Biomedical Engineering for Global Health

Lecture Eighteen

Outline

- The burden of heart disease
- The cardiovascular system
- How do heart attacks happen?
- How do we treat atherosclerosis?
  - Open heart surgery
  - Angioplasty
  - Stents
- What is heart failure?
- How do we treat heart failure?
  - Heart transplant
  - Left ventricular assist devices
  - Artificial heart

Early Warning Signs of Heart Attack

- Many heart attacks start slowly; symptoms may come and go
- Chest discomfort
  - Most heart attacks involve discomfort in the center of the chest that lasts for more than a few minutes, or goes away and comes back. The discomfort can feel like uncomfortable pressure, squeezing, fullness, or pain
- Discomfort in other areas of the upper body
  - Can include pain or discomfort in one or both arms, the back, neck, jaw, or stomach
- Shortness of breath
  - Often comes along with chest discomfort. But it also can occur before chest discomfort
- Other symptoms
  - May include breaking out in a cold sweat, nausea, or light-headedness

Heart Attack Video

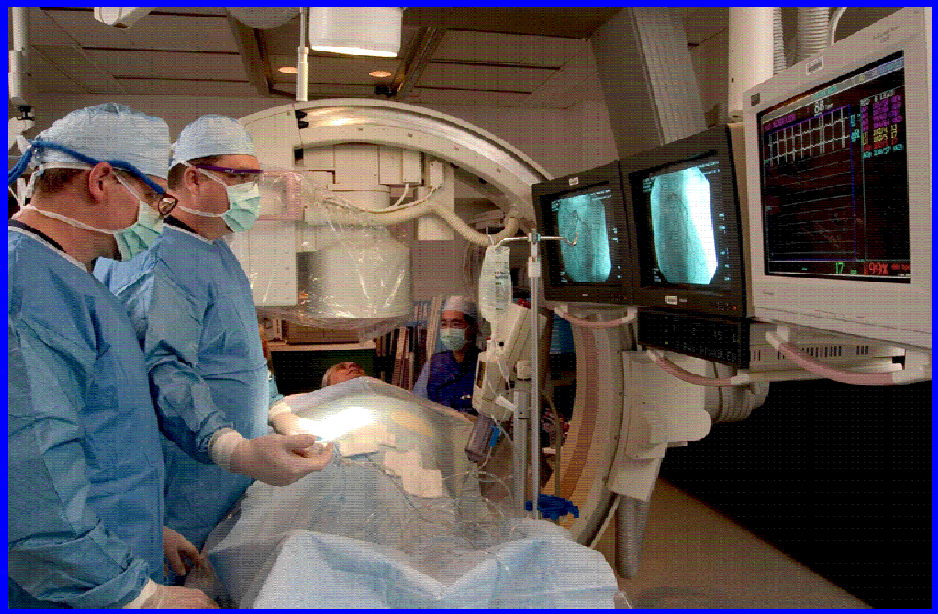
- http://www.heart1.com/attack/guidant.cfm

