to guide therapy | A (9) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Device Evaluation (Including Pacemaker, ICD, or CRT)** | |
| 76. | • Initial evaluation or re-evaluation after revascularization and/or optimal medical therapy to determine candidacy for device therapy and/or to determine optimal choice of device | A (9) |
| 78. | • Known implanted pacing device with symptoms possibly due to device complication or suboptimal pacing device settings | A (8) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Ventricular Assist Devices and Cardiac Transplantation** | |
| 81. | • To determine candidacy for ventricular assist device | A (9) |
| 82. | • Optimization of ventricular assist device settings | A (7) |
| 83. | • Re-evaluation for signs/symptoms suggestive of ventricular assist device-related complications | A (9) |
| 84. | • Monitoring for rejection in a cardiac transplant recipient | A (7) |
| 85. | • Cardiac structure and function evaluation in a potential heart donor | A (9) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Cardiomyopathies** | |
| 86. | • Initial evaluation of known or suspected cardiomyopathy (e.g., restrictive, infiltrative, dilated, hypertrophic, or genetic cardiomyopathy) | A (9) |
| 87. | • Re-evaluation of known cardiomyopathy with a change in clinical status or cardiac exam or to guide therapy | A (9) |

(*Continued*)

Table 19 (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 90. | • Screening evaluation for structure and function in first-degree relatives of a patient with an inherited cardiomyopathy | A (9) |
| 91. | • Baseline and serial re-evaluations in a patient undergoing therapy with cardiotoxic agents | A (9) |
| | **TTE for Adult Congenital Heart Disease** | |
| 92. | • Initial evaluation of known or suspected adult congenital heart disease | A (9) |
| 93. | • Known adult congenital heart disease with a change in clinical status or cardiac exam | A (9) |
| 94. | • Re-evaluation to guide therapy in known adult congenital heart disease | A (9) |
| 98. | • Routine surveillance (≥1 y) of adult congenital heart disease following incomplete or palliative repair<br>◦ with residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | A (8) |
| | **TEE as Initial or Supplemental Test—General Uses** | |
| 99. | • Use of TEE when there is a high likelihood of a nondiagnostic TTE due to patient characteristics or inadequate visualization of relevant structures | A (8) |
| 101. | • Re-evaluation of prior TEE finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) when a change in therapy is anticipated | A (8) |
| 103. | • Guidance during percutaneous noncoronary cardiac interventions including but not limited to closure device placement, radiofrequency ablation, and percutaneous valve procedures | A (9) |
| 104. | • Suspected acute aortic pathology including but not limited to dissection/transsection | A (9) |
| | **TEE as Initial or Supplemental Test—Valvular Disease** | |
| 106. | • Evaluation of valvular structure and function to assess suitability for, and assist in planning of, an intervention | A (9) |
| 108. | • To diagnose infective endocarditis with a moderate or high pretest probability (e.g., staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device) | A (9) |
| | **TEE as Initial or Supplemental Test—Embolic Event** | |
| 109. | • Evaluation for cardiovascular source of embolus with no identified noncardiac source | A (7) |
| | **TEE as Initial Test—Atrial Fibrillation/Flutter** | |
| 112. | • Evaluation to facilitate clinical decision making with regards to anticoagulation, cardioversion, and/or radiofrequency ablation | A (9) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Evaluation of Ischemic Equivalent (Nonacute)** | |
| 115. | • Low pretest probability of CAD<br>• ECG uninterpretable or unable to exercise | A (7) |
| 116. | • Intermediate pretest probability of CAD<br>• ECG interpretable and able to exercise | A (7) |
| 117. | • Intermediate pretest probability of CAD<br>• ECG uninterpretable or unable to exercise | A (9) |
| 118. | • High pretest probability of CAD<br>• Regardless of ECG interpretability and ability to exercise | A (7) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Acute Chest Pain** | |
| 119. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• Low-risk TIMI score<br>• Negative troponin levels | A (7) |
| 120. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• Low-risk TIMI score<br>• Peak troponin: borderline, equivocal, minimally elevated | A (7) |
| 121. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• High-risk TIMI score<br>• Negative troponin levels | A (7) |
| 122. | • Possible ACS<br>• ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm<br>• High-risk TIMI score<br>• Peak troponin: borderline, equivocal, minimally elevated | A (7) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities New-Onset or Newly Diagnosed HF or LV Systolic Dysfunction** | |
| 128. | • No prior CAD evaluation and no planned coronary angiography | A (7) |

(*Continued*)

Table 19 (*Continued*)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Arrhythmias** | |
| 129. | • Sustained VT | A (7) |
| 130. | • Frequent PVCs, exercise-induced VT, or nonsustained VT | A (7) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Syncope** | |
| 134. | • Intermediate or high global CAD risk | A (7) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Elevated Troponin** | |
| 135. | • Troponin elevation without symptoms or additional evidence of ACS | A (7) |
| | **Stress Echocardiography Following Prior Test Results Asymptomatic: Prior Evidence of Subclinical Disease** | |
| 139. | • Coronary calcium Agatston score >400 | A (7) |
| | **Stress Echocardiography Following Prior Test Results Coronary Angiography (Invasive or Noninvasive)** | |
| 141. | • Coronary artery stenosis of unclear significance | A (8) |
| | **Stress Echocardiography Following Prior Test Results Treadmill ECG Stress Test** | |
| 149. | • Intermediate-risk treadmill score (e.g., Duke) | A (7) |
| 150. | • High-risk treadmill score (e.g., Duke) | A (7) |
| | **Stress Echocardiography Following Prior Test Results New or Worsening Symptoms** | |
| 151. | • Abnormal coronary angiography or abnormal prior stress imaging study | A (7) |
| | **Stress Echocardiography Following Prior Test Results Prior Noninvasive Evaluation** | |
| 153. | • Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern | A (8) |
| | **Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Vascular Surgery** | |
| 161. | • ≥1 clinical risk factor<br>• Poor or unknown functional capacity (<4 METs) | A (7) |
| | **Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS STEMI** | |
| 164. | • Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF<br>• To evaluate for inducible ischemia<br>• No prior coronary angiography since the index event | A (7) |
| | **Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS UA/NSTEMI** | |
| 166. | • Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF<br>• To evaluate for inducible ischemia<br>• No prior coronary angiography since the index event | A (8) |
| | **Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Symptomatic** | |
| 169. | • Ischemic equivalent | A (8) |
| | **Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Asymptomatic** | |
| 170. | • Incomplete revascularization<br>• Additional revascularization feasible | A (7) |
| | **Stress Echocardiography for Assessment of Viability/Ischemia Ischemic Cardiomyopathy/Assessment of Viability** | |
| 176. | • Known moderate or severe LV dysfunction<br>• Patient eligible for revascularization<br>• Use of dobutamine stress only | A (8) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Asymptomatic** | |
| 179. | • Severe mitral stenosis | A (7) |
| 185. | • Severe mitral regurgitation<br>• LV size and function not meeting surgical criteria | A (7) |
| 188. | • Severe aortic regurgitation<br>• LV size and function not meeting surgical criteria | A (7) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Symptomatic** | |
| 190. | • Moderate mitral stenosis | A (7) |
| 193. | • Evaluation of equivocal aortic stenosis<br>• Evidence of low cardiac output or LV systolic dysfunction (“low gradient aortic stenosis”)<br>• Use of dobutamine only | A (8) |
| 195. | • Moderate mitral regurgitation | A (7) |
| | **Contrast Use in TTE/TEE or Stress Echocardiography** | |
| 202. | • Selective use of contrast<br>• ≥2 contiguous LV segments are not seen on noncontrast images | A (8) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

