CAR DiAC REHAB

Benefits: 1) increase functional capacity 2) reduce morbidity and mortality
Outcomes: improved exercise tolerance, cardiac symptoms, blood lipid levels, psychosocial well being, reduced mortality
Patient’s referred: MI, CABG, cardiac transplant, post-valve replacement, CHF, arrhythmias

RISK FACTORS
(From: Braddock)
Irreversible: male, fam hx, h/o CAD, PVD, CVA
Reversible: smoking, HTN, Low HDL (<35), High lipoprotein A, abdominal obesity, hypertriglyceridemia (>250), hyperinsulinemia, DM, sedentary lifestyle

Modifiable Risk Factors: (Framing ham Study 1984)
HTN, cigarette, hypercholesterolemia, low HDL (<25), sedentary, DM, stress, obesity

Non-modifiable Risk Factors
age, male, fam hx, EKG showing LVH

PHASES
Phase I: hospital admission – discharge
Mobilizing early has better return-to-work rate
1-2 mets
avoid isometrics (increase afterload) and straight leg raises (increase preload)
precautions: Hold for HR <50 >120, 20 for resting if on beta blocker, SBP should not drop >20
predischarge: submaximal stress test
goal: IADLs, walk 2-3 mph on flat surface x 15-30 min, light housework

Phase II: Outpt training
Cardiac scar forms by 6 weeks post MI
THR determined by ECG: 60-85% of safe maximum
(aerobic conditioning, reacquisition of full activity, risk factor management, lifestyle modification)
Goal: improve VO₂ max, lower HR for given work load, reduce SBP, improved peripheral O₂
extraction and utilization by skeletal muscle, improve depression

Borg scale goal 11-13 (somewhat hard)
May return to sedentary work if walk 3.5 mph comfortable
ETT 6-8 weeks post MI

Phase III: Maintenance 3-9 months
patient monitored continuation of aerobic exercise program, risk-reduction strategies and
activity/work modification
Krohonen formula THR = [(HRmax – HR rest) x %intensity] + HR rest

Phase IV: community setting, self-monitors HR or BORG

“Possible contraindications to exercise programs”: American College of Sports medicine
resting SBP>200 DBP>100
orthostatic BP drop or drop during exercise >20
mod to severe AS
acute systemic illness or fever
Uncontrolled dysrythmias, sinus tach (120), CHF
3rd degree AV block, active pericarditis or myocarditis
recent PE, thrombophlebitis
resting ST displacement >3mm
uncontrolled DM
orthopedic problems prohibiting exercise
TABLE 9.2 Absolute Contraindications for Entry into Inpatient and Outpatient Exercise Training

- Unstable angina
- Resting systolic blood pressure > 200 mm Hg or resting diastolic blood pressure > 110 mm Hg
- Significant drop (20 mm Hg) in resting systolic blood pressure from the patient's average level that cannot be explained by medication
- Moderate to severe aortic stenosis
- Acute systemic illness or fever
- Uncontrolled atrial or ventricular arrhythmias
- Uncontrolled tachycardia (>100 bpm)
- Symptomatic congestive heart failure
- Third-degree heart block without pacemaker
- Active pericarditis or myocarditis
- Recent embolism
- Thrombophlebitis
- Resting ST displacement (>3 mm)
- Uncontrolled diabetes
- Orthopaedic problems that would prohibit exercise

EXERCISE RX: (Braddock)

Modality: lg muscles

Intensity: target HR vs perceived exertion vs METS vs exercise intensity (speed, resistance)

Duration: 20-30 min preceded by warm-up phase and followed by cool-down

Frequency: 3-5 days/week

Rate of progression

Specificity: train muscle groups patient will need in vocation (ie arms for carpenter)

Usual target HR is 85% of maximum HR achieved during ETT

If individual is frail → 60% of max can still achieve training effect

Cardiac transplants and CHF need longer warm up periods

AHA recommends exercise at 40-60% of maximum VO2 for 20-30 minutes, 3-4 times a week

