ASNC imaging guidelines for nuclear cardiology procedures

Standardized reporting of nuclear cardiology procedures

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Abbreviations

AUC	Appropriate use criteria
CAD	Coronary artery disease
ECG	Electrocardiogram
LV	Left ventricular
LVEF	Left ventricular ejection fraction
METS	Metabolic equivalents
MPHR	Maximal predicted heart rate
PET	Positron emission tomography
RV	Right ventricle
SPECT	Single-photon emission computed tomography

INTRODUCTION

The American Society of Nuclear Cardiology (ASNC) published a guideline for the reporting of myocardial perfusion imaging (MPI) in 2009.[1] Over the last eight years there has been significant change in the breadth and depth of nuclear cardiology practice along with significant changes in the landscape of structured reporting. In consideration of this degree of change, it is appropriate that the guideline be updated and expanded to include a broader perspective of nuclear cardiology practice. At the same time, many things have not changed. This includes the fact that the report should provide a basic ''bottom line'' result to the referring physician and that this result must be clear and concise.[2-4] This premise was expanded on by the American College of Radiology (ACR) with its development of a reporting and communication guideline with continued recent updates.[5] All these documents emphasized the need for a defined structure containing standardized data elements to facilitate utilization of the complex data contained in an imaging report into the integrated healthcare of the patient through the electronic health record. The structured report is also an integral part to define quality in nuclear cardiology practices. There continues to be interest in the implementation of structured reporting as a mechanism to improve quality and outcomes and to reduce cost in fulfillment of the triple aim.

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Since the publication of the prior guideline there have been significant developments in the field of nuclear cardiology. Examples of this include the development of the ImageGuide™ Registry by ASNC, the development of additional registries for imaging internationally, the expansion of nuclear cardiology into greater utilization of positron emission tomography (PET) imaging, and new protocols for imaging inflammation, viability, and innervation.[6] These additional areas of interest will be addressed in this updated guideline for nuclear cardiology procedure reporting in contrast to the prior document that was limited to perfusion imaging only.[1] There is also new emphasis on the concept of interpreting the interpretation. Research regarding this important aspect of result utilization has focused on how the referring physician incorporates the report data to affect care and the differences between the referring physicians approach and the imaging physicians anticipated response to the report.[7] This will become an increasingly important area of information science in the future. To help meet the needs of the referring physician, the appearance of a standardized report can and should vary from user to user. There should not be a single standard appearance of a report but one that best conveys the content to the end user. This may be in paragraph form for some laboratories while others might use a table or even a list of structured data elements. All would meet the guidelines for structured reporting as they are derived from defined structured data elements as outlined in this guideline.[1,8]

An essential part of structured reporting is the ability to use and incorporate other standards to facilitate data sharing among many different sources. These standards include the Digital Imaging and Communications in Medicine (DICOM) and the Integrating the Healthcare Enterprise (IHE) standards. The DICOM standard for stress reporting includes the data elements for structured nuclear cardiology reporting.[9,10] The use of the DICOM elements has been integral to the clinical implementation of reporting software by both developers and manufacturers. This is supported through the utilization of the IHE standards for communication of data among different vendor systems and single and multimodality imaging environments.[11,12] The data from this new IHE standard have been incorporated into this document.

Two important documents were utilized in the development of the first nuclear cardiology myocardial perfusion imaging reporting standard and remain important and relevant today. The American College of Cardiology (ACC) ''Health Policy Statement on Structured Reporting and Cardiovascular Imaging'' and the ''Key Data Elements and Definitions for Cardiac Imaging: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Data Standards'' remain as sentinel documents and facilitate the reporting of imaging studies in multimodality environments.[13,14] In addition to the ACC documents, the European Association of Nuclear Medicine and the European Association of Cardiovascular Imaging have published a guideline regarding reporting nuclear cardiology.[15] This important guideline addresses an update to the standards and serves as a guidepost as we move forward to standardized structured reporting internationally. The development of the ImageGuide™ Registry for myocardial perfusion imaging has also been the cause for some redefinition of the data elements that were present in the prior version of the myocardial perfusion imaging study reporting standard. This updated image reporting guideline incorporates and harmonizes the recommendations of all these guidelines and unifies ASNC documents that have been published since the prior reporting guideline.

As with the prior document, this guideline consists of tables composed of the variables, their description (i.e., text, numeric, date), priority (i.e., required, recommended, or optional), and the allowed response(s). With regards to the allowed responses to numerical values, the writing group acknowledges that different units of measurement can be used to express the same value, such as millicuries (mCi) and megabecquerels (MBq). As this guideline is intended for international use, both traditional English units of measure and their metric equivalents are acceptable responses. It is required, however, that the user be consistent throughout the report regarding the system of units utilized. Acceptable units of measure are outlined in Appendix 1. As the structured report may be used to populate data in registries, such as ImageGuide™, it is a requirement of the registry submission process to provide the appropriate conversion factors from the structured report data to assure compliance with the allowed format from the registry's data dictionary. Finally, examples of sample structured reports from numerous laboratories around the United States are incorporated in the appendix as a resource for the reader.

As was noted in the prior document, ASNC continues to support the mandatory use of structured reporting as a mechanism to improve the communication and reporting of nuclear cardiology reports. This

has begun to be incorporated into the laboratory accreditation process, and there has been significant improvement over the course of eight years. There remain significant areas for improvement, particularly with regards to defect size and severity, and consistent reporting of these important variables.[16] This guideline is designed to provide imaging physicians and technologists the necessary information to report nuclear cardiology procedures in a structured format using standardized data elements. While the content of the document has been carefully reviewed by many experts, the document should not be considered as a source of medical advice or professional service.

Table of Contents for Structured Data Elements

Site administrative data	Table 1
Study demographics	
Patient demographics and study referral data	Table 2
Clinical Information	Table 3
Appropriate use reporting	
Study description	
Stress testing data	Table 4
Resting ECG data	Table 5
Stress ECG data	Table 6
Imaging data	
Imaging parameters	Table 7
Additional imaging parameters specific to viability studies	Table 8
Imaging parameters specific for inflammation/infection	Table 9
Imaging parameters for Tc-99m PYP	Table 10
Qualitative LV perfusion assessment (SPECT and PET)	Table 11
Quantitative LV perfusion assessment (SPECT and PET)	Table 12
LV gated function volume assessment at stress	Table 13
LV gated functional and volume assessment at rest	Table 14
Additional PET-specific LV perfusion and function parameters	Table 15
Right ventricular perfusion and function parameters	Table 16
Miscellaneous data	Table 17
FPRNA/ERNA (rest and exercise)	Table 18
Viability—qualitative analysis	Table 19
Viability—quantitative analysis	Table 20
Inflammation/Infection—qualitative parameters	Table 21
Inflammation/Infection—quantitative parameters	Table 22
*m*IBG analysis parameters	Table 23
Tc-99m PYP analysis parameters	Table 24
Coronary artery calcium score analysis parameters	Table 25
Overall impression	Table 26
Combined conclusion	Table 27
Comparison to prior studies	Table 28
ImageGuide Registry CMS reported performance measures	Table 29

ECG, electrocardiographic; *LV*, left ventricular; *RV*, right ventricular; *FPRNA*, first-pass radionuclide angiography; *ERNA*, equilibrium radionuclide angiocardiography

STRUCTURED REPORTING

Components of the Report

According to the ''Health Policy Statement on Structured Reporting in Cardiovascular Imaging,''[13] the standard components of a report include the following major headings: Administrative Information, Patient Demographics, Study Referral Data, History and Risk Factors, Study Description, Study Findings, and other reporting parameters. These elements are outlined in detail in ''Key Data Elements and Definitions for Cardiac Imaging: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Data Standards,''[14] which addresses specific details for each of these major headings for multiple cardiac imaging modalities and these remain unchanged from the prior document.

A few of the general data elements, and many of the specific data elements, may be recorded at the time that the test is performed. Some elements may not be required in the final report. This may be the case for some fields that are required for quality reporting, but not necessarily for reporting the findings from an individual patient's study for specific patient management.

Many different structured reports can be generated from a set of structured data. The potential reports include: a clinical patient-specific report, summary quality report, billing report, reporting the data to registries, and other reports as needed. The greatest strength to structured data utilization is the ability to generate multiple report formats with varying levels of detail depending on the clinical or administrative need.

This document will harmonize these generalized concepts and apply them specifically to nuclear

cardiology. Due to the variability of the study types encompassed by this document, some of the data elements are specific to certain types of acquisitions, or are dependent upon the study indication (e.g., viability determination by PET imaging). Therefore, some data elements may be required for certain acquisitions and clinical indications, while some may be optional or perhaps irrelevant for other indications.

A number of the data elements contained in the tables have been derived from, and harmonized with, other guideline documents, some multisocietal and others ASNC-specific.[3,4,17-21] This update also addresses additional modalities that were not included in the prior versions of the document, such as: broader treatment of PET and viability, and non-perfusion imaging including amyloid detection, inflammation/infection, MIBG in heart failure and coronary calcium scoring, and its incorporation into the nuclear cardiology report. The data elements required for reporting the additional modalities have been added to specific tables where appropriate or additional tables have been added to the document to cover those items that were specific to the modality and could not be generalized to one of the existing table headings. Finally, a perspective on the future direction of nuclear cardiology reporting has been included as a guidepost for the future.

Site Administrative Data

The Site Administrative Data section of the report is the descriptor of the site performing the study. It includes elements such as the physical address, accreditation status, type of facility (e.g., hospital or office), and insurance payer. These data may only need to be collected as part of the reporting process, and some elements may not be recorded in the final report. Some elements may be necessary to inform registry submission of the data and as part of the quality initiatives as we transition from volume-to-value-based practice (Table 1).

Patient Demographics and Study Referral

The Patient Demographics and Study Referral data section provides the clinical indications for the study, information regarding the referring and interpreting provider in addition to the necessary demographic information that could impact the clinical outcomes of the study. Indications to be considered include the following major areas: diagnosis of coronary artery disease (CAD), extent and severity of known CAD, risk stratification including peri-operative risk, determination of viability, assessment of acute chest pain syndromes, evaluation of structural heart disease, and heart failure. The table also allows for a secondary indication to be selected. With the inclusion of the History and Risk Factors section, this would complete the data elements contained in Tables 2 and 3.

The specific purpose for which the test is being performed must be clearly identified. This provides the required documentation for the medical necessity of the study and focuses the report on the question asked by the referring physician. The structured data elements that relate to the indication are in Table 3. The structured reports must contain sufficient information from these areas to ensure correct identification of the patient. The reports must also convey the specific indications for the study and the pertinent portions of the clinical history that allow the caregivers to appropriately place the imaging results in clinical context. This would include the patient's current symptoms or other indication for which the study is being performed, current medications, cardiac history with pertinent risk factors including risk factoring scoring, and prior testing, and therapeutic procedures.

Appropriate Use Reporting

Greater emphasis including elevating to required status for reporting AUC has been a significant change in this document. In response to rapid and unsustainable growth in utilization of radionuclide MPI, professional medical organizations developed appropriate use criteria (AUC) to guide physicians and payers on the effective use of these procedures.[26] Based on symptoms, coronary risk factors, and cardiac history, the AUC classifies testing across a range of clinical scenarios in three categories: appropriate (established value), may be appropriate (uncertain value), and rarely appropriate (no clear value).[25] A significant body of literature demonstrated that appropriate MPI use enhances its acumen in risk stratification, reduces radiation risk, and improves its clinical value.[27-33] Physicians are faced with multiple, occasionally discordant, AUC from different organizations. For example, there is substantial discordance between the multimodality AUC for the detection and risk assessment of stable ischemic heart disease developed by the American College of Cardiology, ASNC, and several other societies and the Appropriateness Criteria set forth by the American College of Radiology (ACR). ASNC recommends the AUC promulgated by the ACC as they are best validated and have been shown to be more effective in guiding providers toward patients with greater potential for myocardial ischemia than the ACR Appropriateness Criteria.[34]

Table 1. Site administrative data

Variable	Description	Datatype	Priority	Response
Site ID	Site ID for national identification	Numerical	Required	XXXXXX
Site of service	Type of facility	Text	Optional	Hospital—inpatient Hospital—outpatient Non-hospital—inpatient Non-hospital—outpatient Mobile-based—inpatient Mobile-based—outpatient
Practice/hospital name	Name of practice or hospital	Text	Required	Variable
Location of imaging study	Imaging facility address	Text	Required	Variable
Imaging facility phone number	Imaging facility phone number	Numerical	Recommended	XX-XXX-XXX-XXXX
Accreditation status	Accreditation status of facility	Text	Recommended	Yes No Application submitted
Accreditation entity	Accreditation entity	Text	Recommended	ACR IAC Nuclear/PET TJC RadSite Other

ID, identification; *ACR*, American College of Radiology; *IAC Nuclear/PET*, Intersocietal Accreditation Commission Nuclear/PET; *TJC*, The Joint Commission

For the past decade, AUC has been promoted as a tool to optimize value of imaging studies. Many health organizations have implemented measures to reduce rarely appropriate studies as an academic or quality improvement exercise. Despite the importance of AUC in the clinical domain, documentation of adherence to AUC in the clinical reports has not been required or widely performed. This will change soon. The Centers for Medicare and Medicaid (CMS) is in the process of implementing §218 of Protecting Access to Medicare Act (PAMA) of 2014. As of 2018, this legislation will require the ordering physician to consult AUC using a CMS-approved, computer-based decision support tool (DST) when ordering MPI studies.[35] Thus far, CMS has approved many qualified professional organizations that have developed or endorsed applicable AUC; among these, the ACC's AUC.[25] CMS finalized eight ''priority clinical areas,'' which will be used to benchmark providers according to their use of rarely appropriate imaging procedures. These clinical areas include suspected or diagnosed coronary artery disease, suspected pulmonary embolism, headache, hip pain, low back pain, shoulder pain, suspected or diagnosed lung cancer, and neck pain. Suspected or known CAD being a ''priority clinical area,'' the majority of MPI studies will be used to benchmark the ordering physician.[35] Based on PAMA, the imaging specialists will not be paid for their services if they do not have documentation that the ordering physician consulted an AUC DST. After collecting two years of data in the aforementioned eight priority clinical areas, referring physicians who are considered ''outliers'' in terms of their utilization of rarely appropriate MPI will be subjected to prior authorization when ordering MPI studies. As a result, there will be a massive shift wherein the burden of reducing inappropriate use will move largely from payers to providers.[36] Imaging specialists, practicing physicians, and health organizations need to adapt to meet this requirement. Nuclear cardiologist need to find practical ways to obtain and document AUC determination, as discerned by a CMS-approved DST used by the ordering physician.