Table 20 Uncertain indications (median score 4–6)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **TTE for General Evaluation of Cardiac Structure and Function Perioperative Evaluation** | |
| 14. | • Routine perioperative evaluation of cardiac structure and function prior to noncardiac solid organ transplantation | U (6) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Hypotension or Hemodynamic Instability** | |
| 20. | • Assessment of volume status in a critically ill patient | U (5) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Respiratory Failure** | |
| 27. | • Respiratory failure or hypoxemia when a noncardiac etiology of respiratory failure has been established | U (5) |
| | **TTE for Evaluation of Valvular Function Native Valvular Regurgitation** | |
| 44. | • Routine surveillance (≥3 y) of mild valvular regurgitation without a change in clinical status or cardiac exam | U (4) |
| 45. | • Routine surveillance (<1 y) of moderate or severe valvular regurgitation without a change in clinical status or cardiac exam | U (6) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Hypertension** | |
| 69. | • Re-evaluation of known hypertensive heart disease without a change in clinical status or cardiac exam | U (4) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy HF** | |
| 72. | • Re-evaluation of known HF (systolic or diastolic) with a change in clinical status or cardiac exam with a clear precipitating change in medication or diet | U (4) |
| 75. | • Routine surveillance (≥1 y) of HF (systolic or diastolic) when there is no change in clinical status or cardiac exam | U (6) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Device Evaluation (Including Pacemaker, ICD, or CRT)** | |
| 77. | • Initial evaluation for CRT device optimization after implantation | U (6) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Cardiomyopathies** | |
| 89. | • Routine surveillance (≥1 y) of known cardiomyopathy without a change in clinical status or cardiac exam | U (5) |
| | **TTE for Adult Congenital Heart Disease** | |
| 96. | • Routine surveillance (≥2 y) of adult congenital heart disease following complete repair<br>◦ without residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | U (6) |
| 97. | • Routine surveillance (<1 y) of adult congenital heart disease following incomplete or palliative repair<br>◦ with residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | U (5) |
| | **TEE as Initial or Supplemental Test—Embolic Event** | |
| 110. | • Evaluation for cardiovascular source of embolus with a previously identified noncardiac source | U (5) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) General Patient Populations** | |
| 126. | • Intermediate global CAD risk<br>• ECG uninterpretable | U (5) |
| 127. | • High global CAD risk | U (5) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Arrhythmias** | |
| 132. | • New-onset atrial fibrillation | U (6) |
| | **Stress Echocardiography Following Prior Test Results Asymptomatic: Prior Evidence of Subclinical Disease** | |
| 137. | • Low to intermediate global CAD risk<br>• Coronary calcium Agatston score between 100 and 400 | U (5) |
| 138. | • High global CAD risk<br>• Coronary calcium Agatston score between 100 and 400 | U (6) |
| 140. | • Abnormal carotid intimal medial thickness (≥0.9 mm and/or the presence of plaque encroaching into the arterial lumen) | U (5) |
| | **Stress Echocardiography Following Prior Test Results Asymptomatic or Stable Symptoms Normal Prior Stress Imaging Study** | |
| 145. | • Intermediate to high global CAD risk<br>• Last stress imaging study ≥2 y ago | U (4) |

(*Continued*)

Table 20 (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| **Stress Echocardiography Following Prior Test Results Asymptomatic or Stable Symptoms Abnormal Coronary Angiography or Abnormal Prior Stress Study No Prior Revascularization** | | |
| 147. | • Known CAD on coronary angiography or prior abnormal stress imaging study<br>• Last stress imaging study ≥2 y ago | U (5) |
| **Stress Echocardiography Following Prior Test Results New or Worsening Symptoms** | | |
| 152. | • Normal coronary angiography or normal prior stress imaging study | U (6) |
| **Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Intermediate-Risk Surgery** | | |
| 157. | • ≥1 clinical risk factor<br>• Poor or unknown functional capacity (<4 METs) | U (6) |
| **Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Asymptomatic** | | |
| 172. | • ≥5 y after CABG | U (6) |
| 174. | • ≥2 y after PCI | U (5) |
| **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Asymptomatic** | | |
| 178. | • Moderate mitral stenosis | U (5) |
| 181. | • Moderate aortic stenosis | U (6) |
| 182. | • Severe aortic stenosis | U (5) |
| 184. | • Moderate mitral regurgitation | U (5) |
| 187. | • Moderate aortic regurgitation | U (5) |
| **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Symptomatic** | | |
| 189. | • Mild mitral stenosis | U (5) |
| 194. | • Mild mitral regurgitation | U (4) |
| **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Pulmonary Hypertension** | | |
| 198. | • Suspected pulmonary hypertension<br>• Normal or borderline elevated estimated right ventricular systolic pressure on resting echocardiographic study | U (5) |
| 200. | • Re-evaluation of patient with exercise-induced pulmonary hypertension to evaluate response to therapy | U (5) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

Table 21 Inappropriate indications (median score 1–3)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| **TTE for General Evaluation of Cardiac Structure and Function Arrhythmias** | | |
| 3. | • Infrequent APCs or infrequent VPCs without other evidence of heart disease | I (2) |
| 6. | • Asymptomatic isolated sinus bradycardia | I (2) |
| **TTE for General Evaluation of Cardiac Structure and Function Lightheadedness/Presyncope/Syncope** | | |
| 8. | • Lightheadedness/presyncope when there are no other symptoms or signs of cardiovascular disease | I (3) |
| **TTE for General Evaluation of Cardiac Structure and Function Evaluation of Ventricular Function** | | |
| 10. | • Initial evaluation of ventricular function (e.g., screening) with no symptoms or signs of cardiovascular disease | I (2) |
| 11. | • Routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam | I (3) |
| 12. | • Evaluation of LV function with prior ventricular function evaluation showing normal function (e.g., prior echocardiogram, left ventriculogram, CT, SPECT MPI, CMR) in patients in whom there has been no change in clinical status or cardiac exam | I (1) |
| **TTE for General Evaluation of Cardiac Structure and Function Perioperative Evaluation** | | |
| 13. | • Routine perioperative evaluation of ventricular function with no symptoms or signs of cardiovascular disease | I (2) |

(*Continued*)

Table 21 (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| | **TTE for General Evaluation of Cardiac Structure and Function Pulmonary Hypertension** | |
| 16. | • Routine surveillance (<1 y) of known pulmonary hypertension without change in clinical status or cardiac exam | I (3) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Pulmonary Embolism** | |
| 28. | • Suspected pulmonary embolism in order to establish diagnosis | I (2) |
| 30. | • Routine surveillance of prior pulmonary embolism with normal right ventricular function and pulmonary artery systolic pressure | I (1) |
| | **TTE for Cardiovascular Evaluation in an Acute Setting Cardiac Trauma** | |
| 33. | • Routine evaluation in the setting of mild chest trauma with no electrocardiographic changes or biomarker elevation | I (2) |
| | **TTE for Evaluation of Valvular Function Murmur or Click** | |
| 35. | • Initial evaluation when there are no other symptoms or signs of valvular or structural heart disease | I (2) |
| 36. | • Re-evaluation in a patient without valvular disease on prior echocardiogram and no change in clinical status or cardiac exam | I (1) |
| | **TTE for Evaluation of Valvular Function Native Valvular Stenosis** | |
| 38. | • Routine surveillance (<3 y) of mild valvular stenosis without a change in clinical status or cardiac exam | I (3) |
| 40. | • Routine surveillance (<1 y) of moderate or severe valvular stenosis without a change in clinical status or cardiac exam | I (3) |
| | **TTE for Evaluation of Valvular Function Native Valvular Regurgitation** | |
| 42. | • Routine surveillance of trace valvular regurgitation | I (1) |
| 43. | • Routine surveillance (<3 y) of mild valvular regurgitation without a change in clinical status or cardiac exam | I (2) |
| | **TTE for Evaluation of Valvular Function Prosthetic Valves** | |
| 48. | • Routine surveillance (<3 y after valve implantation) of prosthetic valve if no known or suspected valve dysfunction | I (3) |
| | **TTE for Evaluation of Valvular Function Infective Endocarditis (Native or Prosthetic Valves)** | |
| 53. | • Transient fever without evidence of bacteremia or a new murmur | I (2) |
| 54. | • Transient bacteremia with a pathogen not typically associated with infective endocarditis and/or a documented nonendovascular source of infection | I (3) |
| 56. | • Routine surveillance of uncomplicated infective endocarditis when no change in management is contemplated | I (2) |
| | **TTE for Evaluation of Intracardiac and Extracardiac Structures and Chambers** | |
| 60. | • Routine surveillance of known small pericardial effusion with no change in clinical status | I (2) |
| | **TTE for Evaluation of Aortic Disease** | |
| 66. | • Routine re-evaluation for surveillance of known ascending aortic dilation or history of aortic dissection without a change in clinical status or cardiac exam when findings would not change management or therapy | I (3) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Hypertension** | |
| 68. | • Routine evaluation of systemic hypertension without symptoms or signs of hypertensive heart disease | I (3) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy HF** | |
| 74. | • Routine surveillance (<1 y) of HF (systolic or diastolic) when there is no change in clinical status or cardiac exam | I (2) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Device Evaluation (Including Pacemaker, ICD, or CRT)** | |
| 79. | • Routine surveillance (<1 y) of implanted device without a change in clinical status or cardiac exam | I (1) |
| 80. | • Routine surveillance (≥1 y) of implanted device without a change in clinical status or cardiac exam | I (3) |
| | **TTE for Evaluation of Hypertension, HF, or Cardiomyopathy Cardiomyopathies** | |

