Postoperative Cognitive Dysfunction after Cardiac Surgery

Wyoming Health Care Systems/University of Scranton
Nurse Anesthesia

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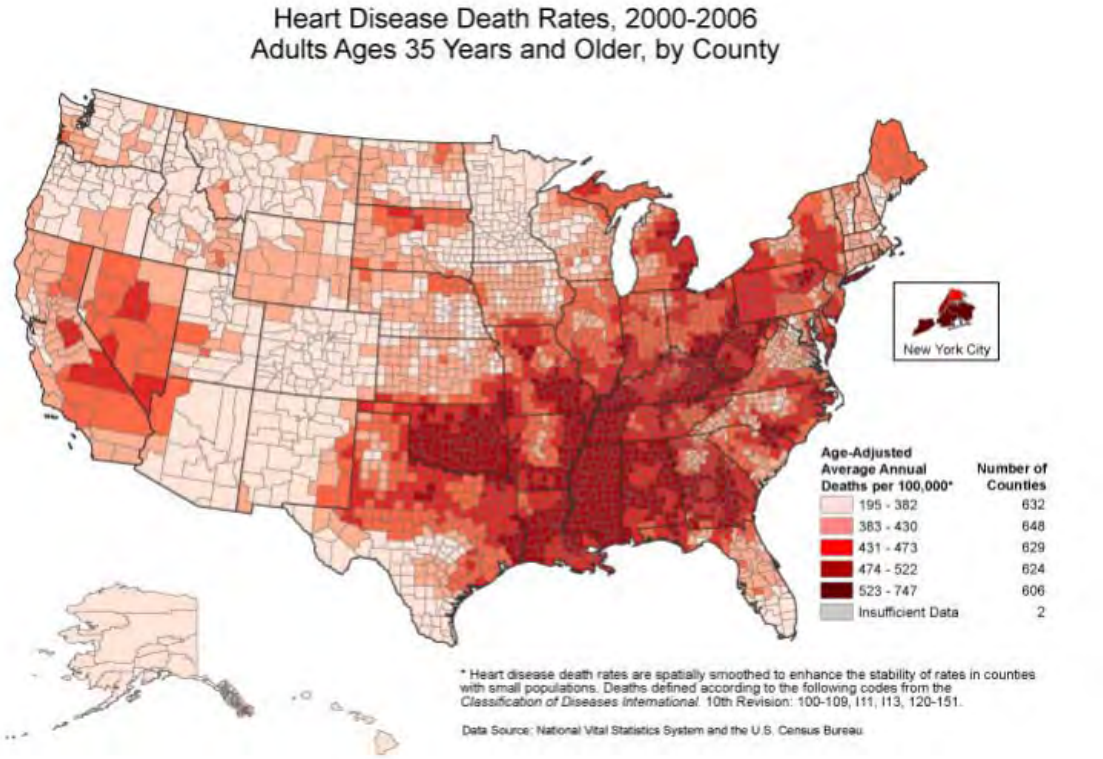
Objectives

- Review cardiovascular disease history
- Define Postoperative Cognitive Dysfunction (POCD)
- Identify possible risk factors associated with POCD
- Analyze potential mechanisms for POCD
- Examine interventions on improving cognitive functioning
- Discuss POCD future research needs

Cardiovascular Disease Statistics



- #1 health problem
- 70 million affected (34%)
- 25% of deaths (1/4 in U.S.)
- Leading cause of death
- Coronary heart disease
  - Most common type

Cardiac Surgery Background

- Historical Dates:
  - 1952
    - 1st open-cardiac procedure
  - 1953
    - Heart-lung machine
      - AKA - Cardiopulmonary Bypass (CPB)

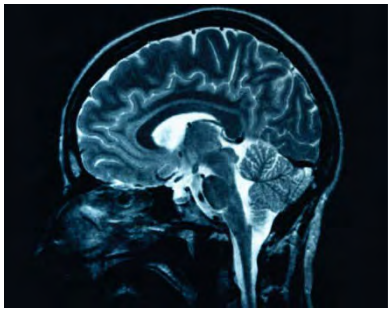
- Cardiac Surgery:
  - Coronary artery bypass grafting (CABG)
  - Valves
  - Abnormalities
  - Transplantation
- Open-heart
  - On-pump
  - Off-pump
    - AKA - Beating heart

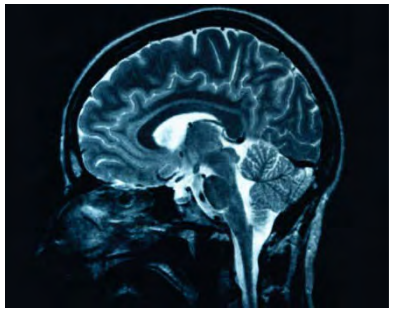
“Grandpa was never the same after his operation!”

