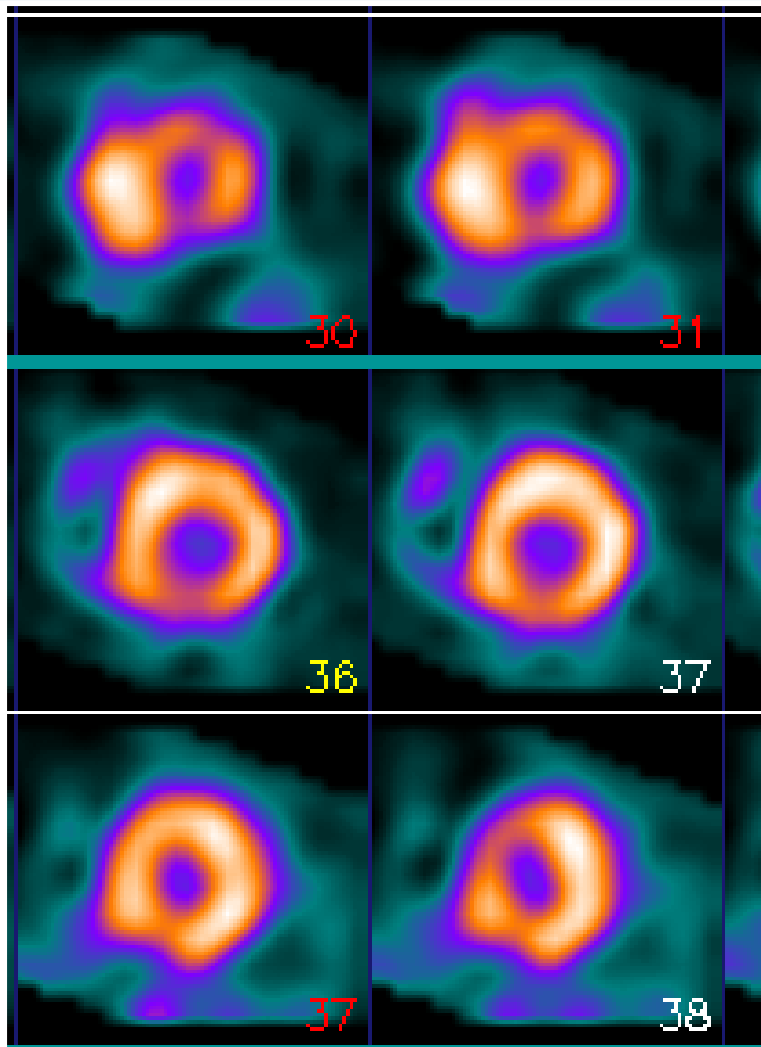


Nuclear Cardiology Job/Task Analysis Summary Report – 2016/2017



Prepared for CBNC/
ACPA by
The Caviart Group

Nuclear Cardiology Job/Task Analysis Report – 2016/2017



By

Caviart

The Caviart Group, LLC

May 2017

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The Caviart Group

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ACKNOWLEDGMENTS

The researchers conducting this study would like to thank the people who generously contributed their time, energy, and expertise toward the completion of this study.

FOREWORD

The Alliance for Physician Certification & Advancement™ (APCA™) is part of the Inteleos™ family of Councils that also includes ARDMS®. Spun out of ARDMS in 2016 to meet the exclusive needs of physicians, the APCA Council represents 21,000 physicians dedicated to continual learning and providing high-quality and compassionate patient care through certification. APCA joins ARDMS in furthering its long-standing mission of raising the global standards of excellence in healthcare and patient safety.

In January 2016, the APCA Council, led by physician volunteers, assumed oversight of the CBNC™ – Certification Board of Nuclear Cardiology™ certification program.

In August 2016, CBNC began the process of assessing and revising the Certification Board of Nuclear Cardiology™ examination by undertaking the process of conducting a job/task analysis.

CBNC engaged The Caviart Group to conduct this study.

The CBNC JTA study was designed to:

1. Identify those tasks performed by Nuclear Cardiology professionals that are important to the competent practice of the profession and identify the knowledge, skills and abilities (KSAs) that are required to perform those tasks.
2. Provide information for an examination specification indicating the content and weighting for future CBNC examinations.

Definition of a Job/Task Analysis

The term “job/task analysis” refers to a variety of systematic procedures designed to obtain information about the tasks performed on a job and/or the knowledge, skills and abilities and skills necessary to perform those tasks (Arver & Faley, 1988; Gael, 1983). A job/task analysis is the primary mechanism for establishing the job-relatedness of decisions concerning standards for professional certification and for supporting arguments of content validity for examinations constructed from the results of a job/task analysis. The job/task analysis described in this report was designed to be consistent with the AERA/APA/NCME Standards for Educational and Psychological Testing; the ANSI/ISO/IEC International Standard 17024; the NCCA Standards for the Accreditation of Certification and current best practices in testing.

THE JOB/TASK ANALYSIS METHODOLOGY

A diverse panel of experienced Nuclear Cardiology practitioners was formed into a JTA Working Group. This group was charged with the primary responsibility of defining a draft list of the tasks performed by Nuclear Cardiology professionals and the knowledge, skills and abilities believed to be important for competent performance of those tasks.

The JTA Working Group met face-to-face on August 19 and 20, 2016 in Tysons Corner, VA. The meeting was facilitated by Clarence “Buck” Chaffee, President of The Caviart Group. During this meeting, the group discussed and came to consensus on the characteristics of a newly certified CBNC professional.

The description of the characteristics of such individuals created by the JTA Working Group is as follows:

DEFINITION OF A NEWLY CERTIFIED NUCLEAR CARDIOLOGIST

A newly certified nuclear cardiologist is an experienced physician who is trained in nuclear cardiology and has the ability to determine the appropriateness of a nuclear cardiology study and then properly select, safely perform and accurately interpret nuclear cardiology studies. These physicians are able to understand the diagnostic and prognostic implications of the test results and effectively communicate the results to other health professionals.

They understand the strengths and limitations of different stressor protocols and their impact on the interpretation of nuclear cardiac imaging. They are able to effectively integrate the clinical, stress electrocardiographic and imaging findings into a single comprehensive and clinically relevant report.

They oversee the activities of technologists/medical personnel according to institutional protocols. They are able to safely receive, handle and administer radioactive materials and understand basic radiation safety concepts and instrumentation in accordance with US Nuclear Regulatory Commission regulations.

MAJOR TASKS

With consideration for the characteristics described above, the JTA Working Group drafted a list of major tasks and subtasks, organized across four phases of nuclear cardiology that such individuals might undertake.

PILOT SURVEY

The information prepared by the subject matter experts working group was compiled and formed into a draft survey instrument. This draft survey was distributed to the JTA Working Group members and other nuclear cardiology professionals. In addition to responding to the survey items, the Pilot Testers also completed a feedback form with suggestions for clarifications and additional survey questions.

The results for the pilot study were very good. Participants indicated no difficulty understanding the instructions or rating scales. They also offered some changes to improve the survey many of which were incorporated into the final survey document.

SURVEY ADMINISTRATION

CBNC used an internet survey software system to deliver the final survey. Any computer with a web browser and a web connection could be used to access the survey.

