COMMON CLINICAL PRACTICES IN SPECT MPI

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DISCLOSURE

I have no actual or potential conflicts of interest in relation to this presentation.

KEY TOPICS FOR DISCUSSION

- What is SPECT MPI and why is it used?
- SPECT MPI guidelines from ASNC
- Hospital survey results
- Compare and contrast common protocols
- The future of SPECT MPI

WHAT IS SPECT MPI AND WHY IS IT USED?

- Single
- Photon
- Emission
- Computed
- Tomography
- Myocardial
- Perfusion
- Imaging

HISTORY OF SPECT MPI[1]

1973: First exercise stress-test myocardial scan

1973: Thallium-201 introduced for MPI

1976: First general purpose SPECT camera

1977: FDA approval to distribute Tl-201 for MPI

1991: First Tc99m MPI agent approved by FDA

WHY IS SPECT MPI USED?

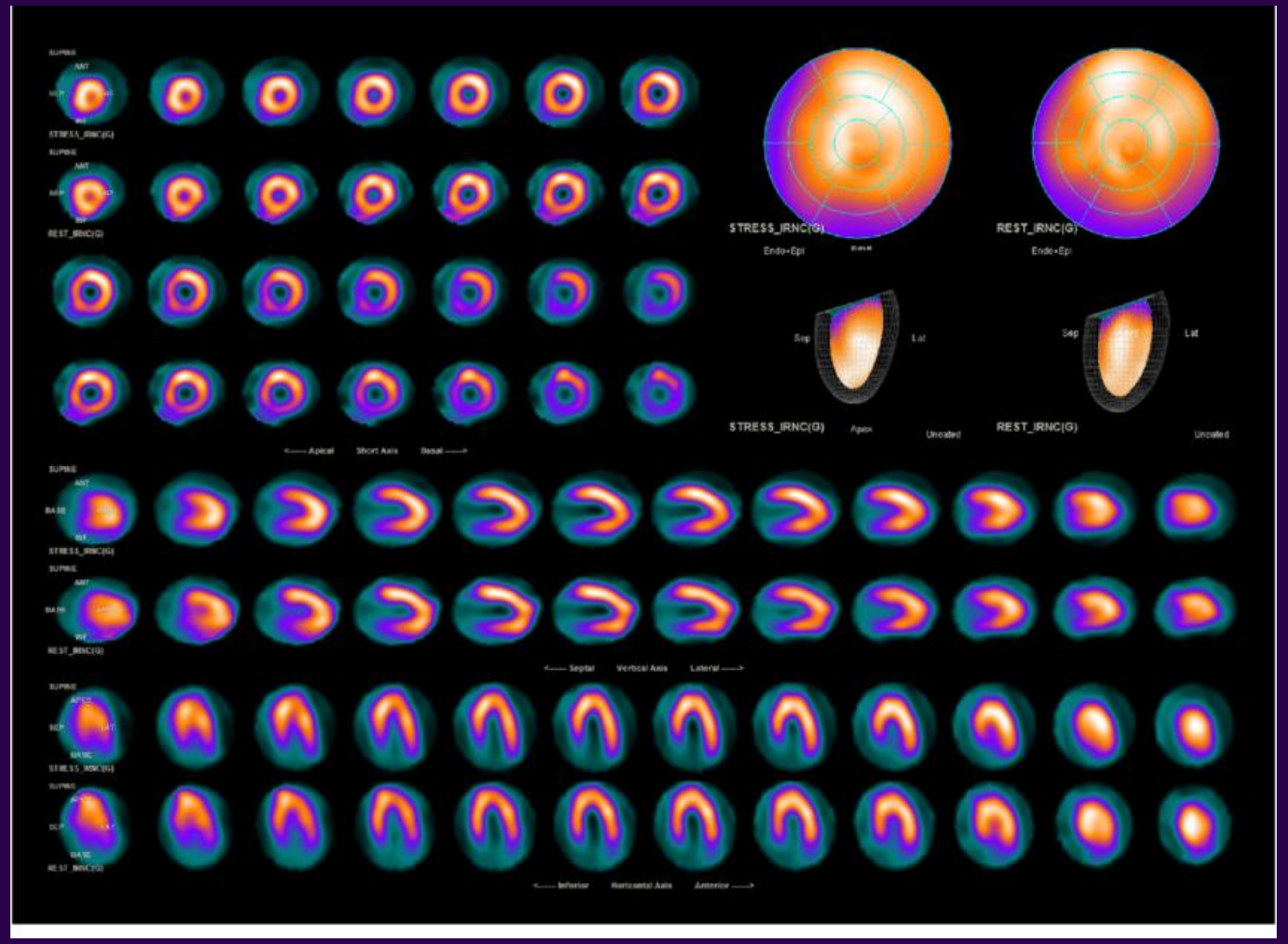

Image credit: Researchgate.net

WHAT IS MYOCARDIAL ISCHEMIA?[2]

