When To Order A Nuclear Stress Test & Interpreting the Results

Mustapha Kazmi
Faculty Presenter Disclosure

Cardiology for the Non-Cardiologist
Faculty: Mustapha Kazmi

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Potential Conflicts of Interest: None
Mitigating Potential Bias

- While we have received unrestricted educational grants from several pharmaceutical companies, most presentations have no mention of specific products and are unrelated to the supporting companies or their products. No specific presentations will be supported or sponsored by a specific company.

- Information on specific products will be presented in the context of an unbiased overview of all products related to treating patients.

- All scientific research related to, reported or used in this CME activity in support or justification of patient care recommendations conforms to the generally accepted standards.

- Clinical medicine is based in evidence that is accepted within the profession.
Outline

• Appropriate testing
• Options for investigating stable CP
• Ordering an MPI
• Interpreting MPI results
Appropriate Testing
Take Home Message #1

Too many cardiac tests are ordered unnecessarily
Asymptomatic Patients

• Essentially, do not need cardiac testing!!

• Assess and manage risk factors:
  • HTN Management
  • DM Management
  • Obesity Management
  • Smoking Cessation
  • Dyslipidemia Management (Use Framingham/ACC Risk Scores)
Role for Ca Score in select Asymptomatic patients

- Limitations of Risk Scores
  - generally overestimate risk, and may underestimate risk in some patients

- To better stratify risk and therefore need for statin therapy, consider use of CT Calcium Score
  - If Agatston score > 100, recommend initiation of a statin
Ordering a Ca Score

- Use an AHS general CT requisition

- Request: “Cardiac CT - Ca Score Only”
  - If you order just Cardiac CT, the requisition will likely get protocolled for a CT angiogram
Asymptomatic patients generally do not need stress testing

- Diagnosing disease will not change quality of life
- No evidence to suggest that stress testing (and subsequent revascularization) will decrease mortality beyond risk factor management
Symptomatic Patients

• Appropriate to test for obstructive CAD in patients with symptoms
  • Chest pain
  • A suspected anginal equivalent
    • Exertional dyspnea
    • Exertional arm/shoulder/jaw pain
Not all symptomatic patients need testing either

• History, Exam, Bloodwork may successfully exclude CAD or portend such a low pretest probability that further testing is of minimal incremental value
CCS Algorithm

Stable Chest Pain Syndrome (1 – 3/3 anginal symptoms)

Cardiovascular history, physical, laboratory tests, 12-lead EKG

2 or 3/3 Chest pain criteria

1/3 Chest pain criteria

Significant non-CV comorbidities and quality of life issues are present

Male ≥ 40 yo
Female ≥ 60 yo
or single severe or multiple risk factors

Male < 40 yo
Female < 60 yo
No risk factors

Noninvasive testing for diagnostic and/or prognostic purposes (tailored to patient characteristics, access and local expertise)

Assess for other causes as appropriate

Conservative diagnostic and treatment strategy

Mancini et al. Stable Ischemic Heart Disease guidelines. CJC 2014.
CP in the ER

- Consider no testing in patients who reliably describe chest pain >30min + negative hs-Troponin

- More formally, consider calculating a risk score to further guide management
  - TIMI Risk Score
  - HEART Score
# HEART Score

## HEART score for chest pain patients

<table>
<thead>
<tr>
<th>History (Anamnesis)</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly suspicious</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately suspicious</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly suspicious</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECG</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant ST-deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-specific repolarisation disturbance / LBBB / PM</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>≥ 65 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 – 65 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 45 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk factors</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 3 risk factors or history of atherosclerotic disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 or 2 risk factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No risk factors known</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Troponin</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>≥ 3x normal limit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3x normal limit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ normal limit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

## Risk factors for atherosclerotic disease:

- Hypercholesterolemia
- Cigarette smoking
- Hypertension
- Positive family history
- Diabetes Mellitus
- Obesity (BMI>30)

## Literature
1. Chest pain in the emergency room: value of the HEART score.
2. Chest pain in the emergency room: a multicenter validation of the HEART Score.
3. A prospective validation of the HEART score for chest pain patients at the emergency department.
4. The HEART score for the assessment of patients with chest pain in the emergency department.
5. Impact of using the HEART score in chest pain patients at the emergency department: a stepped wedge, cluster randomized trial.

