Non-Invasive evaluation of CAD

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North Cascade Cardiology
Outline

• Brief overview of indications for non-invasive evaluation of CAD
• Review of modalities available
  • Exercise stress testing
  • Stress echo
  • Nuclear stress testing
  • Coronary CTA
  • PET stress test
  • MRI
• Summary of each modality
• How to choose the best test for each patient
• Case examples
Scope of problem

- ~4% of all office visits are for chest pain
- 9,800,000 (4.4%) people in US with stable angina
- 500,000 new cases of stable angina/year
- ~9 million nuclear cardiac stress tests were performed in US/year
Who needs Stress Testing?

- Patients with symptoms
  - Initial evaluation for suspected CAD
  - Known CAD with change in status
  - Surveillance screening of patients who presented with atypical or no symptoms – up to every 2 years
  - Other – LV dysfunction, arythmias, valvular disease
- Post MI
  - Prognostic assessment
- Do not test asymptomatic patients
Stress Testing: Who?

- Adults with intermediate (10-90%) pre-test probability of CAD

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What info can a stress test provide

- Diagnosis of CAD
  - Are the patients symptoms from CAD – **Specificity** of the stress test
  - Does the patient have CAD - **Sensitivity** of stress test
- Prognosis
  - Is the patient going to die
  - What is the risk that the patient will have an MI
  - Has patient already had an MI
- Other
  - Valve function, LV function, other cardiovascular structures
Types of non-invasive test

- Exercise stress testing
- Stress echo
- Nuclear stress testing
- PET stress test
- Coronary CTA
- MRI
Exercise stress testing

- Treadmill
- Bike
- Standardized protocol
  - Bruce protocol – 3 minute stages of incremental difficulty
- Look for changes in ST segment on EKG
Exercise stress testing - example
ETT – Diagnostic Data

![Graph Showing Post-Test Likelihood of CAD (%) vs. Pre-Test Likelihood of CAD (%) for Different ST Changes](image)
## ETT – Diagnostic Data

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ETT - Prognostic data

- Early positive-stage I: Mortality >5%/year
- Strongly positive > 2.5 mm ST depression
- Fall in SBP >10 mm Hg
- Early onset ventricular arrhythmia's
- Prolonged Ischaemic changes in recovery > 2mm lasting > 6 minutes
- Duke treadmill score < -10
  - Duration of exercise in minutes on the Bruce protocol - (5 x maximal mm ST deviation) - (4 x treadmill angina index)
Advantages to exercise stress testing

- Cheap
- Readily available in many locations
- Gives an idea of functional capacity
- Reasonable prognostic data in intermediate probability patients
Disadvantages to exercise stress testing

- Non-diagnostic in patients:
  - On digoxin
  - Left ventricular Hypertrophy
  - Pre-excitation (WPW)
  - Paced rhythm
  - LBBB or QRS>120 ms
  - > 1 mm resting ST depression
- Women – very poor sensitivity/specificity
- Overall, mediocre sensitivity/specificity
- Must be able to exercise
- Does not localize ischemia
- Does not visualize infarction
Nuclear stress testing

- Treadmill /Bicycle
- Pharmacologic
  - Indicated for LBBB, Paced, Unable to exercise
    - Dipyridamole (Persantine®)
    - Adenosine (Adenoscan®)
    - Dobutamine
    - A2 Receptor specific (Lexiscan)
  - Thallium/Tectnecium or both injected at rest and with stress
Nuclear stress testing
Cath – before and after
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Nuclear prognostic data

![Graph showing event rates for different conditions](image-url)
Nuclear testing - Advantages

- Widely available
- Well tested – huge amounts of data
- Can be performed in patients whom ekg’s are non-diagnostic
- Can be performed in patient who cannot exercise
- Excellent prognostic data
- Good sensitivity
Nuclear testing - disadvantages

- Radiation exposure ~11 mSeV
- Time consuming
- Expensive
- Cannot see small endocardial defects well
- Artifacts
  - Diaphramatic artifact
  - Breast artifact – 11% of women and 2% men
PET imaging

• Pharmacological perfusion imaging
  • Adenosine
  • Persantine
  • Lexiscan

• Infarct/Viability imaging

• Higher energy level isotopes and less artifacts lead to better images than standard nuclear stress test
PET image
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PET - Advantages

- Excellent sensitivity and specificity
- Good prognostic data
- Infarct imaging/viability
- Fast – good turn around time for patients
- Lower artifacts than standard nuclear imaging
  - Particularly good in obese or female patients
  - Can be used when false positive nuclear study is suspected
Pet - Disadvantages

- Need to make isotope on site
- Availability
  - Only modality not available in Whatcom County
  - Limited availability nationally
- Vasodilator only
- Patient prep is difficult
Stress echo

- Exercise stress echo
- Dobutamine stress echo
Stress echo example
Stress echo example - Cath
### Stress echo diagnostic data

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Stress echo prognosis

- Rates of cardiac death or nonfatal MI after a normal stress echo.
Stress echo prognosis
Stress echo advantages

- Excellent specificity, reasonable sensitivity
- Better data for women
- Significant amount of non-coronary data
  - Valve function
  - LV thickness/size
  - Global LV function
Stress echo - Disadvantages

- Worse sensitivity than other modalities in men
- Poor imaging windows can interfere with images
  - Obesity
  - COPD
- Difficult to diagnose wall motion when
  - LBBB
  - Paced
  - Post-CABG
Coronary CTA
Normal CTA
Abnormal CTA
CABG example
Coronary calcium
# CT diagnostic data

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Coronary CTA – New data

- 64 detector 0.5-mm slice CTA vs Cath for detecting a 50% stenosis
- Nine centers enrolled patients who calcium scores of <600
- Sensitivity of 85% and specificity of 90%.
- A positive predictive value of 91%.
- A negative predictive value of 83%.
- Conclusions: “The negative and positive predictive values indicate that multidetector CT angiography cannot replace conventional coronary angiography at present.”