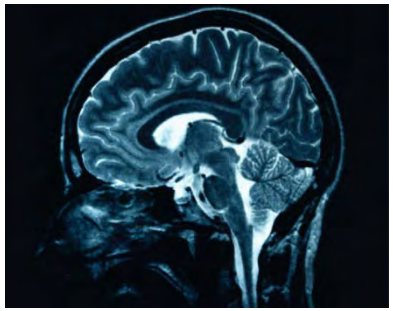
Definition

Postoperative Cognitive Dysfunction (POCD):

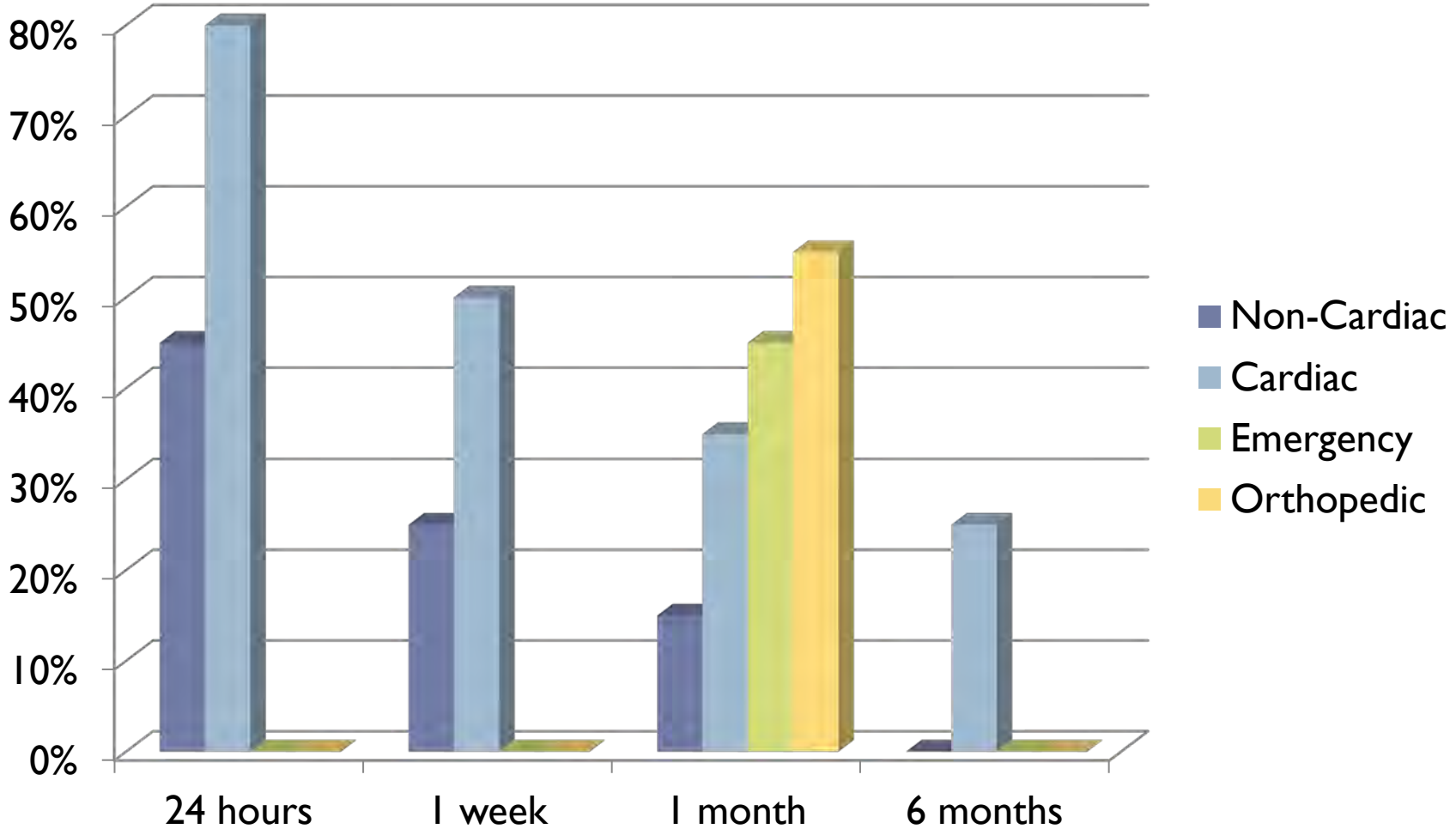
"A state of cerebral cognitive alterations following surgery and anesthesia that is characterized by impairment of attention, concentration, and memory that may have long-term implications."