## Questions and comments:
- Barbra Backus  backus@heartscore.nl
- Jacob Six  six@heartscore.nl
- Judith Poldervaart  poldervaart@heartscore.nl

## HEART score reliably predicts endpoints

<table>
<thead>
<tr>
<th>HEART</th>
<th>% pts</th>
<th>MACE/n</th>
<th>MACE</th>
<th>Death</th>
<th>Proposed Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>32%</td>
<td>38/1993</td>
<td>1.9%</td>
<td>0.05%</td>
<td>Discharge</td>
</tr>
<tr>
<td>4-6</td>
<td>51%</td>
<td>413/3136</td>
<td>13%</td>
<td>1.3%</td>
<td>Observation, risk management</td>
</tr>
<tr>
<td>7-10</td>
<td>17%</td>
<td>918/1046</td>
<td>50%</td>
<td>2.8%</td>
<td>Observation, treatment, CAG</td>
</tr>
</tbody>
</table>

* MACE = Major Adverse Cardiac Event = Myocardial Infarction, PCI/CABG, all-cause death. Based on N=6174
• There remain a large number of patients who DO require cardiac testing to evaluate chest pain

• Non-invasive testing is useful to detect disease and help decide who will benefit from revascularization
Testing Options
What test do I order?

• Many options:
  • Exercise Treadmill Testing
  • Stress MPI
  • Stress Echo
  • Stress MRI
  • Cardiac CTA
  • Coronary Angiogram

• No single best test for every patient, each have pros & cons
# Exercise Treadmill Test

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less costly</td>
<td>Patients need to be able to exercise</td>
</tr>
<tr>
<td>Get assessment of exercise capacity</td>
<td>Need a normal or near normal baseline ECG</td>
</tr>
<tr>
<td>Able to assess correlation of exertion &amp; symptoms</td>
<td>Does not assess for subclinical atherosclerosis</td>
</tr>
<tr>
<td>Good prognostic information</td>
<td>Limited sensitivity &amp; specificity</td>
</tr>
<tr>
<td>No radiation</td>
<td></td>
</tr>
</tbody>
</table>
### CT Angiography

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent Sensitivity</td>
<td>Difficult patient preparation</td>
</tr>
<tr>
<td>Can detect subclinical atherosclerosis</td>
<td>Poor specificity once there is a high burden of coronary artery calcium</td>
</tr>
<tr>
<td></td>
<td>Contrast media/renal dysfunction</td>
</tr>
<tr>
<td></td>
<td>Not a test in patients with known CAD</td>
</tr>
<tr>
<td></td>
<td>Radiation exposure</td>
</tr>
<tr>
<td></td>
<td>Patients need to be in sinus rhythm</td>
</tr>
</tbody>
</table>
### Stress Echo

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good specificity</td>
<td>Sensitivity lower than other imaging tests</td>
</tr>
<tr>
<td>No radiation</td>
<td>Dependent on image quality</td>
</tr>
<tr>
<td>Pharmacologic option for those who cannot exercise</td>
<td>Less reliable when there are pre-existing wall motion abnormalities/LBBB</td>
</tr>
</tbody>
</table>
### MPI

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good SN and SP</td>
<td>Long test</td>
</tr>
<tr>
<td>Can use in those with baseline abnormal ECG</td>
<td>Patients need to be fasting</td>
</tr>
<tr>
<td>Exercise &amp; Pharm stress options</td>
<td>Radiation exposure</td>
</tr>
<tr>
<td>CTAC used to assess for subclinical disease</td>
<td></td>
</tr>
<tr>
<td>Prognostic Information</td>
<td></td>
</tr>
<tr>
<td>Can use in those with known CAD/prior MI</td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Summary estimates of pooled sensitivity and specificity (with 95% confidence intervals) for noninvasive cardiac tests for the diagnosis of coronary artery disease