- Under stress, coronary arteries dilate
- If narrowed by more than 50%, myocardial ischemia
- May also cause reduced or absent contraction

ECG GATING

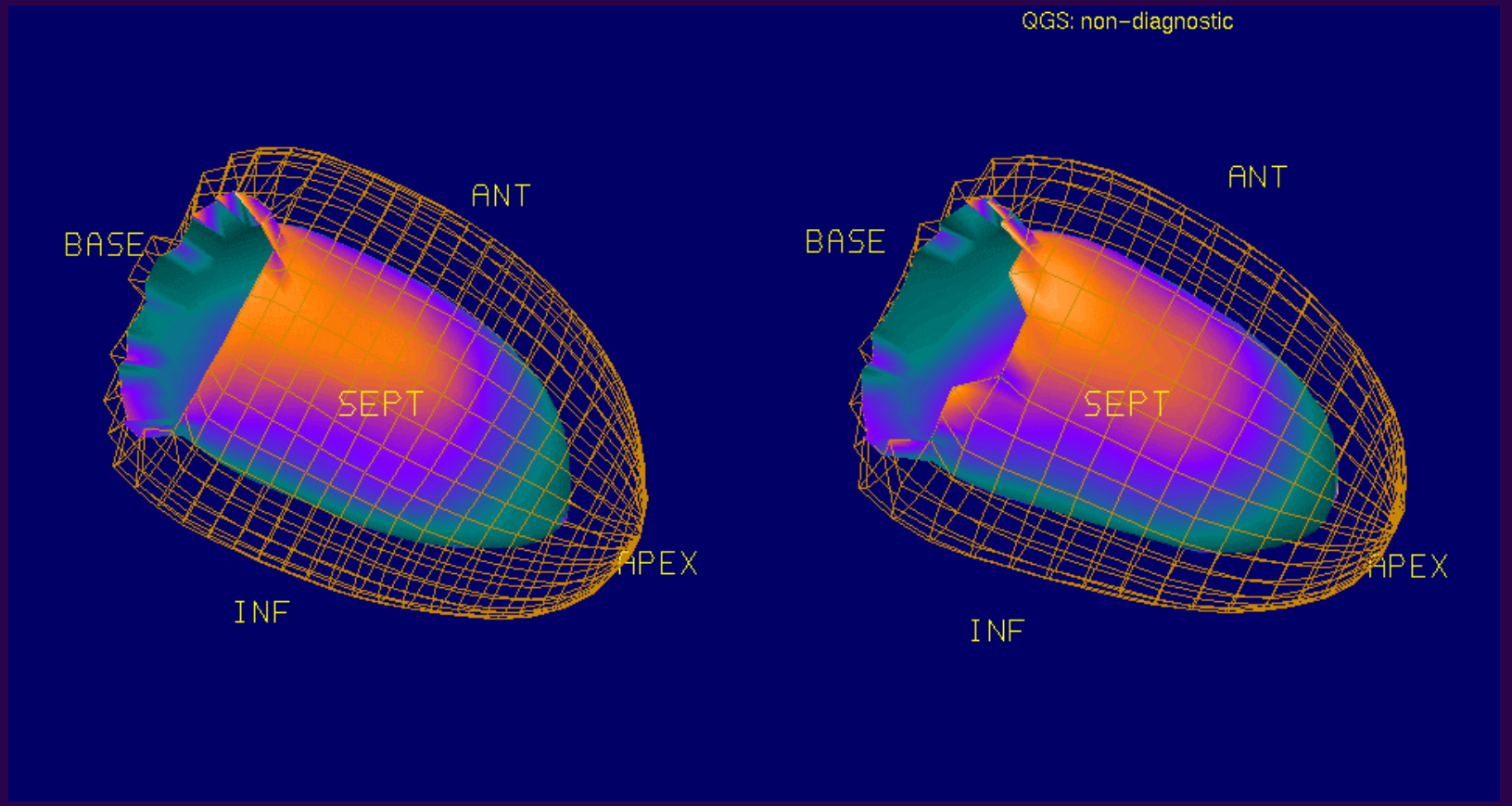

Image credit: NorfolkNuclear.com

HOW DOES MPI WORK?[2]