On October 25, 2016 the CBNC JTA survey was launched. Individuals were recruited to respond through direct email invitations. A total of 9,617 emails were sent to CBNC certificate holders. 684 emails were returned as undeliverable. We are not able to determine the number of emails that were actually delivered and opened. Two follow-up emails were sent to everyone who had not started the survey as well as those who had started the survey but had not completed the survey. The survey was closed on November 20, 2016.

A total of 895 responses were received during the survey period. Of these responses, 595 were deemed to be sufficiently complete and from individuals whose demographic information represented them as qualified nuclear cardiology professionals. Responses were received from around the world with individuals from 37 countries responding.

Since we are unable to determine how many surveys were actually delivered, we are unable to calculate a response rate for this study. The 595 usable survey responses however exceeds the minimum required for statistically reliable results for the study.

In addition, the distribution of the demographic characteristics of the respondent population is believed to be representative of the breadth of the profession¹.

ANALYSIS OF DEMOGRAPHIC INFORMATION

The following charts graphically depict the demographic information gathered in the job/task analysis survey. The purpose of collecting this data was to describe the population of individuals who responded to the survey and whose data was included in the final analysis. “N” represents the total number of responses for that demographic question. (Note: Respondents were not required to respond to any question if they chose not to.)

The purpose of this analysis is to determine whether the respondent population is demographically representative of the population of certification professionals. Since no data exists identifying the actual demographic distribution of professionals in the field, subject matter experts were asked to review this data. They concluded that this sample was a reasonable representation of the population.