Heart Attacks

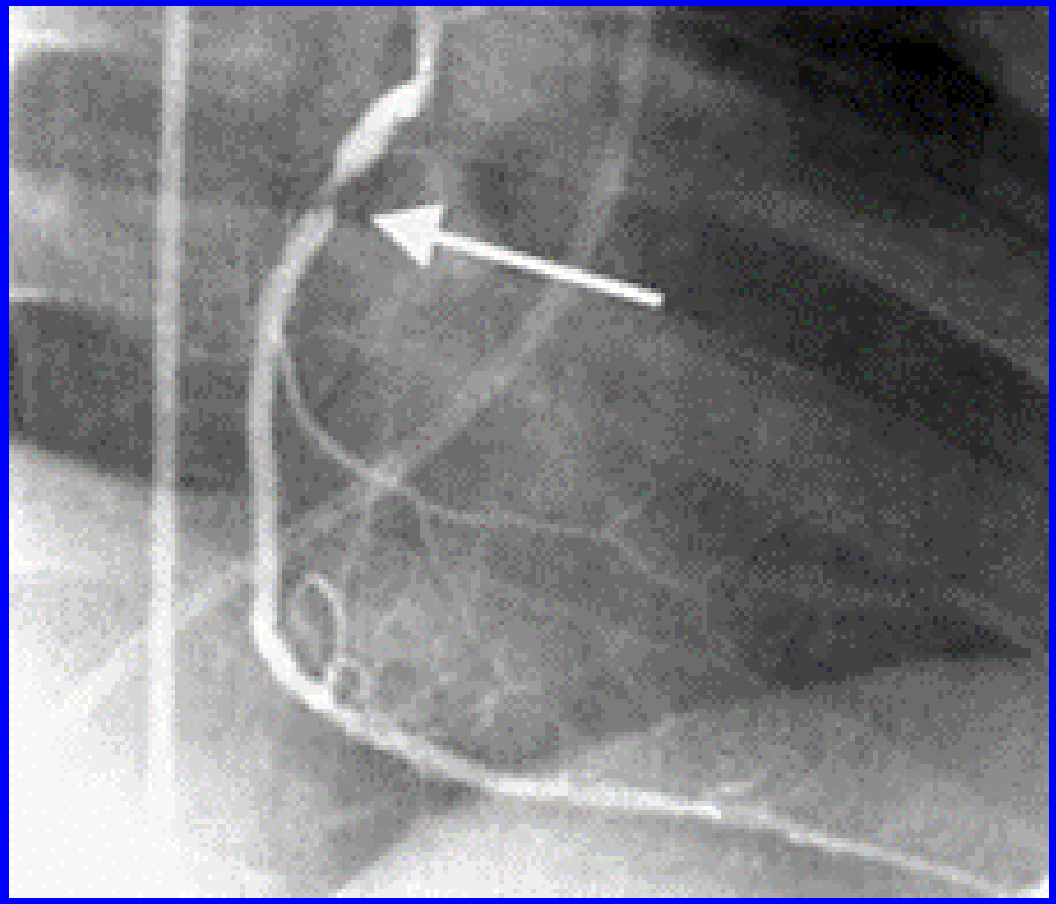
Diagnosis of Atherosclerosis

Detection of Atherosclerosis

Oregon Health and Science University Hospital with Siemens Asion Artis System