<table>
<thead>
<tr>
<th>Technology</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise treadmill</td>
<td>0.68 (0.23-1.0)</td>
<td>0.77 (0.17-1.0)</td>
</tr>
<tr>
<td>Attenuation-corrected SPECT</td>
<td>0.86 (0.81-0.91)</td>
<td>0.82 (0.75-0.89)</td>
</tr>
<tr>
<td>Gated SPECT</td>
<td>0.84 (0.79-0.88)</td>
<td>0.78 (0.71-0.85)</td>
</tr>
<tr>
<td>Traditional SPECT</td>
<td>0.86 (0.84-0.88)</td>
<td>0.71 (0.67-0.76)</td>
</tr>
<tr>
<td>Contrast stress echocardiography (wall motion)</td>
<td>0.84 (0.79-0.90)</td>
<td>0.80 (0.73-0.87)</td>
</tr>
<tr>
<td>Exercise or pharmacologic stress echocardiography</td>
<td>0.79 (0.77-0.82)</td>
<td>0.84 (0.82-0.86)</td>
</tr>
<tr>
<td>Cardiac computed tomographic angiography</td>
<td>0.96 (0.94-0.98)</td>
<td>0.82 (0.73-0.90)</td>
</tr>
<tr>
<td>Positron emission tomography</td>
<td>0.90 (0.88-0.92)</td>
<td>0.88 (0.85-0.91)</td>
</tr>
<tr>
<td>Cardiac MRI (perfusion)</td>
<td>0.91 (0.88-0.94)</td>
<td>0.81 (0.75-0.87)</td>
</tr>
</tbody>
</table>

Mancini et al. Stable Ischemic Heart Disease guidelines. CJC 2014.
Ordering an MPI
1. Choose the right patient:

- Does my patient have chest pain/anginal equivalent?

- Do they have an intermediate pre-test probability of CAD?
  - If very low: ETT or CTA
  - If high: Coronary angiogram
2. Choose Exercise vs. Pharmacologic Stress Stress

- Can my patient exercise for 5 minutes on a treadmill?
  - If not, order a pharmacologic stress test

- Does my patient have LBBB (or paced rhythm)?
  - If so, order a dipyridamole/pharmacologic stress test

- Does my patient have a contraindication to dipyridamole?
Pharm Stress - Dipyridamole

• Coronary vasodilator

• 4 minute IV infusion then injection of thallium at minute 7 (maximal hyperemia)

• Patient then receives aminophylline to reverse the effects of dipyridamole

• **Patient needs to be caffeine free for 12 hours**

• Contraindications:
  • Severe asthma, SBP <90mmHg, 2nd/3rd degree AV block

• If Pharmacologic stress required, and patient has a contraindication to Dipy, a dobutamine MPI can be done at one of the hospital sites
Vasodilator Stress

- Arterioles downstream from a significant stenosis are already maximally dilated.

- Exercise/vasodilators will only dilate arterioles downstream from non-stenotic arteries, resulting in increased flow to this myocardium.

- This increased perfusion to normal tissue will make the “ischemic” myocardium appear under-perfused.
3. Decide whether to do the test on the patient’s anti-anginal therapy

- If there is no known CAD – hold anti-ischemics (Beta-blockers, CCB, NTG)

- If the patient has known stable CAD that is medically managed – continue his/her meds
  - i.e. if a patient with a known 50% RCA lesion is c/o CP at home while on a beta-blocker, do the test on that beta-blocker to evaluate presence/degree of ischemia
# MPI Form

## Referring Information

<table>
<thead>
<tr>
<th>Name:</th>
<th>PRACID:</th>
<th>Phone:</th>
<th>Fax:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Specialty:</th>
<th>PHN:</th>
<th>Gender:</th>
<th>DOR:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Family MD Name:</th>
<th>Height: cm / ft-in</th>
<th>Weight: kg / lbs</th>
</tr>
</thead>
</table>

## Patient Demographics (please provide Height and Weight)

## Cardio-Diagnostic Test Requisition

**For MPI or Exercise Stress Test please complete the following:** (Please refer to the guidelines on the back of this requisition)

**Have you asked your patient to hold anti-ischemic medications?**
- [ ] Yes
- [ ] No

**Does your patient have:**
- [ ] Diabetes? Yes No
- [ ] Asthma? Yes No
- [ ] Pacemaker? Yes No
- [ ] ICD? Yes No
- [ ] CABG? Yes No
- [ ] Angioplasty/Stent? Yes No

**Is your patient:**
- [ ] Asymptomatic
- [ ] Symptomatic
  - [ ] Chest pain
  - [ ] Dyspnea
  - [ ] Other:

**Pretest likelihood of CAD?** (based on age, gender, +/- symptoms)
- [ ] Very Low
- [ ] Low
- [ ] Intermediate
- [ ] High
- [ ] Known CAD