DEMOGRAPHIC DATA

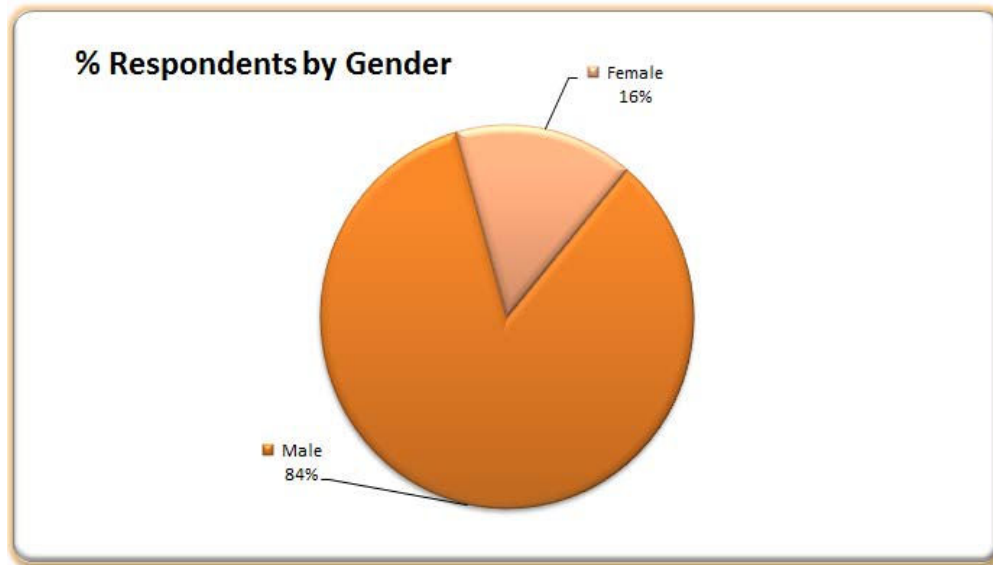


Figure 1 % Respondents by Gender

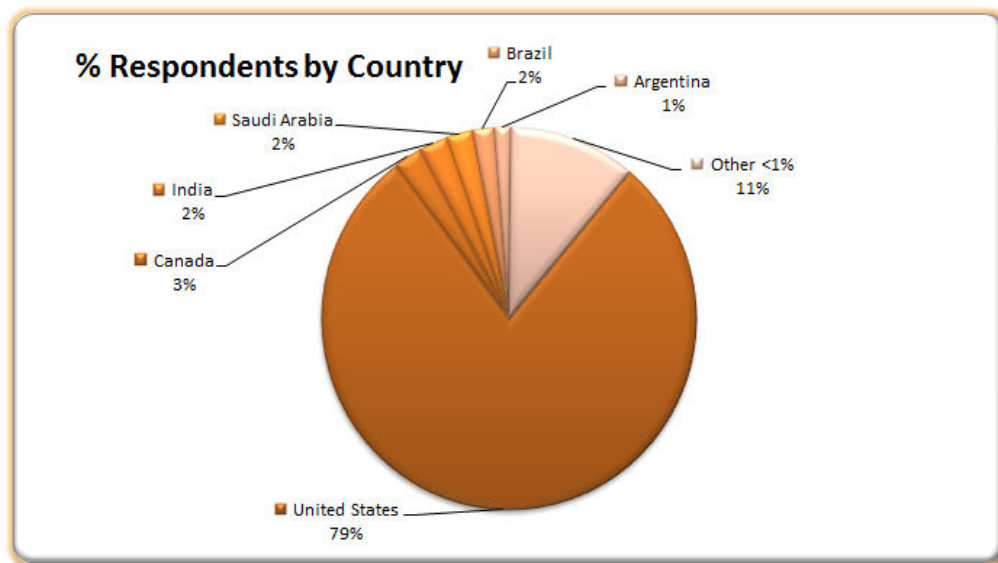


Figure 2 % Respondents by Gender

% Respondents by State

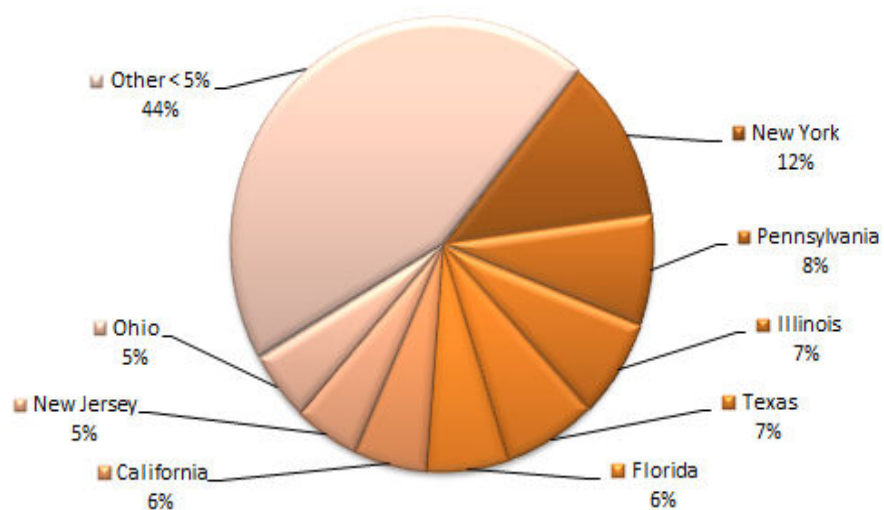


Figure 3 % Respondents by State

% Respondents by Level of Nuclear Cardiology Training

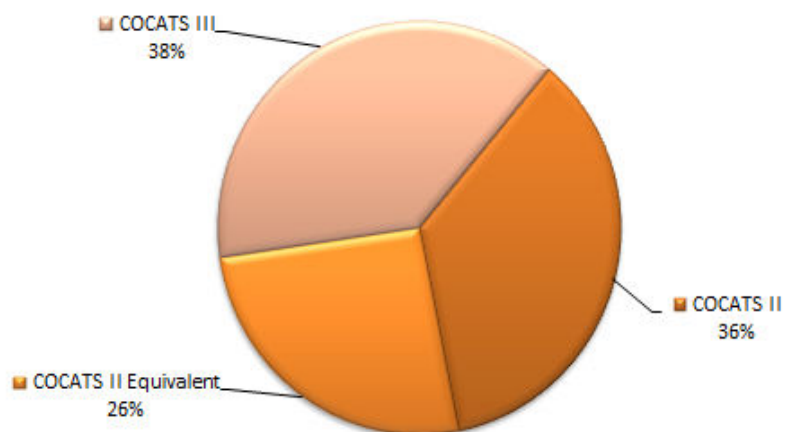


Figure 4 % Respondents by Level of Cardiology Training

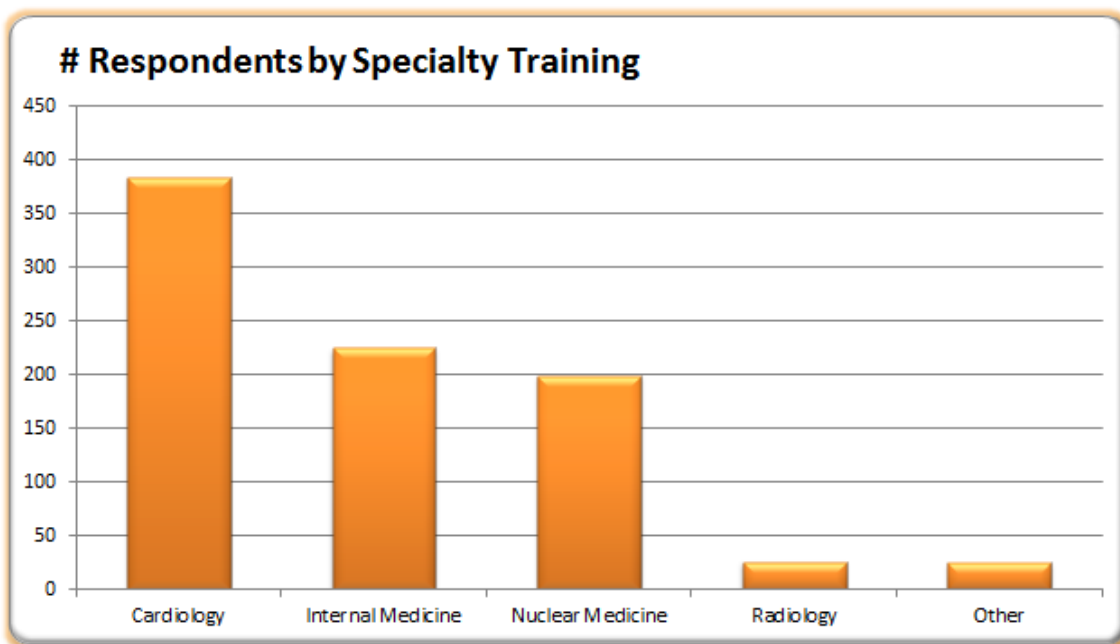


Figure 5 # Respondents by Specialty Training

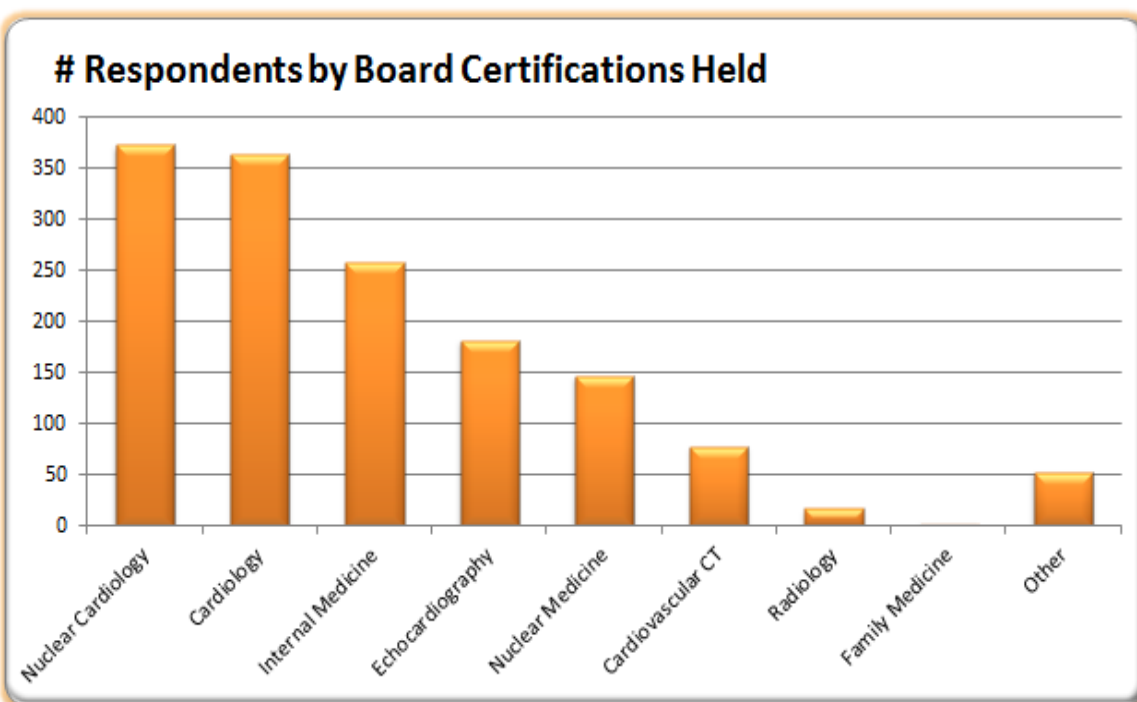


Figure 6 # Respondents by Board Certification

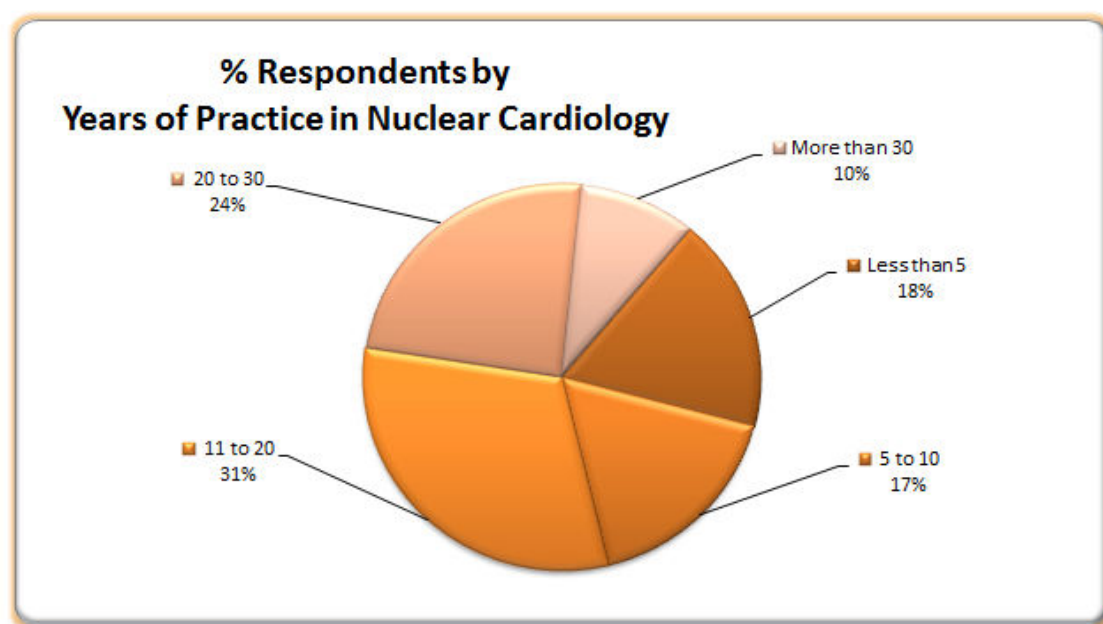


Figure 7 % Respondents by Years of Practice in Cardiology

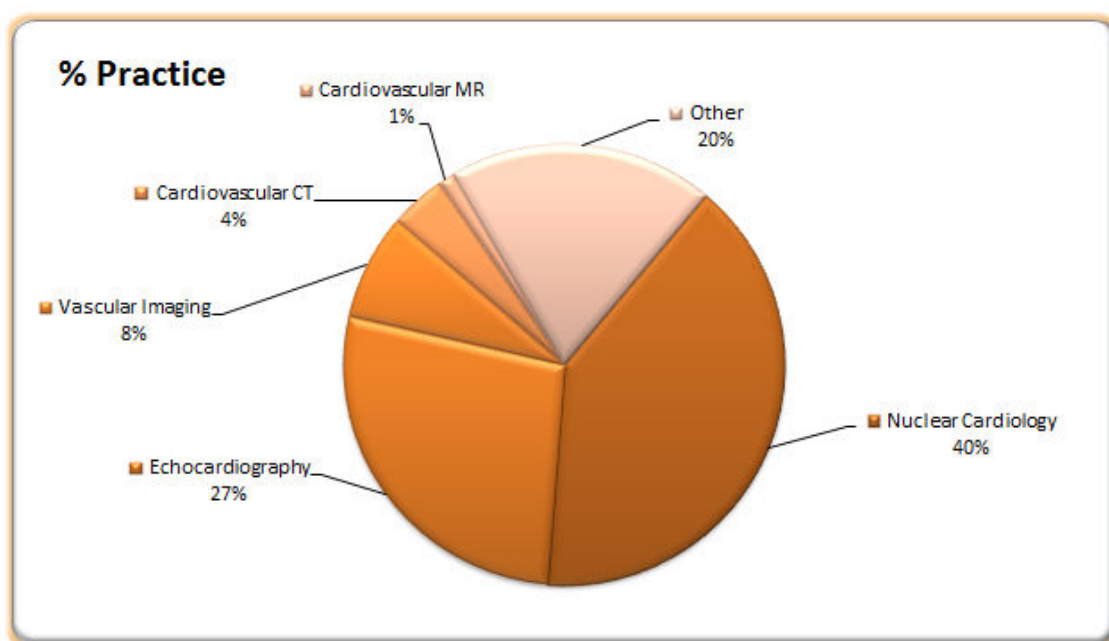


Figure 8 % Respondents by Practice

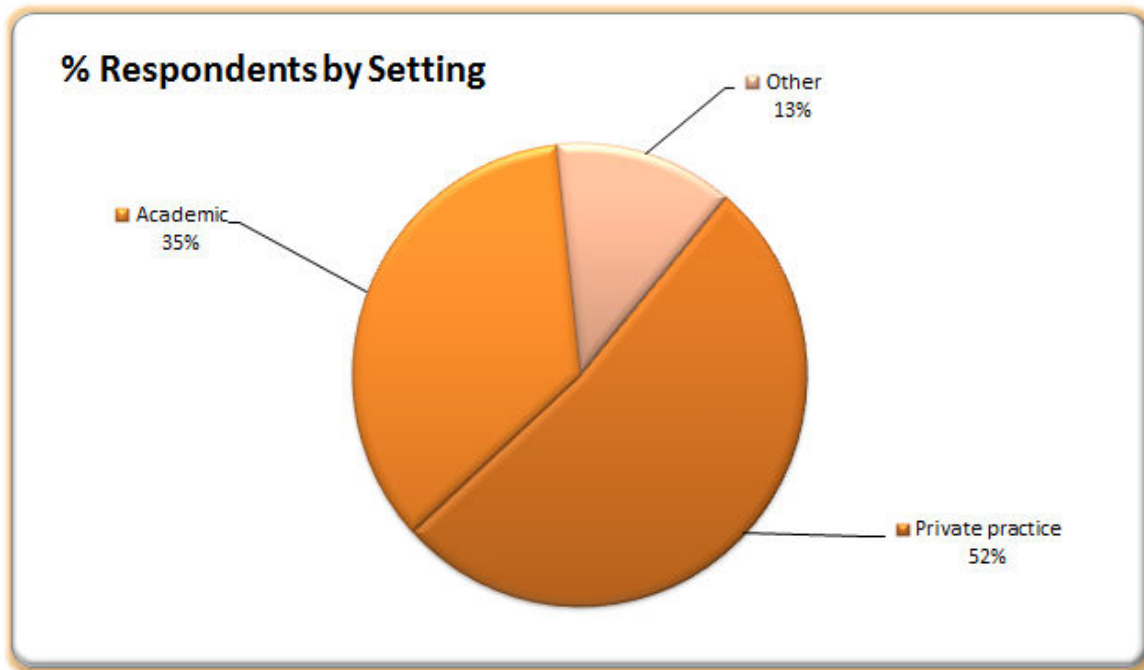


Figure 9 % Respondents by Setting

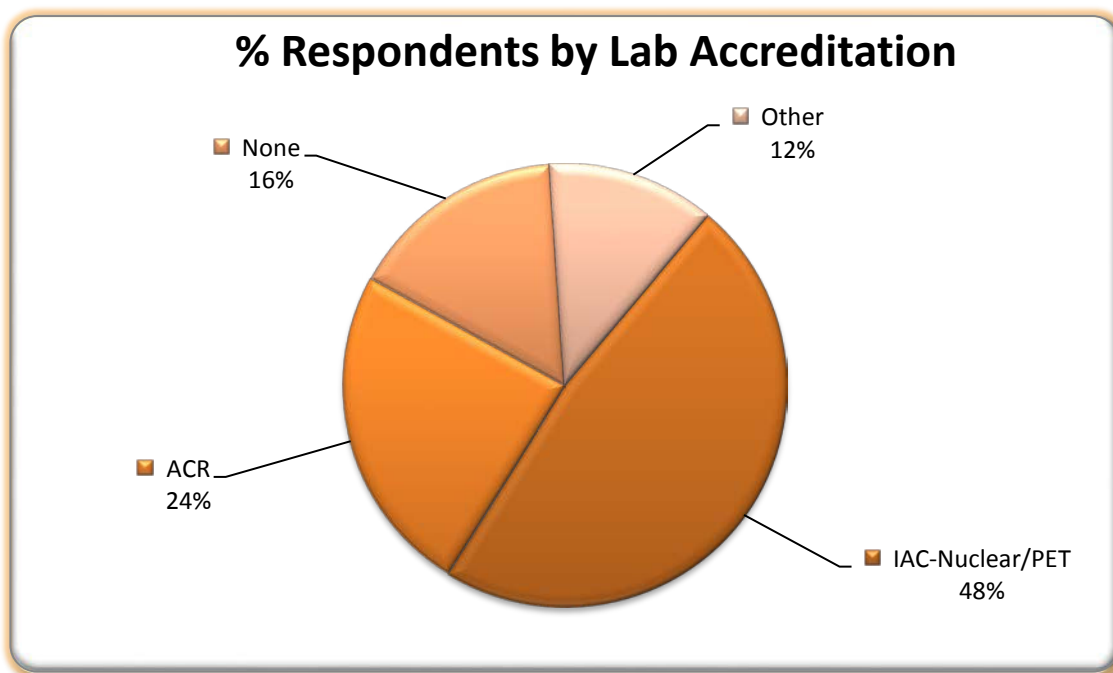


Figure 10 % Respondents by Lab Accreditation

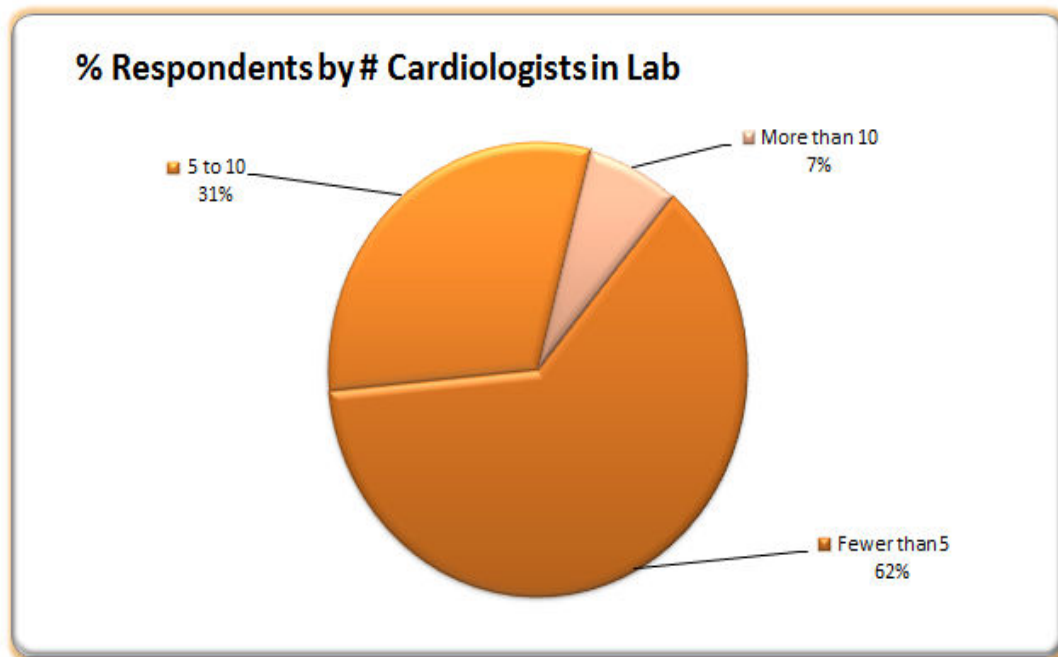


Figure 11 % Respondents by # of Cardiologists in Lab

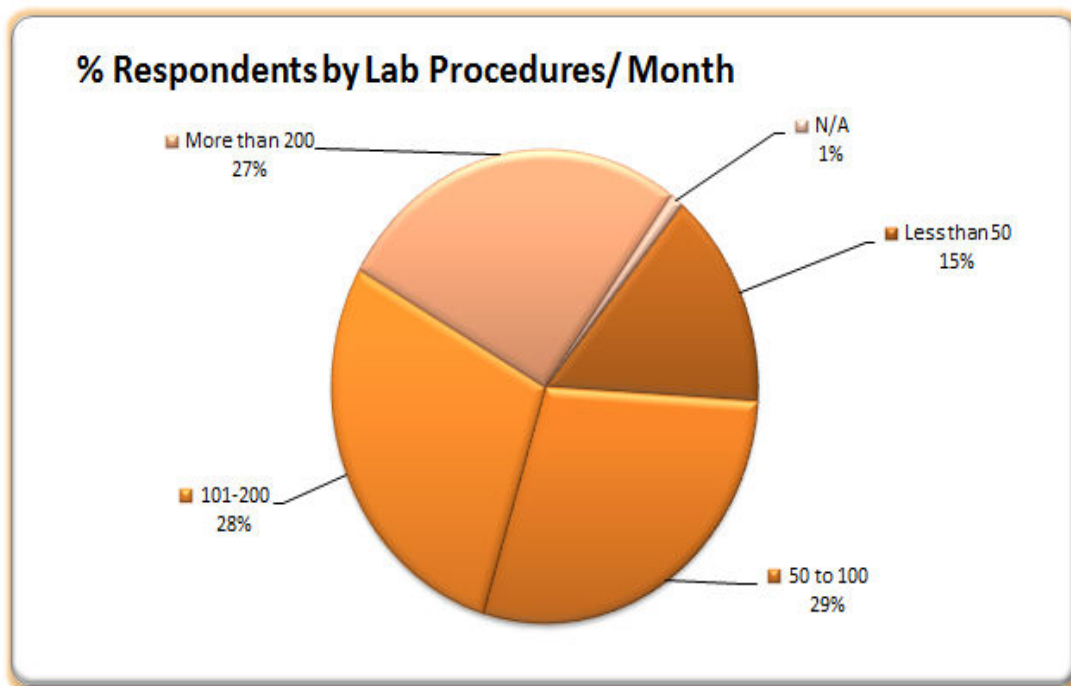


Figure 12 % Respondents by Lab Procedures per Month

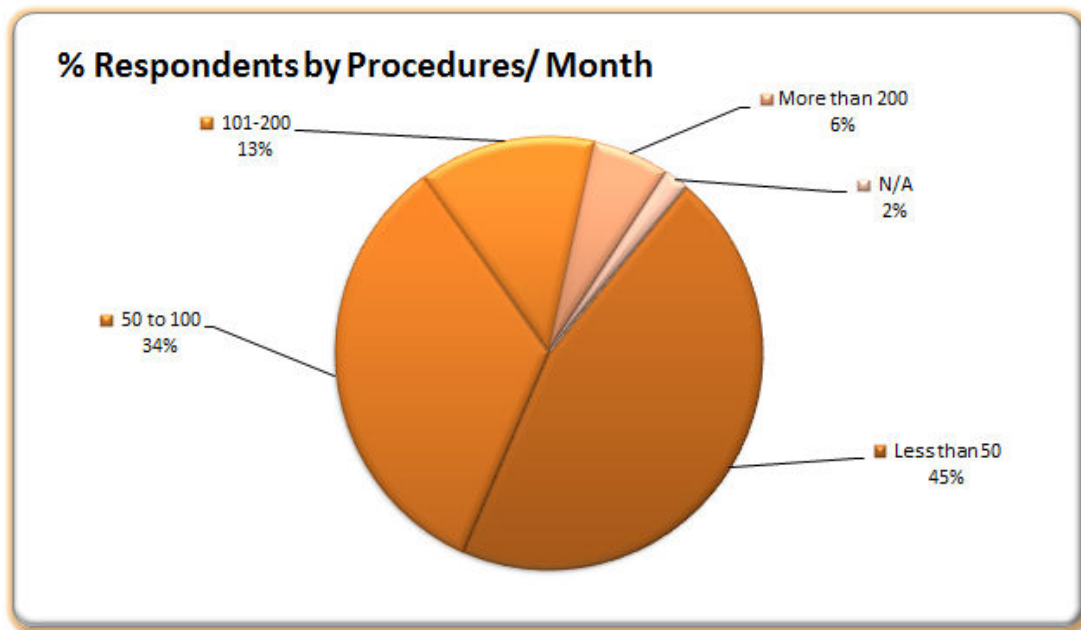


Figure 13 % Respondents by Procedures per Month

Physical Attributes

Respondents were asked about the importance of one physical attribute – sight. The results are shown in Table 14 below.

How important is the ability to see clearly enough, with or without assistive technology devices, to readily read and interpret studies to the competent performance of the job of a Nuclear Cardiologist?	N	%
Not Important	1	0.2%
Somewhat Important	8	1.7%
Important	48	9.9%
Very Important	150	31.0%
Critically Important	278	57.4%
Total	485	100%
Table 14. Physical Attributes		

Data Analysis

The purpose of the data analysis is to determine whether the survey population validates that the tasks identified by the JTA Working Group as being required for the job.

The analysis identifies those tasks that are performed by a majority of the population and are deemed to be important for competent practice.

