Metabolic Disorders and Stress Testing

Metabolic Disorders

- Causes:
  - drugs can induce cellular changes, changes in respiratory or cardiac function resulting in acidosis or alkalosis
  - Changes in ventilation
    - hyper-v, alkalosis
    - hypo-v, acidosis
    - Metabolic diseases

Drugs

- Acidosis
  - Aspirin
  - tranquilizers
- Alkalosis
  - stimulants

Effects of ventilation

- Hyperventilation
  - Low PCO₂
    - alkalosis
    - coronary vasoconstriction (ischemia)
    - may occur during exercise
    - occurs with altitude
- Hypoventilation
  - high PCO₂
    - acidosis
    - vasodilation in the brain

Respiratory Acidosis

- May occur with chronic exercise
  - endurance athletes build up a tolerance against acidosis
  - reverses rapidly during recovery
- Cardiac effects (good and bad)
  - depresses cardiac function
  - suppresses arrhythmias
- EKG changes
  - lowering of T waves
  - prolongation of QT interval

Respiratory Alkalosis

- Chronic hyperventilation
  - emotionally labile women
    - chest pain
    - ST depression
    - pH 7.5
    - low serum potassium
  - untrained exercisers
  - altitude
Metabolic Diseases

- Thyroid
- Diabetes
- Obesity
- Renal Failure

Thyroid Hormone Disorders

- Hyperthyroidism
  - Increased appetite
  - Loss of weight
  - Trouble sleeping
  - \( \uparrow \) HR, BP, ejection rate, coronary bf
  - \( \downarrow \) TPR
  - arrhythmias
  - at maximal exercise, \( \downarrow \) EF
  - Feel good
  - normal exercise capacity

Hypothyroidism

- Weight gain
- Tired, increased sleep
- \( \downarrow \) cardiac output, myocardial contractility, HR
- T wave flattening, ST depression
- decreased exercise capacity

Metabolic Syndrome

- Can precede diabetes for many years
- Metabolic syndrome
  - hypertension, dyslipidemia, obesity
  - upper body fat patterning
- sedentary lifestyle is the major risk factor
- Prevention
  - Lifestyle
  - Lipid lowering drugs
  - Glucose lowering drugs

Diabetes, prevalence

- 6% of US population and 10% of those over 65
- 1/3 more are undiagnosed
- Increasing at a fast rate
  - 0.4% in 1935
  - 3.0% in 1994
  - 6% in 2000
  - 12% in 2015?

Diabetes, CV complications

- Damage to the vasculature (retina)
- Deposits of mucopolysaccharides in the myocardium
  - \( \uparrow \) incidence of congestive heart failure
- Metabolic dysfn, \( \uparrow \) ammonium
  - acidosis, \( \downarrow \) cardiac contractility
- Autonomic neuropathy
  - lower HRmax, higher BP
  - ST depression
Why do diabetics usually die from CV disease?

- Association with obesity, dyslipidemias, hypertension
- “fear” of exercise-induced glucose dysregulation-sedentary
- greater occurrence of CAD, congestive heart failure
- nerve damage masks ischemic pain

Responses to Exercise

- Improves insulin action
  - decreases blood glucose
- Insufficient insulin before exercise
  - impairs glucose transport
  - Hyperglycemia, ketosis, acidosis,
- Too much insulin before exercise
  - hypoglycemia
  - seizures and unconscious

ACSM recommendations before exercise

- Measure blood glucose before, during and after exercise
  - >300mg/dl or >240 mg/dl with ketosis don’t exercise
- Avoid exercise at peak insulin times
- extra carbohydrates (20-30 g) 30 min before exercise
- reduce insulin (50-90%)
- have easily absorbed carbs handy
- know signs and symptoms

Stress Testing Diabetics

- Diabetics are high risk and should undergo stress testing before exercise
- Thompson criteria for exercise stress testing
  - type 2 > 10 yrs
  - all > 35 yrs
  - presence of microvascular disease
  - presence of autonomic neuropathy

Diabetics with autonomic neuropathy

- EXTRA EXERCISE PRECAUTIONS
- ANS dysfn can result in high resting HR and blunted exercise HR
- ventricular dysfunction
  - blunted cardiac output
  - reduced exercise capacity
- excessive increase in BP
- Post-exercise fainting

Possible adverse effects of exercise training

- Cardiovascular
  - arrhythmias, htn
- Microvascular
  - retinal hemorrhage, proteinuria, microvascular lesions
- Metabolic
  - hyperglycemia and acidosis, hypoglycemia
- Musculoskeletal
  - foot ulcers, orthopedic injury, degen joint disease
Recommended exercises for diabetics with neuropathy

- Swimming
- bicycling
- rowing
- chair exercises
- arm exercises
- other non-weight-bearing exercises

Famous Athletes with Diabetes

- Type 1
  - Jim “Catfish” Hunter, NY Yankee Hall of Famer
  - Gary Hall, Jr, 1996 Olympic Gold medalist
  - Sugar Ray Robinson, boxer
- Type 2
  - Arthur Ashe (tennis)
  - Air Steven Redgrave, rower- 5 Olympic gold medals

Renal Disease

- Causes of renal disease
  - Hypertension and diabetes cause most cases
  - Polycystic kidney disease
    - Affects over 600,000 people in US

Renal Disease: detection

- Urine albumin
- Light exercise screening test
  - 2 watts/kg for 30 min
  - Reveals increased protein in urine early in the course of diabetes

Renal Disease: metabolic effects

- Inefficient excretion of waste products results in a build-up of urea and creatinine and acidosis
- Symptoms
  - Increased cardiac troponin and myocardial dysfunction
  - Weakness, hypertension, anorexia, fatigue

Renal Disease and exercise capacity

- Lower maximal HR and exercise capacity
  - 50-60% VO2max of predicted
  - May be related to renal anemia
- Muscle weakness and fatigue
- Metabolic effects of acidosis
  - Glucose intolerance
  - Altered lipid metabolism
  - Increased protein breakdown
Kidney Transplants

- 9% of dialysis patients receive a kidney transplant
- Despite reversal of uremia, cardiovascular disease is a major cause of death in transplant patients
- Exercise is becoming a major therapy for patients on dialysis and after transplant
- Treatments include EPO, dialysis, and exercise therapy (aerobic and resistive)

Estrogens and ST changes

- Estrogens are associated with ST depression!
  - cause of false positives in young women?
  - women with ST depression reverted to a normal EKG after their ovaries were removed
  - patients with CAD had greater ST depression after 2 wks treatment with estrogen

Androgens

- Testosterone has been shown to improve ST depression!
  - surprising results for estrogens and androgens—opposite to what would be predicted from epidemiology mortality studies of gender differences
- Positive effects of androgens
  - increase cardiac muscle strength
  - increase hct and oxygen carrying capacity
  - ↓ angina

Carbon Monoxide

- Patients with CAD
  - extremely sensitive to CO
  - 2-4% CO levels in blood will cause ↓ exercise capacity, earlier ST depression and ischemia
  - these levels can occur with cigarette smoking or during a long ride on a crowded freeway

Metabolic Abnormalities

Summary

- Clients with metabolic abnormalities may have altered exercise responses
  - T (tablets), psychological stress, exercise stress, metabolic diseases
- During exercise
  - arrhythmias, ST depression, reduced exercise capacity
- Diabetes is a common metabolic disease
  - extra precautions should be taken during stress testing