Navigating Cardiac Stress Test Emergencies

“Events that Stress the Stressor”
Todd Nolen, MPA, PA-C
Nuclear Medicine: Nuclear Cardiology
Department of Veterans Affairs
Dallas, Texas
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Disclosures

- No disclosures.
Objectives

- Identify adverse events that may occur during cardiac stress testing.

- Discuss practical approaches to managing adverse events during cardiac stress.

- Identify strategies to minimize adverse events during cardiac stress.
Modalities

- Exercise
- Pharmacologic
- Combined low level exercise and pharmacologic agent
Exercise Stress

“...a way to give patients a stress test while they carry files to the ninth floor for me.”
Exercise Stress Devices

- Treadmill
  - Standard protocol
    - (Bruce vs. modified Bruce vs. combined)
  - Incremental increase in incline and speed

- Ergometer Cycle
  - Standardized speed
  - Incremental increase in resistance
Navigation vs. Litigation
Get It Right!

- **Right…**
  - **Candidate**
    - Pretest risks?
    - Indications vs. Contraindications?
  - **Time**
    - MI <2days?
    - Active symptoms?

- **Right…**
  - **Study**
    - Patient’s Tolerance to modality?
  - **Equipment**
    - Resuscitation?
    - Adequate monitoring?
  - **Personnel**
    - Physician vs. Non-physician supervision?
Indications

Who to stress?

- Symptoms suggesting angina.
- Chest pain (ACS ruled out)
- Recent ACS after 3 months of conservative therapy
- Known CHD and change in clinical status.
- Prior coronary revascularization.
- Valvular heart disease.
- New heart failure or cardiomyopathy.
- Chronic left ventricular dysfunction and CHD who are candidates for revascularization.
- Selected arrhythmias
- Undergoing non-urgent non-cardiac surgery.
Contraindications

Who NOT to stress?

- Unstable angina
- Myocardial infarction (MI <2 days)
- Arrhythmia with hemodynamic instability
- Aortic dissection
- Symptomatic aortic stenosis
- Symptomatic severe heart failure
- Pulmonary embolism
- Myocarditis, Pericarditis
Evaluating Chest Pain

Typical Angina (definite)
- Substernal chest discomfort
- Provoked by exertion or emotion stress
- Relieved by rest or NTG

Atypical Angina (probable)
- Meets 2 of the above characteristics

Noncardiac Chest Pain
- Meets 1 or none of the typical anginal characteristics

Potential Complications
Exercise Stress

“It’s not looking good. His pulse is up to 202 just from getting out of the chair and stepping on to the treadmill.”
The frequency of serious adverse cardiac events (ie, myocardial infarction, sustained ventricular arrhythmia, and death) has been estimated to be about 1 in 2500.1

The National Heart Lung Blood Institute (NHLBI) defines major complications of treadmill testing as either myocardial infarction or death.

COMPLICATIONS OF 38,821 EXERCISE STRESS TESTS PERFORMED IN A COMMUNITY CARDIOLOGY CLINIC
<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total exercise treadmills</td>
<td>39,851</td>
<td></td>
</tr>
<tr>
<td>Missing complication data</td>
<td>1,030</td>
<td>2.6%</td>
</tr>
<tr>
<td>Total analyzable stress tests</td>
<td>38,821</td>
<td>97.4%</td>
</tr>
<tr>
<td>Deaths</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Major complications</td>
<td>14</td>
<td>0.04%</td>
</tr>
<tr>
<td>Atrial fibrillation/flutter</td>
<td>159</td>
<td>0.41%</td>
</tr>
<tr>
<td>Supraventricular tachycardia</td>
<td>73</td>
<td>0.19%</td>
</tr>
<tr>
<td>Non-sustained ventricular tachycardia</td>
<td>115</td>
<td>0.30%</td>
</tr>
<tr>
<td>Other ventricular arrhythmias</td>
<td>1,265</td>
<td>3.26%</td>
</tr>
<tr>
<td>Other supraventricular arrhythmias</td>
<td>299</td>
<td>0.77%</td>
</tr>
<tr>
<td>Conduction abnormalities</td>
<td>89</td>
<td>0.23%</td>
</tr>
<tr>
<td>Other</td>
<td>53</td>
<td>0.14%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,067</strong></td>
<td><strong>5.32%</strong></td>
</tr>
</tbody>
</table>
Other Complications

- **Cardiac Arrhythmias (Most Common Complication!)**
  - Atrial fibrillation
  - Atrial Flutter
  - Supraventricular tachycardia
  - Heart block
  - Ventricular tachycardia
  - Ventricular fibrillation