To assist in the interpretation of the survey results, cut-points were established to differentiate more important activities from less important activities. Activities not meeting one or more of the criteria were flagged for possible omission from the certification examination. The cut-points that were set in this study and their rationales are provided below.

Analysis of Tasks

Percent “Do”

The first analysis is the percentage of respondents who indicated that they expect a newly certified professional to perform the task in their job. The respondents were asked to indicate how frequently they expected a newly certified professional to perform the task. The “Percent Do” scale reflects the percentage of the respondents that indicated that they expect newly certified professionals to perform the task at least occasionally. If less than 51% of the respondents fell into this category, the task was not considered to be a core task for this job and was therefore not included for consideration in the certification program.

No tasks fell below this flag.

Mean Importance Ratings

Mean importance ratings were computed for all task statements. The importance scale ranged from 1 (not important) to 5 (critically important). Statements with mean importance ratings of 3.00 (the point on the scale that is equal to “important”) or less were flagged as potentially failing the importance rating.

Importance ratings play a critical role in the design of certification examinations. Professional and legal guidelines indicate that if content is to be included in an examination, the developer or user must be able to demonstrate that it is important for competent performance (AERA, 1985). The 3.00 cut-point recommended by The Caviart Group is consistent with this requirement of demonstrating job relevance.

Six tasks fell below this flag and were reviewed by the JTA Working Group to determine whether they should be excluded from the examination.

Standard Deviation of Importance Ratings