- Rest and Stress images acquired
- Rest perfusion defect typically caused by scarring (MI)
- Stress defect:
  - Matched defect at rest?
    - If yes (matched), then myocardial scar
    - If no (mismatched), then myocardial ischemia

RESULTS FROM SPECT MPI$_3$

Final result grants us the following data:

- ✓Resting ECG data
- ✓Stress ECG data
- ✓Quantitative and Qualitative LV perfusion assessments
- ✓LV gated functional volumes at rest and stress
- ✓Opportunity to assess RV if desired
- ✓Comparison to prior SPECT MPI studies
- ✓Correlation with other imaging

WHY WOULD A SPECT MPI BE ORDERED BY A PHYSICIAN?[3]

- Assess symptomatic patients with nondiagnostic ECG
- Identify severity and extent of ischemia
- Assess patients with high likelihood of CAD
- Assessment of asymptomatic patients with known CAD

RADIOPHARMACEUTICALS$_3$

Tc99m Tetrofosmin (Myoview)

Tc99m Sestamibi (Cardiolite)

Tl-201 Thallous Chloride

STRESS PHARMACEUTICALS$_3$

Regadenoson (Lexiscan)

Dobutamine

Adenosine

Dipyridamole (Persantine)

TC99M TETROFOSMIN & TC99M SESTAMIBI: WHAT THEY HAVE IN COMMON[3]

- Single, 140-keV photopeak
- Minimal redistribution
- Approximately 2% of injected dose localizes in heart
- Excreted mostly via hepatobiliary system into GI tract
- Biological half-life in myocardium greater than 5 hours

TC99M TETROFOSMIN & TC99M SESTAMIBI: HOW ARE THEY DIFFERENT?

- Liver clearance of tetrofosmin is quicker than sestamibi[2]
  - Tetrofosmin allows for imaging 15 minutes post-injection[4]
- Per package insert, recommended dose:
  - Tetrofosmin: 5-33 mCi[4]
  - Sestamibi: 10-30 mCi[5]

TL-201 THALLOUS CHLORIDE$_2$

- Acts as a potassium analog
- Photopeaks are around 70 and 167 keV
- 3-4% of injected dose localizes in myocardium
- Washes out of myocardium in 10-15 minutes
- Allows for myocardial viability imaging

TL-201 THALLOUS CHLORIDE$_2$

- Cleared primarily via the kidneys
- Higher whole-body radiation dose than Tc99m
- Max dose is about 4 mCi
- Typically only used as a last resort for SPECT MPI

STRESS PHARMACEUTICALS$_2$

- Regadenoson, adenosine, and dipyridamole
  - All stimulate A_2A receptors, causing coronary dilation
  - Caffeine competes for A_2A uptake
- Dobutamine
  - For patients unable to exercise or receive vasodilator
  - Typically for patients with bronchospastic airway disease
  - Produces dose-related increase in heart rate

SPECT MPI PROTOCOLS: ASNC SUGGESTIONS[3]

- Use lowest activity possible of Tc99m-based agents
- Tl-201 only during a Tc99m shortage or for viability
- Avoid dual-isotope protocols with Tc99m and Tl-201
  - Higher patient radiation exposure
  - Differential spatial resolution for the two radiotracers

HOSPITAL SURVEY

- 4 major DFW hospitals provided detailed SPECT MPI protocols
- Surveyed hospitals' SPECT MPI patient volume:
  - H1: 80% of total studies are SPECT MPI
  - H2: 115 per month
  - H3: 130 per month
  - H4: 60-70 per month
- The following are key ASNC recommendations
  - Hospital survey results given to discuss common practices

SPECT MPI PROTOCOLS COMPARED

For same-day rest-stress Tc99m acquisition for Anger cameras:

<u>Rest study dose</u>

ASNC: 8-12 mCi[3]

Hospital survey average: 10 mCi

<u>Delay time from rest injection to rest scan</u>

ASNC: 30-60 minutes[3]

Hospital survey average: 27 minutes (range: 15-45 minutes)

SPECT MPI PROTOCOLS COMPARED

For same-day rest-stress Tc99m acquisition for Anger cameras:

Rest time per projection

ASNC: 25 seconds[3]

Hospital survey average: 22 seconds

Number of projections for rest

ASNC: 60-64[3]

Hospital survey average: 42 (some only 30, some 64)

SPECT MPI PROTOCOLS COMPARED

For same-day rest-stress Tc99m acquisition for Anger cameras:

Rest image ECG gating

ASNC: Preferred[3]

Hospital survey average: 50% gate rest; 50% do not

Stress study dose

ASNC: 24-36 mCi[3]

Hospital survey average: 30 mCi

SPECT MPI PROTOCOLS COMPARED

For same-day rest-stress Tc99m acquisition for Anger cameras:

Delay time from stress injection to stress scan

ASNC: 15-60 minutes[3]

Hospital survey average: 24 minutes (range: 0-60 minutes)

Stress time per projection

ASNC: 20 seconds[3]

Hospital survey average: 19 seconds

SPECT MPI PROTOCOLS COMPARED

For *two-day stress-rest* Tc99m acquisition for Anger cameras:

<u>Stress study dose (day 1)</u>

ASNC: 18-30 mCi if BMI is 35 or higher;

8-12 mCi if BMI is less than 35_3

Hospital survey average: 30 mCi

*1 hospital noted 30 mCi if BMI is 30 or higher and 10 mCi if BMI less than 30

SPECT MPI PROTOCOLS COMPARED

For *two-day stress-rest* Tc99m acquisition for Anger cameras:

<u>Rest study dose (day 2)</u>

ASNC: 18-30 mCi if BMI is 35 or higher;

8-12 mCi if BMI is less than 35_3

Hospital survey average: 30 mCi

*1 hospital noted 30 mCi if BMI is 30 or higher and 10 mCi if BMI less than 30

SPECT MPI PROTOCOLS COMPARED

For *two-day stress-rest* Tc99m acquisition for Anger cameras:

<u>Two-day stress time per projection</u>

ASNC: 25 seconds[3]

Hospital survey average: 19 seconds

<u>Two-day rest time per projection</u>

ASNC: 20 seconds[3]

Hospital survey average: 19 seconds

ADDITIONAL HOSPITAL SURVEY RESULTS

- Only 1 of the 4 hospitals performs CT with SPECT MPI
  - ASNC notes that CT may be used for attenuation correction[3]
- Patient preparation prior to SPECT MPI:
  - NPO
    - H1 and H3: “after midnight”
    - H2 and H4: 6 hours
  - No caffeine
    - H4: 6 hours
    - H2 and H3: 12 hours
    - H1: 24 hours
    - Lexiscan package insert recommends at least 12 hours

ADDITIONAL HOSPITAL SURVEY RESULTS

- Other patient prep. instructions:
  - No diabetic medication the morning of
  - No beta or calcium channel blockers for 12 hours
- How is one-day vs. two-day determined?
  - H1: Based on the technologist's discretion
  - H2: No 2-day protocols
  - H3: Patient BMI over 30 is 2-day
  - H4: Patient weight over 250 lbs is 2-day

ADDITIONAL HOSPITAL SURVEY RESULTS

- No prep. instructions for 2-day rest-only
- 3 out of 4 hospitals use tetrofosmin; 1 sestamibi
- Prone imaging:
  - H1: No prone imaging; most patients cannot tolerate
  - H2: No prone imaging
  - H3: Prone is almost always performed
  - H4: Prone per request by radiologist or cardiologist

ADDITIONAL HOSPITAL SURVEY RESULTS

- Regadenoson is the most-used pharmaceutical stress agent
- Dobutamine used very rarely
- None of the 4 hospitals use dipyridamole or adenosine

REGADENOSON PATIENT PREP[6]

Which foods, drinks, and medications should I avoid before my test?

DO NOT consume caffeine-containing foods and drinks or medications that contain methylxanthines (eg, caffeine, aminophylline, or theophylline) in the 12 hours before your scheduled stress test in the event that pharmacologic stress is used. In addition, avoid any prescription medications containing dipyridamole in the 48 hours before your stress test.

See Tables 1-3 for a list of some foods, drinks, and drugs to avoid before the test. Remember, it is only a partial list. Your doctor and pharmacist will know about other products, foods, drinks, and medications you shouldn't have before your test. Be sure to tell your doctor which over-the-counter (OTC) and prescription drugs you're currently taking. Your doctor will then give you instructions about those medications.