Table 2. Patient demographics and study referral data

Variable	Description	Datatype	Priority	Response
GUID	Globally unique identifier	Text	Required	36 positions (32 digits plus 4 dashes) (0–9 and a–f) e.g., d28d6188-41e8-47f6-b0b9-3a2b36377c61
MRN	Medical record number	Alphanumeric	Required	
Patient DOB	Date of birth	Numerical	Required	mm/dd/yyyy
Patient zip code	Zip code for home address	Numerical	Recommended	XXXXX Other (e.g., International zip code)
Sex	Patient gender at birth	Text	Recommended	Male Female Unknown
Patient hospitalized	Patient status at time of study	Text	Optional	Ambulatory Inpatient Observation/ER
Study completion date and time	Imaging component completed	Date/Time	Required	mm/dd/yyyy hh:mm
First name	Patient first name	Text	Required	Variable
Last name	Patient last name	Text	Required	Variable
Weight	Patient weight	Numerical	Required	Value in units (XXX.XX)
Height	Patient height	Numerical	Required	Value in units (XXX.XX)
Chest circumference	Chest circumference	Numerical	Optional	Value in units (XXX.XX)
Bra cup size	Bra cup size	Text	Optional	Variable
Ethnicity	Ethnic origin	Text	Recommended	Hispanic or Latino Not Hispanic or Latino
Race	Patient race (multi-select)	Text	Optional	American Indian/Alaskan native Asian Black/African American Native Hawaiian/Pacific Islander White

Table 2. continued

Variable	Description	Datatype	Priority	Response
Insurance payer	Insurance payer for current study (multi-select)	Text	Recommended	Indian Health Service Medicaid Medicare Medicare advantage Military healthcare Non-US insurance Private health insurance State-specific plan (non-Medicaid) None
Referring provider first name	Referring provider first name	Text	Recommended	Variable
Referring provider middle name	Referring provider middle name	Text	Recommended	Variable
Referring provider last name	Referring provider last name	Text	Required	Variable
Referring provider NPI number	Referring provider NPI number	Numeric	Recommended	XXXXXXXXXX
Interpreting provider first name	Interpreting provider first name	Text	Required	Variable
Interpreting provider middle name	Interpreting provider middle name	Text	Recommended	Variable
Interpreting provider last name	Interpreting provider last name	Text	Required	Variable
Interpreting provider NPI number	Interpreting provider NPI number	Numeric	Required	XXXXXXXXXX
Quantitative package provider	Quantitative software manufacturer used to process study	Text	Optional	Cedars-Sinai Digisonics GE Generic INVIA Philips Positron Siemens Syntermed Other

Table 2. continued

Variable	Description	Datatype	Priority	Response
Interpreting MD board certification	Name of board	Text	Optional	Cardiovascular disease Radiology Nuclear medicine Other None
Physician subspecialty certification	Name of certifying board	Text	Optional	CBNC ABNM ACR certificate of added qualification
Interpretation date and time	Date of interpretation	Date/Time	Required	00/00/0000 hh:mm
Signature date and time	Date of transcription	Date/Time	Required	00/00/0000 hh:mm

DOB, date of birth; *GUID*, Globally Unique Identifier; *ID*, identification; *MD*, physician or doctor of medicine; *MRN*, medical record number; *CBNC*, Certification Board of Nuclear Cardiology; *ABNM*, American Board of Nuclear Medicine; *ACR*, American College of Radiology

Study Description

The Study Description should be the next section of the structured report. This section should include all the parameters used in acquiring the study. It must include a description of the stress test performed, including the type of stress test (i.e., exercise or pharmacologic). For stress tests, it is necessary to include the type of protocol, duration of exercise, and its adequacy as determined by exercise time, peak heart rate, percent maximal predicted heart rate (MPHR), pressure rate product (PRP), and estimated metabolic equivalents (METS). For pharmacologic stress tests, the pharmacologic agent used, the dose received, including the infusion rate and duration, hemodynamic response to the dose, and use of adjunctive exercise must be documented. If pharmacologic stress is performed after attempted exercise, exercise parameters should be reported in addition to pharmacologic parameters. The time of administration of radioactivity is also required for either modality. The specific data elements for this section as well as their responses are found in Table 4.

The electrocardiographic (ECG) data pertinent to the test should be reported next. This would include the presence of any baseline ECG abnormalities that might preclude a conclusive interpretation of the ECG stress portion of the test (Table 5).

The stress ECG interpretation must evaluate the parameters defined in Table 6, commenting on any changes from baseline with regards to either the ST segments or onset of arrhythmias. Comparison to prior tests and inclusion of parameters that allow calculation of validated risk scores (e.g., the Duke treadmill score)[37] are recommended. Ideally, Stress ECG data would be presented in a tabular format, with documentation of many of the following variables at each stage of stress and recovery.

The structured report format continues with variables that define the imaging process including the protocol utilized, the patient position, and radiopharmaceutical doses administered to the patient. It also includes their time of administration and whether attenuation correction or other modalities were used. These data elements are presented in detail in Tables 7, 8, 9, and 10.

Following the section on imaging parameters, the left ventricular (LV) perfusion results should be provided. The results will differ slightly for SPECT vs PET MPI. Every qualitative assessment of LV perfusion should include a summary that provides an overall statement of LV perfusion abnormality. This should be followed by the size, location, severity, and degree of reversibility of any perfusion defects as shown in Table 11. Perfusion defect location should be described according to the standardized 17-segment model

Table 3. Clinical information

Variable	Description	Datatype	Priority	Response
Primary indication	Primary study indication	Text	Required	Abnormal electrocardiogram Abnormal stress test Angina or angina equivalent Arrhythmia Assessing functional significance of known CAD Assessment of symptoms with suspected cardiac etiology Assessment of ventricular function Cardiac morphology (including cardiac mass) Chest pain Claudication Congenital heart disease Coronary artery disease* Coronary risk factors Dyspnea/SOB Evaluation for cardiomyopathy Evaluation for valvular heart disease Heart failure History of CABG History of PCI Hypertension Hypotension Initial detection/risk assessment of CAD Palpitations Pericardial disease Preoperative evaluation within 30 days preceding low-risk non-cardiac surgery Preoperative evaluation within 30 days preceding non-cardiac surgery. (Note: If this value is selected, also note the type of non-cardiac surgery.) Syncope Viability Not provided Other (If this value is selected, complete the Other text field.)

Table 3. continued

Variable	Description	Datatype	Priority	Response
Secondary indication	Secondary study indication(s) (multi-select)	Text	Required	Abnormal electrocardiogram Abnormal stress test Angina or anginal equivalent Arrhythmia Assessing functional significance of known CAD Assessment of symptoms with suspected cardiac etiology Assessment of ventricular function Cardiac morphology (including cardiac mass) Chest pain Claudication Congenital heart disease Coronary artery disease Coronary risk factors Dyspnea/SOB Evaluation for cardiomyopathy Evaluation for valvular heart disease Heart failure History of CABG History of PCI Hypertension Hypotension Initial detection/risk assessment of CAD Palpitations Pericardial disease Preoperative evaluation within 30 days preceding low-risk non-cardiac surgery Preoperative evaluation 30 days preceding non-cardiac surgery. (If this value is selected, also note the type of non-cardiac surgery.) Syncope Viability Not provided Other (if this value is selected, complete the Other text field.)

Table 3. continued

Variable	Description	Datatype	Priority	Response
Pretest chest pain	Type of chest pain	Text	Required for perfusion viability otherwise recommended	Typical angina Atypical angina Non-anginal chest pain Anginal equivalent No chest pain
Medications	Medications (multi-select)	Text	Recommended	ACE/ARB Aminophylline or theophylline Antiarrhythmics Anticoagulant Aspirin, other antiplatelet agents Beta blocker Ca^{++} blocker Diabetic medications Digoxin Dipyridamole Diuretics Erectile dysfunction medication Inhaler Lipid-lowering agents Metformin Neprilysin inhibitor Nitrates Other anti-hypertensives Ranolazine None

Table 3. continued

Variable	Description	Datatype	Priority	Response
Test medications	Medications taken on day of test (multi-select)	Text	Recommended	ACE/ARB Aminophylline or theophylline Antiarrhythmics Anticoagulant Aspirin, other antiplatelet agents Beta blocker Ca^{++} blocker Diabetic medications Digoxin Dipyridamole Diuretics Erectile dysfunction medication Inhaler Lipid-lowering agents Metformin Neprilysin inhibitor Nitrates Other anti-hypertensives Ranolazine None
Cardiac risk factors	Risk factors (multi-select)	Text	Recom -mended	Chronic kidney disease Diabetes Erectile dysfunction Family history Hypercholesterolemia Hypertension Metabolic syndrome Obesity Obstructive Sleep Apnea Peripheral vascular disease Smoking

Table 3. continued

Variable	Description	Datatype	Priority	Response
Cardiac history	Cardiac history (multi-select)	Text	Recommended	s/p PCI/stent s/p CABG s/p MI History of peripheral vascular disease Arrhythmia Heart failure s/p heart transplant Other
Risk score patients without chest pain	Calculated risk score	Text	Optional	Low (<10% 10-year risk) Intermediate (10%-20% 10-year risk) High (>20% 10-year risk or a coronary risk equivalent as defined by ATP III/NCEP [diabetes, PAD, etc.]) Not applicable
Risk score utilized	Calculated Risk score	Text	Optional	Framingham[22] ATP III ASCVD Pooled cohort Other
Pretest probability of CAD—patients with chest pain	Diamond and Forrester calculation[23]	Text	Optional	Low (<10%) Intermediate (10%-90%) High (>90%) Known CAD Not applicable
Chest pain symptom stability	History of chest pain pattern	Text	Optional	Stable Worsening
Prior testing	Prior cardiac testing (multi-select)	Text	Recommended	ETT

Table 3. continued

Variable	Description	Datatype	Priority	Response
				Perfusion imaging Stress echo Catheterization MRI CT Inflammation imaging Sarcoid imaging Amyloid imaging FPRNA ERNA PET Unknown None
Date of prior testing	Date of prior cardiac testing	Date	Recom -mended	mm/dd/yyyy
HDL cholesterol	HDL cholesterol level	Numerical	Optional	XX units
LDL cholesterol	HDL cholesterol level	Numerical	Optional	XX units
Total cholesterol	Total cholesterol level	Numerical	Optional	XXX units
Appropriate use criteria	Appropriate use criteria indication	Text	Required	Appropriate (Indication xx) Maybe appropriate Seldom appropriate
Appropriate use criteria utilized	Appropriate use criteria utilized	Text	Required	CMS-approved AUC**
Comments		Text	Optional	Free text comments

SOB, shortness of breath; *CABG*, coronary artery bypass grafting; *PCI*, percutaneous coronary intervention; *CAD*, coronary artery disease; *ACE*, angiotensin-converting enzyme; *ARB*, angiotensin receptor blocker; *MI*, myocardial infarction; *ATP III,* Adult Treatment Panel III; *NCEP,* National Cholesterol Education Panel; *PAD,* peripheral artery disease; *ETT*, exercise tolerance test; *MRI*, magnetic resonance imaging; *CT*, computed tomography; *FPRNA,* first-pass radionuclide angiography; *ERNA,* equilibrium radionuclide angiocardiography; *PET,* positron emission tomography

* CAD definition: Known significant narrowing of the coronary arteries with or without obstruction; treated CAD is also included

** Please see approved CMS website for updated information[24]; ASNC recommends the 2013 multisocietal multimodality Appropriate Use Criteria for the detection and risk assessment of stable ischemic heart disease.[25]

(Appendix 6). This pattern can be repeated for multiple perfusion abnormalities. Inclusion of a bulls-eye polar plot showing the location and degree of perfusion defects can aid in visualization. The associated segmental function of myocardium with a perfusion defect can inform the clinical interpretation. A clinical interpretation of each perfusion defect provided in this portion of the report can help increase clarity (ischemia, infarction, peri-infarct ischemia). Any uncertainty can be reported here. For instance, probable ischemia (vs artifact) can be selected when perfusion is probably abnormal or probable artifact can be chosen if perfusion is categorized as probably normal. Classification of the perfusion defect as visual only, quantitative only, or visual and quantitative is optional but provides additional information on the degree of evidence to support the conclusions made. The presence or absence of transient ischemic dilation (TID) is a required element and can also be classified as visual, quantitative, or both. Reporting of the stress and rest perfusion cavity sizes and ratio of these two parameters (the TID ratio) are optional. The presence of normal LV tracer uptake and myocardial wall thickness vs increased values in the setting of LV hypertrophy should be documented. Finally, increased tracer uptake in the right ventricle and the lungs at stress and rest can be reported.

Quantitative image processing for LV perfusion is recommended, with suggested data elements outlined in Table 12. Each segmental score should be adjusted for attenuation prior to calculation. No segment should have a negative score. The derived extents of perfusion and ischemia require division of the respective SSS, SRS, and SDS by 68, the maximal perfusion score of 4 across all 17 segments.

Stress and/or rest-gated imaging should be performed when technically feasible. LV global and segmental function and volumes should be reported as detailed in Tables 13 and 14. The timing of stress function assessment (during stress [i.e., first-pass], post-stress, rest) is recommended. The following values can be repeated for each phase assessed (stress and rest). An overall assessment of global LV function is required, and the calculated left ventricular ejection fraction (LVEF) should be provided. Segmental functional abnormalities can be described both by regional thickening and wall motion. Severity should be described by location according to the 17-segment model.[17] Numerical documentation of LV volumes and/or volume indices and subjective assessment of the LV cavity sizes at both end-diastole and end-systole are optional. The information in these tables may be repeated as required to describe multiple perfusion defects.