Finally, the standard deviation of importance responses was calculated. This is a measure of the degree to which the respondents agreed with each other. Low standard deviations indicate a high level of agreement while higher numbers mean that there was less agreement as to how the importance of the statement should be rated. Statements with a standard deviation above 1.50 were flagged for special review by the subject matter experts working group due to the relatively high level of disagreement among the survey respondents.

No tasks fell above this flag.

Conclusions

On May 17, 2018, the JTA Working Group unanimously approved the domain weightings and final content outline via an electronic vote. The detailed content outline is in Appendix A. The Final Report was approved by the APCA Council on July 25, 2018. This content outline will be applied to the 2018 administration of the CBNC examination.

Certification Board of Nuclear Cardiology (CBNC) Content Outline (Outline Summary)

	Domain	Tasks	Percentage
1	Selection of Nuclear Cardiology Imaging Tests	• Synthesize clinical data (history, physical exam, other test results, etc.) • Determine appropriateness of test ordered • Select appropriate stressor • Select appropriate radiopharmaceutical and dose (including knowledge of radiation biology, radiation physics, and instrumentation) • Select appropriate imaging protocol (stress/rest, rest/stress, stress only, viability, etc.) • Select appropriate imaging modality (SPECT, PET, radionuclide ventriculography, etc.)	20 %
2	Performance of Nuclear Cardiology Imaging Tests (including Instrumentation, Protocols, and Processing)	• Instruct and prepare patient (use printed/recorded material, secure patient consent, etc.) • Perform stress tests (including complications and side effects of stress testing) • Administer radiopharmaceuticals • Define acquisition parameters (positioning of patient, etc.) • Acquire images [with or without attenuation correction] • Utilize solid-state cameras • Perform SPECT, PET, SPECT/PET imaging (including viability, perfusion, novel methods, myocardial flow reserve, and inflammation imaging) • Interpret coronary blood flow • Select optimal imaging protocol [PET vs SPECT] • Process images (filtered back projection, iterative reconstruction, motion correction, etc.) • Perform routine camera quality control processes (daily flood tests, center-of-rotation checks, etc.) • Perform routine non-camera instrumentation quality control processes (survey meter calibration, dose calibrators, etc.)	32 %