NEJM
## CTA – diagnostic data

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CTA – prognostic data

VERY LIMITED DATA
Advantages of CTA

• Evaluation of native CAD
  • Excellent negative predictive value
    • Good for those with false positive stress test
  • Shows anatomy very well
    • In some cases better than catheterization (remodeling)
• Graft patency post-CABG
• Anomalous coronaries
• Other
  • LV function
  • Ascending aorta
Disadvantages of CTA

- Cardiac motion – requires EKG gating
  - Problem for those with high heart rates or Afib
- Radiation dose 10-15 mSv
- Breath hold 15 seconds
- Coronary calcium
  - >60 y/o caucasian males
- Lack of insurance/Government reimbursement
- Prospective data lags way behind technology
- Small studies only looking at prognosis
- Cannot image those with prior stents
- Requires 80-100 ml contrast
Cardiac MRI

- MRI stress testing
  - Dobutamine stress MRI
  - Adenosine/Lexiscan stress perfusion
- Coronary anatomy
- Infarct imaging
- Other
  - Valves
  - LV function
Dobutamine MRI
Myocardial perfusion

Baseline

RV contrast uptake

LV contrast uptake

Myocardial contrast uptake

Stress-Perfusion

Rest-Perfusion
Myocardial perfusion
Myocardial Perfusion Case
Myocardial Infarction
Myocardial Infarction
Other Info
## MRI – diagnostic data

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MRI – prognostic data

- 2 Larger trials looking at this
- DETERMINE Trial
Advantages of cardiac MRI

- Good sensitivity/specificity for detecting CAD
- Can see infarction
- Provides significant non-CAD data
- Excellent (albeit small numbers) prognostic data
Disadvantages of MRI

- Many contra-indications
  - Metal in your head/eye
  - Claustrophobia - 4% of patients
  - Pacemakers /ICD’s**
  - Renal insufficiency
    - Nephrogenic Systemic Fibrosis
- Costs
- Availability – Very few place have the technology
  - Not quite doing stress perfusion here
- Patient tolerability
  - Adenosine in a MRI
What is the best test?

• No study has performed all available non-invasive tests in the same group of patients to compare their diagnostic accuracy.
• There are few studies that compare results of even two noninvasive tests in the same patients.
• IE: There is no overall proven “best stress test”
What is the best test for my pt?

- What modalities are available in your area?
- What test are contraindicated or won’t work?
- What data is the most important?
  - Prognosis – is my pt going to die
  - Diagnosis - (sensitivity/specificity)
    - Do they have cad (yes/no)
    - Are the patients symptoms from CAD
  - Anatomy
- What other data would be nice to have?
  - LV function, infarct/viability, valve function
Summary - ETT

- Cheap
- Readily available
- Non-diagnostic in many patients
  - On digoxin, LVH, WPW, Paced, LBBB
- Must be able to exercise
- Overall, mediocre sensitivity/specificity – particularly bad in women
- Does not localize ischemia
- Does not visualize infarction
Summary - nuclear

- Widely available
- Well tested
- Very few contraindications
- Good sensitivity
- Excellent prognostic data
- Time consuming
- Expensive
- Artifacts – particularly in women
  - Diaphragmatic artifact
  - Breast artifact – 11% of women and 2% men
Summary - PET

- Excellent sensitivity and specificity
- Good prognostic data
- Lower artifacts than standard nuclear imaging
  - Particularly good in obese or female patients
- Infarct imaging/viability
- Poor availability
  - Only modality not available in Whatcom County
  - Limited availability nationally
- Vasodilator only
- Patient prep is difficult
Summary - CTA

- Good negative predictive value
  - For those with false positive stress test
- Anomalous coronaries
- Graft patency post-CABG
- Not good for patients with prior stents
- Requires 80-100 ml contrast
- Cardiac motion – require regular heart rate
- Coronary calcium
  - Old caucasian males
- Lack of insurance/Government reimbursement
- Prospective data lags way behind technology
Summary - MRI

- Good sensitivity/specificity for detecting CAD
- Can see infarction
- Provides significant non-CAD data
- Excellent prognostic data
- Many contra-indications
- Expensive
- Poor availability
## Summary

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Case examples #1

65 y/o male with h/o CABG, HTN, dyslipidemia. Presents with recurrent angina with exertion 4 months after RCA PCI.

A) Cath – stent everything that has changed
B) Stress echo
C) Nuclear stress test
D) Coronary CTA
E) MRI – stress perfusion
F) Exercise treadmill
Case examples #1
Cath
Case examples #2

55 y/o female with long smoking history, hyperlipidemia, and a FH of CAD. Previously presented with small NSTEMI and had very small diagonal stented. Now with recurrent exertional angina.

A) Cath
B) Nuc stress
C) Stress echo
D) Stress MRI
E) Exercise stress test
Case example #2
Case examples #2
Case examples #3

• 68 y/o male with +family history and atypical angina. He underwent a nuclear stress test with small inferior defect.

• What do you do now?
  A) medical management
  B) CTA
  C) Nothing
  D) Cath
Case examples #3