Ozarks Medical Center



Texas Heart Institute

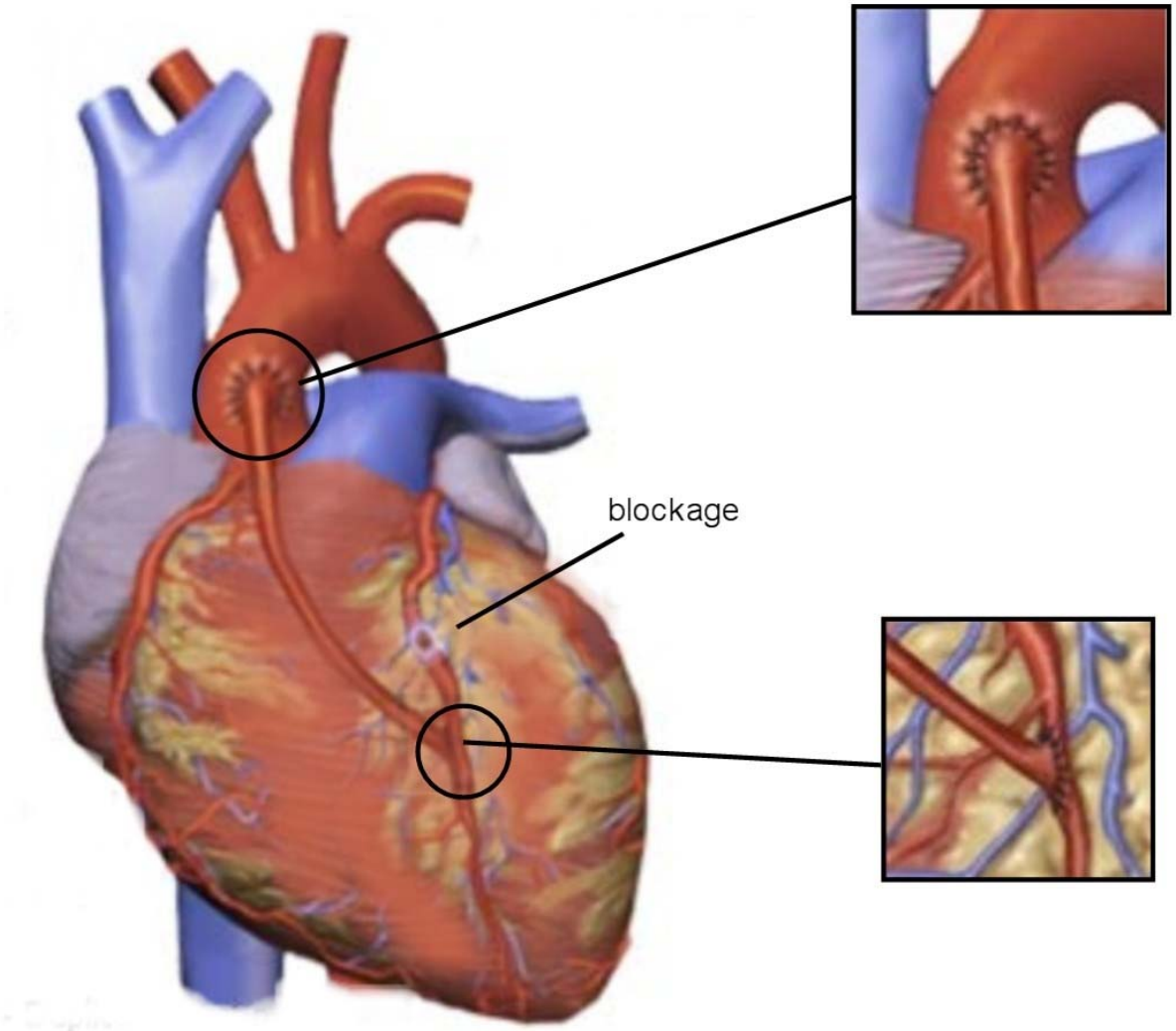
Heart Attacks

Treatment of Atherosclerosis

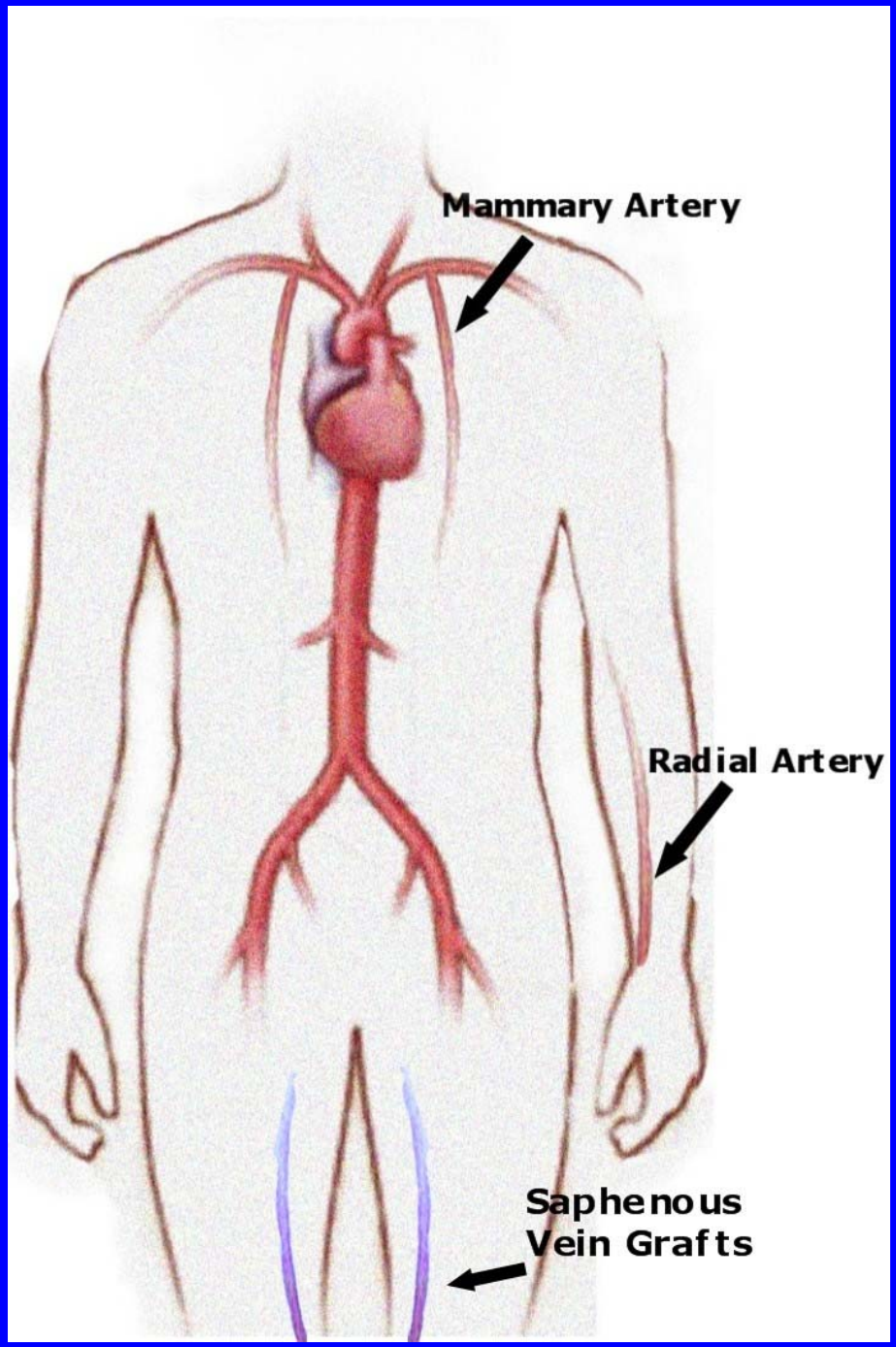
How Do We Treat Atherosclerosis?