(*Continued*)

Table 21 (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 88. | • Routine surveillance (<1 y) of known cardiomyopathy without a change in clinical status or cardiac exam | I (2) |
| | **TTE for Adult Congenital Heart Disease** | |
| 95. | • Routine surveillance (<2 y) of adult congenital heart disease following complete repair<br>◦ without a residual structural or hemodynamic abnormality<br>◦ without a change in clinical status or cardiac exam | I (3) |
| | **TEE as Initial or Supplemental Test—General Uses** | |
| 100. | • Routine use of TEE when a diagnostic TTE is reasonably anticipated to resolve all diagnostic and management concerns | I (1) |
| 102. | • Surveillance of prior TEE finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) when no change in therapy is anticipated | I (2) |
| 105. | • Routine assessment of pulmonary veins in an asymptomatic patient status post pulmonary vein isolation | I (3) |
| | **TEE as Initial or Supplemental Test—Valvular Disease** | |
| 107. | • To diagnose infective endocarditis with a low pretest probability (e.g., transient fever, known alternative source of infection, or negative blood cultures/atypical pathogen for endocarditis) | I (3) |
| | **TEE as Initial or Supplemental Test—Embolic Event** | |
| 111. | • Evaluation for cardiovascular source of embolus with a known cardiac source in which a TEE would not change management | I (1) |
| | **TEE as Initial Test—Atrial Fibrillation/Flutter** | |
| 113. | • Evaluation when a decision has been made to anticoagulate and not to perform cardioversion | I (2) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Evaluation of Ischemic Equivalent (Nonacute)** | |
| 114. | • Low pretest probability of CAD<br>• ECG interpretable and able to exercise | I (3) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Acute Chest Pain** | |
| 123. | • Definite ACS | I (1) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) General Patient Populations** | |
| 124. | • Low global CAD risk | I (1) |
| 125. | • Intermediate global CAD risk<br>• ECG interpretable | I (2) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Arrhythmias** | |
| 131. | • Infrequent PVCs | I (3) |
| | **Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Syncope** | |
| 133. | • Low global CAD risk | I (3) |
| | **Stress Echocardiography Following Prior Test Results Asymptomatic: Prior Evidence of Subclinical Disease** | |
| 136. | • Coronary calcium Agatston score <100 | I (2) |
| | **Stress Echocardiography Following Prior Test Results Asymptomatic or Stable Symptoms Normal Prior Stress Imaging Study** | |
| 142. | • Low global CAD risk<br>• Last stress imaging study <2 y ago | I (1) |
| 143. | • Low global CAD risk<br>• Last stress imaging study ≥2 y ago | I (2) |
| 144. | • Intermediate to high global CAD risk<br>• Last stress imaging study <2 y ago | I (2) |

(*Continued*)

Table 21 (*Continued*)

| | Indication | Appropriate use score (1–9) |
|---|---|---|
| | **Stress Echocardiography Following Prior Test Results Asymptomatic or Stable Symptoms Abnormal Coronary Angiography or Abnormal Prior Stress Study No Prior Revascularization** | |
| 146. | • Known CAD on coronary angiography or prior abnormal stress imaging study<br>• Last stress imaging study <2 y ago | I (3) |
| | **Stress Echocardiography Following Prior Test Results Treadmill ECG Stress Test** | |
| 148. | • Low-risk treadmill score (e.g., Duke) | I (1) |
| | **Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Low-Risk Surgery** | |
| 154. | • Perioperative evaluation for risk assessment | I (1) |
| | **Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Intermediate-Risk Surgery** | |
| 155. | • Moderate to good functional capacity (≥4 METs) | I (3) |
| 156. | • No clinical risk factors | I (2) |
| 158. | • Asymptomatic <1 y post normal catheterization, noninvasive test, or previous revascularization | I (1) |
| | **Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Vascular Surgery** | |
| 159. | • Moderate to good functional capacity (’4 METs) | I (3) |
| 160. | • No clinical risk factors | I (2) |
| 162. | • Asymptomatic <1 y post normal catheterization, noninvasive test, or previous revascularization | I (2) |
| | **Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS STEMI** | |
| 163. | • Primary PCI with complete revascularization<br>• No recurrent symptoms | I (2) |
| 165. | • Hemodynamically unstable, signs of cardiogenic shock, or mechanical complications | I (1) |
| | **Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS**<br>ACS—Asymptomatic Postrevascularization (PCI or CABG) | |
| 167. | • Prior to hospital discharge in a patient who has been adequately revascularized | I (1) |
| | **Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS Cardiac Rehabilitation** | |
| 168. | • Prior to initiation of cardiac rehabilitation (as a stand-alone indication) | I (3) |
| | **Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Asymptomatic** | |
| 171. | • <5 y after CABG | I (2) |
| 173. | • <2 y after PCI | I (2) |
| | **Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Cardiac Rehabilitation** | |
| 175. | • Prior to initiation of cardiac rehabilitation (as a stand-alone indication) | I (3) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Asymptomatic** | |
| 177. | • Mild mitral stenosis | I (2) |
| 180. | • Mild aortic stenosis | I (3) |
| 183. | • Mild mitral regurgitation | I (2) |
| 186. | • Mild aortic regurgitation | I (2) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Symptomatic** | |
| 191. | • Severe mitral stenosis | I (3) |
| 192. | • Severe aortic stenosis | I (1) |
| 196. | • Severe mitral regurgitation<br>• Severe LV enlargement or LV systolic dysfunction | I (3) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Acute Valvular disease** | |

(*Continued*)

**Table 21** (*Continued*)

| Indication | | Appropriate use score (1–9) |
|---|---|---|
| 197. | • Acute moderate or severe mitral or aortic regurgitation | I (3) |
| | **Stress Echocardiography for Hemodynamics (Includes Doppler During Stress)**<br>**Pulmonary Hypertension** | |
| 199. | • Routine evaluation of patients with known resting pulmonary hypertension | I (3) |
| | **Contrast Use in TTE/TEE or Stress Echocardiography** | |
| 201. | • Routine use of contrast<br>• All LV segments visualized on noncontrast images | I (1) |

A indicates appropriate; *I*, inappropriate; *U*, uncertain.

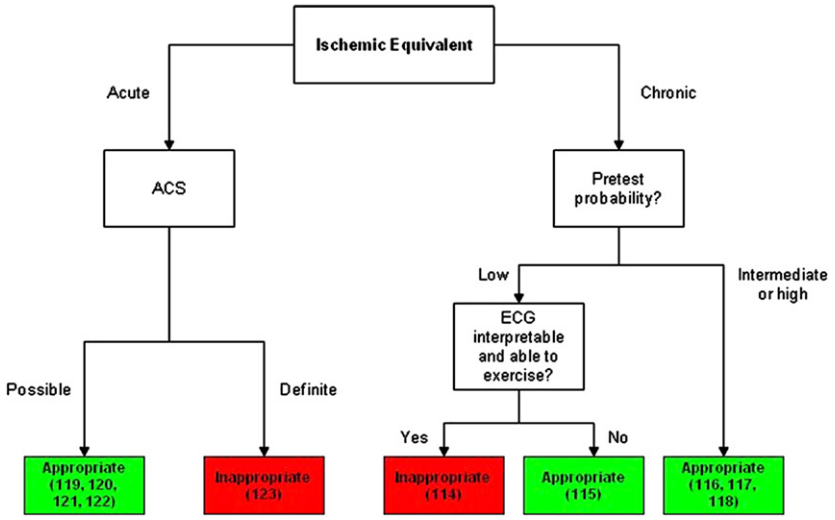


**Figure 1** Stress echocardiography for detection of CAD/Risk assessment: Symptomatic or ischemic equivalent.



## 8. DISCUSSION

Appropriate use criteria define patient subgroups where the available medical evidence supplemented by expert opinion are combined to assess whether the net benefit or risks of a test or procedure make it reasonable to perform testing (in this document, echocardiography) in a particular clinical situation. The intent of these criteria is to guide the rational use of a procedure, namely avoidance of either under- or over-utilization, and thereby lead to improved outcomes, more optimal healthcare delivery, and justifiable healthcare expenditures.

