Cardiovascular Screening in Asymptomatic Adults: Lessons for the Diving World

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Ursula Geller Professor of Cardiovascular Diseases
Duke University
Case Presentation: 2004

- 58 yo healthy WM, No Sx
- Multiple cardiac risk factors
  - Family history
  - High blood pressure (Rx’d)
  - High cholesterol (LDL 177)
  - Obesity, High stress, Poor diet
- Statin started, discontinued
- Negative Stress MPI
- CP at rest → repeat MPI
- Urgent CABG x 4
Another Case: 2008

- 58 yo healthy WM, No Sx
  - HBP, Low HDL, High TG, LVH, overweight, stress
  - Negative yearly stress tests
  - Coronary Ca++ = 210 in 1998

- Clinical risk stratification
  - Framingham Risk <10%
  - Diamond & Forrester - low risk
  - CASS likelihood of CAD – 20%

- LAD plaque rupture; SCD
Another Case: 2010

• 48 yo AA male, No Sx
  – Smoker, high stress
  – Good diet, exercise
  – LDL 138, HDL 62
  – BP 105/62
  – HsCRP 0.015
• ECG, EBCT: ‘normal’
• Outcome??
Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider
WHO Screening Principles

• There should be an important problem
• There should be an accepted treatment
• Facilities must exist for diagnosis and treatment
• There should be a recognizable latent or early symptom stage
• A suitable test or examination must exist
• The test must be acceptable to the population
• The natural history must be understood
• Agreed policy on treatment
• Cost must be related to other medical care expenditure
• There must be a continuing process

Cardiovascular Screening

• Principles of screening
• Screening tools and tests
• Current recommendations
• What is being done now in diving?
• Program design issues to consider
Ideal Screening Tests

• Easy, inexpensive, and comfortable
• Valid for diagnosis of disease(s) of interest
• High sensitivity / specificity
• Valid for prognosis
• Reliable: Low variability of test results
Causes of Sudden Death in Athletes: What Diseases Are Relevant?

> 35 yo
- CAD ~75% deaths
- CAD is rare

< 35 yo
- HCM, LVH ~40% deaths
- CAD is rare
Two Screening Programs: Focus for Younger Athletes

- Genetic cause
- Structural abnormalities
- Abnormalities are detectable at rest
- Screening approach:
  - History is very important
  - Physical exam for murmurs
- Most screening data in this group
Two Screening Programs: Focus for Older Athletes

- Multi-factorial cause
- Vascular abnormalities (atherosclerosis)
- Few abnormalities at rest; spontaneous events

Screening approach:
- History helpful for RFs
- Physical exam for BP
- Current tests are poor for vulnerable plaque

- Little screening data
Screening for Younger Athletes

- Extensive guidelines and experience
- Generally limited to competitive athletes
- Universal: History and physical exam
  - AHA 12 point tool- Pre-participation Checklist
  - Cardiac exam
- Controversial: Testing
  - ECG - required in Europe, not in US
  - Echocardiography - not widely used
- Goals are to detect those who need additional testing…not to diagnose disease.
Additive Value of Pre-Participation ECG

- History and physical exam **plus** ECG
  - Feasibility in US: Cost, qualified practitioners, false (+)s
- Remarkable reduction in SCD in Italy
- Young, competitive athletes

Corrado JAMA 2006;296:1593
• 510 Harvard athletes; 11 w Abns ID by Echo
• 5 ID’d by H&P alone (sens 45%, spec 94%)
• 10 ID’d by H&P + ECG (sens 91%; spec 83%)

• H&P screening (cost $199) adds 2.6 life years per 1000 young athletes; Cost/year = $76,100
• Addn of ECG (cost $89) to screening saves 2 life years; Cost/year = $42,900
Screening in Older Athletes