3	Interpretation of Nuclear Cardiology Imaging Tests	• Review raw data and interpret extracardiac findings (including oddities out of normal perfusion interpretation, RV hypertrophy, and papillary muscle) • Assess and manage image quality (repeat scan; perform prone imaging; wait for gastrointestinal clearance; have patient drink water; perform upright imaging; perform usual supine imaging; etc.) • Assess functional information and its reliability (including gated images and viability) • Assess disease-specific processes (sarcoid, amyloid, infection, heart failure, sympathetic innervation, coronary calcium score, etc.)	35 %

		• Assess processed perfusion images (including attenuation-corrected images and viability) • Assess prognosis (including risk stratification) • Perform quantitative analysis (SSS, SRS, SDS, numerical quantitation, TID, LHR, EF, EDV, ESV, etc.) • Integrate data from different modalities (ECG, clinical; CT/calcium scoring and hybrid studies; etc.) • Generate report using standardized nomenclature • Identify and communicate critical results (appropriate report content, vascular territories, etc.)	
4	Radiation Safety and Management of Radiopharmaceuticals	• Perform daily surveys and wipes • Ensure radiation safety (including knowledge of radiation biology and dosimetry) • Respond to radiation emergencies • Respond to radiopharmaceutical misadministration • Follow patient and occupational radiation safety protocols • Manage the ordering, receiving, unpacking, and handling of radioactive materials safely, and perform related radiation surveys • Calculate, calibrate, and safely prepare radiation dosages (including generator elution; radiochemistry; mathematics pertaining to the use and measurement of radioactivity; quality control of radionuclide purity; etc.) • Perform red blood cell radiolabeling for radionuclide ventriculography (in vitro, in vivo, etc.) • Understand radiation physics and instrumentation	13 %