This document is a revision and combination of the original AUC for transthoracic and transesophageal echocardiography (1) and stress echocardiography (2). The revision adds insight provided by interim clinical data and standards documents recently published in the literature and clarifies areas in which omissions or lack of clarity existed in the original criteria. Additionally, since publication of the original AUC, several studies have assessed the application of these criteria in clinical practice; results from these studies were incorporated into this revision and will be briefly summarized here.

### Implementation Studies

Application of the 2007 AUC for TTE has been evaluated at academic medical centers (22,24–26), in Veterans Affairs (VA) hospitals (27), and in community settings (28,29). Several common themes deserve emphasis. First, the majority of clinical scenarios for which TTEs were ordered were captured by AUC indications (11% to 16% of TTEs were unclassified) (24,27). Second, across the implementation studies, there are remarkably similar rates of appropriate and inappropriate use of TTE. Among those TTEs with an indication addressed by the AUC (thus removing unclassifiable patients), the majority were rated as appropriate (87% to 91%) and the rate of inappropriate TTEs was consistently low (9% to 13%) (24–27). In 1 study of outpatient TTEs (29), the rate of appropriate TTEs was lower (74%), although this may be attributable to a higher proportion of unclassified studies in the outpatient setting, a pattern that has been observed by others (24,26). The presence of a greater proportion of unclassified TTEs in the outpatient setting might be expected given that many of the indications in the original AUC (1) specifically address symptoms or a "change in clinical status."

The most common appropriate indications for TTE included initial evaluation of symptoms potentially caused by suspected cardiac etiology, prior testing concerning for heart disease, evaluation of valvular disease, and evaluation of a heart failure indication (24) and are repeated in this revision as Indications 1, 2, 34, and 70. Recommendations for expanding the AUC related to addressing 1) perioperative evaluation (Indications 13 and 14); 2) timing of follow up for valvular heart disease (Indications 38 to 41 and 43 to 49); 3) assessment for device therapy (Indications 76 to 83); and 4) use in some specialized care or "niche" programs (e.g., solid organ transplantation)

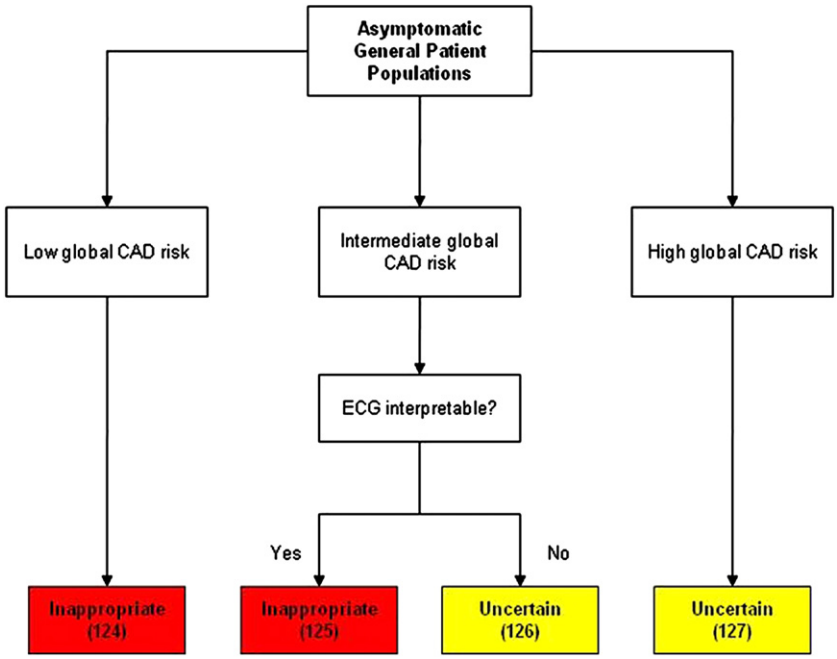


Figure 2 Stress echocardiography for detection of CAD/Risk assessment: Asymptomatic (without ischemic equivalent).

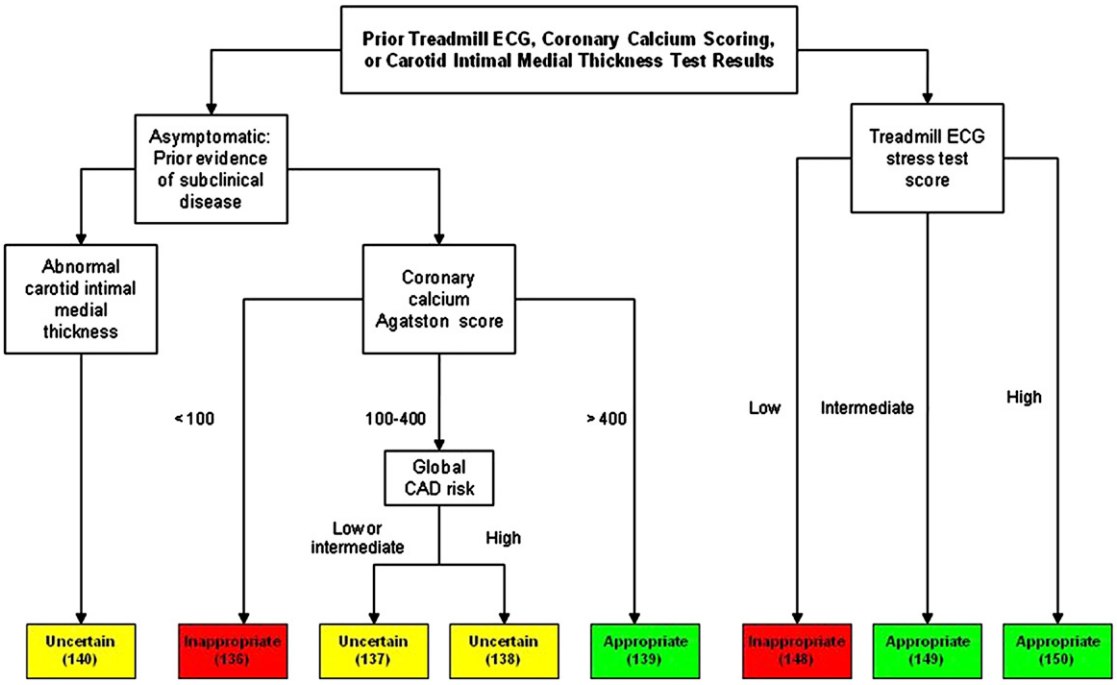


Figure 3 Stress echocardiography following prior treadmill ECG, coronary calcium scoring, or carotid intimal medial thickness test results.

(Indications 14, 84, and 85), and these scenarios were included in the current document. Finally, more indications reflecting outpatient clinical scenarios (e.g., no change in clinical status) were added.

Studies evaluating the application of AUC for TEE had similar results, with the vast majority of classifiable TEEs being ordered for appropriate indications (94% to 97%) and a smaller number not being classified by the AUC (6% to 9%) (30–32). The fact that the operator is more intimately involved in the decision to perform TEE may help to explain the higher appropriate use rate of TEE compared with TTE.

The most common indication for an initial TEE was to guide anticoagulation decisions in patients with atrial fibrillation or flutter (Indications 112 and 113) (30,31). Recommendations for revision focused on refinement of the indications for evaluation of cardiovascular source of embolus (Indications 109 to 111).