- Few guidelines; Limited literature
- Focus on CAD risk
- Universal: History and physical
  - Cardiac symptoms and risk factors
  - Cardiac exam
- Controversial: Testing
  - Several options
  - No consensus
- Goals are to detect those who are **at risk** for CAD...not to diagnose disease.
NCEP - ATP III: 10 year vs Global Risk Calculation

• 10 year CVD risk calculation
  – FRS: Age, sex, HBP, cholesterol, smoking
  – CAD ‘equivalent’ - Diabetes or PVD
  – Stroke: Use same risk calculator

• Interventions based on 10 y CVD risk results
  – Low: 10 year risk <10%
    → Reassurance, No further risk assmts for 5 yrs
  – High: 10 year risk >20%
    → Aggressive risk factor modification
  – Intermediate: 10 year risk 10-20%
    → Further tests for reclassification ????
Screening for Cardiovascular Risk in Asymptomatic Patients

Jeffrey S. Berger, MS, MS,*† Courtney O. Jordan, MD,‡ Donald Lloyd-Jones, MD, SCM,§ Roger S. Blumenthal, MD||

New York, New York; Philadelphia, Pennsylvania; Minneapolis, Minnesota; Chicago, Illinois; and Baltimore, Maryland

- Clinical case: 56 yo F, s/p CVA, TC 210

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Estimated Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framingham</td>
<td>2%</td>
</tr>
<tr>
<td>10-yr CHD risk score</td>
<td>2%</td>
</tr>
<tr>
<td>Global CVD score</td>
<td>10%*</td>
</tr>
<tr>
<td>Heart age/vascular age</td>
<td>73</td>
</tr>
<tr>
<td>Reynolds</td>
<td>6%</td>
</tr>
<tr>
<td>SCORE (fatal CVD)</td>
<td>1%-2%†</td>
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<tr>
<td>QRISK</td>
<td>11%</td>
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<tr>
<td>ASSIGN</td>
<td>14%</td>
</tr>
<tr>
<td>Lifetime risk for CVD</td>
<td>39%</td>
</tr>
</tbody>
</table>
Stress Testing

ECG

ECHO

NUCLEAR
Predictive Value of Screening ETT

- 25,927 healthy men (20-82 yo); 8.4 y f/u
- Positive tests: 6%
- Sensitivity 61%; enhanced in those w RFs

AJC 2000 86:53
In asymptomatic individuals:

**Class IIa**
1. Evaluation of asymptomatic persons with diabetes mellitus who plan to start vigorous exercise. *(Level of Evidence: C)*

**Class IIb**
1. Evaluation of asymptomatic men > 45 y, women > 55 y:
   - Who plan to start vigorous exercise (esp if sedentary)
   - With occupations in which impairment might impact public safety

**Class III**
1. Routine screening of asymptomatic men or women.
B-mode Measurement of Carotid Intima-Media Thickness (CIMT)
### Predictive Value of CIMT

- Meta analysis: 12 studies, ~50,000 older subjects

#### A. Hazard ratio (HR) for MI per 0.1mm difference in CCA-IMT, adjusted for age, sex and other vascular risk factors

<table>
<thead>
<tr>
<th>Study</th>
<th>HR</th>
<th>[95% CI]</th>
<th>n</th>
<th>Data source</th>
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<tr>
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<td>Cardiovascular Health Study (CHS)</td>
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<td>Rotterdam Study</td>
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<td>[1.05-1.17]</td>
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<td><strong>TOTAL</strong></td>
<td>1.10</td>
<td>[1.08-1.13]</td>
<td>30162</td>
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</tr>
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</table>

*P for heterogeneity 27.9%

#### B. Hazard ratio (HR) for stroke per 0.1mm difference in CCA-IMT, adjusted for age, sex and other vascular risk factors

<table>
<thead>
<tr>
<th>Study</th>
<th>HR</th>
<th>[95% CI]</th>
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<th>Data source</th>
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<tr>
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*P for heterogeneity 0.0%
Coronary Artery Calcium (CAC) Score