CABG

Coronary Artery Bypass



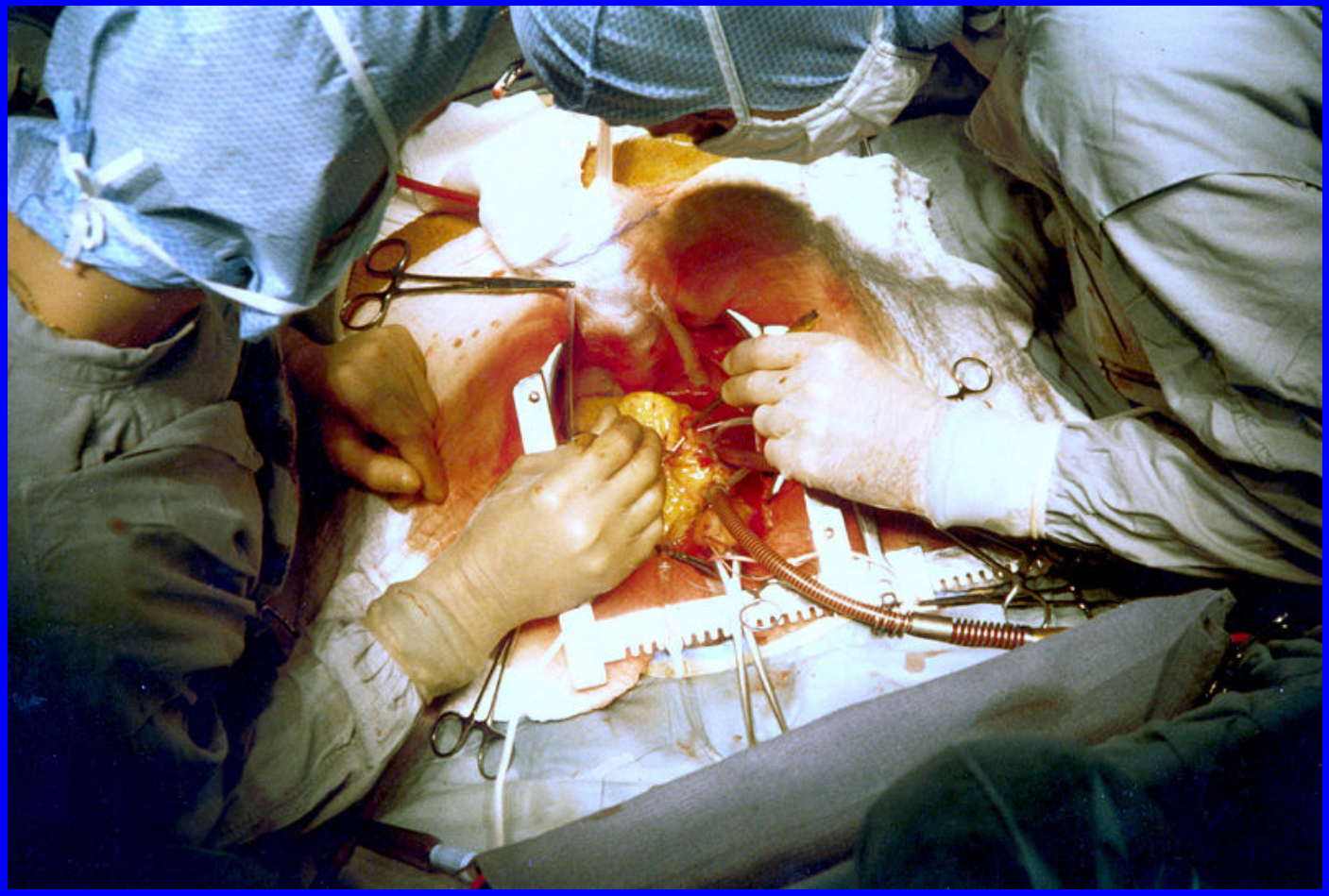
NHLBI



MetroHealth System, Cleveland Ohio

CABG Procedure

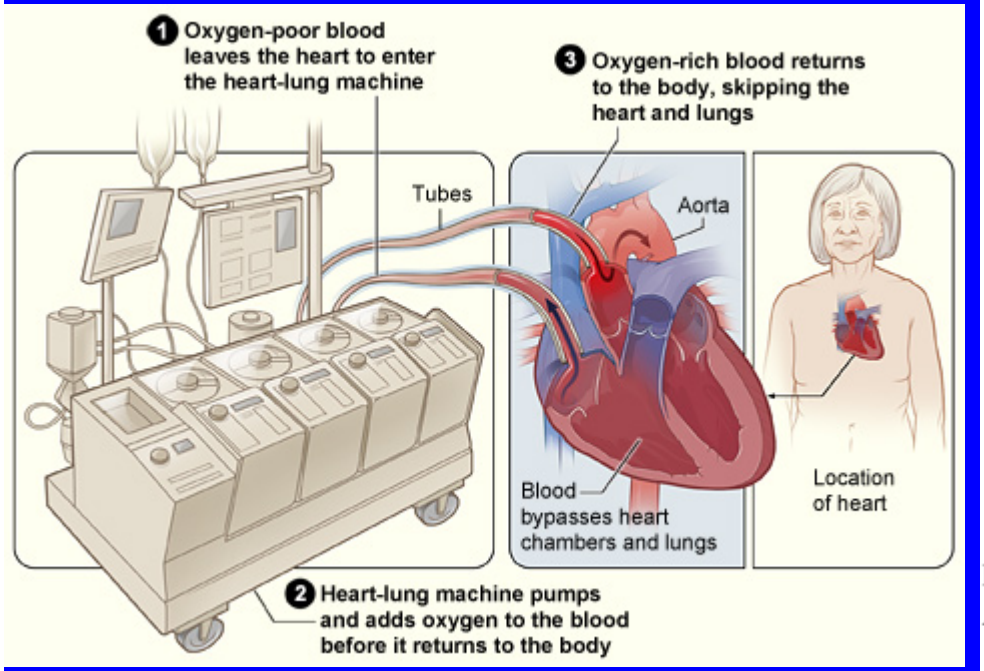
- Patient is prepped, general anesthesia
- Chest access is gained, through sternum
- Graft vessel is retrieved
- Expose heart through pericardium
- Divert blood through heart lung machine
- Stop heart
- Insert graft
- Return circulation to heart