LV perfusion and function assessment by PET has additional parameters not typically assessed in SPECT studies that can be reported as shown in Table 15. Stress and rest myocardial blood flow (MBF) can be quantitated during PET MPI and can provide additional information on LV perfusion. Values are typically provided for stress and rest globally and by coronary perfusion territory (left anterior descending [LAD], left circumflex [LCX], right coronary artery [RCA]). The ratio of stress to rest flow is defined as the myocardial flow reserve. Stress MBF and MFR can be classified as preserved (>2 mL/min/g), mildly reduced (1.5˜2 mL/min/g), or severely reduced (<1.5 mL/min/g).[20] Thresholds for MBF and MFR can vary by protocol and lab. The calculation of a true stress LVEF during vasodilator stress has led to calculation of LVEF reserve, the difference between stress and rest LVEFs that has diagnostic and prognostic significance. An LVEF reserve <0%, indicating a drop in LVEF with stress, has diagnostic and prognostic significance and can be optionally reported.[38]

SPECT and PET MPI also allow interpretation of the perfusion, size, and global and segmental function of the right ventricle (RV). Data elements for this assessment are provided in Table 16. These parameters are not typically reported unless abnormal or in the presence of specific indications for their assessment.

There are several miscellaneous factors that should be present in the report and will be detailed in Table 17. Comment on the overall study quality can assist in study interpretation and serve as a quality reporting mechanism for the nuclear laboratory. Appreciated artifacts seen on the primary MPI images and CT attenuation

Table 4. Stress testing data

Variable	Description	Datatype	Priority	Response
Test type	Type of test	Text	Required	Rest Exercise Pharmacologic Pharmacologic conversion with prior attempt at exercise Pharmacologic with fixed low-level exercise Other
Pharmacologic stress agent	Pharmacologic stress agent	Text	Required	Adenosine Atropine Dipyridamole Dobutamine Dobutamine and Atropine Regadenoson Adenosine Triphosphate* Other
Indication for pharmacologic stress	Reason exercise only is not appropriate	Text	Required	LBBB or pacemaker PET Inability to exercise adequately Unable to exercise Other
Pharmacologic stress dose	Pharmacologic stress dose	Text	Required	Units
Pharmacologic stress time	Time to deliver pharmacologic stress dose	Numerical	Required	XX:XX min:sec
Pharmacologic stress exercise	Adjunctive low-level exercise use	Text	Required	Yes No
Estimated ability to exercise	Pretest estimate of ability to exercise based on daily activities	Test	Recommended	Less than 4 METS Greater than or equal to 4 METS

Table 4 continued

Variable	Description	Datatype	Priority	Response
Exercise protocol	Exercise protocol used	Text	Required	Arm ergometry Bicycle ergometer Bruce Fixed low level for use in combination with vasodilating agents Modified Bruce Modified Naughton Naughton Ramp Other
Resting HR	Resting HR	Numerical	Required	Beats/minute
Resting BP	Resting BP	Numerical	Required	mm Hg
Stress HR	Maximum HR achieved	Numerical	Required	Beats/minute
HR Response to exercise	HR response to exercise	Text	Recommended	Normal Blunted Accentuated
HR Response to vasodilator stress	% change in HR from baseline to peak (Max HR − Baseline HR)/Baseline HR	Numerical	Optional	Normal Blunted
Heart rate recovery	Heart rate recovery at 1 min	Text	Optional	Normal (>12 bpm) Abnormal (<12 bpm)
% MPHR	% of MPHR	Numerical	Required	%
Stress BP	Peak BP achieved during test	Numerical	Required	mm Hg
BP response	BP response to exercise	Text	Recommended	Blunted Hypertensive Hypotensive Normal
Pressure rate product	SBP × HR	Numerical	Optional	Adequate (≥25,000) Inadequate (<25,000)
Exercise duration	Time on treadmill/bicycle	Numerical	Required	Minutes (0.0 format)
Functional capacity	Exercise functional capacity	Text	Recommended	Average Below average Above average
METS	Peak estimated METS level	Numerical	Recommended	METS

Table 4 continued

Variable	Description	Datatype	Priority	Response
Anginal stress symptoms	Chest pain symptoms during stress	Text	Required	Typical angina Atypical angina Non-anginal chest pain Anginal equivalent No chest pain
Duration of symptoms	Duration of anginal stress symptoms	Numerical	Required if anginal stress symptom is present	XX:XX min:sec
Severity of anginal symptoms	Severity of anginal symptoms	Numerical	Required if anginal stress symptom is present	Numerical value on 1–10 scale (1, mild; 10, severe)
Other stress symptoms	Other symptoms during stress	Text	Recommended	Claudication Dizziness Dyspnea/SOB Fatigue Flushing Nausea Syncope
Reason for termination	Reason for termination	Text	Required	Achievement of target HR Arrhythmia Chest pain Claudication CNS symptoms Conduction abnormalities Drop in systolic blood pressure Dyspnea ECG changes End of protocol Fatigue Hypertension Hypotension Increasing chest pain Leg pain Moderate to severe angina

Table 4 continued

Variable	Description	Datatype	Priority	Response
				Mortality
				Non-CNS symptoms
				Patient request
				Procedure-related complication
				Reached target HR
				Signs of poor perfusion
				Technical problems
				Other

LBBB, left bundle branch block; *METS*, metabolic equivalents; *HR*, heart rate; *BPM*, beats per minute; *MPHR*, maximal predicted heart rate; *BP*, blood pressure; *ECG*, electrocardiographic
* Used internationally

correction images should be documented. Increased lung uptake can be commented on, particularly in the setting of Thallium administration. Finally, any incidental findings should be documented including from any associated CT attenuation correction images.

FPRNA and ERNA

FPRNA and ERNA utilize a number of variables included in other tables, such as those describing LV and RV function at rest and with exercise. Some variables, however, are not covered adequately and are not assignable to other existing tables. Table 18 describes the variables that are recommended for FPRNA and ERNA at rest or with exercise. The majority of the variables in Table 18 are optional, with the required elements noted at the top.

Viability Imaging

Viability reporting should detail imaging parameters including patient dietary state; glucose loading or use of the euglycemic-hyperinsulinemic clamp; radiopharmaceutical dose; time of viability imaging; and time delay from injection of radiopharmaceutical to imaging (Tables 7 and 8). Resting left and right ventricular perfusion and function should be described according to parameters listed in Tables 11, 12, 14, and 16.

Assessment of myocardial viability should include visual and quantitative analysis. Metabolism defects, perfusion/metabolism matched defects, and perfusion/metabolism mismatched defects must be described with regards to location, size, and severity.[20] The remaining elements in Table 19 are recommended for use in reporting myocardial viability.

The use of quantitative image elements (i.e., number of viable segments and extent of matched and mismatched defects) is also recommended. Table 20 outlines the quantitative data for myocardial viability.

Inflammation and Infection Imaging

Inflammation and infection imaging is based on increased glucose metabolism by activated immune cells.[39] In inflammatory conditions (e.g., cardiac sarcoidosis, myocarditis) and infection (e.g., endocarditis, cardiac implantable electrical device [CIED] infections), immune cell activation and infiltration into the myocardium can be visualized by uptake of F-18 FDG, a glucose analog. An important aspect of imaging infection and inflammation is suppression of physiological cardiomyocyte uptake of glucose, so upon injection of F-18 FDG, uptake of the radiopharmaceutical is limited

Table 5. Resting ECG data

Variable	Description	Datatype	Priority	Response
Rest rhythm	Resting ECG rhythm	Text	Required	Sinus rhythm Sinus bradycardia Sinus tachycardia Junctional rhythm Ectopic atrial rhythm Atrial fibrillation Atrial Flutter Atrial paced Ventricular paced AV sequential paced Other
Resting conduction	Resting AV conduction	Text	Required	Normal IVCD LBBB RBBB Incomplete RBBB Incomplete LBBB RBBB + LAFB RBBB + LPFB First-degree AV block Second-degree AV block Third-degree AV block Pre-excitation Other
Resting arrhythmias	Resting ECG arrhythmias	Text	Required	None APC VPC Non-sustained ventricular tachycardia
Repolarization	Resting ECG repolarization	Text	Required	Normal Early repolarization Non-specific ST-T abnormality ST depression ST elevation Secondary ST-T abnormality
ECG interpretable	Resting ECG able to be interpreted for ischemia*	Text	Recommended	Interpretable for ischemia Not interpretable for ischemia

HR, heart rate; *BP*, blood pressure; *ECG*, Electrocardiographic; *SVT*, supraventricular tachycardia; *AV*, atrioventricular; *IV*, intraventricular; *IVCD*, intraventricular conduction delay; *LBBB*, left bundle branch block; *RBBB*, right bundle branch block; *LAFB*, left anterior fascicular block; *LPFB*, left posterior fascicular block; *APC*, atrial premature contraction; *VPC*, ventricular premature contraction

* The absence of resting ST-segment changes, T wave changes, left bundle branch block (LBBB), pre-excitation (Wolf–Parkinson–White Syndrome), left ventricular hypertrophy, digoxin use, or paced rhythm, any of which would preclude the accurate interpretation of ischemic changes on the ECG

Table 6. Stress ECG data

Variable	Description	Datatype	Priority	Response
Stress rhythm	Stress ECG rhythm	Text	Required	Sinus rhythm Sinus bradycardia Sinus tachycardia Junctional rhythm SVT Ectopic atrial rhythm Atrial fibrillation Atrial flutter Atrial paced Ventricular paced AV sequential paced Other
Stress conduction	Stress ECG AV conduction	Text	Recommended	Normal IVCD LBBB RBBB Incomplete RBBB Incomplete LBBB Bifascicular block RBBB + LAFB RBBB + LPFB First-degree AV block Second-degree AV block Third-degree AV block
Stress arrhythmias	Stress-induced ECG arrhythmias	Text	Required	None APC VPC Atrial fibrillation SVT Non-sustained ventricular tachycardia Ventricular tachycardia Ventricular fibrillation

Table 6. continued

Variable	Description	Datatype	Priority	Response
Stress repolarization	Resting repolarization abnormalities	Text	Required	Normal Early repolarization Non-specific ST-T changes ST depression ST elevation Secondary ST-T changes
ST-segment change in each stage	ST-segment change in each stage	Text	Required	Normal Non-diagnostic low heart rate Non-diagnostic resting ST abnormalities Non-diagnostic V-pacing or LBBB
ST-segment depression amount in each stage	Millimeters of ST-segment change	Numerical	Required if ST-segment change is not normal	mm
Maximum ST-segment change	Maximum millimeters of ST-segment change	Numerical	Required if ST-segment change is not normal	mm
ST-segment configuration	Configuration of ST-segment change	Text	Required if ST-segment change is not normal	Horizontal Upsloping Downsloping Elevation
ST-segment location	Location of ST-segment change	Text	Required if ST-segment change is not normal	Anterior Inferior Lateral Septal Apical
Number of leads with ST-segment change	Number of leads with ST-segment change	Numerical	Required if ST-segment change is not normal	XX
Timing of ST-segment depression	Time when ST-segment depression occurs	Text	Required if ST-segment change is not normal	Stress only (minute or stage of exercise) Stress and recovery Recovery only
Timing of resolution of ST changes	Time when ST-segment depression returns to normal	Text	Recommended	Stress or recovery
Presence of Resolution of ST segments within 1 min	If ST segments resolve within 1 min	Text	Recommended	Rapid resolution of ST segments (decreases the specificity of the test)
ETT compared to prior-exercise tolerance	Comparison to prior ETT (METS)	Text	Recommended	Same Lower Higher

Table 6. continued

Variable	Description	Datatype	Priority	Response
ETT compared to prior-ST segment	Comparison of ST segment to prior test	Text	Recommended	No change New ischemia Resolution of ischemia Ischemia at higher workload Ischemia at lower workload
Duke treadmill score	Duke score	Numerical	Recommended	XXX
Duke treadmill score risk category	Duke prognosis	Text	Recommended (derived)	Low Moderate High
Heart rate recovery	Heart rate recovery	Text	Recommended (derived)	Normal Abnormal

ECG, electrocardiographic; *SVT*, supraventricular tachycardia; *AV*, atrioventricular; *IV*, intraventricular; *IVCD*, intraventricular conduction delay; *LBBB*, left bundle branch block; *RBBB*, right bundle branch block; *LAFB*, left anterior fascicular block; *LPFB*, left posterior fascicular block; *APC*, atrial premature contraction; *VPC*, ventricular premature contraction; *ETT*, exercise tolerance test; *METS*, metabolic equivalents

to inflammatory cells.[20,40] Reporting should include patient preparation relevant to the suppression of physiological cardiomyocyte glucose uptake as well as abnormal uptake of F-18 FDG (Table 21).

Assessment of myocardial inflammation includes both visual and quantitative analysis. For sarcoidosis imaging, rest perfusion imaging is required for co-localization of F-18 FDG images with the myocardium and to evaluate for the presence of active inflammation.[20,41] Current guidelines do not require myocardial perfusion images for the imaging of cardiovascular device or prosthetic infections.[20] Reporting of left ventricular resting perfusion should follow the recommendations set forth in Table 12 of this document. Table 21 lists the qualitative parameters recommended for use in reporting myocardial inflammation and/or infection. The use of quantitative measurements for myocardial uptake of F-18 FDG and for measurement of blood pool (background) activity is summarized in Table 22.

Iodine-123 *meta*Iodobenzylguanidine (I-123 *m*IBG) Imaging

Reporting metaiodobenzylguanidine (*m*IBG) imaging should include visual and quantitative analysis. Decreased *m*IBG uptake and heart-to-mediastinal ratio (HMR) are key components of I-123 *m*IBG imaging and should be clearly stated in the report.[42] Calculation of washout and specific localization of sympathetic activity defects may also be included.[43-45] The remaining elements in Table 23 are recommended for use in reporting *m*IBG imaging.

Tc-99m Pyrophosphate Imaging for Transthyretin Cardiac Amyloidosis

There is increasing use of Technetium 99m pyrophosphate (Tc-99m PYP) imaging to diagnose cardiac transthyretin amyloidosis (ATTR).[46,47] The American Society of Nuclear Cardiology published a Practice Points statement detailing the critical components of Tc-99m PYP imaging and reporting.[48] Reports should include semi-quantitative and quantitative analysis of cardiac uptake of Tc-99m PYP in addition to visual scan interpretation (Table 24). The report should include all applicable elements of a nuclear cardiology report as detailed in Tables 1, 2, 3, 7, and 10 of this guideline.