Variable CAC Despite Similar RF Burden
Predictive Value of CAC

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>CACS Range</th>
<th>Effect</th>
<th>(95% CI)</th>
<th>Higher Risk</th>
<th>Low Risk</th>
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<td>Kondos (2003)</td>
<td>4-30.5</td>
<td>1.8</td>
<td>(0.8-3.8)</td>
<td>15 / 1,633</td>
<td>12 / 2,349</td>
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<td>31-169</td>
<td>1.5</td>
<td>(0.7-3.2)</td>
<td>16 / 2,045</td>
<td>12 / 2,349</td>
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<td>170-1,700</td>
<td>3.7</td>
<td>(1.9-7.3)</td>
<td>27 / 1,424</td>
<td>12 / 2,349</td>
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<td>Greenland (2004)</td>
<td>1-100</td>
<td>1.5</td>
<td>(0.8-2.9)</td>
<td>21 / 321</td>
<td>14 / 316</td>
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<td>101-299</td>
<td>2.0</td>
<td>(0.98-4.0)</td>
<td>15 / 171</td>
<td>14 / 316</td>
<td>0.053</td>
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<td>≥300</td>
<td>3.5</td>
<td>(1.9-6.3)</td>
<td>34 / 221</td>
<td>14 / 316</td>
<td>&lt;0.0001</td>
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<td>Arad (2005)</td>
<td>1-100</td>
<td>1.9</td>
<td>(0.8-4.3)</td>
<td>20 / 1,973</td>
<td>8 / 1,512</td>
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<td>101-399</td>
<td>10.5</td>
<td>(4.9-22.3)</td>
<td>38 / 688</td>
<td>8 / 1,512</td>
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<td>≥400</td>
<td>26.5</td>
<td>(12.8-54.8)</td>
<td>63 / 450</td>
<td>8 / 1,512</td>
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<td>Taylor (2005)</td>
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<td>(0.1-43.2)</td>
<td>0 / 120</td>
<td>2 / 1,281</td>
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<td>10-44</td>
<td>10.5</td>
<td>(1.5-73.9)</td>
<td>2 / 120</td>
<td>2 / 1,281</td>
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<td>25.4</td>
<td>(5.0-129.9)</td>
<td>5 / 124</td>
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<td>Vliegenhart (2005)</td>
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<td>6 / 905</td>
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<tr>
<td></td>
<td>401-1,000</td>
<td>5.6</td>
<td>(2.1-15.3)</td>
<td>10 / 269</td>
<td>6 / 905</td>
<td>&lt;0.0001</td>
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<tr>
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<td>&gt;1,000</td>
<td>10.8</td>
<td>(4.2-27.7)</td>
<td>14 / 196</td>
<td>6 / 905</td>
<td>&lt;0.0001</td>
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<td>LaMonte (2005)</td>
<td>1-16</td>
<td>5.5</td>
<td>(1.2-24.5)</td>
<td>3 / 379</td>
<td>4 / 2,780</td>
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<td>17-112</td>
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<td>5 / 376</td>
<td>4 / 2,780</td>
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<tr>
<td></td>
<td>113</td>
<td>12.9</td>
<td>(3.8-44.0)</td>
<td>7 / 376</td>
<td>4 / 2,780</td>
<td>&lt;0.0001</td>
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<tr>
<td></td>
<td>1-38</td>
<td>1.1</td>
<td>(0.3-4.3)</td>
<td>6 / 4,968</td>
<td>3 / 2,692</td>
<td>0.91</td>
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<td>39-249</td>
<td>12.3</td>
<td>(3.7-41.6)</td>
<td>19 / 1,382</td>
<td>3 / 2,692</td>
<td>&lt;0.0001</td>
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<tr>
<td></td>
<td>≥250</td>
<td>22.1</td>
<td>(6.8-71.9)</td>
<td>34 / 1,380</td>
<td>3 / 2,692</td>
<td>&lt;0.0001</td>
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<tr>
<td>Summary RR Ratio</td>
<td>4.3</td>
<td>4.3</td>
<td>(3.5-5.2)</td>
<td>364 / 19,039</td>
<td>49 / 11,815</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