POCD Incidence



POCD: Significance

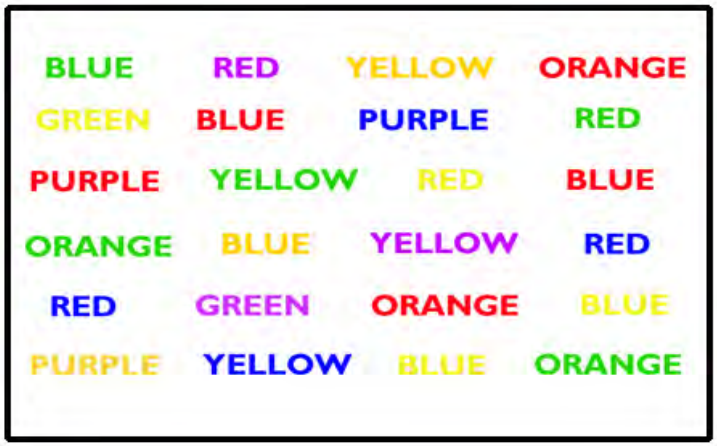
- Annoyance
- Social integration
- Loss of job
- Relationship issues
- Loss of independence
- Quality of life

- Poor outcomes
  - Longer hospital stay
  - Long-term facility admission
  - Increased mortality
  - Poor cognitive & functional recovery



Neuropsychological Testing

- Immediate Memory:
  - Digit Span test of the Wechsler Memory Scale-Revised (WMS-R)
  - Rey Auditory Verbal Learning Test
  - Visual Memory Span Test of the WMS-R
- Learning & Recent Memory:
  - Rey Auditory Verbal Learning Test
- Attention & Psychomotor Speed:
  - The Bourdon – Vos Test
  - The Trail Making Test parts A and B of the Halstead-Reitan Neuropsychological Battery
  - The Stroop Color and Word Test
  - The Symbol Digit Modalities Test
- Verbal Fluency:
  - Stroop Test
- Assessing Mood:
  - Amsterdam Mood States Questionnaire



Etiology

- Unclear
  - Genetic
  - Inflammation
  - Neurotransmitter function alteration
  - Stress response
  - Anesthesia
  - Cardiopulmonary bypass (CPB) technique
    - Off-pump
    - On-pump