Fewer studies have focused on the clinical application of AUC for stress echocardiography (33,34). In 1 study, 19% of stress echocardiograms could not be classified by the AUC (33). Of the echocardiograms that were classified, 66% were for appropriate


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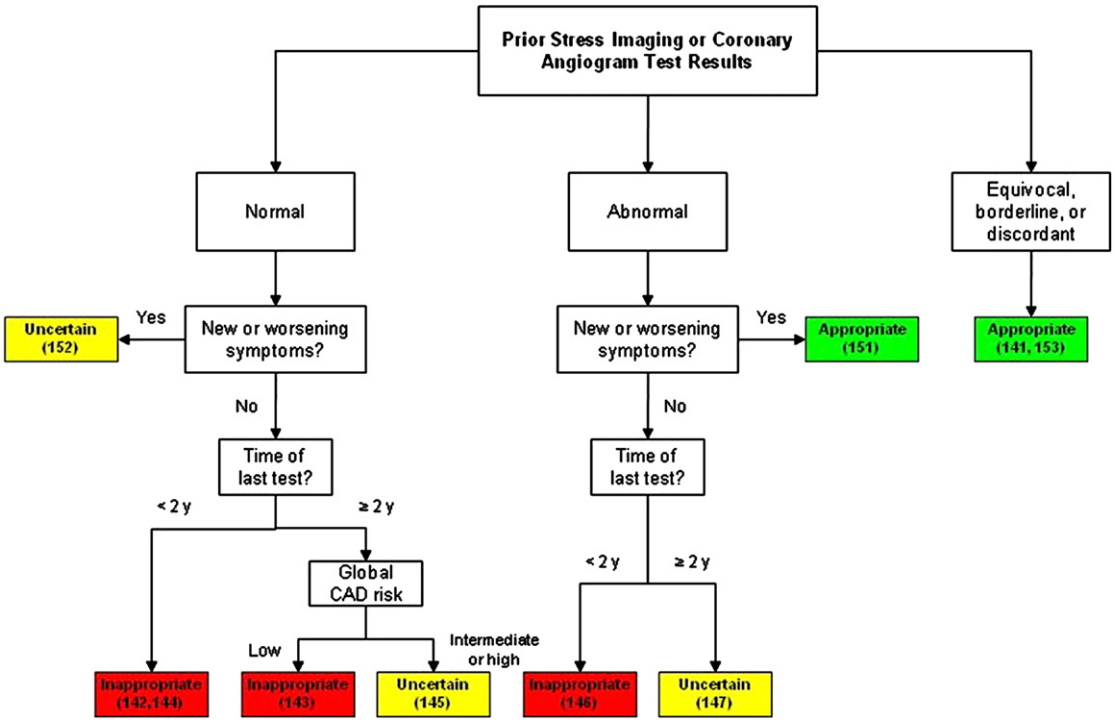


Figure 4 Stress echocardiography following prior stress imaging or coronary angiogram test results.

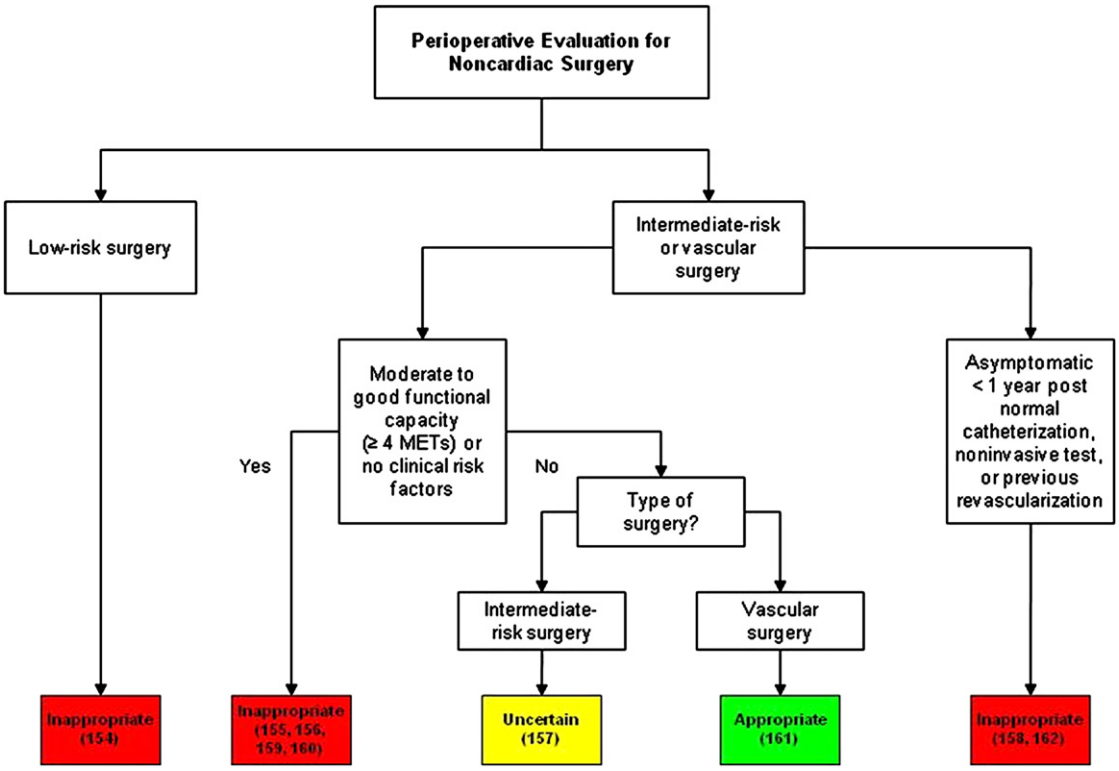


Figure 5 Stress echocardiography for risk assessment—perioperative evaluation for noncardiac surgery without active cardiac conditions.


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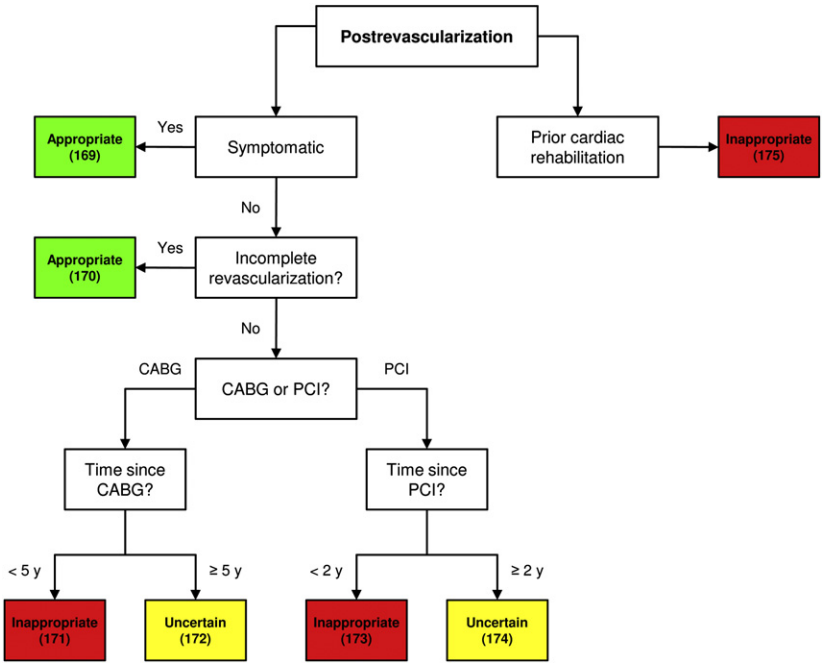


Figure 6 Stress echocardiography for risk assessment—postrevascularization (PCI or CABG).



indications. The majority of unclassified studies were centered in 2 areas: perioperative risk assessment and risk assessment with prior test results. In another study, 88% (n=253) of stress echocardiograms were ordered for indications outlined in the AUC, whereas 12% (n=36) were ordered for indications not addressed by the AUC (34). Of the 253 studies for which the AUC document could be applied, 71% (n=180) studies were appropriate, 9% (n=23) were uncertain, and 20% (n=50) were inappropriate studies.

The results of the implementation studies demonstrate that the rate of inappropriate use of echocardiography is similar in various regions of the United States. In contrast, other studies of resource utilization have documented regional differences in utilization patterns (35). A recent study (36) suggests that a substantial amount of the observed geographic variability in use is attributable to corresponding regional differences in patient health, a conclusion supported by the AUC implementation data which, unlike claims data, inherently address clinical status. Further application of AUC may help to dissect the true variations in care delivery by supplementing claims data with clinical data; however, this warrants further study.