Coronary Artery Calcium Scoring

Coronary artery calcium score, if performed with SPECT/CT or PET/CT imaging, should be reported

Table 7. Imaging parameters

Variable	Description	Datatype	Priority	Response
Perfusion imaging protocol	Describes protocol used to acquire perfusion images	Text	Required for perfusion	Rest Rest/delayed rest Rest/stress 1-day Rest/stress 2-day Stress only Stress/rest 1-day Stress/rest 2-day Stress/rest/delayed rest ERNA modified in vivo/in vitro labeling ERNA in vitro labeling FPRNA Other
Metabolic imaging Protocol	Describes protocol used to acquire metabolic images	Text	Required for metabolic imaging	Metabolic viability Metabolic inflammation
Study acquisition	Mode study acquired in	Text	Required for ERNA and FPRNA	Gated SPECT Frame mode acquisition
Imaging position	Describes patient positioning	Text	Recommended	Supine Prone Upright
Stress radiopharmaceutical	Stress imaging agent used	Text	Required	N-13 Ammonia O-15 Water Rb-82 Tc-99m Tetrofosmin Tc-99m Sestamibi Thallium-201
Stress dose	Dose of radioactivity	Numerical	Required	Numerical value XX.X
Stress date	Date of stress study	Numerical	Required	XX/XX/XXXX
Stress injection time	Time of stress injection	Numerical	Recommended	Month/day/year XX:XX:XX (hours)
Stress imaging time	Time of stress imaging	Numerical	Required	Month/day/year XX:XX:XX (hours)
Exercise time after injection	Exercise time after injection	Numerical	Optional	XX:XX min:sec

Table 7 continued

Variable	Description	Datatype	Priority	Response
Rest radiopharmaceutical	Rest imaging agent used	Text	Required	I-123 N13-Ammonia O-15 Water Rb-82 Tc-99m PYP Tc-99m Tetrofosmin Tc-99m Sestamibi Thallium-201
Rest dose	Dose of radioactivity	Numerical	Required	Numerical value XX.X
Rest date	Date of rest study	Numerical	Required	mm/dd/yyyy
Rest injection time	Time of rest injection	Numerical	Recommended	Month/day/year XX:XX:XX (hours)
Rest imaging time	Time of rest imaging	Numerical	Required	Month/day/year XX:XX:XX (hours)
Viability/metabolic/ inflammation radiopharmaceutical	Viability/metabolic/ inflammation imaging agent used	Text	Required	Tl-201 F-18 FDG
Viability dose	Dose of radioactivity	Numerical	Required	Numerical value XX.X
Viability date	Date of viability study	Numerical	Required	mm/dd/yyyy
Viability injection time	Time of viability Injection	Numerical	Recommended	Month/day/year XX:XX:XX (hours)
Viability imaging time	Time of viability imaging	Numerical	Required	Month/day/year XX:XX:XX (hours)
Rest/delayed imaging time	Time difference between rest and delayed images	Text	Required	Month/day/year XX:XX:XX (hours)
Fasting state	Fasting state of the patient	Text	Required (PET only)	Glucose-loaded Fasting Carb restricted/Fasting
Camera	Vendor and name of camera	Text	Recommended	Digirad GE Phillips Mediso Siemens Spectrum dynamics Toshiba Other

Table 7 continued

Variable	Description	Datatype	Priority	Response
Quantitative software	Vendor/name of processing software used	Text	Recommended	Cedars-Sinai Digisonics GE Generic INVIA Philips Positron Siemens Syntermed Other
Attenuation correction	Use of attenuation correction	Text	Required	Yes—stress only Yes—stress/rest No
Attenuation correction type	Type of attenuation correction	Text	Required if attenuation correction type is yes	CT scan Transmission Prone imaging—stress only Prone imaging—stress/rest Other (if this value is selected, complete the Other text field)
Attenuation correction type other	Other type of attenuation correction	Text	Required if attenuation correction type other is selected	Variable
Motion correction	Motion correction software used	Text	Optional	Yes No
Resolution recovery	Resolution recovery software used	Text	Optional	Yes No
Half-time imaging	Half-time imaging used	Text	Optional	Yes No
Half-dose imaging	Half-dose imaging used	Text	Optional	Yes No

CT, Computed tomography; *FDG*, fluorodeoxyglucose; *ERNA,* equilibrium radionuclide angiocardiography; *FPRNA,* first-pass radionuclide angiography; *SPECT,* single-photon emission computed tomography; *DTPA,* diethylene triamine pentaacetic acid; *HDP,* hydroxymethylene diphosphonate; *PET,* positron emission tomography

Table 8. Additional imaging parameters specific to viability studies

Variable	Description	Datatype	Priority	Response
Viability imaging wait time	Time from injection to start of image acquisition	Text	Required	XX.X minutes
Imaging parameters specific to F-18 FDG PET viability study				
Fasting state	Patient was fasting	Text	Required	Yes No
Fasting time	Time patient fasted prior to viability study	Numerical	Required	Month/day/year XX:XX:XX (hours)
Glucose protocol	Type of patient preparation used for viability assessment	Text	Recommended	Oral glucose load Euglycemic-hyperinsulinemic clamp
Blood glucose level	Blood glucose level of patient at time of FDG injection	Numerical	Recommended	XX units
Imaging parameters specific to Tl-201 SPECT viability study				
Redistribution imaging time	Time from injection to start of image acquisition	Text	Required	XX:XX hours:minutes
Additional redistribution imaging time (if applicable)	Time from initial Tl-201 injection to start of additional image acquisition	Text	Required (if additional 18- to 24-hour redistribution images are obtained)	XX:XX hours:minutes
Reinjection (if additional dose of Thallium is given)	Dose of radioactivity	Numerical	Required if additional dose is given	XX.X units
Nitrate-enhanced protocol used	Use of nitrates to enhance viability assessment	Text	Recommended	Yes No

FDG, fluorodeoxyglucose; *PET*, positron emission tomography

Table 9. Imaging parameters specific for inflammation/infection

Variable	Description	Datatype	Priority	Response
Inflammation/ infection imaging wait time	Time from injection to start of image acquisition	Text	Required	XX minutes (0.0 format)
Fasting state	Fasting state of the patient	Text	Required	Yes No
Fasting time	Time patient fasted prior to inflammation/infection study	Numerical	Required	XX:XX hours
Diet protocol	Use of high fat/low carbohydrate diet	Text	Recommended	Yes No
Unfractionated heparin	Use of unfractionated heparin prior to inflammation/infection scan	Text	Recommended	Yes No
Unfractionated heparin dose(s)	Dose(s) of unfractionated heparin used prior to inflammation/infection scan	Numerical	Recommended	XX IU/kg XX doses
Timing of unfractionated heparin dose	Administration of dose relative to injection of F-18 FDG in infection/ inflammation scan	Numerical	Recommended	XX.X minutes prior to injection of F-18 FDG
Blood glucose level	Blood glucose level of patient at time of FDG injection	Numerical	Recommended	XX units

IU, international unit; *kg,* kilogram; *FDG*, fluorodeoxyglucose

Table 10. Imaging parameters for Tc-99m PYP

Variable	Description	Datatype	Priority	Response
Rest radiopharmaceutical	Rest imaging agent used	Numerical	Required	XX.X units
Time between injection and acquisition	Time between injection of Tc-99m PYP and imaging	Text	Required	XX:XX:XX (hours:minutes: seconds)
Field of view	Field of view for image acquisition	Text	Required	Cardiac or chest Whole body
Imaging protocol	Describes protocol used to acquire images	Text	Required	Rest Tc-99m PYP
Study acquisition	Scan technique	Text	Required	Planar Gated SPECT Both planar and gated SPECT
Imaging position	Describes patient positioning	Text	Required	Supine
Imaging views	Angulation of camera for image acquisition	Text	Required	Anterior Lateral Left anterior oblique
Image duration	Count-based image duration	Numerical	Recommended	XX counts

PYP, pyrophosphate; *SPECT*, single-photon emission computed tomography

Table 11. Qualitative LV perfusion assessment (SPECT and PET)

Variable	Description	Datatype	Priority	Response
LV perfusion summary	Summary of left ventricular perfusion	Text	Required	Normal Probably normal Probably abnormal Abnormal Equivocal
Perfusion Defect size	Size of perfusion defect	Text	Required	Small (1–2 segments) Medium (3–4 segments) Large (≥5 segments)
Perfusion defect location	Location of perfusion defect	Text	Required	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)
Perfusion defect severity	Severity of perfusion defect	Text	Required	Mild (10%-<25% reduction from baseline) Moderate (25%-<50% reduction from baseline) Severe (≥50% reduction from baseline) Absent tracer uptake (background radiation levels)
Reversibility degree	Degree of reversibility	Text	Required	Reversible Fixed (no reversibility) Mildly reversible Moderately reversible Predominantly reversible Predominantly fixed
Segmental function	Classification of the function of the myocardial region with abnormal perfusion	Text	Required if abnormal	Normal Abnormal

Table 11 continued

Variable	Description	Datatype	Priority	Response
Perfusion defect clinical interpre -tation	Clinical interpretation of the perfusion defect	Text	Recommended	Ischemia Infarction Ischemia and infarction Peri-infarct ischemia Probable ischemia Probable infarction Probable artifact Uninterpretable
Perfusion defect classification	Classification of the perfusion defect as present visually, quantitatively, or both	Text	Optional	Visual only Quantitative only Visual and quantitative
Bulls-eye polar plot	Bulls-eye polar plot of perfusion defect location and severity	Figure	Optional	Bulls-eye polar plot of the 17 segments with each color coded by perfusion defect severity
TID	Qualitative assessment of transient ischemic dilation	Text	Required	Present Absent Unable to assess (for Stress-only imaging)
TID classification	Classification of TID as present visually, quantitatively, or both	Text	Recommended	Visual only Quantitative only Visual and quantitative
Stress perfusion cavity size	Non-gated perfusion cavity size at stress	Numerical	Optional	XXX mL
Rest perfusion cavity size	Non-gated perfusion cavity size at rest	Numerical	Optional	XXX mL
TID ratio	Ratio of stress to rest perfusion cavity sizes	Numerical	Optional	XX:XX ratio
LV myocardial wall thickness	Presence of increased wall thickness consistent with hypertrophy.	Text	Required	Increased Normal
Stress RV myocardial uptake	RV tracer uptake at stress	Text	Optional	Normal Increased
Rest RV myocardial uptake	RV tracer uptake at rest	Text	Optional	Normal Increased
Lung uptake, stress	Stress lung uptake	Text	Optional	Yes No
Lung uptake, rest	Tracer uptake in the lungs at rest	Text	Optional	Yes No

The information in this table may be repeated as required to describe multiple perfusion defects
TID, transient ischemic dilation; *LV*, left ventricular; *RV*, right ventricular

Table 12. Quantitative LV perfusion assessment (SPECT and PET)

Variable	Description	Datatype	Priority	Response
Summed stress score (SSS)	Extent and severity of LV perfusion defects at stress across the 17 segments.	Numerical	Recommended	XX
Summed rest score (SRS)	Extent and severity of LV perfusion defects at rest across the 17 segments.	Numerical	Recommended	XX
Summed difference score (SDS)	SSS-SRS. Extent and severity of reversible perfusion defects across the 17 segments.	Numerical	Recommended (derived)	XX
Stress perfusion extent	SSS/68% myocardium with perfusion defects at stress.	Numerical	Recommended (derived)	XX%
Rest perfusion extent	SRS/68% myocardium with perfusion defects at stress.	Numerical	Recommended (derived)	XX%
Stress ischemia extent (% LV ischemia)	SDS/68% myocardium with reversible perfusion defects at stress.	Numerical	Recommended (derived)	XX%

SSS, summed stress score; *SRS,* summed rest score; *SDS,* summed difference score

quantitatively and by percentile ranking based on age and sex (Table 25).[49,50]

Section on Overall Impressions

The overall impression is the most important portion of the nuclear cardiology report, as it assimilates and summarizes the most important details presented in the preceding sections. Data elements specific to this section are outlined in Table 26. Summaries of LV perfusion, function, and viability (when indicated) should be provided with clear indication of normal vs abnormal findings. For perfusion defects, a statement of whether these findings indicate ischemia, infarction, or both should be provided. This information may have been provided in preceding sections but should be highlighted in the overall impression. The number of coronary territories involved and possibly even specific vessel territories can be indicated, though caution should be advised in correlating perfusion results to coronary anatomy in the absence of prior invasive or CT coronary angiography to precisely define the epicardial distributions. For positive studies, it is recommended that a statement be made regarding the significance of the LV perfusion results. The overall impression should also contain additional statements from the body of the report if additional emphasis is needed. For instance, if transient ischemic dilation or significant RV perfusion or functional defects are present, these should be mentioned. Furthermore, to ensure timely access to the data, the report needs to be compliant with the standard for timely reporting requiring completion of the interpretation within one business day and transmittal from the lab to the referring physician within two business days.[51]

Conclusion and Communication of High-Risk Results

An important additional component of the overall impression section is a combined conclusion that incorporates results from both imaging and the stress test, including the electrocardiogram, hemodynamics, and stress-induced symptoms. It is also important to note discordant results between perfusion and non-perfusion imaging results, such as normal perfusion and increased lung uptake. As detailed in Table 27, combining the results is straightforward when the ECG and imaging are concordant. Likewise, when the studies are discordant with abnormal imaging, the combined test is typically treated as abnormal. However, the combined conclusion is more challenging

Table 13. LV gated functional and volume assessment at stress

Variable	Description	Datatype	Priority	Response
Timing of function	Timing of function assessment	Text	Recommended	During exercise (i.e., first-pass) Post-stress
Stress global LV function	Subjective assessment of global LV function	Text	Required	Normal (>55%-<70%) Low normal (50%-55%) Mildly reduced (45%-<50%) Moderately reduced (35%-<45%) Severely reduced (<35%) Hyperdynamic (≥70%)[14]
Stress LVEF	Calculated quantitative LVEF	Numerical	Required	XX%
Stress regional wall thickening	Subjective regional wall thickening (WT)	Text	Recommended	Normal Mildly decreased WT Moderately decreased WT Severely decreased WT Hyperdynamic WT
Stress regional wall-thickening location	Subjective regional wall-thickening location	Text	Recommended	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)

Table 13. continued

Variable	Description	Datatype	Priority	Response
Stress regional wall motion	Subjective regional wall-motion assessment	Text	Recommended	Normal Mild hypokinesis Moderate hypokinesis Severe hypokinesis Akinesis Dyskinesis
Stress regional wall-motion location	Subjective regional wall-motion location	Text	Recommended	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)
Stress LV end-diastolic volume (EDV)	LVEDV	Numerical	Optional	XXX mL
Stress LV end-diastolic volume index (EDVI)	LVEDV normalized to body surface area	Numerical	Optional	XXX mL/m^2
Stress LV end-diastolic cavity size	Subjective assessment of LV end-diastolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged
Stress LV end-systolic volume (ESV)	LVESV	Numerical	Optional	XXX mL
Stress LV end-systolic volume index (ESVI)	LVESV normalized to body surface area	Numerical	Optional	XXX mL/m^2
Stress LV end-systolic cavity size	Subjective assessment of LV end-systolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged

Table 13. continued

Variable	Description	Datatype	Priority	Response
Stress LV diastolic function—qualitative	Visual assessment of time-activity curve	Text	Optional	Normal Abnormal
Stress LV diastolic function—quantitative	LV peak filling rate	Numerical	Optional	X.XX EDV/second

The information in this table may be repeated as required to describe multiple segmental functional abnormalities
LV, left ventricular; *EF*, ejection fraction; *EDV*, end-diastolic volume; EDVI, end-diastolic volume index; *ESV*, end-systolic volume; ESVI, end-systolic volume index; *WT*, wall thickening

when there are discordant results with a positive stress ECG and negative imaging. One solution is to categorize the cardiovascular risk as low, intermediate, or high. This is difficult if the reader is not the ordering physician. Detailing supporting clinical information used to classify the risk (such as young age or atypical presentation for low risk and stress angina or high-risk ECG findings such as multiple millimeters of persistent ST depression for intermediate or high risk) can inform the referring physician of the parameters considered even when the reader has not seen the patient. A clinical recommendation can then be offered based on the risk classification. A low-risk designation could suggest that further cardiac evaluation may not be necessary. Intermediate and high-risk designations could suggest that further cardiac evaluation ''could'' and ''should'' be considered, respectively.