- Chest Pain/Angina
- Shortness of Breath/Dyspnea
- Hypotension
- Hypertension
- Syncope
- Musculoskeletal Injury
Highest Risk Patients

- Malignant Ventricular Arrhythmias
  - Sustained Ventricular Tachycardia

- Ventricular Fibrillation

- Non-revascularized Post-MI Patient
“Tap Out?”
Management of Complications from Exercise Stress

Recognize indications for early termination of the study

- 1) Moderate to severe angina pectoris
- 2) Marked dyspnea or fatigue
- 3) Ataxia, dizziness, or near-syncope
- 4) Signs of poor perfusion (cyanosis and pallor)

- 5) Patient’s request to terminate the test
- 6) Excessive ST-segment depression (> 2mm)
- 7) ST elevation (> 1mm) in leads without diagnostic Q waves (except for leads V1 or aVR)
- 8) Sustained supraventricular or ventricular tachycardia
Management of Complications from Exercise Stress Cont’d
Recognize indications for early termination of the study

- Development of LBBB or intraventricular conduction delay that cannot be distinguished from ventricular tachycardia
- Drop in systolic blood pressure of greater than 10mm Hg from baseline, despite an increase in workload, when accompanied by other evidence of ischemia
- Hypertensive response (systolic blood pressure > 250mm Hg and/or diastolic pressure > 115 mm Hg)
- Technical difficulties in monitoring the ECG or systolic blood pressure
Exercise Induced Left Bundle Branch Block (Resting ECG)
Exercise Induced Left Bundle Branch Block (Peak Exertion ECG)
Management of Complications from Exercise Stress Cont’d

- Have a process to alert essential personnel of urgent/emergent situations that clearly identifies the location of the event.
- Ensure appropriate equipment and personnel availability prior to initiating the study.
- Initiate plans for rapid transfer for ongoing and definitive care.
• Stop the test
• Initiate internal vs. external response system
• Transfer to definitive care as appropriate.

<table>
<thead>
<tr>
<th>Complications of Exercise</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF/Pulseless VT/Arrest</td>
<td>• Initiate CODE response procedures immediately and follow ACLS guidelines</td>
</tr>
<tr>
<td>Acute Myocardial Ischemia/Injury</td>
<td>• Initiate STEMI response as appropriate</td>
</tr>
<tr>
<td></td>
<td>• Treat underlying physiology according to BLS/ACLS and other guideline</td>
</tr>
<tr>
<td></td>
<td>directed therapy recommendations, to include oxygen, aspirin, nitrates,</td>
</tr>
<tr>
<td></td>
<td>serial ECG, urgent/emergent invasive angiography, etc.</td>
</tr>
<tr>
<td>Cardiac Arrhythmias</td>
<td>• Initiate internal response system</td>
</tr>
<tr>
<td></td>
<td>• Follow BLS/ACLS guidelines for appropriate algorithm for specific arrhythmia</td>
</tr>
<tr>
<td>Hypotension</td>
<td>• Position appropriately</td>
</tr>
<tr>
<td></td>
<td>• Initiate IV fluid resuscitation</td>
</tr>
<tr>
<td></td>
<td>• Closely monitor</td>
</tr>
</tbody>
</table>
“My doctor says I need to take a stress test.
I thought sitting in his waiting room surrounded by
coughing children for two hours WAS the stress test!”
Pharmacologic Stress
Why Pharmacologic Stress?

- Inability to perform adequate exercise
  - exercise is the preferred modality
- Baseline ECG abnormalities
  - Left Bundle Branch Block
  - Pacemaker
  - Preexcitation
  - Recent presumptive acute coronary syndrome
Recognizing ECG Abnormalities Obscuring Baseline ECG

Left Bundle Branch Block

Pre-excitation (Delta Wave)
Recognizing ECG Abnormalities Obscuring Baseline ECG Cont’d (Pacemaker)
Recognizing ECG Abnormalities Obscuring Baseline ECG Cont’d (LVH)

<table>
<thead>
<tr>
<th>Normal</th>
<th>LVH voltage</th>
<th>LVH voltage with minor T-wave flattening</th>
<th>LVH voltage with minor T-wave inversion</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Normal ECG" /></td>
<td><img src="image2" alt="LVH voltage" /></td>
<td><img src="image3" alt="LVH voltage with minor T-wave flattening" /></td>
<td><img src="image4" alt="LVH voltage with minor T-wave inversion" /></td>
</tr>
</tbody>
</table>

**CLASSICAL:** LVH voltage with typical repol. abnormalities (“strain”)

- ![LVH voltage with typical repol. abnormalities](image5)