- Close incision



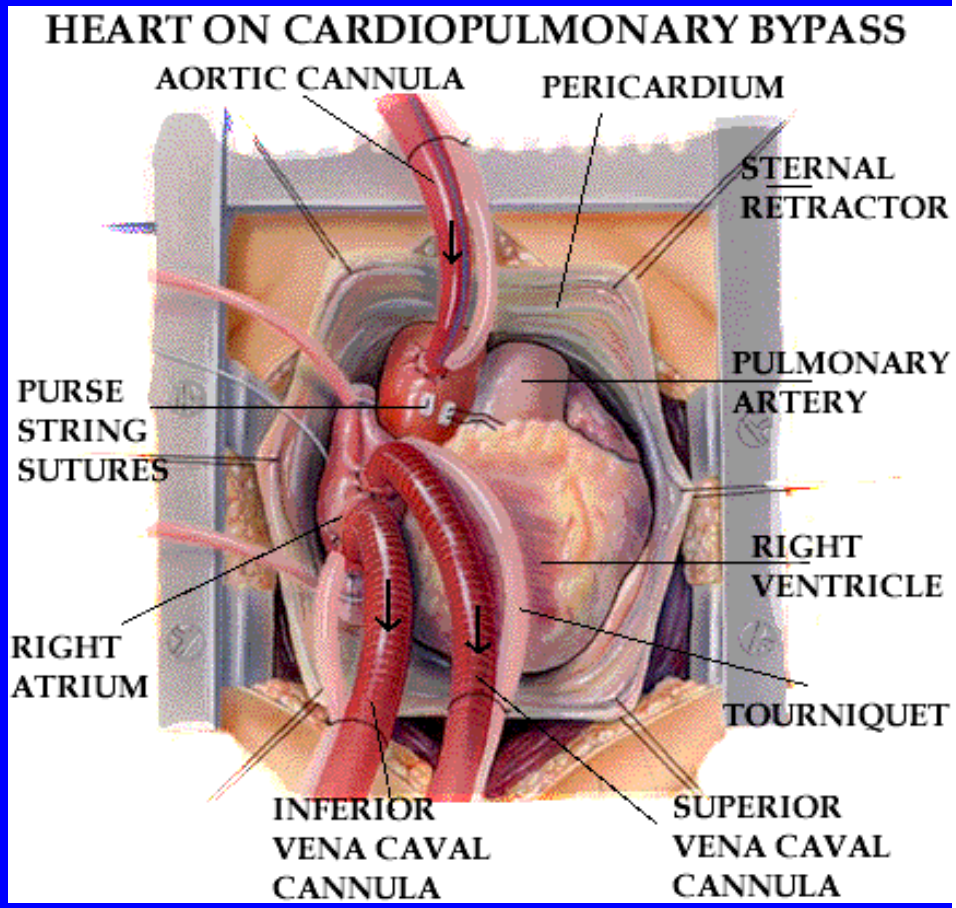
Heart-Lung Machine

- The heart-lung machine:
  - Consists of a chamber that receives the blood from the body
  - Blood is pumped by machine through an oxygenator
  - Oxygenator removes CO2 and adds oxygen
  - Pump then pumps this newly oxygenated blood back to the body
  - Connected to patient by a series of tubes that the surgical team places