New Federal recommendation of 60-90 minutes a day

Metabolic Equivalents

1 MET is resting metabolic rate = 3.5 mL O2/kg/min

<table>
<thead>
<tr>
<th>Sport Activity</th>
<th>Energy Cost in Metts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf</td>
<td>2-3</td>
</tr>
<tr>
<td>Bowling</td>
<td>1.5</td>
</tr>
<tr>
<td>Volleyball</td>
<td>3.4</td>
</tr>
<tr>
<td>Ping pong</td>
<td>3.4</td>
</tr>
<tr>
<td>Tennis</td>
<td>1.7</td>
</tr>
<tr>
<td>Roller-skating</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Physical Activity Program

Slow walk 2 mph 2-3 mets
Regular speed walk 3 mph 3-4 mets
Brisk walk 3.5 mph 4-5 mets
Very brisk walk 4 mph 5-6 mets
Sexual intercourse* 3-4 mets
Outdoor work—shovel snow, spade soil 7 mets
Jog walk 5 mph 9 mets
Mop floor 2.4 mets
Push power lawn mower 4 mets

* Note: met level for sexual intercourse varies depending upon reference source. Tardif states that patients who reach 3-6 mets on stress-testing without ischemia or arrhythmias can, in all likelihood, resume their normal sexual activities without any risk. (Tardif 1989)

The goal is the improvement of the cardiovascular capacity through physical exercise training whether in a minimally-supervised or unsupervised setting.
Return to Work guidelines by ETT
<5 mets = no return
5-7 mets= household chores and sedentary work
>7 mets = most jobs except heavy industrial labor
5-6 mets = flights of stairs, sex

sex tolerance test = safe if can walk level surface 10 minutes followed by 2 flights of stairs in 10 seconds without symptoms, advise less strenuous positions

Aerobic training program
Increases VO_{2max}, CO, resting stroke volume, workload
Decreases resting HR, resting MVO_{2}, submax MVO_{2}
No change in maximum MVO_{2} -> determined by anginal threshold (not affected by aerobic conditioning)
No effect on coronary circulation, anginal threshold

ETT
Absolute Contraindications: unstable angina, untreated life-threatening cardiac arrhythmias, uncompensated CHF, advanced A-V block, acute myocarditis/pericarditis, critical AS, severe hypertrophic obstructive cardiomyopathy, uncontrolled HTN 200/110, acute MI, active endocarditis, acute PE, acute systemic illness

Relative Contraindications: significant pulmonary HTN, HTN, tachy/bradyarrhythmias, moderate valvular heart disease, myocardial heart disease, electrolyte abnormalities, left main coronary obstruction, hypertrophic cardiomyopathy

<table>
<thead>
<tr>
<th>BRUCE PROTOCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>
TABLE 9.4. Contraindications to Exercise Testing

### Absolute Contraindications

1. A recent significant change in the resting ECG, suggesting infarction or other acute cardiac events
2. Recent complicated myocardial infarction
3. Unstable angina
4. Uncontrolled ventricular dysrhythmia
5. Uncontrolled atrial dysrhythmia that compromises cardiac function
6. 3rd degree A-V block
7. Acute congestive heart failure
8. Severe aortic stenosis
9. Suspected or known dissection aneurysm
10. Active or suspected myocarditis or pericarditis
11. Thrombophlebitis or intracardiac thrombus
12. Recent systemic or pulmonary embolus
13. Acute infection
14. Significant emotional distress (psychosis)

### Relative Contraindications

1. Resting diastolic blood pressure > 120 mmHg or resting systolic blood pressure > 200 mmHg
2. Moderate valvular heart disease
3. Known electrolyte abnormalities (hypokalemia, hypomagnesemia)
4. Fixed-rate pacemaker (rarely used)
5. Frequent or complex ventricular ectopy
6. Ventricular aneurysm
7. Cardiomyopathy, including hypertrophic cardiomyopathy
8. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
9. Chronic infectious disease (e.g., mononucleosis, hepatitis, AIDS)
10. Neuromuscular, muscular dystrophy, or rheumatoid disorders that are exacerbated by exercise
11. Advanced or complicated pregnancy