TABLE 1: FOODS TO AVOID
chocolate candies
chocolate cakes
brownies
chocolate pudding
energy bars
foods containing guarana

TABLE 2: DRINKS TO AVOID
chocolate milk
hot cocoa
coffee (brewed, instant, iced, decaf)
tea (brewed, instant, iced, decaf)
soda pop (including "caffeine-free")
energy drinks
drinks containing guarana

REGADENOSON PATIENT PREP[6]

TABLE 3: MEDICATIONS TO AVOID		
OTC drugs containing caffeine	**Prescription drugs containing caffeine**	**Prescription drugs containing dipyridamole (withhold for 48 hours)**
Anacin® (aspirin, caffeine)	Cafergot® (ergotamine tartrate, caffeine)	
Excedrin® (acetaminophen, aspirin, caffeine)	Esgic® (butalbital, acetaminophen, caffeine)	Aggrenox® (aspirin, dipyridamole)
Vivarin® (caffeine)	Fioricet® (butalbital, acetaminophen, caffeine)	Persantine® (dipyridamole)
NoDoz® (caffeine)	Fiorinal® (butalbital, aspirin, caffeine)	**Prescription drugs containing theophylline**
		Elixophylline® (theophylline)
		Theo-24® (theophylline)

EXAMPLE COMMON PROTOCOL

- Patient asked to avoid caffeine for 12 hours and NPO 4-6 hours prior
- Lowest possible Tc99m rest dose given to patient (8-12 mCi)
- Patient waits 30-60 minutes (ASNC recommendation)[3]
  - Generally, tetrofosmin allows for less wait time than sestamibi

EXAMPLE COMMON PROTOCOL[3]

- Patient obtains rest SPECT MPI
  - Noncircular, continuous acquisition
  - 60-64 projections
  - 128 x 128 matrix
  - 25 seconds/stop
  - Gating with 16 frames/cycle and 20-100% R-R window

EXAMPLE COMMON PROTOCOL[3]

- Rest images are evaluated for technical quality before stress
  - Prone or delayed imaging obtained if needed
- Patient has either exercise, regadenoson, or dobutamine stress
  - I.e. if patient cannot exercise, consider regadenoson
  - Only use dobutamine if regadenoson and exercise are clinically ruled out
- Lowest possible Tc99m stress dose injected (24-36 mCi)

EXAMPLE COMMON PROTOCOL[3]

- Patient waits 15-60 minutes post-stress prior to stress imaging
  - Minimum 15 minutes after exercise stress
    - Allows for heart rate to return to baseline
    - Avoids “upward creep” from changes in respiratory patterns
    - Minimizes hepatic uptake

EXAMPLE COMMON PROTOCOL[3]

- Patient obtains stress SPECT MPI
  - Noncircular, continuous acquisition
  - 60-64 projections
  - 128 x 128 matrix
  - 20 seconds/stop
  - Gating with 16 frames/cycle and 20-100% R-R window

EXAMPLE COMMON PROTOCOL[3]

- Stress images are evaluated for technical quality
  - Prone or delayed imaging obtained if needed
- If there is significant patient motion:
  - ASNC recommends repeat imaging, possibly in prone position
- SPECT MPI Processing
  - Use low-pass filter such as Hanning and Butterworth
  - Optimize cutoff to reduce noise but not oversmooth
  - Iterative reconstruction preferred to FBP
  - Attenuation correction applied with iterative reconstruction

ADDITIONAL ASNC RECOMMENDATIONS[3]

- ASNC recommends stress imaging first, whenever feasible
  - If stress is normal, rest would not be necessary
- Weight-based radiotracer dosing
  - Consider reduced dose and increased acquisition times

FUTURE OF SPECT MPI[7]

- SPECT MPI advantages over PET MPI:
  - SPECT is more widely available than PET
  - SPECT equipment and radiopharmaceuticals cost less
  - SPECT MPI insurance reimbursement is reliable

FUTURE OF SPECT MPI,

- PET MPI advantages over SPECT MPI:
  - Equal dose amounts can be given at rest and stress
    - Allows for same filters and processing parameters for each
    - Less count variability than with SPECT
    - Ultimately leads to greater confidence in interpretation

FUTURE OF SPECT MPI

- Cost and availability continue to make SPECT MPI common
- The future may trend toward an increase in PET MPI
  - Change will likely be gradual

FUTURE OF SPECT MPI$_3$

- Newer semiconductor radiation detectors
  - No scintillation crystal
  - Currently made of CZT
  - Improved energy resolution
  - Allows lower radiotracer activity
  - Allows shorter acquisitions

CONCLUSION

- It is important to reference established ASNC guidelines
- Minimize site-to-site variations in SPECT MPI protocols
  - Enables reproducibility and reliable study comparisons
- Adequate patient preparation for MPI is very important
- Utilize stress-first protocols when feasible[3]
- Processing defaults should be set up and used[3]
- SPECT MPI has a bright future, even alongside PET MPI

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THANK YOU