**LVH voltage with typical repolarization abnormalities and QRS widening**

- ![LVH voltage with typical repolarization abnormalities and QRS widening](image6)

**Incomplete LBBB** (absent septal Q in leads I and V6)

- ![Incomplete LBBB](image7)

**Complete LBBB**

- ![Complete LBBB](image8)
Pharmacologic Stress Agents

- Regadenoson
- Adenosine
- Dipyridamole
- Dobutamine
Serious Complications
Pharmacologic Stress

- Very low rate of serious adverse events
  - severe myocardial ischemia, sinoatrial and atrioventricular nodal block, atrial tachyarrhythmias
    - atrial fibrillation
    - Flutter
  - Hypotension
  - Bronchoconstriction
  - **Seizure** *(Reversal with Aminophylline NOT Recommended)*
  - Stroke
  - Transient ischemic attack.

Common medical conditions in which potential complications may occur with vasodilator stress testing

- Severe aortic stenosis
- Hemodynamically severe carotid artery disease
- Critical left main coronary artery disease
- Severe proximal multivessel coronary artery disease
- Autonomic dysfunction
- Baseline hypotension
- Hypovolemia
**Management of Complications of Pharmacologic Stress Agents (Regadenoson).**

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Complications</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Patients with second- or third-degree AV block or sinus node dysfunction without a functioning pacemaker</td>
<td>• Severe hypotension (SBP &lt;80mmHg)</td>
<td>• Aminophylline should be considered at 50 mg to 250 mg by slow intravenous injection (Avoid with seizure)</td>
</tr>
<tr>
<td></td>
<td>• Development of symptomatic, persistent second degree or complete heart block</td>
<td>• Consider Caffeine Citrate Slow IV</td>
</tr>
<tr>
<td></td>
<td>• Wheezing</td>
<td>• IV fluid resuscitation</td>
</tr>
<tr>
<td></td>
<td>• Persistent chest pain or ST depression</td>
<td>• Treat underlying physiologic insult</td>
</tr>
<tr>
<td></td>
<td>• Signs of poor perfusion (pallor, cyanosis, cold skin)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Seizure</td>
<td></td>
</tr>
<tr>
<td>• Systolic blood pressure less than 90mm Hg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Henzlova et al Journal of Nuclear Cardiology
SPECT nuclear cardiology procedures
May/June 2016
## Management of Complications of Pharmacologic Stress Agents (Adenosine).

### Contraindications
- Bronchospastic lung disease with ongoing wheezing
- Systolic BP less than 90 mmHg
- Uncontrolled hypertension (systolic BP [200 mmHg or diastolic BP [110 mmHg).
- Sinus node disease, such as sick sinus syndrome or symptomatic bradycardia, without a functioning pacemaker.
- Recent (<48 hours) use of dipyridamole or dipyridamole-containing medications (e.g., Aggrenox)

### Complications
- Hypotension (SBP <80 mm/Hg)
- AV Block
- Wheezing
- Severe chest pain with ischemic ECG
- Poor perfusion
- Seizure

### Management
- Discontinue infusion
- Aminophylline should be considered 50 mg to 250 mg by slow intravenous injection (Avoid with seizure)
- IV fluid resuscitation
- Treat underlying specific physiologic insult

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1 Henzlova et al Journal of Nuclear Cardiology
SPECT nuclear cardiology procedures May/June 2016
Management of Complications of Pharmacologic Stress Agents (Dipyridamole).¹

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Complications</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bronchospastic lung disease with ongoing wheezing</td>
<td>• Severe hypotension (systolic BP&lt;80 mmHg).</td>
<td>Aminophylline 50-250 mg intravenously at least 1 minute after the tracer injection</td>
</tr>
<tr>
<td>• Systolic BP less than 90 mmHg</td>
<td>• Development of symptomatic, persistent second degree or complete heart block.</td>
<td></td>
</tr>
<tr>
<td>• Uncontrolled hypertension (systolic BP [200 mmHg or diastolic BP [110 mmHg).</td>
<td>• Other significant cardiac arrhythmia.</td>
<td></td>
</tr>
<tr>
<td>• Caffeinated foods or beverages (e.g., coffee, tea, sodas) within the last 12 hours</td>
<td>• Wheezing.</td>
<td></td>
</tr>
<tr>
<td>• Unstable angina, acute coronary syndrome, or less than 2 days after an acute myocardial infarction</td>
<td>• Severe chest pain associated with ST depression of 2 mm or greater.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Signs of poor perfusion (pallor, cyanosis, cold skin).</td>
<td></td>
</tr>
</tbody>
</table>