TABLE 9.5. Indications for Stopping an Exercise Test

### Symptom-Limited maximal test

1. Progressive angina (stop at 3+ level or earlier on a scale of 1-4)
2. Ventricular tachycardia
3. Any significant drop (20 mm Hg) of systolic blood pressure or a fall of the systolic blood pressure in rise with an increase in exercise load
4. Light-headedness, confusion, ataxia, pellagra, cyanosis, nausea or signs of severe peripheral circulatory insufficiency
5. 3mm horizontal or downsloping ST depression or elevation (in the absence of other indicators of ischemia)
6. Otis of second- or third-degree A-V block
7. Increasing ventricular ectopy, multiform PVCs, or R on T PVCs
8. Excessive rise in blood pressure; systolic > 250 mm Hg; diastolic pressure > 120 mmHg
9. Chromodepulmonary impairment

10. Combined supraventricular bradycardia
11. Exercise-induced left bundle branch block
12. Subject requests to stop

Bicycle: better ECG tracing & BP recording, takes up less room
RPP artificially elevated for given VO₂ in alternative testing protocols compared to treadmill
(see definitions)

Exercise: ST depression > 1-2 mm = positive test
Women have higher likelihood of false positive tests
ECHO STRESS TEST
3 assumptions:
1) induction of ischemia results in area of ventricular dyssynergy
2) wall motion abnormalities are specific for ischemia
3) these wall motion changes can be seen on TTE
Treadmill – echo pre and post
Bicycle – continuous echo

NUCLEAR STRESS - THALLIUM
More accurate than stress echo or ECG alone
Imaging done in conjunction with treadmill
Thallium-201 taken up by cardiac myocytes via NA/K ATPase pump
First pass extraction of 85% and is continuous
Early images – myocardial blood flow
Late images – myocardial viability

PHARMACOLOGIC STRESS
Questionable usefulness for functional eval for exercise Rx
Dipyridamole: induces cardiac stress, may be used with thallium
Coronary artery vasodilator – increases blood flow by 3-5x
Adenosine: more rapid onset due to shorter half life (10-30 seconds)
Dobutamine: causes increased SV and CO
Strong β1, moderate β2, mild α1 stimulation
Raises RPP by ionotropy and chronotropy

LIFESTYLE MODIFICATION
Quitting smoking lowers risk of recurrent cardiac events by 50% in one year and approaches risk of
nonsmokers in two years

DEFINITIONS
Heart rate: increases linearly against VO₂ (limited by age)
Maximum HR: max during ETT, estimated by 220-age
Cardiac Output: increases with increasing work via frank-starling mechanism in late exercise, increased
primarily through an increase in ventricular rate (HR)
linear relationship with VO₂
CO=HRxSV

Stroke Volume:
determined by diastolic filling volume which is inversely related to HR
blood ejected with each ventricular contraction, increases w/exercise to become max at 50% over resting
basal HR

Maximum aerobic capacity (VO₂ max): greatest rate of O₂ consumption a person is able to metabolize,
relates directly to max output in watts
VO₂ increases linearly with workload until it plateaus = VO₂ max of the individual
total VO₂ provides a measure of the increasing metabolic work of the peripheral skeletal muscles (not the
heart)
SV x HR x (A-V O₂ difference)
decreases with age, inactivity, after MI

Aerobic capacity (VO₂): measures work capacity of an individual
Goal is to increase in aerobic training program
While VO₂ max increases, there is no change in resting VO₂ or VO₂ at submax workload

5
anginal threshold: CO at which myocardial O₂ demand exceeds O₂ delivered

Myocardial oxygen consumption (MVO₂)
linear relationship to VO₂ until anginal threshold
limited by angina threshold: point where myocardial oxygen demand exceeds the ability of the coronary circulation to meet that demand,
correlates well with HR and SBP

rate pressure product (RPP) = (HR x SBP)/100

activities with the UE generate higher MVO₂ than LE at same VO₂
activities performed supine as opposed to upright generate a higher MVO₂ at low intensities and lower MVO₂ at higher intensities
activities performed under emotional stress, after smoking, eating, or in cold weather generate a higher MVO₂ at the same VO₂ than activities performed at baseline
activities with higher isometric component generate higher MVO₂

