

## EDUCATIONAL TRACK FOR RESIDENTS—REVIEW ARTICLE

## Choosing the Appropriate Examination for Diagnosis of Stable Ischemic Heart Disease

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## Abstract

Choosing the appropriate modality is important for diagnosis of ischemic heart disease in clinical settings. The Appropriate Use Criteria (AUC) were published by the American College of Cardiology Foundation along with key specialty and subspecialty societies. The AUC provides information on which modality is “appropriate” according to various clinical situations, and is widely utilized especially in the United States. In this article, we introduce “2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease”.

**Keywords:** Appropriate use criteria, Examination, Indication, Nuclear cardiology

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Although the prevalence of ischemic heart disease is lower in Japan compared with it in the United States, managing coronary risk factors and precise diagnosis of ischemic heart disease are important because the aging population rapidly increases in Japan (1).

Several modalities have been utilized for the diagnosis of stable ischemic heart disease. There are some diagnostic algorithms for stable ischemic heart disease based on the guidelines in Japan and the United States (1,2). In general, it is not easy to diagnose stable ischemic heart disease by a simple test because we have to consider the patients’ clinical backgrounds. Therefore we need to choose a modality suitable for a specific indication rather than a single best test. In this article, we introduce “2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease” which is expected to help us utilize several diagnostic modalities for daily clinical practice.

### What are the Appropriate Use Criteria?

The AUC was published by the American College of Cardiology Foundation (ACCF) along with key specialty and subspecialty societies. The objective of the AUC is to improve patient care and health outcomes in a cost-effective manner but is not intended to ignore ambiguity and nuance intrinsic to

clinical decision making (3). The first AUC was published in 2005 and included single-photon emission computed tomography myocardial perfusion imaging (4). The range of modalities included in the AUC extended to stress echocardiography, calcium scoring, coronary computed tomography angiography (CCTA), stress cardiac magnetic resonance (CMR), and invasive coronary angiography for stable ischemic heart disease (5-9).

### How is the appropriateness evaluated?

Evaluation of the appropriateness was done by a rating panel composed of individuals with a diversity of expertise. The appropriateness was scored by the rating panel and classified into four categories: appropriate, may be appropriate, rarely appropriate, and uncertain (4). When there was a disagreement among the rating panel, the indication was categorized as uncertain.

### AUC for symptomatic patients with suspected stable ischemic heart disease

According to the AUC, when the patient has symptom suspicious for coronary artery disease (CAD), we initially have to evaluate the patient’s pre-test probability. Pre-test probability is evaluated by age, sex, and symptoms using

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**Table 1** Symptomatic patients

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Low pre-test probability of CAD ● ECG interpretable AND able to exercise	A	R	M	R	R	R	R
● Low pre-test probability of CAD ● ECG uninterpretable OR unable to exercise	—	A	A	M	R	M	R
● Intermediate pre-test probability of CAD ● ECG interpretable AND able to exercise	A	A	A	M	R	M	R
● Intermediate pre-test probability of CAD ● ECG uninterpretable OR unable to exercise	—	A	A	A	R	A	M
● High pre-test probability of CAD ● ECG interpretable AND able to exercise	M	A	A	A	R	M	A
● High pre-test probability of CAD ● ECG uninterpretable OR unable to exercise	—	A	A	A	R	M	A

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CAD: coronary artery disease, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

**Table 2** Asymptomatic (without symptoms or ischemic equivalent) patients

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Low global CHD risk ● Regardless of ECG interpretability and ability to exercise	R	R	R	R	R	R	R
● Intermediate global CHD risk ● ECG interpretable and able to exercise	M	R	R	R	M	R	R
● Intermediate global CHD risk ● ECG uninterpretable OR unable to exercise	—	M	M	R	M	R	R
● High global CHD Risk ● ECG interpretable and able to exercise	A	M	M	M	M	M	R
● High global CHD Risk ● ECG uninterpretable OR unable to exercise	—	M	M	M	M	M	R

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CCTA: coronary computed tomography angiography, CHD: coronary heart disease, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

Diamond and Forrester pre-test probability of CAD, or by the other databases such as NIPPON DATA 80 (10-12).