**MYOCARDIAL PERFUSION IMAGING (MPI) STRESS TEST**
- [ ] Exercise
- [ ] Pharmacologic
- [ ] Rest viability only

**Assess Myocardial Ischemia/Infarction/Viability/Left Ventricular systolic function**

**Global Cardiac Risk stratification OR Pre-op risk assessment for non-cardiac surgery**

**Abnormal Exercise Stress Test**

**EXERCISE STRESS TEST** (No imaging)

**MPI or STRESS TEST Appt Date & Time:**

<table>
<thead>
<tr>
<th>MODALITY</th>
<th>INDICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECHO</td>
<td>Cardiac structure and function, Valvular heart abnormalities, Cardiac source of embolus, Adult congenital heart disease</td>
</tr>
<tr>
<td>CAROTID DOPPLER</td>
<td>Syncope, Presyncope, TIAs, Stroke, Evaluation of carotid bruits, Vascular disease or Risk factors</td>
</tr>
<tr>
<td>HOLTER</td>
<td>Syncope, Presyncope, Known Atrial fibrillation / or Atrial flutter, Suspected dysrhythmia</td>
</tr>
</tbody>
</table>

**Along with the requested test(s), I would like to book a consultation with the next available cardiologist.**

**Provisional Diagnosis / Additional History**

<table>
<thead>
<tr>
<th>MD signature / Clinic Name / STAMP</th>
</tr>
</thead>
</table>

**Copy reports to**

**You can choose TotalCardiology as your ECG interpreter on your CLS or lab requisition form.**

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*Cardio-Diagnostics #110, 2891 Sunridge Way NE, Calgary, AB T1Y 7K7
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Aug 19, 2019
For MPI or Exercise Stress Test please complete the following: (Please refer to the guidelines on the back of this requisition)

Have you asked your patient to hold anti-ischemic medications?  ○ Yes  ○ No

Does your patient have:  
- Diabetes?  ○ Yes  ○ No
- Asthma?  ○ Yes  ○ No
- Pacemaker?  ○ Yes  ○ No
- ICD?  ○ Yes  ○ No
- CABG?  ○ Yes  ○ No
- Angioplasty/Stent?  ○ Yes  ○ No

Is your patient?  ○ Asymptomatic  ○ Symptomatic  □ Chest pain  □ Dyspnea  □ Other: __________________________

Pretest likelihood of CAD? (based on age, gender, +/-symptoms)  ○ Very Low  ○ Low  ○ Intermediate  ○ High  ○ Known CAD

☐ MYOCARDIAL PERFUSION IMAGING (MPI) STRESS TEST  ○ Exercise  ○ Pharmacologic  ○ Rest viability only

☐ EXERCISE STRESS TEST  (No imaging)

☐ Assess Myocardial Ischemia/Infarction/Viability/Left Ventricular systolic function

☐ Global Cardiac Risk stratification OR Pre-op risk assessment for non-cardiac surgery

☑ Abnormal Exercise Stress Test

MPI or STRESS TEST Appt Date & Time: __________________________
Patient Preparation

• Need to be fasting from midnight

• No caffeine for a minimum of 12 hours before the test!!!
  • Caffeine is antagonist to dipyridamole (pharm stress agent)

• Decide whether you want the patient to do the test on his/her anti-anginal therapy.
  • Beta-blockers, Calcium Channel Blockers, Nitrates

• Give the patient a pamphlet!
Patient Information & Forms

The following section contains links to important documents and forms for TotalCardiology Patients.

New Patient Clinic Questionnaire:
- Clinic Questionnaire

Cardio Diagnostic Test Instructions
- MPI Nuclear Stress Test
- Exercise Stress Test
- Echocardiogram
- Carotid Doppler Ultrasound
1. Patient checks in at front desk
2. At patient preparation bay – IV inserted, screening history obtained by techs
3. At Treadmill bay – MD gets consent, decides exercise vs. pharmacologic study
4. Stress test performed – Thallium injected
5. Nuc stress pictures acquired
6. Low dose CT performed to help correct for attenuation artifacts on MPI images
7. Patient has a 4 hour break
8. Patient returns for Nuc rest pictures
MPI Results
MPI Images
CTAC Images

• Very low dose CT

• Can visually assess presence and rough degree of coronary artery calcium

• Can roughly estimate:
  • None (may miss small amounts of Ca c/w a formal Ca score)
  • Mild (roughly equivalent to an Agatston score <100)
  • Moderate (Agatston score ~100-400)
  • Large (Agatston score ~>400)
**Myocardial Perfusion Imaging Stress Test**

