Cardiac Positron Emission Computed Tomography
New Approach to Cardiac Imaging

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I do not have anything to disclose

Indications for stress testing

Stress test modalities

Types of pharmacological stress agents and radiotracers

Cardiac PET – principles, protocols, indications, clinical cases, advantages and disadvantages
Indications for Stress Testing

- Pts. with symptoms suggesting angina with intermediate or high pre-test likelihood of CHD
- Pts. with acute CP after ACS exclusion
- Within three months post-ACS for risk assessment
- Known CHD and change in clinical status
- After five years post CABG one time in asympt.
- For newly dg. CHF or cardiomyopathy
- For valvular heart disease – AS with low output
- For active cardiac condition prior non-cardiac surgery
Stress Test Modalities

For pts. who can attain an adequate level of exercise (5 min walk or 1-2 flights of stairs) - exercise testing is preferred

For pts. who are unable to exercise to sufficient cardiac workload – pharmacological stress testing

Modality based on factors:

- resting ECG
- clinical indication for performing the test
- body habitus
- history of prior revascularization
Stress Tests with Imaging Modalities

- Stress echocardiography (exercise or dobutamine)
- Radionuclide stress myocardial perfusion imaging (SPECT or PET)
- Stress cardiac magnetic resonance imaging
Myocardial Perfusion Stress Imaging (SPECT and PET)

Goal: assessment of relative myocardial blood flow or perfusion between the resting and stressed states

Focus: intracellular myocardial extraction and retention of tracer (reversible vs. fixed defect)
Vasodilators

Adenosine, dipyridamole and selective A2A receptor agonists – **regadenoson** (Lexiscan)

- Increase coronary blood flow through their effects on adenosine A2A receptors (up to 4x)
- Presence of flow-limiting obstructive CHD leads to perfusion defects. The increase of blood flow is attenuated and there is relative reduction of radiotracer uptake
- Can be combined with low level of exercise
- May be administered at peak exercise in pts. who fail to achieve target HR
Positron Emission Tomography

Utilizes radionuclide tracer techniques that produce images of in vivo radionuclide distribution using external detector system

Similar to CT the images represent cross-sectional slices through the heart; however the image intensity reflects organ function as opposed to anatomy

PET allows noninvasive evaluation of myocardial blood flow, function, and metabolism, using physiological substrates prepared with positron-emitting radionuclides.
Cardiac PET CT
PET Principle

Positron Emission

Unstable element

Proton decays to Neutron in nucleus

Positron and neutrino emitted

511 keV

Positron combines with Electron and annihilates

Two anti parallel 511 keV Photons produced

180°
PET Radioactive Tracers

- **Rb-82** analog of K, has only 75 s half life; the most widely used radiotracer for clinical PET. It is extracted from plasma by myocardial cells via Na/K/ATP pump – uptake predom. depends on myocardial blood flow
- **Sr-82** generator producing Rb-82 replaced usually every 28 days
- **N-13** has 9.96 min half life; limited to institutions with a cyclotron on site
- **N-13** longer half life permits exercise stress
- **F-18 FDG** fluoro-2-deoxyglucose - 110 min half life; viability imaging
PET Protocol

1. Topogram/Scout scan
2. Transmission scan
3. Emission scan
4. Stress test
5. Topogram/Scout scan
6. Emission scan
7. Transmission scan

Rest PET MPI

Stress PET MPI
PET Indications

- Suspected CHD and risk stratification of pts. with known CHD when unable to exercise
- Large body habitus; chest deformity, large breasts or implants
- Indeterminate SPECT; LBBB, paced rhythm
- Assessment of myocardial viability
- Assessment of myocardial inflammation - sarcoidosis
- Quantification of myocardial blood flow
Normal Perfusion PET
74 y Obese Female Without Known CHD but with CP and DOE
74 y Obese Female Without Known CHD but with CP and DOE
47 y Female with DM, HTN, CP and BMI 55
47 y Female with DM, HTN, CP and BMI 55
3v CAD with Diffuse Dissection of RCA to PDA
61y Male with HTN, DM and DOE but no CP
BMI 42
61y Male with HTN, DM and DOE but no CP
PCI to CTO RCA
76 y Female with HTN, DM, DOE and Anteroseptal MI on ECG but no CP; BMI 42
PET Viability

With reduced oxygen supply, myocytes compensate the loss of oxidative potential by utilization of glucose to generate high-energy phosphates. Reversible metabolic changes will occur in the setting of diminished regional myocardial blood flow.

F-18 radiolabel, produced in cyclotron, decays by the emission of a positron with half life 110 minutes. F-18 FDG, an analog of glucose used to image regional myocardial glucose uptake in vivo.

After fasting period patient gets oral glucose load (to maximize FDG uptake) with supplemental insulin prior F-18 FDG injection followed by imaging.
Cardiac F-18 FDG PET

Myocardial perfusion using Rubidium-82 (left) and myocardial FDG uptake (right) in the corresponding segments.

Perfusion

Metabolism

Mismatch: Hibernation

Match: Transmural scar

Non-transmural match
Non-transmural scar
Advantages of PET

- Rapid imaging protocols and throughput
- Increased diagnostic accuracy (Rb-82 sensitivity 84-93% vs 88% SPECT, specificity 82 % vs 61-76% SPECT)
- More accurate attenuation correction
- Higher spatial (4-5mm) and temporal (5-10 s) resolution
- Lower radiation exposure (3-5mSv vs. 11mSv)
- Excellent myocardial viability assessment
- Potential for quantification of myocardial blood flow
- Tool to identify inflammation and sarcoidosis
Disadvantages of PET

- Limited availability
- More expensive equipment and associated cost
- Difficult to use with exercise stress
- Difficult in patients with severe claustrophobia
- Requires experienced staff
Cardiac PET Requirements by Insurance Payer

- BC/BS TN  BMI > 30
- BC/BS GA  BMI > 40
- Cigna          BMI > 30
- UHC            BMI > 35
- Aetna         BMI > 40
- Medicare/Palmetto – inconclusive SPECT

Other indications for majority of payers: large breasts, breast implants, chest wall deformity and post heart transplant assessment
Conclusion

- Cardiac PET provides superior diagnostic accuracy
- Improved spatial and temporal resolution
- Allows the potential to measure regional blood flow
- Plays an important role in risk stratification
- Exposes patient to less radiation
- Leads to less downstream testing