JACC 2007;49:378
CAC vs CIMT: MESA Head to Head

- 6700 pts; F/u 3.9 y
- Composite: CV death, MI stroke
- CIMT HR 1.3 (1.1-1.4); AUC 0.78
- CAC HR 2.1 (1.8-2.5); AUC 0.81

Arch Intern Med. 2008; 168:1333
CT Angiography
• High NPV for obstructive CAD
• High false positive rate
• Anatomy, not ischemia
• Unclear if px info better than ex testing
• Radiation exposure
Data That **ANY** CAD Risk Assessment or Testing Strategy Improves Outcomes in Asymptomatic People
Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider
Screening Recommendations

• Younger athletes
  – AHA Pre Participation checklist

• Older individuals (not athletes)
  – Medicare
  – ACC/AHA Primary Prevention
  – USPSTF

• Older athletes
  – As above PLUS
  – AHA Exercise testing
  – Further testing in intermediate risk individuals?
AHA Pre Participation Screening: Targeted at Young Athletes

Medical history

Personal history
1. Exertional chest pain/discomfort
2. Unexplained syncope/near-syncope†
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure

Family history
6. Premature death < 50 years due to heart disease, in 1 relative
7. Disability from heart disease in a close relative 50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical examination
9. Heart murmur
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)

Maron Circ 2007; 115:1643
Lifestyle/Risk factor screening
Dietary intake counseling
Physical activity counseling
Tobacco use assessment/cessation
Weight/adiposity assessment/management
Blood pressure measurement/control
Blood lipid therapy/control
Global risk estimation
Aspirin use
Medicare Coverage for CV Screening Tests

• Tests covered - once every 5 years
  – Total Cholesterol
  – HDL
  – Triglycerides

• Not covered - everything else
  – ECG, Stress test, CIMT, CAC, CTA
• For older competitive athletes (>35 to 40 yo)
  – Knowledge of a personal history of CAD risk factors
  – Familial occurrence of premature CAD
• Selectively perform stress testing IF
  – Performing vigorous training and competitive sports
  – Men >40 y; women >55 y
  – With > 2 RF or 1 severe RF (other than age)
• Education: prodromal cardiac symptoms, such as exertional chest pain.

Maron Circ 2007; 115:1643
Cardiovascular Risk Assessment: Which Tests Are Suitable and Acceptable for Screening?

<table>
<thead>
<tr>
<th></th>
<th>&lt; 35 yo</th>
<th>&gt; 35 yo</th>
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</thead>
<tbody>
<tr>
<td>History</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td>Physical Exam</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td>Noninvasive Testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting ECG</td>
<td>+++</td>
<td>+</td>
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<tr>
<td>Exercise ECG</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Stress Imaging</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>CIMT</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>Coronary Ca++</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>CT Angio</td>
<td>-</td>
<td>+</td>
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</tbody>
</table>
Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider
The UK Experience: Pre-Dive Screening

- 3 UK organizations
- Questionnaire = legal declaration
- Required general MD exam
  - Q 5y if <40y, Q3 y if 40-50y, Annual > 50y
- Data on 2962 exams on 2094 divers
  - CV sx 1.2%, murmur 1%, med use 4%
  - 2% failure rate, 1% referral to CV MD
  - No significant unknown abns detected

BJSM 2000 34:375
The UK Experience: Pre-Dive Screening - Conclusions

“Diving is a safe sport requiring medical supervision, but routine clinical examination of all divers is unlikely to detect significant abnormalities relevant to their fitness to dive.”