Appropriateness for modalities varies according to the pre-test probability (Table 1). When the patient has a low pre-test probability of CAD, most modalities are considered to be “rarely appropriate” except for exercise electrocardiogram (ECG) (4). The other stress tests, including stress radionuclide imaging (RNI) and stress echocardiography, are “appropriate” if the ECG is uninterpretable or the patient is unable to exercise. When the patient has an intermediate pre-test probability of CAD, most stress tests (stress RNI, stress echocardiography, and stress CMR) are considered “appropriate” or “may be appropriate”. However, CCTA is considered “appropriate” only if the ECG is uninterpretable or the patient is unable to exercise. When the patient has a high pre-test probability of CAD, invasive coronary angiography is

considered “appropriate”. Interestingly, CCTA turns into “may be appropriate” in this indication. Calcium scoring remains “rarely appropriate” regardless of any pre-test probability (4).

#### AUC for asymptomatic patients

When the patient has no symptoms, almost all modalities are considered “may be appropriate” or “rarely appropriate” (Table 2). Exercise ECG is only found to be an appropriate modality if the patient has a high global coronary heart disease (CHD) risk and interpretable ECG (4). Global CHD risk is estimated by standard methods such as Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (13).

## Appropriate Use Criteria for Diagnosing Ischemic Heart Disease

**Table 3** Sequential testing (≤90 days): abnormal prior test/study

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Abnormal rest ECG findings (potentially ischemic in nature such as LBBB, T-wave inversions)	—	A	A	M	R	M	R
● Low global CAD risk							
● Abnormal rest ECG findings (potentially ischemic in nature such as LBBB, T-wave inversions)	—	A	A	A	R	M	M
● Intermediate to high global CAD risk							
● Abnormal prior exercise ECG test	—	A	A	A	R	A	A
● Abnormal prior stress imaging study (assumes not repeat of same type of stress imaging)	R	M	M	M	R	A	A
● Obstructive CAD on prior CCTA study	M	A	A	A	—	—	A
● Obstructive CAD on prior invasive coronary angiography	M	A	A	A	R	R	—
● Abnormal prior CCT calcium (Agatston Score >100)	A	A	A	M	—	M	R

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CAD: coronary artery disease, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

**Table 4** Sequential or follow-up testing (≤90 days): uncertain prior results

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
Equivocal, Borderline, or Discordant Prior Noninvasive Evaluation Where Obstructive CAD Remains a Concern							
● Prior exercise ECG test	—	A	A	A	R	A	M
● Prior stress imaging study (assumes not repeat of same type of stress imaging)	R	M	M	M	R	A	A
● Prior CCTA	M	A	A	A	—	—	A
Prior Coronary Angiography (Invasive or Non invasive)							
● Coronary stenosis or anatomic abnormality of unclear significance found on cardiac CCTA	M	A	A	A	—	—	A
● Coronary stenosis or anatomic abnormality of unclear significance on previous coronary angiography	M	A	A	A	R	R	—

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

### AUC for patients who underwent prior testing or procedure

Stress imaging and anatomical imaging such as CCTA or invasive coronary angiography are performed complementarily if the patient has already undergone prior testing or procedures (Tables 3 and 4). If any stress imaging reveals abnormal findings, anatomical imaging is considered “appropriate”, and vice versa (4). If prior exercise ECG is found to be abnormal, both stress imaging and anatomical imaging are considered “appropriate” (Table 3).

### AUC for patient with post-revascularization (PCI or CABG)

Indications for patients with post-revascularization also vary depending on whether the patient is symptomatic or not (Tables 5 and 6). If the patient is asymptomatic, almost all

examinations are considered “rarely appropriate” or “may be appropriate” except for patients who have had incomplete revascularization (4). Stress tests are considered “appropriate” or “may be appropriate” for patients who have undergone incomplete revascularization, but anatomical imaging is considered “rarely appropriate” (Table 6). If the patient is symptomatic and is considered to be ischemic equivalent, almost all examinations are found to be “appropriate” or “may be appropriate”, except for calcium scoring (Table 5).

### AUC for patients at pre-operative evaluation for noncardiac surgery

Appropriate indications of the modalities for patients at a pre-operative evaluation for noncardiac surgery are limited only for a specific condition especially for patients with poor or unknown functional capacity (<4 METs) (Table 7). Only

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**Table 5** Post-revascularization (PCI or CABG): symptomatic (ischemic equivalent)

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Evaluation of ischemic equivalent	M	A	A	A	R	M	A

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

**Table 6** Post-revascularization (PCI or CABG): asymptomatic (without ischemic equivalent)

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Incomplete revascularization							
● Additional revascularization feasible	M	A	A	M	R	R	R
● Prior left main coronary stent	M	M	M	M	R	M	M
● <5 years after CABG	R	R	R	R	R	R	R
● ≥5 years after CABG	M	M	M	M	R	R	R
● <2 years after PCI	R	R	R	R	R	R	R
● ≥2 years after PCI	M	M	M	M	R	R	R