¹ Henzllova et al Journal of Nuclear Cardiology
SPECT nuclear cardiology procedures May/June 2016
LABEL CHANGES TO ADENOSINE AND REGADENOSON IN 2013-2014

- “Rare but serious risk of heart attack and death with the use of the cardiac nuclear stress test vasodilators such as regadenoson and adenosine…”¹

Seizure

“As a result of reports of seizures during post-marketing surveillance, the package inserts were revised for both adenosine (in 2005) and regadenoson (in 2009) to warn of new onset or recurrence of convulsive seizures. This adverse effect is probably rare, even in patients with a known seizure disorder…”

Management of Complications of Pharmacologic Stress Agents (Dobutamine).  

<table>
<thead>
<tr>
<th>Contraindications</th>
<th>Complications</th>
<th>Management</th>
</tr>
</thead>
</table>
| • Unstable angina, acute coronary syndrome, or less than 2 days after an acute myocardial infarction.  
  • Hemodynamically significant left ventricular outflow tract obstruction.  
  • Atrial tachyarrhythmias with uncontrolled ventricular response.  
  • Prior history of ventricular tachycardia.  
  • Uncontrolled hypertension (systolic BP [200 mmHg or diastolic BP [110 mmHg].  
  • Patients with aortic dissection. | • Palpitation (29%)  
  • Chest pain (31%)  
  • Headache (14%)  
  • Flushing (14%)  
  • Dyspnea (14%)  
  • Significant supraventricular/Ventricular arrhythmias (8% to 10%).  
  • Ischemic ST-segment depression occurs in approximately one-third of patients undergoing dobutamine infusion. | • Discontinue the infusion  
  • IV administration of a short acting b-blocker (esmolol, 0.5 mg/kg over 1 minute).  
  • IV metoprolol (5 mg) can also be used. |

- Dobutamine reportedly carries the highest risk for adverse events of all the stress modalities.  
- Rate of serious adverse events is estimated to range from 1/210 to 1/557

1 Henzlova et al Journal of Nuclear Cardiology  
SPECT nuclear cardiology procedures  
May/June 2016  
Combined Low Level Exercise and Pharmacologic Stress

Pros
- Likely improves imaging
- May reduce symptoms
- Usually well tolerated

Potential Complications
- Inherits complications of each modality
- Inherits similar limitations of exercise

1 Henzlova et al Journal of Nuclear Cardiology
SPECT nuclear cardiology procedures May/June 2016
Miscellaneous Events
Miscellaneous Events

- Mechanical Falls/Injury
  - Footwear?
  - Inpatient fall precautions?
- Patient/Staff Contamination
Strategies to Minimize the Impact of Complications

AN OUNCE OF PREVENTION IS MORE THAN WORTH A POUND OF CURE
<table>
<thead>
<tr>
<th><strong>Table 2. Recommendations for Patients Requiring Personal Physician Supervision Based on Clinical Safety Criteria</strong>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate to severe aortic stenosis in an asymptomatic or questionably symptomatic patient</td>
</tr>
<tr>
<td>Moderate to severe mitral stenosis in an asymptomatic or questionably symptomatic patient</td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy: risk stratification and exercise gradient assessment</td>
</tr>
<tr>
<td>History of malignant or exertional arrhythmias, sudden cardiac death</td>
</tr>
<tr>
<td>History of exertional syncope or presyncope</td>
</tr>
<tr>
<td>Intracardiac shunts</td>
</tr>
<tr>
<td>Genetic channelopathies</td>
</tr>
<tr>
<td>Within 7 d of myocardial infarction or other acute coronary syndrome</td>
</tr>
<tr>
<td>New York Heart Association class III heart failure</td>
</tr>
<tr>
<td>Severe left ventricular dysfunction (particularly patients whose clinical status has recently deteriorated and those who have never undergone prior exercise testing)</td>
</tr>
<tr>
<td>Severe pulmonary arterial hypertension</td>
</tr>
<tr>
<td>Broader context of potential instability resulting from noncardiovascular comorbidities, (eg, frailty, dehydration, orthopedic limitations, chronic obstructive lung disease)</td>
</tr>
</tbody>
</table>

*Personal supervision defined as physical presence in the room.*
Recommendations At the Organizational Level

- High-risk patients require that a physician be physically present (ie, in the room) during exercise testing
  - ↑ risk for CAD instability
  - history of malignant ventricular arrhythmias
  - significant pulmonary arterial hypertension
  - moderate to severe valvular stenosis