(Detailed Outline)

I	Selection of Nuclear Cardiology Imaging Tests (20%)	Knowledge, Skill, or Ability related to Selection of Nuclear Cardiology Imaging Tests
I.A.	Synthesize clinical data (history, physical exam, other test results, etc.)	○ Ability to take relevant history for risk assessment ○ Ability to perform a target-oriented physical examination to ascertain safety for stress testing ○ Ability to utilize other test results to complement nuclear imaging ○ Knowledge of pretest risk (Bayes theorem, etc.) ○ Knowledge of statistics as it applies to evaluating clinical tests ○ Ability to apply appropriate use criteria ○ Ability to assess patient's ability to perform sufficient exercise ○ Knowledge of indications and contraindications of various stressor modalities (pharmacologic stress, exercise stress, etc.) ○ Knowledge of indications for transition from submaximal exercise to pharmacologic stress ○ Knowledge of impact of current medications (caffeine, dipyridamole, theophylline, etc.) on pharmacologic vasodilator stress test ○ Knowledge of mechanism of action of stressors (pharmacologic, exercise, etc.) ○ Ability to synthesize patient characteristics in selecting radiopharmaceutical and dose (weight-based dosing, circumference/distribution of weight, etc.) ○ Knowledge of SPECT radiopharmaceuticals and their characteristics (production, energy, half-life, etc.) ○ Knowledge of importance of understanding hazards of radiation and need for ALARA ○ Knowledge of principles of radiation physics (scatter, types of electromagnetic emissions, shielding, etc.) ○ Knowledge of radiation biology (absolute dose, equivalent dose, effective dose, units, etc.) ○ Knowledge of first-pass myocardial extraction, redistribution, and retention of different perfusion tracers ○ Knowledge of biological effects on the body ○ Knowledge of how SPECT and PET systems acquire images ○ Knowledge of impact of SPECT and PET radiopharmaceuticals and their characteristics on test selection ○ Knowledge of advantages and limitations of SPECT and PET imaging ○ Ability to synthesize patient characteristics with other considerations in selecting protocols ○ Knowledge of imaging protocols and their advantages/disadvantages ○ Knowledge of different viability protocols (PET FDG, thallium, SPECT, nitrate-enhanced technetium, etc.) ○ Knowledge of benefits and applications of stress-only imaging
I.B.	Determine appropriateness of test ordered	
I.C.	Select appropriate stressor	
I.D.	Select appropriate radiopharmaceutical and dose (including knowledge of radiation biology, radiation physics, and instrumentation)	
I.E.	Select appropriate imaging protocol (stress/rest, rest/stress, stress only, viability, etc.)	
I.F.	Select appropriate imaging modality (SPECT, PET, radionuclide ventriculography)	

2	Performance of Nuclear Cardiology Imaging Tests (including Instrumentation, Protocols, and Processing) (32%)	Knowledge, Skill, or Ability related to Performance of Nuclear Cardiology Imaging Tests (including Instrumentation, Protocols, and Processing)
2.A.	Instruct and prepare patient (using printed/recorded material, securing patient consent, etc.)	○ Knowledge of impact of medications on stress myocardial perfusion results ○ Knowledge of impact of patient positioning on results
2.B.	Perform stress tests (including complications and side effects of stress testing)	○ Knowledge of potential complications of agents used in stress testing ○ Knowledge of stress protocols
2.C.	Administer radiopharmaceuticals	○ Knowledge of pertinent physiology/pathophysiology as it applies to stress testing
2.D.	Define acquisition parameters (positioning of patient, etc.)	○ Knowledge of how to manage complications ○ Knowledge of when to terminate test
2.E.	Acquire images [with or without attenuation correction]	○ Knowledge of pharmacokinetics of radiopharmaceuticals ○ Knowledge of SPECT and PET tracers and their effects
2.F.	Utilize solid-state cameras	○ Knowledge of adequacy of counts
2.G.	Perform SPECT, PET, SPECT/PET imaging (including viability, perfusion, novel methods, myocardial flow reserve, and inflammation imaging)	○ Knowledge of standard acquisition parameters and variables ○ Knowledge of time vs radiotracer dose concepts ○ Knowledge of types of attenuation correction ○ Knowledge of benefits and limitations of attenuation correction
2.H.	Interpret coronary blood flow	○ Knowledge of optimal timing of acquisition after radiotracer administration, based on radiotracer kinetics and distribution
2.I.	Select optimal imaging protocols [PET vs SPECT]	○ Knowledge of equipment and quantum mechanisms in play in image acquisition (collimators, crystals, photomultiplier tubes, etc.)
2.J.	Process images (filtered back projection, iterative reconstruction, motion correction, etc.)	○ Knowledge of multigated acquisitions (MUGAs) ○ Knowledge of the physics of imaging
2.K.	Perform routine camera quality control processes (daily flood tests, center-of-rotation checks, etc.)	○ Knowledge and application of specific protocols for perfusion and viability assessment
2.L	Perform routine non-camera instrumentation quality control processes (survey meter calibration, dose calibrators, etc.)	○ Knowledge and application of dynamic myocardial blood flow imaging protocols, and calculation of coronary flow reserve ○ Knowledge and application of novel SPECT, PET, and SPECT/PET protocols (sarcoid, amyloid, I-123-MIBG, etc.) ○ Knowledge of pertinent physiology/pathophysiology ○ Knowledge of physiology/pathophysiology ○ Ability to assess absolute coronary blood flow ○ Ability to assess coronary flow reserve ○ Knowledge of benefits and limitations of different methods of image processing (ramp filter, iterative reconstruction, etc.) ○ Knowledge of the physics and mechanisms of image processing (including filtered back projections) ○ Knowledge of frequency cutoffs ○ Knowledge of different filters and reconstruction methods ○ Knowledge of data reorientation and display ○ Knowledge and application of motion-correction algorithms ○ Knowledge of strengths and limitations of motion correction (vertical, horizontal, etc.) ○ Knowledge of gated SPECT processing and artifacts ○ Knowledge of processing of MUGA images, including quantifying EF and volumes (septal view, background noise, etc.)