A complete report should include documentation of the communication of high-risk results, including what findings were communicated, the person to whom they were communicated, and the date and time of the communication.

A section comparing the current imaging to prior studies is recommended in all reports as shown in Table 28. The date of the study being compared should be provided, and a statement of whether there are new changes or if the imaging is unchanged. Changes in perfusion and function should be detailed, with comment on both changes in LVEF and segmental function. A statement on the clinical significance of the changes should be provided.

FUTURE DIRECTIONS

Available and evolving technology solutions can ameliorate the burden of comprehensive nuclear cardiology reporting and further enhance the value of the report in providing diagnostic, prognostic, and decision-guiding information, while meeting all regulatory requirements. Taking full advantage of these technology tools will facilitate evidence-based and patient-centered reporting.

Structured Reporting Software

Providing high-quality medical care and satisfying all guidelines and regulatory requirements is ever more complex; this certainly applies to nuclear cardiology reporting. Building new habits to satisfy all reporting elements is rather difficult. Using structured reporting software with hard-wired, guideline-driven reporting standards as well as built-in reminders and hard-stops for high importance reporting elements would ensure a complete and informative report every single time. Structured reporting packages can be fitted with DSTs capable of exploiting the wealth of objective clinical, stress, ECG, perfusion, functional, and ancillary data (chamber volumes, mass, and TID) to produce diagnostic and prognostic assessment using a catalogue of widely accepted nuclear cardiology literature. These determinations can be translated into hard-wired, evidence-based, and patient-centered diagnostic, prognostic, and decision-guidance statements. Furthermore, structured reporting software can facilitate reporting to accreditation bodies, automate data entry in public registries, aid in conducting research and quality improvement initiatives, and track radiation dose and critical findings.

Structured reporting software packages vary in their quality, ease of use, and comprehensiveness. They also vary in terms of their ability to auto-populate readily available data in electronic health records, previous testing reports, and stress testing data. Commonly used nuclear cardiology analysis software packages are fitted with structure reporting capabilities. Other structured reporting software can import and auto-populate imaging data from nuclear cardiology analysis packages and stress testing data from the treadmill computer console. Finally, structured reporting software may facilitate the

Table 14. LV gated functional and volume assessment at rest

Variable	Description	Datatype	Priority	Response
Resting global LV function	Qualitative assessment of global LV function at rest	Text	Required	Normal (>55%–<70%) Low normal (50%–55%) Mildly reduced (45%–<50%) Moderately reduced (35%–<45%) Severely reduced (<35%) Hyperdynamic (≥70%)[14]
Resting LVEF	Calculated quantitative LVEF	Numerical	Required	XX%
Resting regional wall thickening	Subjective regional wall thickening	Text	Recommended	Normal Mildly decreased WT Moderately decreased WT Severely decreased WT Hyperdynamic WT
Resting regional wall-thickening location	Subjective regional wall-thickening location	Text	Recommended	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)

Table 14. continued

Variable	Description	Datatype	Priority	Response
Resting regional wall motion	Subjective regional wall-motion assessment	Text	Recommended	Normal Mild hypokinesis Moderate hypokinesis Severe hypokinesis Akinesis Dyskinesis
Resting regional wall-motion location	Subjective regional wall-motion location	Text	Recommended	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)
Resting LV end-diastolic volume (EDV)	LVEDV	Numerical	Optional	XXX mL
Resting LV end-diastolic volume index (EDVI)	LVEDV normalized to body surface area	Numerical	Optional	XXX mL/m^2
Resting LV end-diastolic cavity size	Subjective assessment of LV end-diastolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged
Resting LV end-systolic volume (ESV)	LVESV	Numerical	Optional	XXX mL
Resting LV end-systolic volume index (ESVI)	LVESV normalized to body surface area	Numerical	Optional	XXX mL/m^2
Resting LV end-systolic cavity size	Subjective assessment of LV end-systolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged
Resting LV diastolic function—qualitative	Visual assessment of time-activity curve	Text	Optional	Normal Abnormal

Table 14. continued

Variable	Description	Datatype	Priority	Response
Resting LV diastolic function—quantitative	LV peak filling rate	Numerical	Optional	X.XX EDV/second

The information in this table may be repeated as required to describe multiple segmental functional abnormalities
LV, left ventricular; *EF*, ejection fraction; *EDV*, end-diastolic volume; EDVI, end-diastolic volume index; *ESV*, end-systolic volume; ESVI, end-systolic volume index; *WT*, wall thickening

generation of all-encompassing nuclear cardiology reports by combining separately interpreted stress and imaging data while maintaining two provider signatures: a cardiologist (stress portion) and an imaging specialist (nuclear portion). Unfortunately, structured reporting software packages are not universally used across various practice settings. ASNC recommends the use of structure reporting packages to ensure comprehensive nuclear cardiology reporting to optimize decision-making and facilitate continuous quality improvement through accreditation and public reporting.

Decision Support Tools (DST)

Computer-based DSTs can complement nuclear cardiology reporting on two main levels.

(1) Discerning Appropriate Use: Computer-based DST can mine data readily available in electronic health records in discerning appropriateness of MPI, and when testing is rarely appropriate it can provide guidance on appropriate alternative testing, for example, exercise tolerance test (without imaging) instead of stress MPI. Deep integration of DST in the electronic order entry in electronic health information systems can provide seamless, real-time guidance on study appropriateness with minimal provider burden. AUC adherence data can then seamlessly flow into interconnected electronic structured reporting software and hence to the clinical report. Such practical technologic applications can be easily developed to enhance adherence to AUC, improve value of imaging, and facilitate compliance with PAMA requirements.
(2) Risk assessment and Guiding Decision-Making: Structured reporting software can be fitted with DST that can leverage the wealth of objective clinical, stress, ECG, perfusion, functional, and ancillary data in the nuclear cardiology study to provide individualized diagnostic and prognostic statements using a catalogue of widely accepted nuclear cardiology literature. Specific examples of such statements: (1) No history of CAD or diabetes mellitus, normal exercise stress MPI and ejection fraction, and no TID: Patient is at <1% annual risk for major adverse cardiac events; (2) Abnormal MPI and abnormally high TID ratio: Perfusion imaging is predictive of multi-vessel CAD and increased risk of adverse cardiac events; (3) Normal MPI but abnormal heart rate response to vasodilator stress agent: Patient is at increased risk of mortality and adverse cardiac events; (4) Ischemic myocardial perfusion deficit 15%: observational outcome data favor coronary revascularization over medical therapy (if clinically indicated and feasible); (5) Ischemic myocardial perfusion deficit 5%: observational outcome data favor medical therapy over coronary revascularization. In such fashion, structure reporting software can be leveraged to hard-wire evidence-based and patient-centered diagnostic, prognostic, and decision-guidance statements. Decision support in nuclear cardiology reporting can be further enhanced by applying machine learning algorithms.

Machine Learning

The interpretation of MPI is currently performed primarily by experienced readers who mentally combine clinical, ECG, stress, perfusion, and functional data to generate an overall diagnostic and prognostic impression. However, this interpretation is primarily subjective, semi-quantitative, and heavily dependent on reader's wealth of knowledge, acumen, and experience.[52] Furthermore, traditional prognostic risk assessment in patients undergoing nuclear cardiology imaging is based on a limited menu of clinical and

Table 15. Additional PET-specific LV perfusion and function parameters

Variable	Description	Datatype	Priority	Response
Stress myocardial blood flow	Stress myocardial blood flow in mL/min/g	Numerical	Optional	Global: X.XX mL/min/g LAD Territory: X.XX mL/min/g LCX Territory: X.XX mL/min/g RCA Territory: X.XX mL/min/g
Stress myocardial blood flow conclusion	Subjective assessment of stress myocardial blood flow	Text	Optional	Preserved (>2 mL/min/g) Mildly reduced (1.5-2 mL/min/g) Severely reduced (<1.5 mL/min/g)
Rest myocardial blood flow	Rest myocardial blood flow in mL/min/g	Numerical	Optional	Global: X.XX mL/min/g LAD Territory: X.XX mL/min/g LCX Territory: X.XX mL/min/g RCA Territory: X.XX mL/min/g
Rest myocardial blood flow conclusion	Subjective assessment of absolute rest myocardial blood flow	Text	Optional	Preserved (>2 mL/min/g) Mildly reduced (1.5-2 mL/min/g) Severely reduced (<1.5 mL/min/g)
Myocardial flow reserve (MFR)	Ratio of stress and rest myocardial blood flows	Numerical	Optional (derived)	Global: X.XX LAD Territory: X.XX LCX Territory: X.XX RCA Territory: X.XX
MFR conclusion	Subjective assessment of myocardial flow reserve	Text	Optional	Preserved (>2) Mildly reduced (1.5-2.0) Severely reduced (<1.5)
LVEF reserve	Difference between the stress and rest LVEF	Numerical	Optional (derived)	XX%
LVEF reserve conclusion	Subjective assessment of LVEF reserve	Text	Optional	Normal (≥0%) Abnormal (<0%)

LAD, left anterior descending; *LCX,* left circumflex; *RCA,* right coronary artery; *MFR,* myocardial flow reserve; *LVEF,* left ventricular ejection fraction

imaging findings. Many of these findings are continuous variables (ejection fraction, chamber volumes, TID, SSS, etc.) that are difficult to incorporate in a simple diagnostic or prognostic determination.

Machine learning can consider a greater number (dozens) and complexity of variables and correlate them with specific outcomes in very large training datasets. These machine-learned algorithms are validated in

Table 16. Right Ventricular Perfusion and Function Parameters

Variable	Description	Datatype	Priority	Response
RV perfusion	Subjective assessment of the perfusion of the RV	Text	Optional	Normal Abnormal
Global RV function	Subjective assessment of global RV function	Text	Optional	Normal Mildly reduced Moderately reduced Severely reduced
RVEF	Calculated quantitative RVEF	Numerical	Optional	XX%
RV end-diastolic volume (EDV)	RVEDV	Numerical	Optional	XXX mL
RV end-diastolic cavity size	Subjective assessment of RV end-diastolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged
RV end-systolic volume (ESV)	RVESV	Numerical	Optional	XXX mL
RV end-systolic cavity size	Subjective assessment of RV end-systolic cavity size	Text	Optional	Normal Mildly enlarged Moderately enlarged Severely enlarged
RV regional wall motion	Subjective assessment of regional wall motion	Text	Optional	Normal Abnormal
RV regional wall motion	Subjective comparison of RV regional wall motion with perfusion	Text	Optional	Consistent with perfusion Inconsistent with perfusion

RV, right ventricular; *FPRNA,* first-pass radionuclide angiography; *ERNA,* equilibrium radionuclide angiocardiography; *EF,* ejection fraction, *LV,* left ventricle; *EDV,* end-diastolic volume; *ESV,* end-systolic volume

testing datasets before they can be applied clinically.[53,54] Unlike multivariate regression modeling, machine learning algorithms are not fitted models, and thus are not affected by collinearity between variables. Furthermore, they can be improved in an ongoing basis incorporating accumulative observations after clinical implementation. It has been shown that machine learning algorithms derived from integrating clinical, perfusion, and functional data elements for diagnosis of obstructive CAD yield results similar to or better than those obtained by experienced readers.[55] Furthermore, machine learning applications, integrating clinical, ECG, exercise, hemodynamic, defect quantification, and ancillary imaging data provide a patient-specific estimate of likelihood of early revascularization and all-cause mortality, thus aiding in individualized decision-making in a way the human brain cannot do.[53,56]

Machine learning algorithms are a natural complement to nuclear cardiology analyses packages and structured reporting software, from which multi-faceted data can be derived to generate risk estimates factored in DSTs and patient-centered decision guidance.