**Patient:**
- PHN/ULI: [Redacted]
- DOB: [Redacted]
- Height: [Redacted]
- Gender: Male
- BSA: 1.8 m²

**Study Date:** September 14, 2018

**Referring MD:** Maria Figura
**Family MD:** Sadrudin Adatia
**Supervising MD:** Dr. Mustapha Kazmi

**Reason for Test:** Atrial Fibrillation, Chest pain NYD

<table>
<thead>
<tr>
<th>Exercise Stress Test Stress Information</th>
<th>Stage</th>
<th>Heart Rate</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM Protocol</td>
<td>Bruce</td>
<td>1</td>
<td>75</td>
<td>100</td>
<td>78</td>
</tr>
<tr>
<td>9:30</td>
<td>1</td>
<td>99</td>
<td>108</td>
<td>70</td>
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<td>151</td>
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<td>91</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Fatigue</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Technical Data**
- Thallium Dose: 60 mBq
- Dipyridamole Dose: Yes
- Aminophylline Dose: Yes
- ECG gating?: Yes
- Attenuation Correction: Yes

**ECG Interpretation**
- Rest ECG: Sinus rhythm - normal QRS, ST morphology
- Stress ECG: No significant / diagnostic ST changes
- Stress Dysrhythmias: None

**Myocardial Perfusion Information**
- Transient Ischemic Dilation? No
- Post Stress LVEF: 73 %
- Wall Motion: Normal
- LV Size: Normal
- Myocardial perfusion: No perfusion abnormalities were observed.

**Coronary Calcium:** Absent

**Summary**
- Exercise Capacity: Good exercise capacity for age, gender
- Stress Symptoms: None
- Stress ECG: No significant changes
- Stress LV Systolic Function: Normal global function with no regional abnormalities
- Scintigraphic Interpretation: No evidence of myocardial ischemia or infarct
- Prognostic Information: Low risk, no evidence of subclinical atherosclerosis

**Report Date:** September 14, 2018
**Technologist:** [Redacted]
MPI results

• Normal perfusion
  • patient can be reassured symptoms are not cardiac

• Small/mild ischemia
  • suggest medical therapy > cath/revascularization
  • If false positive test suspected – can consider alternate test (i.e. CTA) if needed for diagnosis

• Moderate ischemia
  • Consider medical therapy or proceed to cath

• Large ischemia/High-risk
  • Recommend cath/revascularization (these patients get captured through the RACC to expedite next steps)
Retrospective Study of Revasc vs. Medical Rx

Incorporating CTAC results

- Normal perfusion & Coronary calcium present
  - Combination of functional & anatomical information!
  - Subclinical coronary atherosclerosis detected!

- Patient can be started on appropriate preventative therapies that will improve outcomes!
  - Statin
  - Possibly ASA

- A major advantage of MPI compared to other non-invasive stress tests!
Preventative Therapies - Statin

• If Ca Score > 100 a statin is recommended
  
  • If moderate or large burden of Ca seen on CTAC – Ca Score is >100
  
  • If small burden of Ca seen on CTAC, formal Ca score likely <100 – still favour statin, but can discuss pros/cons with patient
Preventative Therapies - ASA

- Debatable whether to start based on presence of coronary artery calcium
- Indicated for secondary prevention but guidelines recommend against ASA for primary prevention
- Where does subclinical atherosclerosis fall?

Figure 2. Estimated risk/benefit of aspirin in primary prevention by coronary artery calcium score in Multi-Ethnic Study of Atherosclerosis (MESA) participants. *Coronary heart disease (CHD) risk was calculated using the Framingham Risk Score. The red line represents the estimated 5-year number needed to harm based on a 0.23% increase in major bleeding over 5 years. The five-year number needed to treat estimations is based on an 18% relative reduction in coronary heart disease events.

Take Home Messages

• Avoid stress testing asymptomatic patients

• Not all symptomatic patients need testing

• In those who do need testing, MPI is a very good test
  • Compared to other stress testing, MPI (at TC and at the hospital sites) will provide qualitative assessment of coronary calcium
  • This can help tailor preventative therapies that will improve outcomes

• Ensure patient receives information about preparing for the test
Questions?
## Effective Radiation Doses in Calgary

<table>
<thead>
<tr>
<th>Protocol</th>
<th>First Injection (mCi/MBq)</th>
<th>Second Injection (mCi/MBq)</th>
<th>Effective Radiation Dose (msV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Th-201 TC</td>
<td>1.5/55</td>
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