Heart Lung Machine

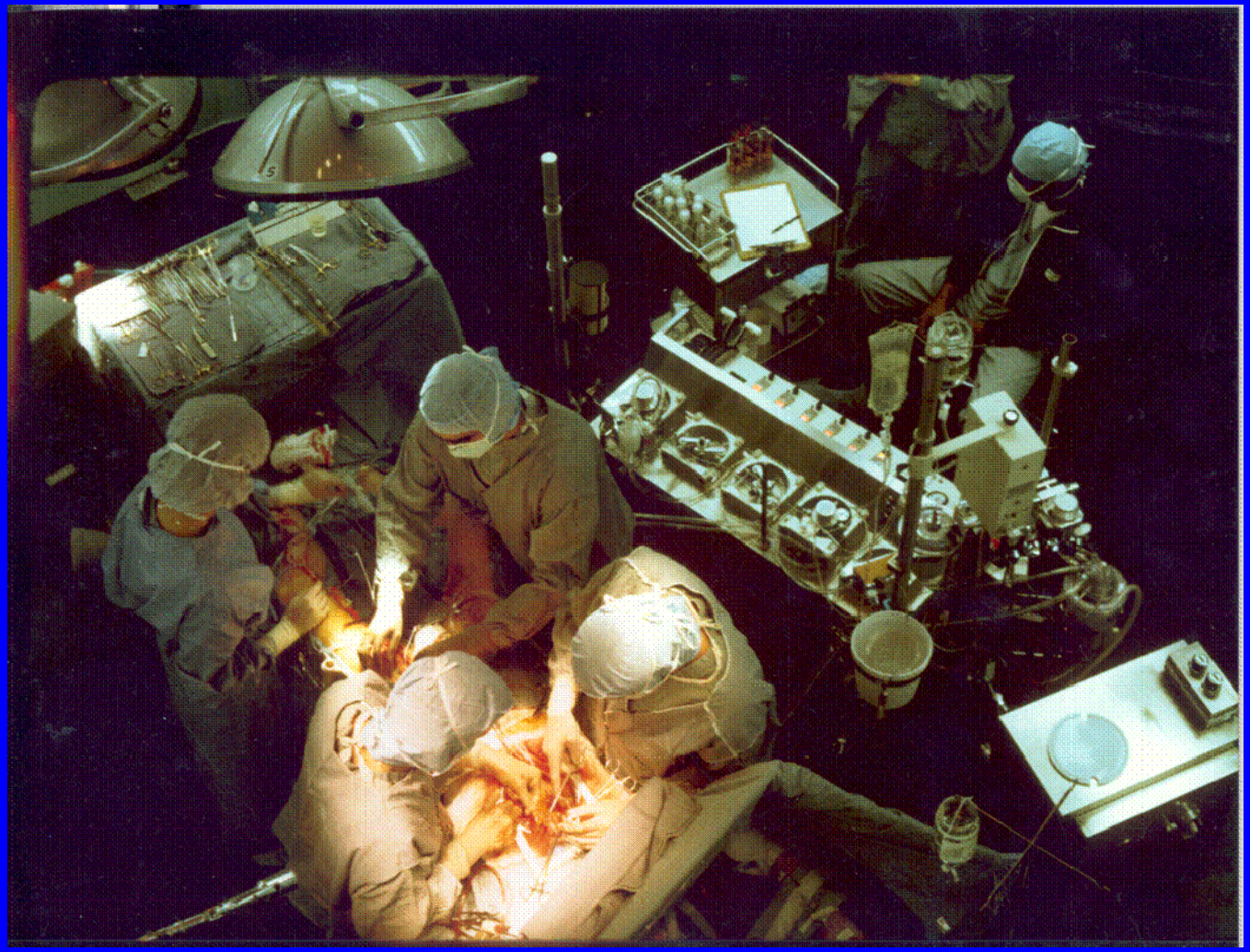


NHLB, NIH



http://www.brucemindich.com/images/bypass1.gif

Heart Lung Machine



http://www.davidfary.com/hlm_small.jpg

CABG Effectiveness

- 2001: 516,000 CABG procedures performed
- Procedure takes 4-6 hours, 5-7 day hospital stay
- Grafts remain open & functioning for 10-15 yrs
- Risks:
  - Heart attack (5%)
  - Stroke (5%) (risk greatest in those over 70 years old)
  - Death (1-2%)
  - Sternal wound infection (1-4%)
  - “Post-pericardiotomy syndrome“ (30%)
    - Occurs few days to 6 months after surgery
    - Symptoms are fever and chest pain
  - Some people report memory loss and loss of mental clarity or "fuzzy thinking" following CABG