SPECIAL POPULATIONS

Amputees

<table>
<thead>
<tr>
<th>AMPUTATION</th>
<th>% INCREASE</th>
<th>METS</th>
</tr>
</thead>
<tbody>
<tr>
<td>No prosthesis with crutches</td>
<td>50%</td>
<td>4.5</td>
</tr>
<tr>
<td>Unilateral BK with prosthesis</td>
<td>9-28%</td>
<td>3.3-3.8</td>
</tr>
<tr>
<td>Unilateral AK with prosthesis</td>
<td>40-65%</td>
<td>4.2-5.0</td>
</tr>
<tr>
<td>Bilateral BK with prosthesis</td>
<td>41-100%</td>
<td>4.2-6.0</td>
</tr>
<tr>
<td>BK plus AK with prostheses</td>
<td>75%</td>
<td>3.3</td>
</tr>
<tr>
<td>Bilateral AK with prostheses</td>
<td>250%</td>
<td>11.4</td>
</tr>
<tr>
<td>Unilateral hip disartic with prosthesis</td>
<td>82%</td>
<td>5.5</td>
</tr>
<tr>
<td>Hemiprostectomy with prosthesis</td>
<td>12.5%</td>
<td>6.75</td>
</tr>
</tbody>
</table>

(DeLee JA, Garts BM, Rehabilitation Medicine, Principles and Practice, 3rd ed. Chapter 34 p.1353)

AMPUTEE EXERCISE TEST

- Pharmacological stress testing using dipyridamole—for patients that are unable to perform any exercise stress test
- Upper extremity cycle ergometer stress test—first determine the safety and ability of mobility
- Telemetry monitoring of ambulation training:
  1. Preprosthetic period
  2. Prosthetic period
  3. Postprosthetic period

Elderly:
need longer phase II
HR not best indicator of exercise intensity
Intensity 50-85% MHR
Include warm up and cool down
Low joint impact exercise – alternate UE and LE

Stroke:
Usually occurs within 2 weeks of MI with 60% mortality
Hemiplegic gait increases oxygen consumption (same if walking at self-selected speed)
Spasticity can increase BP and HR
Watch for orthostatic hypotension
SCI
Greater risk of CAD: low HDL, glucose intolerance, sedentary
Risk of silent ischemia
dependent edema
may need pharmacologic stress test
reduced SV and CO due to reduced preload (venous pooling)

s/p CABG
excellent candidates
Benefits: increased ischemic threshold, coronary collaterals
  Improved LV function, psychologic status
  Ameliorated serum lipids
  Decreased serum catecholamines, platelet aggregation
ETT can be performed 3-4 weeks after surgery
POD 1  sitting, leg mobilization, OOB
POD 2-5 progressive ambulation and exercise

At home intensity of activity
  Low: 2-4 METS, 65-75% THR
  Mod: 3-6.5 METS, walk-jog, 70-80% THR
  High: 5-8 METS, walk-jog to jog, 75-85%

If on beta blocker, THR is 20+ rest

Cardiac Transplant
5 & 10 year survival → 82% and 74%
Lose vagal inhibition to SA node, HR 100
Blunted HR response to exercise by 20-25% on ETT
Resting HTN common 2/2 meds

Lose 10-50% of lean body mass decreasing maximum work output and \( VO_2_{max} \) by \( \frac{2}{3} \)
Increased RPE, minute ventilation, ventilatory equivalent for oxygen
\( VO_2 \) is the same implying earlier onset of anaerobic metabolism
At max effort, there is lower work capacity, CO, HR, SBP and \( VO_2 \)

Goal: 60-70% peak effort, 30-60 min, 3-5x/week
Borg 13-14 (somewhat hard to hard)

Cardiomyopathy
Higher risk of sudden death
Earliest finding is limited exercise capacity
Exercise can decrease SV, CO, EF, BP
Prolonged warm ups and cool downs
Dynamic exercise preferable to isometrics
THR should be 10 beats below any exertional endpoint (ie hypotension, significant dyspnea)

Anticoagulation; avoid high impact exercises
Arrhythmias: very rare to have