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CABG: coronary artery bypass graft, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, PCI: percutaneous coronary intervention, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

**Table 7** Pre-operative evaluation for noncardiac surgery: poor or unknown functional capacity (<4 METs)

Indication	Exercise ECG	Stress RNI	Stress Echo	Stress CMR	Calcium Scoring	CCTA	Invasive Coronary Angiography
● Low-risk surgery							
● ≥1 clinical risk factor	R	R	R	R	R	R	R
● Intermediate-risk surgery							
● ≥1 clinical risk factor	M	M	M	M	R	R	R
● Vascular surgery							
● ≥1 clinical risk factor	M	A	A	M	R	R	R
● Kidney transplant	M	A	A	M	R	R	M
● Liver transplant	M	A	A	M	R	R	M

A: Appropriate, M: May Be Appropriate, R: Rarely Appropriate, CCTA: coronary computed tomography angiography, CMR: cardiac magnetic resonance, ECG: electrocardiogram, Echo: echocardiography, RNI: radionuclide imaging.

Modified from Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease (3).

stress RNI and stress echocardiography are found to be appropriate when patients are scheduled for vascular surgery and have one or more clinical risk factors, have undergone a kidney transplant, or have undergone a liver transplant (4). For the other indications, all the modalities are considered “rarely appropriate” or “may be appropriate”.

### Japanese clinical guideline for noninvasive diagnosis of coronary artery disease

A guideline for noninvasive diagnosis of coronary artery disease has been published in Japan (1). The diagnostic algorithm is provided for diagnosis of stable ischemic heart

disease.

At first, if the patient is able to exercise and is symptomatic, exercise ECG is recommended. According to the results of the exercise ECG, the patient is stratified into one of three categories: low-risk, intermediate-risk, or high-risk group. Patients in the high-risk group are recommended for invasive coronary angiography. Other non-invasive imaging modalities are recommended for patients in the intermediate-risk group. For patients in the intermediate-risk group, stress RNI and CCTA are treated as almost the same importance although both modalities represent different information (1).

## Discussion

The current article represents the introduction of “2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease”. Although there are some discordances in patient care between the United States and Japan, this AUC may provide useful insights for our clinical decision-making.

### Functional test and anatomical test

The AUC seems to emphasize the difference between functional tests and anatomical tests for selecting the most appropriate modality. Functional tests, including stress RNI and stress echocardiography, appear to be appropriate tests not only for patients with low or intermediate risk but also for patients with high-risk. On the other hand, anatomical tests, including CCTA and invasive coronary angiography, are considered “appropriate” only for high-risk patients or when a prior stress test indicated abnormal findings. However, in the Japanese guideline, stress RNI and CCTA are regarded as important modalities, and appear to be treated as almost the same importance (1). Although several requirements are clearly mentioned for performing CCTA, the number of CCTA is rapidly growing recently in Japan (14). Information on the angiographic severity of coronary artery stenosis is needed especially for making the strategy of coronary revascularization. However, functional tests are able to assess physiological changes and predict future cardiac events (15, 16). In fact, physiological change of coronary stenosis has recently been emphasized for the management of stable ischemic heart disease patients (17,18). Although anatomical tests and functional tests are complementary modalities, functional tests are thought to be more important for patients’ risk assessment especially in the initial evaluation.

### Future perspective

Cardiac CT is now able to evaluate not only the anatomy of the coronary artery but also myocardial perfusion (19). This technique provides powerful information of the coronary anatomy and coronary perfusion by one modality. Furthermore, fractional flow reserve, calculated by CCTA, may also enable appropriate therapeutic decision making (20). Cardiac PET is also an important modality for evaluating myocardial perfusion (21,22). Cardiac PET is able to evaluate absolute myocardial blood flow (MBF) and myocardial flow reserve (MFR), estimated by the ratio of hyperemic MBF and rest MBF. MFR is utilized for patients’ risk assessment and is expected for evaluating multivessel coronary disease (23). Furthermore, CFR is able to predict patients’ prognosis superior to fractional flow reserve measured by an invasive coronary catheterization (24). These techniques are desired to

spread widely in clinical practice.

### Conclusion

In conclusion, the AUC is an important statement for the selection of an appropriate modality for patients with stable ischemic heart disease. Although the AUC is made based on the patient’s medical backgrounds in the United States, the AUC is helpful for us to determine clinical decision-making.

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### Conflicts of interest

None

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