Recommendations At the Organizational Level Cont’d

- Provide an emergency medical response plan
- Personnel trained in emergency resuscitation, supported by a physician skilled in exercise testing and emergency response
- Periodic emergency response drills
- Routine communication between non-physician and physician personnel

Best Predictor of The Future…?
Recommendations Prior To Each Study

- Pretest review of potential candidates history
- Pretest interview and brief exam of potential candidates
- Pretest risk stratification
- Ensure essential personnel and equipment
PRE-STRESS TESTING QUESTIONNAIRE NUC-MED

NAME: ____________ SS# ____________ B/P ____________ HR ____________

WT: ____________
HT: ____________

1. Cardiac History:
   
A. Symptoms: ____________________________

   No pain □  Non-cardiac □  Atypical CP □  Classic Angina □  DOE □  Fatigue □  ABl ECG □  SOB □

   Pre Op Clearance □  CAD □  Kidney/Liver transplant wk up □  ND ETT □  Current Chs: __/10

   HCV TX □  Risk Strat: ____________________________

B. Previous MI?  Yes___ No___ How many ________?

C. Previous Cath?  Yes___ No___ Date(s): ____________

D. PTCA/PCI  Yes___ No___ Dates: ____________ Vessel(s): ____________

E. Cardiac Surgery?  Yes___ No___

1. CABG?  Yes___ No___ Date _________ # of vessels _________

2. Redo?  Yes___ No___ Date _________ # of vessels _________

3. Valvular?  Yes___ No___ Aortic □  Mitral □

F. Arrhythmia?  Yes___ No___ Date last EKG: _________ Interp.: ____________________________

VT/VF □  SVT □  AFib □  PAF □  A Flutter □  LBBB □  RBBB □

Pacemaker/ICD?  Yes___ No___

II. Prior Testing:

   Previous Dobutamine/Stress ECHO?  Yes___ No___

   Previous Treadmill?  Yes___ No___ Positive _____ Negative _____ Non-Diagnostic ______

   Previous Myocardial Perfusion Study?  Yes___ No___ Date _________ Result: Pos___ Neg___

III. Pretest Probability?  Very low □  low □  Intermediate □  High □

IV. Date and time of last CAFFEINE consumption? ____________________________

V. Allergies to Medications?  Yes___ No___ List: ____________________________

   PMH: HTN □  HLP □  DM □  CAD □  CHF □  CKD □  SMOKER □  COPD □  OSA □  POLYSUBSTANCE ABUSE □

   HEP C □  AAA ____________ □  CAROTID STENOSIS □  CVA □  ASTHMA □  DIALYSIS □
Summary Recommendations

- Careful screening of the patient—defer the test if it is judged unsafe to proceed
- Intravenous hydration when prolonged period of fasting preceded testing
- Close, careful observation of the patient, ECG monitor, and vital signs during and in the early recovery phase of the test
- Rapid availability of resuscitation equipment and personnel proficient in ACLS

- Addition of anticonvulsant agents, such as intravenous lorazepam, and avoidance of methylxanthines if possible, for rare cases of seizure associated with regadenoson
- Rapid reporting of results of testing including any complications of the procedure to referring health care providers

Summary

- Exercise and pharmacologic cardiac stress tests are associated with low risk of serious complications.\(^1\)

- SPECT and PET allow for reclassification to low risk categories, reducing cardiovascular events and contrasts nephropathies associated with invasive angiography.\(^1\)

---

1. What is the most likely (urgent) complication encountered during nuclear cardiac stress testing?
   A. Myocardial infarction
   B. Cardiac arrhythmia
   C. Death
   D. Injury from fall
   E. Allergic reaction


2. What is the most effective strategy to minimize complications during nuclear cardiac stress?
   A. Ensure that the study is indicated
   B. Avoid proceeding where absolute contraindications exist
   C. Conduct preliminary evaluation of study subject’s history
   D. Ensure appropriately trained and credentialed personnel conduct the study
   E. All of the above
3. Which of the following non-cardiovascular conditions may result in instability during exercise nuclear cardiac stress testing?
   A. Frailty
   B. Orthopedic Limitations
   C. Chronic Obstructive Lung Disease
   D. Dehydration
   E. All of the above

4. Aminophylline is not recommended for treating which of the following complications of pharmacologic nuclear stress testing

A. Myocardial infarction
B. Bronchospasm with shortness of breath
C. Cardiac arrhythmia
D. Seizure
E. Hypotension

5. Pharmacologic nuclear stress testing should be avoided in which of the following pre-existing conditions?

A. Known coronary artery disease
B. Chronic obstructive lung disease
C. AV block
D. Pulmonary hypertension
E. All of the above
Thank You