Table 17. Miscellaneous data

Variable	Description	Datatype	Priority	Response
Overall study quality	Overall quality of the study	Text	Required	Excellent Good Poor Uninterpretable Other
Study quality/ artifacts	Specific problems	Text	Recommended	Breast/chest attenuation Inferior wall/Diaphragmatic attenuation Motion artifact Insertion point artifact LBBB artifact Subdiaphragmatic activity Misregistration artifact Extravasated dose CT for attenuation correction motion artifact CT for attenuation correction metal artifact GI activity Other (free text)
Extracardiac activity	Describe extracardiac activity	Text	Recommended	Normal Increased lung uptake Subdiaphragmatic uptake Other (free text)
Incidental Findings	Describe any incidental findings	Text	Optional	Free text

CT, computed tomography; GI, gastrointestinal

Registries and Public Reporting

ASNC's ImageGuide™ Registry is the first registry of its kind focusing on SPECT and PET imaging. The primary purpose of the registry is quality improvement. It provides a fully integrated platform to seamlessly collect data from nuclear imaging laboratories to measure quality, safety, and efficiency. The registry contains hundreds of data elements such as referral information, demographics, clinical data, stress data, ECG data, imaging parameters, radiation dosing, perfusion, quantification, left ventricular function parameters, study quality, and signature date/time.[54] Data elements in structured reporting applications within commercially available nuclear cardiology analysis packages are fully homogenized with the ImageGuide™. Thus, data from each study can be easily submitted from the laboratory to the ImageGuide™ Registry, which in turn tracks and publicly reports, in real-time, indicators of excellence in radionuclide imaging, including crucial reporting measures.[16,54,55] Such integration provides a constant quality improvement feedback loop for ever-improving report quality and patient care.[57]

The ImageGuide™ Registry is a Qualified Clinical Data Registry (QCDR) through which participating physicians can receive CMS reimbursement credits for participating in a Physician Quality Reporting System (PQRS). Physicians satisfactorily reporting on a minimum of 9 CMS-approved quality measures can avoid reimbursement penalties based on the Merit-Based Incentive Payment System (MIPS). Table 29 lists 2017

Table 18. FPRNA/ERNA (rest and exercise)

Variable	Description	Datatype	Priority	Response
Rest global LV function	Subjective LV function	Text	Required (at rest and if with exercise)	Normal Abnormal Mildly reduced Moderately reduced Severely reduced
Rest LVEF	Calculated EF	Numerical	Required (at rest and if with exercise)	XX%
Rest LV volume subjective	Subjective LV volume	Text	Required	Normal Mildly enlarged Moderately enlarged Severely enlarged
LV diastolic function—qualitative	Visual assessment of time-activity curve	Text	Recommended	Normal Abnormal
LV diastolic function—quantitative	LV peak filling rate	Numerical	Recommended	X.XX EDV/second
Rest regional wall motion	Subjective regional wall motion	Text	Required (at rest and if with exercise)	Normal Mild hypokinesis Moderate hypokinesis Severe hypokinesis Akinesis Dyskinesis
Rest regional wall motion location	Subjective regional wall motion	Text	Required (at rest and if with exercise)	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None Diffuse
Rest global RV function	Subjective RV function	Text	Required if RV study	Normal Abnormal Mildly reduced Moderately reduced Severely reduced

Table 18. continued

Variable	Description	Datatype	Priority	Response
Rest RV EF	Calculated EF	Numerical	Required for RV study	XX%
RV volume subjective	Subjective RV volume	Text	Required for RV study	Normal Mildly enlarged Moderately enlarged Severely enlarged
Right atrial size	Visual assessment of RA size	Text	Optional	Normal Enlarged
Left atrial size	Visual assessment of LA size	Text	Optional	Normal Enlarged
Aortic size	Size of aorta	Text	Optional	Normal Enlarged
Pulmonary artery Size	Size of pulmonary artery	Text	Optional	Normal Enlarged
Qualitative change in LV size—change from exercise to rest	Visual assessment of change from rest LV size with exercise	Text	Optional	Same Larger Smaller
Quantitative change in LV size—change from exercise to rest	Quantitative assessment of change from rest LV size with exercise	Numerical	Recommended for exercise FPRNA/ERNA	XX mL
Qualitative change in RV size—change from exercise to rest	Visual assessment of change from rest RV size with exercise	Text	Optional	Same Larger Smaller
LV regional wall Motion—change from rest	LV regional wall Motion—change from rest	Text	Required for exercise FPRNA/ERNA	List segments in which quantitative score changes by more than 2, where 4 = normal, 3 = mild hypokinesis, 2 = moderate hypokinesis, 1 = severe hypokinesis, 0 = akinetic, -1 = dyskinetic Basal anterior (1) Basal anteroseptal (2) Basal inferior (3) Basal inferoseptal (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11)

Table 18. continued

Variable	Description	Datatype	Priority	Response
				Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)
RV regional wall motion—change from rest	RV regional wall motion—change from rest	Text	Required for exercise FPRNA/ERNA	No change New wall motion abnormality

RA, right atrium; *LA*, left atrium; *LV*, left ventricle; *FPRNA*; first-pass radionuclide angiography; *ERNA*, equilibrium radionuclide angiocardiography; *RV*, right ventricle

CMS-approved nuclear cardiology quality measures. The ImageGuide™ Registry and CMS yearly update the reported quality measures, such that old, highly achievable measures are retired and new measures are introduced in a sustained effort to continuously improve the quality of nuclear cardiology studies.

The appendices to this guideline demonstrate model formats for structured reporting based on the principles and data elements contained in this document. Appendices 2 and 3 are model formats for exercise stress myocardial perfusion imaging, with Appendix 3 specifically demonstrating a combined conclusion. Appendices 4 and 5 are model formats for pharmacologic-based stress myocardial perfusion imaging. They are intended as examples only and ASNC fully acknowledges that there are many allowable structured formats for the reporting of nuclear myocardial perfusion images. Different structured report formats would be required for the other indications covered in this document (e.g., PET, exercise/rest FPRNA/ERNA, and viability imaging). Appendix 6 provides a diagram of the 17-segment model with corresponding vascular territories.[17]

Table 19. Viability—qualitative analysis

Variable	Description	Datatype	Priority	Response PET	Response Thallium	Response Technetium
LV size	Cavity size	Text	Recommended	Normal Enlarged	Normal Enlarged	Normal Enlarged
RV size	Cavity size	Text	Recommended	Normal Enlarged	Normal Enlarged	Normal Enlarged
Lung uptake	Lung uptake	Text	Recommended	Yes No	Yes No	
Increased LV uptake	Subjective LV uptake	Text	Optional	Normal Hypertrophied	Normal Hypertrophied	Normal Hypertrophied
Blood pool activity	Blood pool activity	Text	Optional	Normal Increased		
Metabolism defect location	Location of metabolism defect	Text	Required	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None
Perfusion/metabolism mismatch	Is there a mismatched perfusion/ metabolism defect?	Text	Required	Yes No		
Perfusion/metabolism mismatch size	Size of the perfusion/ metabolism mismatch	Text	Required	Small Medium Large		

Table 19. continued

Variable	Description	Datatype	Priority	Response PET	Response Thallium	Response Technetium
Perfusion/metabolism mismatch location	Location of perfusion/ metabolism mismatch	Text	Required	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None		
Perfusion/metabolism match	Is there a matched perfusion/ metabolism defect?	Text	Required	Yes No		
Perfusion/metabolism match size	Size of the perfusion metabolism match	Text	Required	Small Medium Large		

Table 19. continued

Variable	Description	Datatype	Priority	Response PET	Response Thallium	Response Technetium
Perfusion/metabolism match location	Location of perfusion/ metabolism match	Text	Required	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None		
Comparison to prior LV viability images	Prior image comparison	Text	Recommended	No change New infarction/scar Resolution of area of hypoperfusion		

LV, left ventricular; *RV*, right ventricular

Table 20. Viability—quantitative analysis

Variable	Description	Datatype	Priority	Response PET	Response Thallium	Response Technetium
Number of viable segments	The number of 17-segments that are viable (if PET) or reversible (if Thallium/Technetium)	Numerical	Optional	XX	XX	XX
Metabolism defect extent	Regional metabolism defect extent (% myocardium involved)	Numerical	Optional	XX%		
Perfusion/metabolism mismatch extent	Extent of perfusion/metabolism mismatch (% of rest perfusion defect)	Text	Optional	XX%		
Perfusion/metabolism match extent	Extent of perfusion/metabolism match (% of rest perfusion defect)	Text	Optional	XX%		
Viability extent	Extent of perfusion defect that is viable based on integration of viability radiopharmaceutical uptake, wall thickening and function*	Text	Optional	Entirely >50% Minimally (<50%)	Entirely >50% Minimally (<50%)	Entirely >50% Minimally (<50%)
Viability radiopharmaceutical uptake	Quantitative measure of F-18 FDG radiopharmaceutical uptake in normal and abnormal myocardium (PET only)	Numerical	Optional	XX SUV		

PET, positron emission tomography*; SUV,* standard uptake value
* Reported for each perfusion defect

Table 21. Inflammation/infection—qualitative parameters

Variable	Description	Datatype	Priority	Response
LV size	Cavity size	Text	Optional (Recommended in sarcoid)	Normal Enlarged
RV size	Cavity size	Text	Optional (Recommended in sarcoid)	Normal Enlarged
Adequacy of suppression of myocardial glucose utilization by normal myocardium	Statement regarding the effectiveness of suppression of basal (normal) glucose uptake by myocardium	Text	Required	Complete suppression Incomplete suppression Indeterminate
LV perfusion summary	Summary of left ventricular perfusion	Text	Required	Normal Probably Normal Probably abnormal Abnormal Equivocal
Myocardial F-18 FDG uptake pattern	Pattern of F-18 FDG uptake by the LV myocardium	Text	Required	Absent Diffuse Focal Focal-on-diffuse
F-18 FDG regional uptake location in the LV myocardium	Location of abnormal F-18 FDG LV myocardial uptake	Text	Required	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None

Table 21 continued

Variable	Description	Datatype	Priority	Response
Intensity of F-18 FDG uptake	Relative intensity of abnormal F-18 FDG uptake (compared to normal myocardium and/or to blood pool)	Text	Optional	None Mild uptake Intense uptake
Extent of F-18 FDG uptake region	Extent of abnormal F-18 FDG uptake in the myocardium	Text	Optional	Small (1–2 segments) Medium (3–4 segments) Large (≥5 segments) None
Co-localization of F-18 FDG uptake regions of abnormal perfusion	Describe if area(s) of abnormal F-18 FDG uptake correspond to regions of abnormal perfusion	Text	Recommended (sarcoidosis scans)	Normal perfusion with absent F-18 FDG uptake Normal perfusion with increased FDG uptake Abnormal perfusion with increased FDG uptake Abnormal perfusion with absent F-18 FDG uptake
Myocardial F-18 FDG uptake-RV	Presence of F-18 FDG uptake in the RV myocardium	Text	Required	Present Absent
Myocardial F-18 FDG uptake pattern-RV	Comment on focal vs diffuse RV uptake if F-18 FDG uptake is present	Text	Recommended	Focal Diffuse Focal-on-diffuse
Site of abnormal F-18 FDG uptake in relation to prosthetic material	Describe if area(s) of abnormal F-18 FDG uptake correspond to site of prosthetic material	Text	Recommended (CIED infection and endocarditis scans)	Skin (superficial) Subcutaneous tissue Regions surrounding generator Leads Intravascular/ Intracardiac Site of prosthetic valve Site of aortic graft Site of other intracardiac prosthetic material

Table 21 continued

Variable	Description	Datatype	Priority	Response
Confirmation of abnormal F-18 FDG uptake on non-attenuation-corrected images	Abnormal F-18 FDG uptake on attenuation-corrected images should be confirmed on non-attenuation-corrected images	Text	Recommended (scans in which there is/are high density metallic devices in the field of view)	Present Absent
Cardio-synchronous movement of regions of abnormal F-18 FDG uptake	Describe if areas of abnormal F-18 uptake move in a cardio-synchronous manner. Suggesting an intracardiac focus of F-18 FDG uptake	Text	Optional (if gated F-18 FDG images are acquired)	Yes No
Whole body or chest image interpretation	Describe areas of abnormal F-18 FDG uptake, if whole body F-18 FDG images are acquired	Text	Recommended (can be placed in a separate report if extracardiac findings are interpreted by another physician)	Normal Abnormal
Comparison to prior inflammation/infection imaging study	Prior image comparison	Text	Recommended	No change New regions of F-18 FDG uptake (increased or decreased from previous) New areas of hypoperfusion or resolution of perfusion defects
Comparison to prior rest MPI study and LVEF changes	Yes, especially if area/intensity of scan bigger or smaller	Text	Recommended	No change New regions of perfusion abnormality New regions of improved/normalized perfusion Change in LVEF
Date of prior surgery or CIED implant	Date of insertion of prosthetic material	Date	Recommended (for endocarditis and CIED infection studies)	dd/mm/yyyy
Prior study date	Date of prior study	Date	Recommended	dd/mm/yyyy

LV, left ventricular*; RV,* right ventricular*; FDG,* fluorodeoxyglucose*; MPI,* myocardial perfusion imaging*; LVEF,* left ventricular ejection fraction; *CIED,* cardiac implantable electrical device

Table 22. Inflammation/infection—quantitative parameters

Variable	Description	Datatype	Priority	Response
Resting LVEF	Calculated LVEF	Numerical	Recommended	XX%
SRS	17-segment SRS	Numerical	Recommended for sarcoid scans	XX
SUVmax background	Maximum SUV for background in blood pool	Numerical	Optional	XX
SUVmax abnormal	Maximum SUV of F-18 FDG uptake in abnormal myocardium or region of CIED/ prosthetic material	Numerical	Required	XX
Volume of SUV uptake	Amount of FDG uptake above a pre-specified threshold	Numerical	Recommended	XX mL

LVEF, left ventricular ejection fraction; *SRS,* summed rest score; SUV, standard uptake value; *SUVmax,* standard uptake value maximum*; CIED,* cardiac implantable electrical device

Table 23. *m*IBG analysis parameters

Variable	Description	Datatype	Priority	Response
Administration of Lugol's Iodine or KI prior to *m*IBG imaging	Whether iodine was administered prior to injection of *m*IBG	Text	Optional	Yes No
Imaging Delay	Time from injection of I-123 *m*IBG to initial planar image and time from early to late *m*IBG images	Numeric	Required	XX.X minutes
LV size	Cavity size	Text	Recommended	Normal Enlarged
Rest LVEF	Calculated LVEF	Numerical	Recommended	XX%
LV function	Subjective LV function	Text	Optional (if gated SPECT images are acquired)	Normal Abnormal Mildly reduced Moderated reduced Severely reduced
Lung Uptake	Lung uptake	Text	Recommended	Yes No