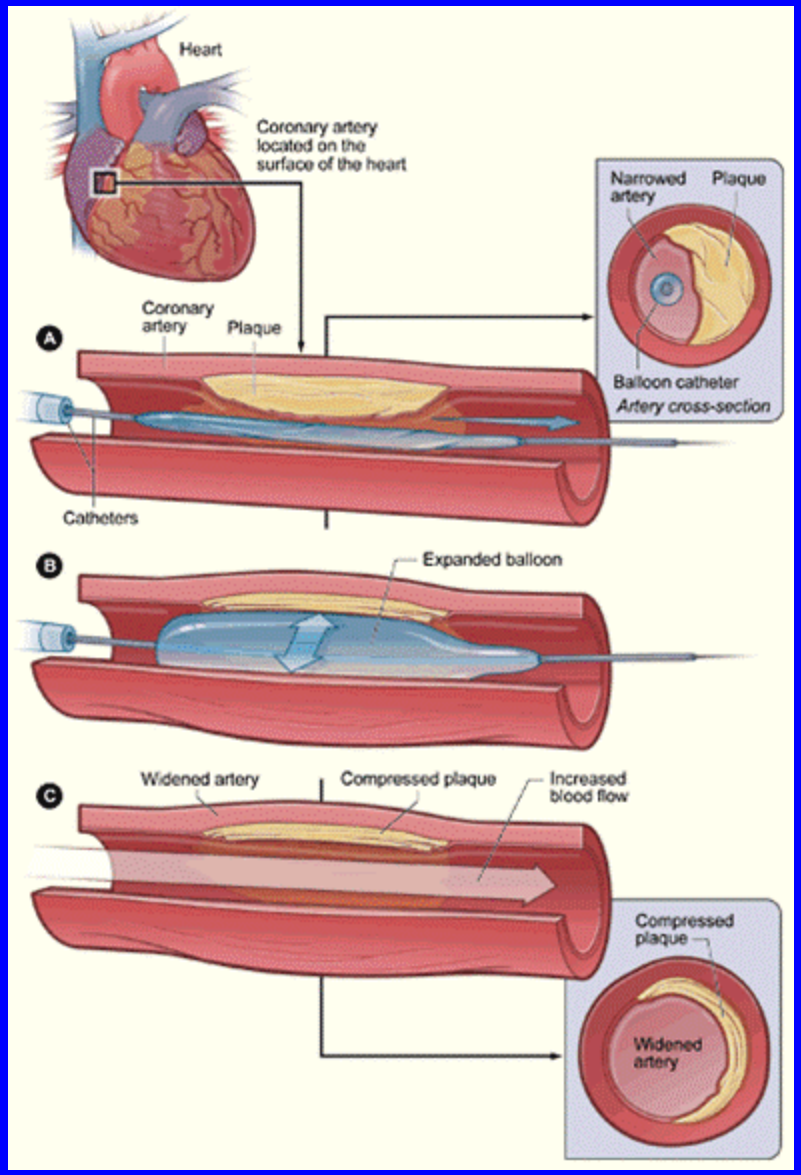
Innovations

- Off-pump CABG:
  - http://www.surgery.usc.edu/divisions/ct/videos-mpeg-offpumpcoronaryarterybypassgrafting.html
- Closed chest CABG:
  - http://www.hsforum.com/stories/storyReader$1537

How Do We Treat Atherosclerosis?

Angioplasty

Balloon Angioplasty



NHLBI

Scott et al. 2007 Abstracts: Subintimal Angioplasty for the Treatment of Claudication and Critical Limb Ischemia: 3-Year Results. Southern Association of Vascular Surgery.

PTCA: Effectiveness

- Cannot always successfully perform procedure
  - Diffuse disease
  - Total occlusion
  - Calcified disease
- Restenosis
  - Occurs in 25-54% of patients
  - Usually occurs within 6 months