		○ Knowledge of mechanics of quality control processes (intrinsic/extrinsic floods, differing radiation detectors, differing dose calibrators, etc.) ○ Knowledge of regulatory requirements for quality control ○ Ability to identify common abnormalities during quality control processes (photomultiplier tube out, center-of-rotation error, etc.)
3	Interpretation of Nuclear Cardiology Imaging Tests (35%)	Knowledge, Skill, or Ability related to Interpretation of Nuclear Cardiology Imaging Tests
3.A.	Review raw data and interpret extracardiac findings (including oddities out of normal perfusion interpretation, RV hypertrophy, and papillary muscle)	○ Knowledge of methods of raw data display (sinograms, etc.) ○ Ability to interpret raw data for artifacts (motion, soft tissue, subdiaphragmatic count activity, shifting breast, etc.) ○ Ability to identify abnormal extracardiac findings (pericardial effusions, soft-tissue masses, hiatal hernias, etc.)
3.B.	Assess and manage image quality (repeat scan; perform prone imaging; wait for gastrointestinal clearance; have patient drink water; perform upright imaging; perform usual supine imaging; etc.)	○ Knowledge of comparison of stress and rest images (comparable breast positioning, motion, arm positioning, etc.) ○ Knowledge of and ability to detect image processing artifacts (motion, soft tissue, subdiaphragmatic count activity, shifting breast, etc.)
3.C.	Assess functional information and its reliability (including gated images and viability)	○ Knowledge of manifestations of rest/stress changes in orientation and alignment ○ Ability to assess proper gating
3.D.	Assess disease-specific processes (sarcoid, amyloid, infection, heart failure, sympathetic innervation, coronary calcium score, etc.)	○ Ability to identify regional wall motion abnormalities and probable vessel territories ○ Ability to use regional wall motion to aid in study interpretation [normal vs abnormal]
3.E.	Assess processed perfusion images (including attenuation-corrected images and viability)	○ Knowledge of limitations of EF estimation (in the presence of large count reductions, LV hypertrophy, ventricular cavity size, etc.)
3.F.	Assess prognosis (including risk stratification)	○ Knowledge of post-stress stunning and its implications ○ Ability to assess MUGA images for LV/RV function
3.G.	Perform quantitative analysis (SSS, SRS, SDS, numerical quantitation, TID, LHR, EF, EDV, ESV, etc.)	○ Knowledge of PET sarcoid imaging protocol (including patient preparation and high-fat diet) ○ Knowledge of SPECT/PET amyloid imaging protocol (including the use of Tc-pyrophosphate, Tc-MDP, and FDG)
3.H.	Integrate data from different modalities (ECG, clinical; CT/calcium scoring and hybrid studies; etc.)	○ Knowledge and application of specific heart failure imaging (including the use of I-123-MIBG)
3.I.	Generate report using standardized nomenclature	○ Knowledge of CT calcium score protocol using dedicated CT, SPECT/CT, or PET/CT
3.J.	Identify and communicate critical results (appropriate report content, vascular territories, etc.)	○ Knowledge of functionality of right ventricle ○ Ability to assess normal vs abnormal findings ○ Ability to assess defect size ○ Ability to assess viability (PET FDG, thallium, SPECT, nitrate-enhanced technetium, etc.) ○ Ability to assess defect reversibility/nonreversibility ○ Ability to assess defect location ○ Ability to assess transient ischemic dilation (TID) ○ Ability to assess defect severity ○ Ability to identify infarct vs ischemia ○ Ability to identify probable vessel territories ○ Ability to understand limitations of predicting vessel territories

		○ Ability to identify left bundle-branch block/pacing artifact patterns ○ Ability to understand limitations of relative perfusion assessment (balanced ischemia) ○ Ability to understand limitations of perfusion assessment for obstructive CAD in specific patient populations (congestive heart failure, myocarditis, hypertrophic cardiomyopathy, issues of partial volume effects, patients with congenital heart disease, etc.) ○ Ability to identify imaging variables that predict prognosis (perfusion defect size; ischemic defect size; LVEF and volumes; etc.) ○ Ability to identify stress test variables (Duke treadmill score, exercise time, symptoms, heart rate recovery, degree of ST depression, etc.) ○ Knowledge of diagnostic and prognostic accuracy of ST changes with pharmacologic stress ○ Knowledge of extent of ischemia and benefit of revascularization ○ Ability to understand implications of low risk with normal stress study (<1%) ○ Knowledge of high risk parameters (depressed LV function, TID, post-stress stunning, large perfusion defects, etc.) ○ Knowledge of special populations (women, diabetics, obese patients, renal, congestive heart failure, hypertrophic cardiomyopathy, elderly patients) ○ Ability to identify differences from prior studies and their implications ○ Ability to identify implications of changes in EF post-chemotherapy ○ Knowledge of implications of viability presence or absence for benefits of revascularization and long-term prognosis ○ Knowledge of implications of test results prior to noncardiac surgery ○ Knowledge of implications in evaluating stable angina, unstable angina, acute chest pain, and acute myocardial infarction ○ Ability to calculate SSS/SRS/SDS ○ Ability to calculate percentage of ischemic burden ○ Knowledge of limitations and benefits of quantitative analysis ○ Knowledge of clinical implications of quantitative analysis (prognosis) ○ Ability to integrate exercise treadmill testing and perfusion imaging data ○ Ability to integrate calcium score and perfusion imaging data ["warranty period"] ○ Ability to compare with previous NC studies ○ Knowledge of nomenclature of 17-segment model ○ Knowledge of what constitutes a complete report (including ASNC imaging guidelines) ○ Ability to communicate significance of findings and test results
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4	Radiation Safety and Management of Radiopharmaceuticals (13%)	Knowledge, Skill, or Ability related to Radiation Safety and Management of Radiopharmaceuticals
4.A.	Perform daily surveys and wipes	○ Knowledge of regulatory requirements for radiation safety ○ Ability to provide specific advice to patients after nuclear imaging (avoiding young people less than 1 year of age; pregnant women; advice slip for border-control purposes; etc.) ○ Knowledge of types of radiation emergencies (spillage, dose misadministration, generator malfunction, fire in nuclear lab, terrorism, etc.) and appropriate response ○ Ability to monitor patient vital signs, advise on diuresis, blood investigations, quarantine, etc. ○ Knowledge of how to identify and report to relevant authorities, how to counsel patients, and how to communicate with test administrators when a radiopharmaceutical misadministration occurs ○ Knowledge of upper limits of annual radiation exposure for patient and occupational workers ○ Knowledge of upper limits of radiation exposure for women per pregnancy ○ Knowledge of tasks usually performed by radiation technologists under the supervision of physician-in-charge ○ Knowledge of proper documentation according to protocol (e.g., frequency of orders; dosage required; delivery of generator/unit doses via approved vehicles/sources; safe delivery of dose/generator to laboratory via specified routes; unpacking the dose/generator; quality control measures; calibrating the dose in a safe environment) ○ Knowledge of how to elute, calculate, and check the radiochemical purity of the radiopharmaceutical ○ Knowledge of mechanisms and procedures of red blood cell radiolabeling for MUGA (in vitro, in vivo, etc.) ○ Knowledge of properties and characteristics of radiation physics ○ Knowledge of instrumentation
4.B.	Ensure radiation safety (including knowledge of radiation biology and dosimetry)	
4.C.	Respond to radiation emergencies	
4.D.	Respond to radiopharmaceutical misadministration	
4.E.	Follow patient and occupational radiation safety protocols	
4.F.	Manage the ordering, receiving, unpacking, and handling of radioactive materials safely and perform related radiation surveys	
4.G.	Calculate, calibrate, and safely prepare radiation dosages (including generator elution; radiochemistry; mathematics pertaining to the use and measurement of radioactivity; quality control of radionuclide purity; etc.)	
4.H.	Perform red blood cell radiolabeling for radionuclide ventriculography (in vitro, in vivo, etc.)	
4.I.	Understand radiation physics and instrumentation	