Table 23. continued

Variable	Description	Datatype	Priority	Response
Overall uptake of *m*IBG	Global myocardial uptake of *m*IBG	Text	Required	Normal Abnormal
Pattern of *m*IBG uptake	*m*IBG uptake in the myocardial is homogenous or variable	Text	Recommended	Homogenous uptake Diffuse uptake abnormalities Focal uptake abnormalities
Abnormal *m*IBG uptake	Location of *m*IBG uptake abnormalities	Text	Recommended (can be derived from SPECT images if performed)	Basal anterior (1) Basal anteroseptal (2) Basal inferior (3) Basal inferoseptal (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17) None
Size of *m*IBG uptake defect	Size of region of abnormal *m*IBG uptake	Text	Recommended	Small Medium Large
Severity of *m*IBG uptake defect	Intensity of defect in myocardial *m*IBG uptake	Text	Recommended	Normal Mild Moderate Severe
Heart-to- mediastinal ratio (HMR)	Ratio of uptake in the myocardium divided by a region of interest in the mediastinum	Numeric	Required	XX
Planar images	Reproduction of anterior planar images	Image	Recommended	n/a
Calculation of *m*IBG washout	Myocardial washout rate of *m*IBG from early to late images, expressed as a percentage	Numeric	Recommended	XX%

*m*IBG, metaiodobenzylguanidine, *LV,* left ventricular; *LVEF,* left ventricular ejection fraction; SPECT, single-photon emission tomography; *HMR*, heart-to-mediastinal ratio

Table 24. Tc-99m PYP analysis parameters

Variable	Description	Datatype	Priority	Response
Myocardial Tc-99m PYP uptake pattern	Qualitative evaluation of Tc-99m PYP myocardial uptake from anterior and lateral planar images, rotating images, and reconstructed SPECT images	Text	Required	Absent Focal Diffuse Focal-on-diffuse
Semi-quantitative visual grading of Tc-99m PYP uptake	Semi-quantitative interpretation of Tc-99m PYP myocardial uptake in relation to contralateral rib uptake	Text	Required	Grade 0: no uptake and normal bone uptake Grade 1: uptake less than rib uptake Grade 2: uptake equal to rib uptake Grade 3: uptake greater than rib uptake with mild/absent rib uptake
Quantitative interpretation of Tc-99m PYP uptake	Quantitative cardiac Tc-99m PYP uptake using heart-to-contralateral lung (H/CL) ratio (ratio of the mean counts)	Numeric	Optional (recommended for positive scans)	XX
Blood pool activity	Qualitative evaluation of blood pool activity compared to myocardial activity	Text	Recommended (SPECT images)	Normal Increased
Myocardial Tc-99m PYP distribution	Assess distribution of myocardial Tc-99m PYP uptake in patients with positive planar scans	Text	Optional (SPECT images)	Basal anterior (1) Basal anteroseptal (2) Basal inferoseptal (3) Basal inferior (4) Basal inferolateral (5) Basal anterolateral (6) Mid anterior (7) Mid anteroseptal (8) Mid inferoseptal (9) Mid inferior (10) Mid inferolateral (11) Mid anterolateral (12) Apical anterior (13) Apical septal (14) Apical inferior (15) Apical lateral (16) Apex (17)
Whole body planar findings	Bone findings on whole body planar images suggestive of ATTR	Text	Optional	Shoulder girdle uptake Hip girdle uptake
Overall interpretation	Overall interpretation of findings as it relates to the diagnosis of ATTR	Text	Required	Not suggestive of ATTR Strongly suggestive of ATTR Equivocal for ATTR

Table 24 continued

Variable	Description	Datatype	Priority	Response
Study quality	Image quality	Text	Required	Uninterpretable Poor Fair Good Excellent

PYP, pyrophosphate; *H/CL,* heart-to-contralateral lung; SPECT, single-photon emission tomography; *ATTR,* transthyretin amyloidosis

Table 25. Coronary artery calcium score analysis parameters

Variable	Description	Datatype	Priority	Response
Coronary artery calcium score	Total coronary artery calcium score (sum of 4 vessels)	Numerical	Required	XX
Coronary artery calcium score by vessel	Coronary artery calcium score measured in each coronary artery	Numerical	Recommended	Left main XX Left anterior descending XXX Left circumflex XXX Right coronary artery XX
Percentile ranking	Percentile ranking of total coronary artery calcium score, based on age and sex	Numerical	Recommended	XX percentile
Calcium in other areas of the heart	Qualitative assessment of calcium in the aortic valve, mitral annulus, aortic wall, pericardium, myocardium	Text	Optional	Absent calcification Mild calcification Moderate calcification Severe calcification

Table 26. Overall impression

Variable	Description	Datatype	Priority	Response
LV perfusion summary	Summary of LV perfusion	Text	Required	Normal Probably normal Probably abnormal Abnormal Equivocal
Perfusion defects	Summary of perfusion defects and clinical interpretation	Text	Required	Infarction Ischemia Ischemia and infarction Peri-infarct ischemia Probable ischemia Probable infarction Probable artifact Uninterpretable

Table 26. continued

Variable	Description	Datatype	Priority	Response
LV global function summary	Summary of global LV function	Text	Required	Normal Low normal Mildly reduced Moderately reduced Severely reduced
LV segmental function summary	Summary of LV segmental function	Text	Recommended	No regional abnormalities Single regional abnormality Multiple regional abnormalities
LV viability summary	Summary of the viability of LV perfusion defects if clinically indicated	Text	Optional	Substantial viability Borderline viability No evidence of viability
Number of diseased vessels	Number of diseased vessels	Numerical	Optional	One Two Three
Diseased vessels or territory	Summary of coronary vessel territory involved		Optional	Left anterior descending (LAD) Left circumflex (LCX) Right coronary artery (RCA)
ECG interpretation summary	ECG changes during stress	Text	Required	Ischemic ECG changes Borderline ischemic ECG changes No ischemia by ECG ECG reported separately ECG uninterpretable Mildly positive Moderately positive Strongly positive Strongly positive-ST elevation
Scan significance	Significance of perfusion results	Text	Recommended	Low risk Moderate risk High risk Uncertain risk
Signature	Signature of interpreting MD	Text	Required	Text or electronic signature
RV perfusion summary	Summary of RV perfusion	Text	Optional	Normal Abnormal
RV function summary	Summary of RV function	Text	Optional	Normal Abnormal
Date signed	Date of final signature	Date	Required	mm/dd/yyyy (time optional)
Time signed	Time of final signature	Time	Optional	XX:XX:XX hours

LAD, left anterior descending; *LCX,* left circumflex; *LV,* left ventricular; *RCA,* right coronary artery; *RV,* right ventricular

Table 27. Combined conclusion

Variable	Description	Datatype	Priority	Response
Combined ECG and imaging conclusion	Conclusion based on both the stress ECG and imaging findings	Text	Required	Concordant negative Concordant positive Discordant: ECG negative, imaging positive Discordant: ECG positive, imaging negative Inconclusive ECG Inconclusive imaging
Combined Perfusion imaging and non-perfusion imaging	Conclusion based on both the perfusion imaging and non-perfusion imaging findings	Text	Recommended	Concordant negative Concordant positive Discordant: Perfusion images normal, non-perfusion imaging abnormal Discordant: Perfusion images abnormal, non-perfusion imaging normal
Cardiovascular risk	Cardiovascular risk if ECG is positive but imaging is negative	Text	Optional	Low risk Intermediate risk High risk
Associated factors: low risk	Factors suggesting a discordant result is low risk	Text	Optional	Absence of stress-induced symptoms Atypical clinical presentation Few cardiovascular risk factors High exercise workload Low-risk stress ECG Young age
Associated factors: intermediate risk, high risk	Factors suggesting a discordant result is intermediate or high risk	Text	Optional	Advanced age Concerning symptoms at presentation High-risk stress ECG Multiple cardiovascular risk factors Poor exercise workload Stress-induced symptoms
Communications of high-risk results	Communications of high-risk results	Text	Required (if high-risk test results)	Text (individual's name who was notified)

ECG, electrocardiographic

Table 28. Comparison to prior studies

Variable	Description	Datatype	Priority	Response
Prior study	Is there a prior study available for comparison	Text	Recommended	Yes No
Prior study date	Date of the prior study used for comparison	Date	Recommended	mm/dd/yyyy
Prior study comparison	Comparison of the current study to prior	Text	Recommended	Unchanged New changes
Perfusion changes	Changes in perfusion on the current study	Text	Recommended	New Worse Improved Resolved
LVEF change	Changes in LVEF on the current study	Text	Recommended	Increased Decreased Normalized
Segmental function changes	Changes in segmental function on the current study	Text	Recommended	New Improved Resolved
Segmental function perfusion comparison	Comparison of function to perfusion results	Text	Recommended	Consistent with perfusion Inconsistent with perfusion
Clinical significance	Clinical significance of new changes	Text	Recommended	Clinically significant Clinically insignificant Uncertain significance
Prior study date	Date of prior study	Date	Recommended	mm/dd/yyyy

LVEF, left ventricular ejection fraction

Table 29. ImageGuide™ CMS reported quality measures

1. Cardiac Stress Nuclear Imaging Not Meeting Appropriate Use Criteria: Preoperative Evaluation in Low-Risk Surgery Patients
2. Cardiac Stress Nuclear Imaging Not Meeting Appropriate Use Criteria: Routine Testing After Percutaneous Coronary Intervention
3. Cardiac Stress Nuclear Imaging Not Meeting Appropriate Use Criteria: Testing in Asymptomatic, Low-Risk Patients
4. Utilization of standardized nomenclature and reporting for nuclear cardiology imaging studies
5. SPECT and PET-MPI studies signed within two business days
6. SPECT-MPI studies meeting appropriate use criteria
7. PET-MPI studies meeting appropriate use criteria
8. SPECT-MPI study quality excellent or good
9. PET-MPI study quality excellent or good
10. SPECT-MPI studies not Equivocal
11. PET-MPI studies not Equivocal
12. Imaging Protocols for SPECT and PET-MPI studies - Use of stress-only protocol
13. SPECT-MPI studies performed without the use of thallium

SPECT, single-photon emission tomography; *PET*, positron emission tomography; *MPI*, myocardial perfusion imaging

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APPENDIX 1: ACCEPTABLE UNITS OF MEASURE

Variable measured	Acceptable units of measure	Table location
Weight	Lbs; kg	2
Height	Inches; cm	2
Chest circumference	Inches; cm	2
HDL cholesterol	mg/dL; mmol/L	3
LDL cholesterol	mg/dL; mmol/L	3
Total cholesterol	mg/dL; mmol/L	3
Pharmaceutical stress dose	mg, mg/kg or $\mu g \cdot kg^{-1} \cdot min^{-1}$	4
Rest dose	mCi; MBq	7; 10
Stress dose	mCi; MBq	7
Reinjection dose	mCi; MBq	8
Blood Glucose level	mg/dL; mmol/L	8 ; 9

mg/dL, milligrams per deciliter; *mmol,* millimoles per liter; *mCi,* millicuries; *MBq,* megabecquerels

Note: Below are sample formats; please note, however, these do not include every variable.

APPENDIX 2: SAMPLE TEMPLATE FOR EXERCISE MYOCARDIAL PERFUSION IMAGING

(Single/2 day) Rest/Stress (or Stress/Rest) Exercise Stress Myocardial Perfusion Imaging with LV function analysis

Indication

(select one) (Diagnosis of coronary artery disease/known coronary artery disease/chest pain/shortness of breath/Preoperative assessment/Evaluation of myocardial viability/Risk Stratification/Other)

Clinical history:

X-year-old man/women with a history of:

Cardiac History:

Cardiac Risk Factors:

Prior cardiac imaging and procedures:

Prior nuclear stress test date:

Current symptoms:

Technique

At rest, the patient received x mCi of x tracer. X minutes later, resting tomographic images of the heart were obtained.

The patient then underwent exercise treadmill/bike stress testing according to the x protocol, exercising for x minutes, achieving a workload of x metabolic equivalents (METS). Resting HR was x with a peak heart rate of x bpm and x% maximum predicted heart rate and pressure rate product of x. Resting BP was x mm Hg and Peak BP was x mm Hg, which is a normal/hypertensive/hypotensive response. The heart rate response to recovery was normal/abnormal. The test was terminated due to chest pain/shortness of breath/fatigue/leg pain. Other symptoms included x.

The resting EKG showed x with no significant ST/T abnormalities that would preclude interpretation. The stress EKG showed (no) ST-segment changes consistent with myocardial ischemia, with x mm horizontal/upsloping/downsloping ST depression in the x leads. ST depressions began at x min of rest/stress and resolved at x min of rest/stress. The Duke Treadmill score was x, predicting a low/intermediate/high risk.

At peak stress, the patient received x mCi of x. Stress tomographic imaging was performed x minutes later. The rest and post-stress images were acquired with ECG gating, for assessment of left ventricular systolic function. All imaging was performed on a x camera and data were analyzed using x software.

Findings

The overall quality of the study is poor/fair/good/excellent. Review of the raw imaging demonstrates (no) significant motion during stress/rest image acquisition. Attenuation artifact was present/absent in the x walls.

Review of the perfusion images shows symmetric or improved uptake of tracer in all portions of the left ventricle from rest to stress imaging OR shows an x severity x sized perfusion defect in the anterior wall that is x reversible, a x sized x severity perfusion defect in the lateral wall that is x reversible and a x sized x severity perfusion defect in the inferior wall that is x reversible. Quantitative evaluation shows a summed stress score of x, a summed rest score of x, and a summed difference score of x. This represents a myocardial ischemic fraction of x%.

Gated SPECT images shows that the left ventricle is normal/enlarged in size and shows normal systolic

performance. The LVEF at rest is x% and x% on post-stress images. No regional wall motion abnormalities are present during either stress or rest imaging.

Transient ischemic dilation, a high-risk marker, is/is not present. Left ventricular/right ventricular hypertrophy is/is not present. Left ventricular/right ventricular dilation is/is not present.

Impression

1. Myocardial perfusion imaging is normal with no evidence of ischemia or scar OR Myocardial perfusion imaging is abnormal with a small/moderate/large area of ischemia/infarction in the distribution of the x artery.
2. Left ventricular systolic function is normal/abnormal with (no)/x regional wall motion abnormalities. Left/Right ventricular hypertrophy/dilation is present.
3. In comparison with the previous study of x date, there has been (no)/a change in left ventricular perfusion, size, or function.