In summary, studies evaluating clinical application of AUC for echocardiography suggest that the majority of clinical scenarios could be classified by the criteria and that the majority of studies were ordered for appropriate indications. Further, the studies identified gaps in the AUC, likely due to both omissions in the initial criteria and subsequent advances in specialized care, which were of substantial utility in guiding the revision process. Although improved, we do not expect this AUC document to be all-inclusive of the wide breadth of all possible clinical scenarios. Although the results from the implementation studies indicate that the original AUC for echocardiography were successful, they also support the need for the current update and revision of the criteria.

## Other Features of the Revision

In addition to incorporating the results from implementation studies, several other aspects of the revision deserve emphasis. First, the revised document combines TTE, TEE, and stress echocardiography, whereas the initial TTE and TEE AUC (1) were published separately from the stress echocardiography AUC (2). The indication tables still focus on each modality separately, for example, TTE (or TEE as an adjunct if TTE nondiagnostic), TEE as an initial test, and stress echocardiography. The exception is the final table (Table 18, Indications 201 and 202), which covers contrast use and is applicable to all of the echocardiographic modalities. Second, a new table was created to cover indications related to patients with adult congenital heart disease, as this patient population is being encountered with greater frequency by adult cardiologists (Table 7, Indications 92 to 98) (37). It should be noted that, with the exception of some adults with ligated or occluded patent ductus arteriosus (covered in Indications 95 and 96), most congenital heart conditions have the potential for residual anatomic or physiologic abnormalities, so that, even for many asymptomatic and stable patients, an echocardiogram will be considered to guide therapeutic decision making rather than for routine surveillance. Third, existing tables were expanded to be more comprehensive in covering various clinical situations. Fourth, efforts were made to address clinical scenarios that have recently been addressed in revised or new practice guidelines, such as valvular heart disease (14), perioperative evaluation (16), and evaluation of thoracic aortic disease (38). The goal of relating indications to the available evidence base was a consistent feature during the revision process (see Online Appendix). If randomized trials or practice guidelines relevant to indications were not available, clinical scenarios addressed in expert consensus documents were identified whenever possible. Finally, indications were added to better address evolving therapeutic options such as CRT (Indications 76 to 78) or treatment/follow-up of pulmonary hypertension (Indications 15 to 18).

An important focus during the revision process was to harmonize the indications across noninvasive modalities, such that the wording of the indications is identical with other AUC criteria (3) whenever feasible. For echocardiography, harmonization with other documents was most relevant for the stress echocardiography portion. For instance, Table 13, which addresses the perioperative assessment for

noncardiac surgery, mirrors Table 4 in the RNI document (3). This should facilitate clinical application of the criteria and assist the process of future revisions and possibly the development of a multimodality imaging AUC document.

Stress echocardiography tests, like many imaging tests, may provide additional useful information beyond the primary purpose outlined by the indication. In addition, stress echocardiography does not use ionizing radiation. However, the AUC for stress echocardiography were not developed to quantify the incremental information or other test characteristics beyond addressing the diagnostic need inherent in an individual indication.

In ranking indications, panelists were asked to not consider comparisons to other imaging procedures while completing their rankings. Nevertheless, stress echocardiography and SPECT MPI have similar bodies of evidence to support their use. Therefore, it is not surprising that the overwhelming majority of final ratings of stress echocardiography and stress RNI were concordant for similar clinical indications. However, a small number of the final scores and rating categories reported in this document differ from those previously published for stress RNI (3). Specifically, 4 indications (Indications 127, 157, 171, and 172) were rated differently. It is noteworthy that of these 4 indications, 3 also appeared in the first stress echocardiography AUC (2), and all 3 indications were rated similarly in this revision, requiring consistency in ratings across the 2 technical panels composed of different individuals. The difference in the rating for Indication 127 may have been directly affected by publication of the DIAD study (39), which was not available at the time of the RNI ratings. Additionally, although the final rankings were different from the RNI ratings, Indications 127 and 171 demonstrated agreement within the current echocardiography technical panel. Therefore, the several indications with ratings that differed from RNI may reflect new literature that has become available since publication of the SPECT appropriateness criteria and differences in the composition of the 2 panels.

Readers should also note that the categorical summaries tend to accentuate differences that sometimes are slight. For example, small fluctuations in a median rating (e.g., 4 versus 3) will cause an indication to switch appropriateness categories (e.g., from uncertain to inappropriate). This phenomenon was relevant for Indication 157, which was rated as uncertain (median score 6) in this document, while the same indication in the RNI document (corresponding Indication 43) was rated appropriate (median score 7). The most likely reason for this is a simple variation in rating by the different panel members, whether because of composition, different levels of clinical experience, publication of additional literature, or different interpretations of data. The AUC Task Force has carefully examined the issue of panel membership and made every effort to ensure similar composition for each panel. The RAND process has documented that the interpretation of the literature by different sets of experts can yield slightly different final ratings (6).

As described in the Methods section, within each main disease category, a standardized approach was used in order to capture the majority of clinical scenarios without making the list of indications excessive. The approach was to create 5 broad clinical scenarios: 1) for initial diagnosis; 2) to guide therapy or management, regardless of symptom status; 3) to evaluate a change in clinical status or cardiac exam; 4) for early follow-up without change in clinical status; and 5) for late follow-up without change in clinical status. It should be noted that many cardiovascular conditions have the potential for residual anatomic or physiologic abnormalities, so that the timing and follow-up use of echocardiographic imaging depends on the patient's clinical status and the magnitude of or risk for residual abnormalities. Thus, routine surveillance indications for echocardiograms should not apply in those situations in which there has been a change in status or where an echocardiogram is being considered to guide therapeutic decision making. For asymptomatic or stable patients with known or suspected residual anatomic or physiologic abnormalities, the timing of the follow-up for considering changes in therapy in patients should be determined by individual patient factors, and not by the suggested intervals for routine surveillance studies.

Overall, indications focusing on initial diagnosis, guidance of therapy, or evaluation of a change in clinical status were viewed favorably by the rating panel. Uncertain or inappropriate ratings were more likely given to early rather than late follow-up, especially for those indications when the optimal interval of follow-up for asymptomatic patients is uncertain. Whenever possible, indications for timing of follow-up attempted to follow practice guidelines (14), although for many indications, the most appropriate follow-up interval for asymptomatic patients is not well established. For this reason, as well as for clinical expediency, the follow-up interval selected is not meant to be rigid but rather to represent an approximate time interval.

Although the overall approach was broad and inclusive, certain specific clinical scenarios warranted focused indications based on results from the previously mentioned implementation studies. Examples include Indications 71 and 72, which differentiate the reevaluation of decompensated heart failure when there is no clear precipitating change in medication or diet versus when there is a clear precipitating factor. In the setting of an obvious change in diet or medication, a trial of appropriate medical therapy and monitoring for clinical improvement may be justified prior to ordering a repeat imaging test for assessment of cardiac function (25). As such, Indication 72 (clear precipitating change in medication or diet) was rated as uncertain, and Indication 71 was rated as appropriate. Another focused clinical situation is reflected in Indication 76, "Initial evaluation or re-evaluation after revascularization and/or optimal medical therapy to determine candidacy for device therapy and/or to determine optimal choice of device." As per the results of an implementation study (24), this clinical scenario was not well captured in the initial AUC document. However, re-evaluation of LV ejection fraction after revascularization or after a period of medical therapy to determine device candidacy represents a standard of care (40) and is a common indication for a TTE. This is now represented by Indication 76, which was rated as appropriate.

Other specific areas identified by implementation studies as common scenarios and now included are bradycardia (Indication 6) and a new subcategory within TTE for the evaluation of syncope (Indications 7 to 9). Additionally, the sections on valvular heart disease (both resting TTE/TEE and stress echocardiography for hemodynamics) have been expanded in an effort to address a greater number of clinical scenarios, and closely follow recent guideline recommendations (14).

Despite these extensive revisions and additions, all potential clinical scenarios were not covered by the revised AUC for echocardiography. Additionally, certain recommendations from implementation studies were considered to represent rare conditions or specialized practices and were therefore not included in the revised document. If certain clinical situations that are not currently covered are found to be more frequent than anticipated, they will be incorporated into future revisions. This emphasizes the iterative nature of this process.