“A carefully designed questionnaire will allow most relevant conditions to be identified and save unnecessary expense for both divers and doctors.”
• NZ Dept of Labour q 5 y interview, MD exam
• 3% with issues, 1/336 DQ’d
• “Q 5y exams have a low detection rate for important health problems”
Cardiovascular Screening

• Principles of screening
• Screening tools and tests
• Current recommendations
• What is being done now in diving?
• Program design issues to consider
The shape of things to come
Goals for Screening

- Improved health of divers
- Identify individuals for additional evaluation/testing
- Identify individuals with CV disease
- Prevention of incidents
- Prevention of deaths
- Improve safety of diving environment
- Reduce insurance premiums
Screening Considerations

• Who to screen?
• When to screen? How often? (Surveillance)
• What disease(s) to screen for?
• What screening questions and tests to use?
• Who will perform screening? Who will perform any needed additional evaluation?
• What will additional evaluation consist of?
• How will results be translated into clearance for diving? What happens if someone ‘fails’?
• Who will pay for all this?
Possible CV Screening Content

• All ages
  – Fitness level assessment
  – ACC/AHA Primary Prevention Performance Measures
  – Cardiovascular history, symptoms and signs
    • Under 35 yo: AHA Pre-Participation check list
    • Over 35 yo: CAD risk factors, symptoms, signs

• Over 35 years old or at least intermediate risk
  – All of the above
  – Selective testing of some kind
  – Stress testing or CAC score?
    • Evidence does not favor CIMT or CT Angio
Education

- Divers, diving staff and physicians
  - Prodromal symptoms and how to respond
  - Management of cardiovascular emergencies
  - What to do if health status changes
Possible Positive Screening F/U

• Positive questionnaire screens
  – All ages:
    • History and physical by MD
    • CAD risk factors modification
  – < 35 yo: ECG, Echo for HCM, congenital abns
  – >35 yo: CAC, ? ETT

• All symptomatic people need a full medical evaluation before diving
Other Considerations

• Ability to respond in an emergency
• The hyperbaric environment
  – PFO, PHTN
  – Altered drug metabolism
• Dive specific risks
  – Sport diving vs professional diving
• How often should screening be repeated?
• Would screening really change behavior?
Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider
NEWS ITEM: U.S. OBESITY GROWING.
Comparison of CAC vs CIMT for Risk Assessment in Asymptomatic Pts

<table>
<thead>
<tr>
<th></th>
<th>CAC Scoring CT</th>
<th>CIMT by US</th>
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<tbody>
<tr>
<td><strong>Imaging Focus</strong></td>
<td>Calcium within plaque</td>
<td>Arterial wall thickening</td>
</tr>
<tr>
<td><strong>Invasive</strong></td>
<td>Non-invasive</td>
<td>Non-invasive</td>
</tr>
<tr>
<td><strong>Radiation</strong></td>
<td>1.0–1.8 mSv</td>
<td>No ionizing radiation</td>
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<tr>
<td><strong>Sensitivity for dx obs CHD</strong></td>
<td>85%</td>
<td>50-70%</td>
</tr>
<tr>
<td><strong>Specificity for dx obs CHD</strong></td>
<td>75%</td>
<td>60-80%</td>
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<tr>
<td><strong>HR for incident CAD/SD</strong></td>
<td>2.1</td>
<td>1.3</td>
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<tr>
<td><strong>Availability</strong></td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Ease of use</strong></td>
<td>+++</td>
<td>++</td>
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<tr>
<td><strong>Operator dependence</strong></td>
<td>Automated</td>
<td>User dependent</td>
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<tr>
<td><strong>Estimated test cost</strong></td>
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<td>$200</td>
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<tr>
<td><strong>Payer reimbursement</strong></td>
<td>None</td>
<td>None</td>
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<tr>
<td><strong>Cost of implementation</strong></td>
<td>Capital $1.5M+ Operating $800,000/y</td>
<td>Capital $100,000 Operating $50,000/y</td>
</tr>
</tbody>
</table>

Circ Imaging 2009 2:150