APPENDIX 3: SAMPLE TEMPLATE EXERCISE MYOCARDIAL PERFUSION IMAGING WITH COMBINED CONCLUSION

Reason for Study: Preoperative evaluation prior to non-cardiac surgery.

Clinical History: Mr. [XXXXXX] is a 56-year-old male with a history of hypertension and dyslipidemia with no prior known coronary artery disease who is currently asymptomatic. He has not had prior coronary angiography and has a SPECT myocardial perfusion imaging study from [xx/xx/xxxx] for comparison.

Stress ECG: (not provided in this appendix for brevity).

Isotope Administration

This was a gated SPECT myocardial perfusion imaging study. A one-day rest-stress imaging protocol was followed. The isotope used for imaging was ^{99m}Tc-sestamibi. Rest imaging was performed after an injection of 7.1 mCi. Stress imaging was performed after an injection of 21.3 mCi.

Nuclear Stress Findings

Nuclear Study Quality

Overall imaging quality was good.

Perfusion Conclusion

LV perfusion is probably normal.

Perfusion Defect #1

There is a small region with moderate reduction in uptake in the apical to mid anterior segment(s) that is predominately reversible. There is normal wall motion in the defect area. The defect appears to be shifting breast artifact, but ischemia cannot be ruled out. The perfusion defect is visually present but not quantitatively significant.

Perfusion Comments

There is no evidence of transient ischemia dilation (TID). The rest study indicates well-preserved viability.

Function Comments

Left ventricular function post-stress was normal with an ejection fraction of 63%. The stress end-diastolic cavity size was normal (52 mL/m^2). The stress end-systolic cavity size was normal (19 mL/m^2).

Interpretation Summary

- The stress electrocardiogram was positive for electrocardiographic evidence of myocardial ischemia.
- The Duke Treadmill Score was intermediate risk at -5.
- The patient developed typical angina at peak stress.
- LV perfusion is probably normal.
- The small region with moderate reduction in uptake in the apical to mid anterior segment(s) appears to be shifting breast artifact but ischemia cannot be ruled out.
- Left ventricular function post-stress was normal with an ejection fraction of 63%.

Nuclear and Stress Combined Conclusion

The ECG and SPECT portions of the stress study are discordant, but the following factors support an intermediate risk of inducible myocardial ischemia:

- Poor exercise workload achieved during stress.
- Anginal symptoms during stress.
- Multiple cardiovascular risk factors.

Further cardiac evaluation for ischemic heart disease could be considered, especially in the setting of progressive or typical angina.

Nuclear Prior Study

Compared with the prior study dated [xx/xx/xxxx], the perfusion defect is new. There has been no significant change in left ventricular function.

APPENDIX 4: SAMPLE TEMPLATE FOR PHARMACOLOGIC-BASED STRESS MYOCARDIAL PERFUSION IMAGING

(Single/2 day) Rest/Stress (or Stress/Rest) Pharmacologic Stress Myocardial Perfusion Imaging with LV function analysis

Indication

(select one) (Diagnosis of coronary artery disease/known coronary artery disease/chest pain/shortness of breath/Preoperative assessment/Evaluation of myocardial viability/Risk Stratification/Other)

Clinical history

X-year-old man/women with a history of:

Cardiac History:

Cardiac Risk Factors:

Prior cardiac imaging and procedures:

Current symptoms:

Technique

At rest, the patient received x mCi of x tracer. X minutes later, resting tomographic images of the heart were obtained.

Pharmacologic stress testing was performed with adenosine/dipyridamole/dobutamine/regadenoson at a rate of ____ for ___minutes. Additionally, low-level exercise was performed along with the vasodilator infusion (specify: ____). Resting HR was x with a peak heart rate of x bpm and x% maximum predicted heart rate . The rest blood pressure was ___ mm/Hg and increased/decreased to ___ mm/Hg, which is a normal/hypotensive/hypertensive response. The patient developed significant symptoms, which included ____.

The resting EKG showed x with no significant ST/T abnormalities that would preclude interpretation. The stress EKG showed (no) ST-segment changes consistent with myocardial ischemia, with x mm horizontal/upsloping/downsloping ST depression in the x leads. ST depressions began at x min of rest/stress and resolved at x min of rest/stress.

At peak stress, the patient received x mCi of x. Stress tomographic imaging was performed x minutes later. The rest and post-stress images were acquired with ECG gating, for assessment of left ventricular systolic function. All imaging was performed on a x camera and data were analyzed using x software.

Findings

The overall quality of the study is poor/fair/good/excellent. Review of the raw imaging demonstrates (no) significant motion during stress/rest image acquisition. Attenuation artifact was present/absent in the x walls.

Review of the perfusion images shows symmetric or improved uptake of tracer in all portion of the left ventricle from rest to stress imaging OR show an x severity x sized perfusion defect in the anterior wall that is x reversible, a x sized x severity perfusion defect in the lateral wall that is x reversible, and a x sized x severity perfusion defect in the inferior wall that is x reversible. Quantitative evaluation shows a summed stress score of x, a summed rest score of x, and a summed difference score of x. This represents a myocardial ischemic fraction of x%.

Gated SPECT images shows that the left ventricle is normal/enlarged in size and shows normal systolic performance. The LVEF at rest is x% and x% on post-stress images. No regional wall motion abnormalities are present during either stress or rest imaging.

Transient ischemic dilation, a high-risk marker, is/is not present. Left ventricular/right ventricular hypertrophy is/is not present. Left ventricular/right ventricular dilation is/is not present.

Impression

1. Myocardial perfusion imaging is normal with no evidence of ischemia or scar OR Myocardial perfusion imaging is abnormal with a small/moderate/large area of ischemia/infarction in the distribution of the x artery.
2. Left ventricular systolic function is normal/abnormal with (no)/x regional wall motion abnormalities. Left/Right ventricular hypertrophy/dilation is present.
3. In comparison with the previous study of x date, there has been (no)/a change in left ventricular perfusion, size, or function.

APPENDIX 5: SAMPLE TEMPLATE FOR PHARMACOLOGIC-BASED STRESS MYOCARDIAL PERFUSION IMAGING

Patient Name: Last, First
Patient ID: xxxxxxxxxxx Age/Sex: xx yrs. / Male/Female

Stress / Rest PET Study Date: MM/DD/YYYY / MM/DD/YYYY

Referring Physician: Last, First, title
Reporting Physician: Last, First, title
Date/Time of Report Generation: MM/DD/YYYY xx:xx (HH:MM)

INDICATIONS: (select one primary, multiple secondary if applicable)
Diagnosis of CAD, evaluation of extent/severity of CAD, evaluation of chest pain; evaluation of dyspnea; arrhythmia; heart failure; syncope; assessment of LV function

CORONARY RISK FACTORS:(select as apply) hypertension, hyperlipidemia, obesity, age, diabetes, family history, smoking, peripheral vascular disease

CARDIAC EVENT HISTORY:(select as apply) s/p PCI/stent; s/p CABG; s/p MI; history of peripheral arterial disease; heart failure; arrhythmia

Patient Height: xx.xx cm Patient Weight: xx.xx kg BSA: x.xx m2

STRESS PROTOCOL: Pharmacologic
The patient was infused intravenously with [stress agent] at [xx.xxx units] for a total duration of [xx time units]. A total [stress agent dose] of xx mg was injected intravenously. Pharmacologic stress was discontinued due to [reason for termination]. The patient's heart rate [increased/decreased] from xx bpm at rest to xx bpm at peak stress. The patient's blood pressure at rest was xxx/xx mmHg and [increased/decreased] to xxx/xx mmHg at peak stress. Blood pressure response was [normal/abnormal/hypotensive/blunted]. Chest pain [did/did not] occur. Other symptoms that occurred included [insert symptoms]. The patient was treated with [a total reversal agent dose of xx mg] intravenously to reverse effects of vasodilator pharmaceutical stress.

STRESS TEST FINDINGS:
The resting EKG demonstrated _____. The stress EKG demonstrated _____. There [were/were not] [describe EKG changes] [consistent/not consistent] with ischemia

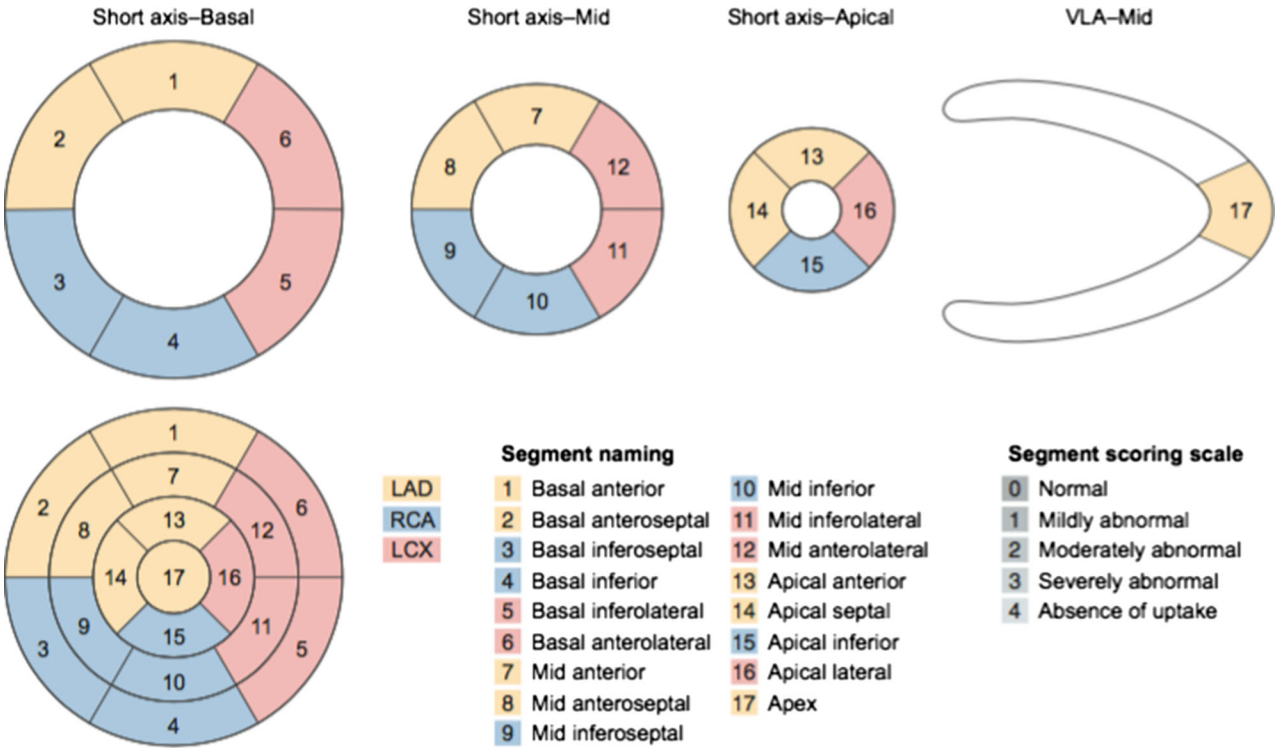
PET IMAGING PROTOCOL:
Dynamic Stress Rb-82 with CT attenuation correction / Dynamic Rest Rb-82 with CT attenuation correction
Rest imaging was performed with CT attenuation correction with the patient in the supine position approximately xx minutes following the intravenous injection of xx.x mCi of [PET perfusion tracer]. Stress imaging was performed; xx.x mCi of [PET perfusion tracer] were injected intravenously after the termination of [pharmacological stress agent] infusion. The heart was imaged with CT attenuation correction with the patient in the supine position approximately xx minutes post-injection.

RV FINDINGS AND INTERPRETATION:
RV Volumes: [Normal/Abnormal]
Regional RV Function: RV wall motion is [normal/abnormal]
RV Perfusion: RV myocardial perfusion was [normal/abnormal].

```
LV FUNCTION FINDINGS AND INTERPRETATION:
           Stress          Rest
Ejection Fraction :   xx%          xx%
ED Volume / Index :  xx ml / xx.x ml/m2   xxx ml /xx.x ml/m2
ES Volume / Index :  xx ml / xx.x ml/m2   xx ml / xx.x ml/m2
Cardiac Output / CI : x.x L/min / x.x L/min/m2
LV Mass :       xxx grams

Global LV Function:
   Stress:      [Normal/Abnormal, mild, moderate, severely decreased]
   Rest:       [Normal/Abnormal, mild, moderate, severely decreased]
LV Volume(s):
   Stress      [Normal/Abnormal, mild, moderate, severely increased]
   Rest       [Normal/Abnormal, mild, moderate, severely increased]
Regional LV Function:
   Stress       LV wall motion is [normal/abnormal, list segments]
   Rest        LV wall motion is [normal/abnormal, list segments]


LV PERFUSION FINDINGS AND INTERPRETATION:
QUANTITATIVE PERFUSION DEFECT EXTENT RESULTS BY TERRITORY
Territory   Stress      Rest      Reversal
LAD       x %       x %       x %
LCX       x %       x %       x %
RCA       x %       x %       x %
Total      x %       x %       0 %

Summed Stress Score (SSS)    : x
Summed Rest Score (SRS)     : x
Summed Difference Score (SDS)  : x

Post Stress / Rest LV Volume Ratio: x.xx, [Normal/Borderline/Abnormal]


LV BLOOD FLOW AND RESERVE
Territory       Stress (ml/g/min)  Rest (ml/g/min) Reserve
LAD           x.xx         x.xx      x.xx
LCx           x.xx         x.xx      x.xx
RCA           x.xx         x.xx      x.xx
Global          x.xx         x.xx      x.xx

IMPRESSION:
LV perfusion is normal/abnormal.
[If abnormal, describe location, size, severity, reversibility of
defect.]

Compared to the prior study on xx/xx/xxxx, the current study reveals
_____.
Scan significance was normal/abnormal/equivocal and indicates a
[low/intermediate/high risk for hard cardiac events.
```

APPENDIX 6: LEFT VENTRICULAR SEGMENTATION[17]

Adapted and reprinted with permission from the American Society of Nuclear Cardiology; originally presented in Cerqueira MD, et al. *J Nucl Cardiol* 2002;9:240-5.



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