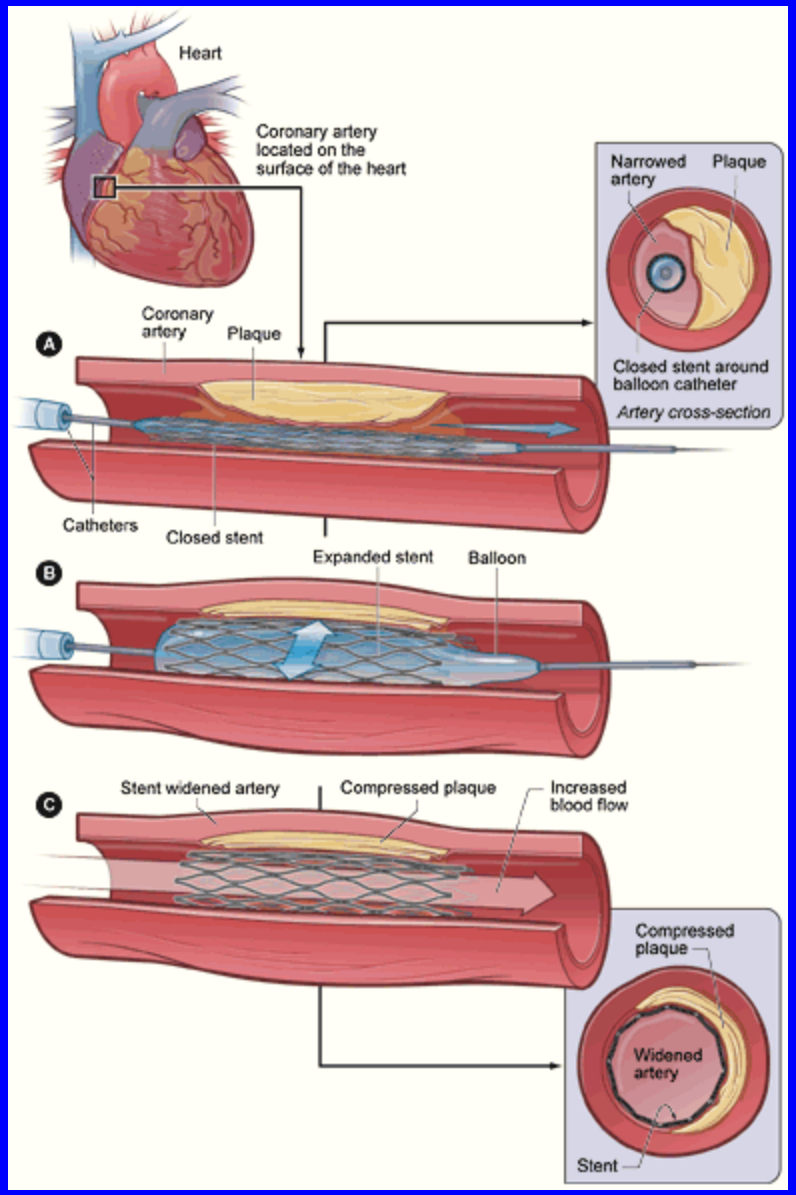
How Do We Treat Atherosclerosis?

Stent

Stents

Hearthealthywomen.org

NHLBI



Drug Eluting Stents

- http://www.npr.org/features/feature.php?wfId=1452217

Comparison of RX Methods

- Hospital Stay:
  - CABG – 4-7 days
  - Angioplasty – 1-2 days
  - Stent – 1-2 days
- Restenosis:
  - CABG – 5-6%, usually after 5 years
  - Angioplasty – 25-45%, usually within 6 months
  - Stent – 15-20%, usually within 6 months

Comparison of RX Methods

- Cost
  - CABG $35,000
  - Angioplasty $17,000
  - Stent $19,000
- Cost-effectiveness
  - Additive procedures:
    - Within 5 years, 20-40% of patients have second PTCA, 25% have CABG
  - Additive costs:
    - 0 years: per patient costs of PTCA 30-50% those of CABG
    - 1 year: 50-60%
    - 3 years: 60-80%
    - >3 years: >80%
  - Moving Target Problem

What Would You Do?

- Angioplasty
- Stent
- CABG

Cost-Effectiveness

Therapy	Patient Group	$ per yr life saved
tPA	Post MI high risk	$3,600
tPA	Acute MI, large infarct, treatment started >2 hours post	$24,200
Counseling	Smoking cessation	$1300-$3900
CABG	Two vessel disease, severe angina	$9,200-$42,500

http://www.sciencedirect.com/science?_ob=ArticleURL&_aset=B-WA-A-A-MsSAYZA-UUAAUYWDCBYZYAUYUBBVZZYBWAUBWEUBAU&_rdoc=1&_fmt=full&_udi=B6T1048NJXK25&_coverDate=5%2F22%2F2003&_cdi=4876&_orig=search&_st=13&_sort=d&view=c&_acct=C000004378&_version 1&_urlVersion=0&_userid=108429&md5=5f493caa5f65762c23c0d90eaea8b92d

Prevention or Treatment?

- http://www.nytimes.com/2004/03/21/health/21HEAR.html

Progression of Heart Disease