Furthermore, there are several general categories that were purposefully not addressed. For example, intraoperative use of TEE for cardiac surgery was felt to be beyond the scope of this document.

More highly specialized echocardiographic techniques, such as 3-dimensional echocardiography or epicardial imaging, are not addressed in this document. Additionally, as stated in the first paragraph of the Assumptions section, the AUC for TTE, TEE, and stress echocardiography are for adult patients. Indications for pediatric echocardiograms were not covered.

### New Assumptions and Definition

In addition to adding new clinical indications and clarifying existing indications from the original TTE/TEE AUC (1) and stress echocardiography AUC (2), the writing group also revised and added specific assumptions and definitions. Several general assumptions were added. First, the assumption that cost should be implicitly considered in determining appropriate use of an echocardiogram was added. Second, a new assumption addresses the category of uncertain indications and clarifies that such a rating should not be considered grounds for withholding reimbursement. Third, a new assumption indicates that appropriateness ratings reflect whether a specific test is appropriate for a given patient, not whether it is preferred over another modality (e.g., RNI, CT). Thus, the AUC should not be used to provide clinical support for administrative policies regarding test preferences. Finally, an assumption clarifies that routine or surveillance echocardiograms represent a "periodic" evaluation after a certain period of time has elapsed, and are not being ordered because of any other clinical factors. Other more specific assumptions were also added. These include consideration of prosthetic and native valves together (unless otherwise specified) and that use of Doppler for hemodynamics includes assessment of both right and left heart hemodynamics. Furthermore, it is assumed that if a perioperative patient has symptoms or signs of cardiovascular disease, the study should be classified under a symptomatic indication (e.g., Indication 1), as opposed to an indication in the perioperative category.

Similar to the RNI AUC (3), the writing group revised the definition of "chest pain syndrome" and adopted the term "ischemic equivalent," which encompasses chest pain syndromes as well as other symptoms and signs that the clinician believes may be attributable to CAD. The writing group also adopted the use of global risk assessment when assessing risk in asymptomatic patients (41). This revision was supported by the writing group, technical panel, and external reviewers and is in harmony with the most recent AUC for Cardiac CT (4).

### Limitations

The ratings of the indications as appropriate, uncertain, or inappropriate are reflective of the body of knowledge at the time the rating process occurred. It is likely and expected that as science progresses and new evidence-based guidelines are published, certain indications that are given 1 rating may subsequently be determined to have a different appropriateness rating in the future. Although this necessarily reflects the evolving nature of medical science, it may also introduce apparent discrepancies between appropriateness of similar indications for different modalities evaluated at different time points. The current evidence base and practice guidelines were used to develop the indications whenever available, although for certain indications the literature was limited and clinical expertise played a larger role. This is consistent with the standard methodology and principles of evidence-based medicine as endorsed by the Physician Consortium for Performance Improvement (42). Additionally, as mentioned in the previous text, certain clinical scenarios were intentionally not covered by the indications. When future implementation studies evaluating this revised AUC for echocardiography are conducted, it may become apparent that frequent situations were not covered. As was the case for this current revision, results and recommendations from implementation studies will help shape future modifications to the AUC.

### Use of AUC to Improve Care

The AUC in this report provide an estimate of whether it is reasonable to use echocardiography for a particular clinical scenario, specifically for 1 of the 202 indications listed in this document. These criteria are expected to be useful for clinicians, healthcare facilities, and third-party payers engaged in the delivery of cardiovascular imaging. The AUC is expected to be valuable across a broad range of situations, including guiding care of individual patients, educating caregivers, and informing policy decisions regarding cardiovascular imaging.

AUC represent the first component of the chain of quality domains for cardiovascular imaging (43). After ensuring proper test selection, the achievement of quality in imaging includes adherence to best practices in image acquisition, image interpretation and results communication, as well as incorporation of findings into clinical care. All components are important for optimal patient care, although the development of AUC and their ranking by the technical panel is intended to address only the first quality domain, and assumes no barriers to other quality standards are being met.

Although these criteria are intended to provide guidance for care decisions, they cannot serve as substitutes for sound clinical judgment and practice experience. The writing group recognizes that patients encountered in clinical practice may not be represented in these AUC or may have extenuating features when compared with the clinical scenarios presented. Additionally, uncertain indications often require individual physician judgment and an in-depth understanding of the patient to better determine the usefulness of a test for a particular scenario. As such, the ranking of an indication as uncertain (4 to 6) should not be viewed as limiting the use of echocardiography for such patients. It should be emphasized that the technical panel was instructed that the "uncertain" designation was still designed to be considered as a "reimbursable" category.

These ratings reflect the critical medical literature as well as expert consensus and are intended to evaluate the appropriate use of specific patient scenarios to determine overall patterns of care regarding echocardiography. In situations where there is substantial variation between the appropriate use rating and what the clinician believes is the best recommendation for the patient, further considerations or actions, such as a second opinion, may be appropriate. Moreover, it is neither anticipated nor desirable that all physicians or facilities will have 100% of their echocardiograms deemed appropriate. However, it is desirable, though not realistic, that 0% be inappropriate. Related to the overall patterns of care, if the national average of appropriate and uncertain ratings is 80%, for example, and a physician or facility has a 40% rate of inappropriate procedures, further examination of the patterns of care may be warranted and helpful. The use of AUC to guide clinical decision making and its impact on patient outcomes and healthcare quality/efficiency needs to be studied rigorously. AUC are also useful as educational tools for both echocardiography providers and referring physicians. The recently announced and soon to be implemented incorporation of AUC into echocardiography laboratory accreditation requirements will encourage their use (44). However, the greatest opportunity to optimize the use of echocardiography is in improving individual patient decision making. The successful application of AUC into clinical practice represents an important area of ongoing quality improvement.

## APPENDIX A: ADDITIONAL ECHOCARDIOGRAPHY DEFINITIONS

### 1. Angina

- ***Typical* Angina (Definite):** Defined as 1) substernal chest pain or discomfort that is 2) provoked by exertion or emotional stress and 3) relieved by rest and/or nitroglycerin (45).
- ***Atypical* Angina (Probable):** Chest pain or discomfort that **lacks 1** of the characteristics of definite or typical angina.
- ***Nonanginal* Chest Pain:** Chest pain or discomfort that **meets 1 or none** of the typical angina characteristics.

### 2. Acute Coronary Syndrome (ACS)

As defined by the ACC/AHA Guidelines for the Management of Patients with ST-Elevation Myocardial Infarction: patients with an ACS include those whose clinical presentations cover the following range of diagnoses: unstable angina, myocardial infarction without ST-segment elevation (NSTEMI), and myocardial infarction with ST-segment elevation (STEMI) (46).

### 3. Evaluating Perioperative Risk for Noncardiac Surgery

***Method for Determining Perioperative Risk.*** See Figure A1, "Stepwise Approach to Perioperative Cardiac Assessment," from the ACCF/AHA guidelines on perioperative cardiovascular evaluation and care for noncardiac surgery (16). Based on the algorithm, once it is determined that the patient does not require urgent surgery, the clinician should determine the patient's active cardiac conditions (see Table A1) and/or perioperative risk predictors (see Table A2). If any active cardiac conditions and/or major risk predictors are present, Figure A1 suggests consideration of coronary angiography and postponing or canceling noncardiac surgery. Once perioperative risk predictors are assessed based on the algorithm, then the surgical risk and patient's functional status should be used to establish the need for noninvasive testing.

### 4. Thrombolysis In Myocardial Infarction (TIMI) Risk Scores

The TIMI risk score (48) is a simple tool composed of 7 (1-point) risk indicators rated on presentation. The composite end points (all-cause mortality, new or recurrent MI, or severe recurrent ischemia prompting urgent revascularization within 14 days) increase as the TIMI risk score increases. The model remained a significant predictor of events and test sensitivity and was relatively unaffected/uncompromised by missing information, such as knowledge of previously documented coronary stenosis of ≥50%. The model's predictive ability remained intact with a cutoff of 65 years of age.

The TIMI risk score is determined by the sum of the presence of 7 variables at admission; 1 point is given for each of the following

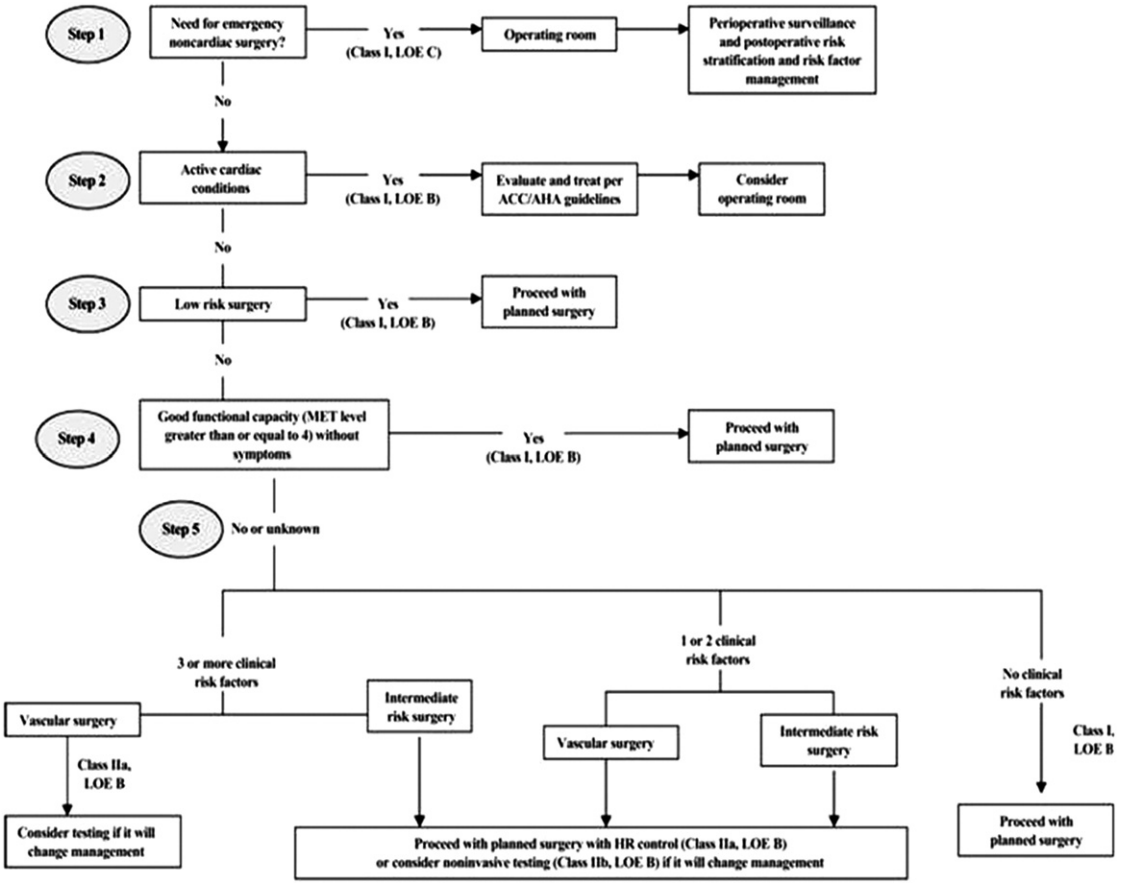


Figure A1 Stepwise approach to perioperative cardiac assessment.
Cardiac evaluation and care algorithm for noncardiac surgery based on active clinical conditions, known cardiovascular disease, or cardiac risk factors for patients ≥50 years of age. HR indicates heart rate; LOE, level of evidence; and MET, metabolic equivalent. Modified from (16).

**Table A1** Active cardiac conditions for which the patient should undergo evaluation and treatment before noncardiac surgery (class I, level of evidence: B)

| Condition | Examples |
|---|---|
| Unstable coronary syndromes | Unstable or severe angina* (CCS class III or IV)† |
| | Recent MI‡ |
| Decompensated HF (NYHA functional class IV; worsening or new-onset HF) | |
| Significant arrhythmias | High-grade atrioventricular block |
| | Mobitz II atrioventricular block |
| | Third-degree atrioventricular heart block |
| | Symptomatic ventricular arrhythmias |
| | Supraventricular arrhythmias (including atrial fibrillation) with uncontrolled ventricular rate (HR >100 bpm at rest) |
| | Symptomatic bradycardia |
| | Newly recognized ventricular tachycardia |
| Severe valvular disease | Severe aortic stenosis (mean pressure gradient >40 mm Hg, aortic valve area <1.0 $cm^2$, or symptomatic) |
| | Symptomatic mitral stenosis (progressive dyspnea on exertion, extertional presyncope, or HF) |

CCS indicates Canadian Cardiovascular Society; HF, heart failure; HR, heart rate; MI, myocardial infarction; and NYHA, New York Heart Association.
*According to Campeau (47).
†May include "stable" angina in patients who are unusually sedentary.
‡The American College of Cardiology National Database Library defines recent MI as >7 days but ≤1 month (within 30 days). Reprinted from Fleisher et al. (16).

variables: age ≥65 years, at least 3 risk factors for CAD, prior coronary stenosis of ≥50%, ST-segment deviation on ECG presentation, at least 2 anginal events in prior 24 hours, use of aspirin in prior 7 days, and elevated serum cardiac biomarkers.

Low-Risk TIMI Score: TIMI score <2

High-Risk TIMI Score: TIMI score ≥2

### 5. ECG–Uninterpretable

Refers to ECGs with resting ST-segment depression (≥0.10 mV), complete LBBB, pre-excitation (Wolff-Parkinson-White Syndrome), or paced rhythm.

### 6. Coronary Angiography

The term *coronary angiography* refers to invasive cardiac catheterization or to established noninvasive methods of imaging the coronary arteries, such as coronary CT angiography.

**Table A2** Perioperative clinical risk factors*

- History of ischemic heart disease
- History of compensated or prior heart failure
- History if cerebrovascular disease
- Diabetes mellitus (requiring insulin)
- Renal insufficiency (creatinine >2.0)

*As defined by the 2009 ACCF/AHA Focused Update on Perioperative Beta Blockade Incorporated Into the ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery (16). Note that these are not standard coronary artery disease risk factors.

## APPENDIX B: ADDITIONAL METHODS

See the Methods section of the report for a description of panel selection, indication development, scope of indications, and rating process.

### Relationships With Industry and Other Entities

A list of all individuals participating in the development and review of this document and their institutional and/or organizational affiliations is presented in Appendix C. The American College of Cardiology Foundation and its partnering organizations rigorously avoid any actual, perceived, or potential conflicts of interest that might arise as a result of an outside relationship or personal interest of a member of the technical panel. Specifically, all panelists are asked to provide disclosure statements of all relationships that might be perceived as real or potential conflicts of interest. These statements were reviewed by the Appropriate Use Criteria Task Force, discussed with all members of the technical panel at the face-to-face meeting, and updated and reviewed as necessary. A table of disclosures by the technical panel and oversight working group member can be found in Appendix D. In addition, to ensure complete transparency, complete disclosure information—including relationships not pertinent to this document—is available online as a document supplement.

### Literature Review

The technical panel members were asked to refer to the relevant literature provided for each indication table when completing their ratings (see Online Appendix).

## APPENDIX C: ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011

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(*Continued*)

**Appendix C** (*Continued*)

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This table represents the relevant relationships with industry and other entities that were disclosed by participants at the time of participation. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of 5% or more of the voting stock or share of the business entity, or ownership of $10 000 or more of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review. Participation does not imply endorsement of this document.
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## APPENDIX D: ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 APPROPRIATE USE CRITERIA FOR ECHOCARDIOGRAPHY WRITING GROUP, TECHNICAL PANEL, INDICATION REVIEWERS, AND TASK FORCE—RELATIONSHIPS WITH INDUSTRY AND OTHER ENTITIES (IN ALPHABETICAL ORDER WITHIN EACH GROUP)

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**Appendix D** (*Continued*)

| Participant | Consultant | Speaker | Ownership/ Partnership/ Principal | Research | Institutional, Organizational, or Other Financial Benefit | Expert Witness |
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This table represents the relevant relationships with industry and other entities that were disclosed by participants at the time of participation. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of 5% or more of the voting stock or share of the business entity, or ownership of $10,000 or more of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review. Participation does not imply endorsement of this document.

*Significant relationship.

## SUPPLEMENTARY DATA

For supplementary data, please see the online version of this article.

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