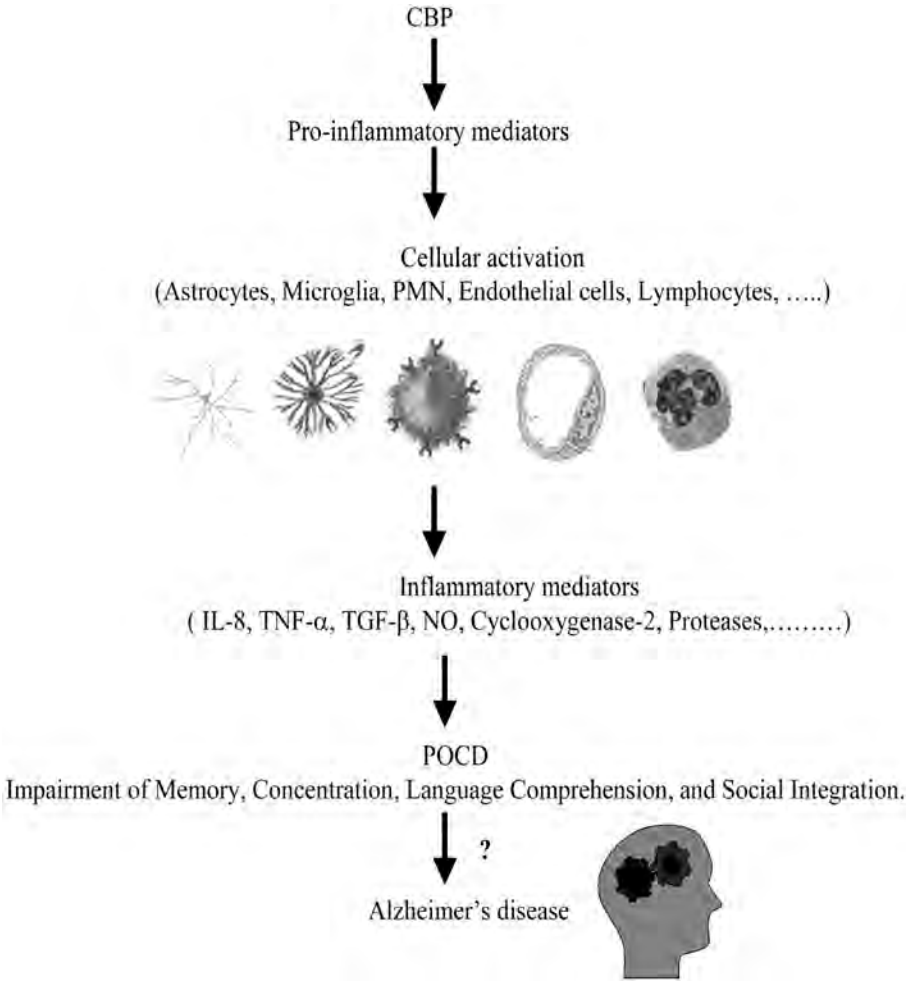
Etiology: Genetic

- Apolipoprotein E
  - ε4 allele
  - Alzheimer's disease
  - Neurodegenerative disorders
- Phospholipases A2
  - Lowers mental state scores
- Interleukin-6
- C-reactice protein (CRP)
- Tumoral necrosis factor-alpha

CPB inflammatory response

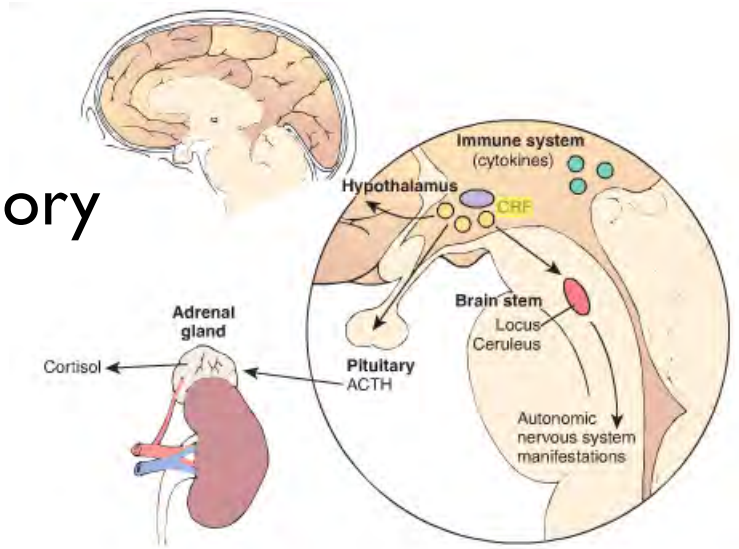
Etiology: Inflammation

- CPB → Inflammatory response:
  - Contact activation
  - Aortic cross-clamp
  - Nonspecific activators
    - Surgical trauma
    - Blood loss
    - Transfusions



Etiology: Stress

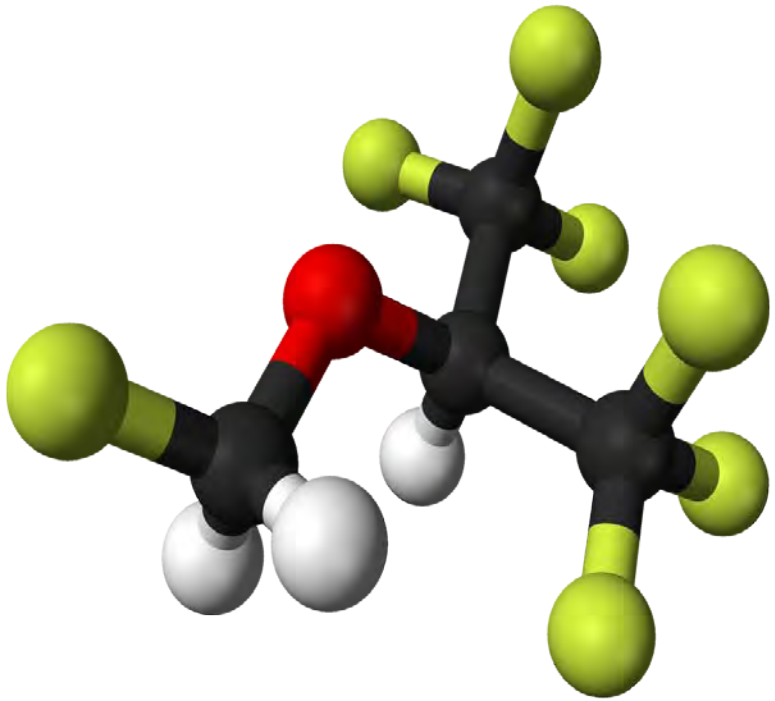
- Stress response
  - Increase cortisol
  - Increase catecholamines
- High stress levels → Inhibit memory
  - Altered hippocampal function
    - Organizing
    - Forming
    - Storing
- Surgery
  - Immune mechanisms
  - Inflammatory cascade



Corticotropin-releasing factor (CRF) → Adrenocorticotropic hormone (ACTH) release → Adrenal gland → Cortisol

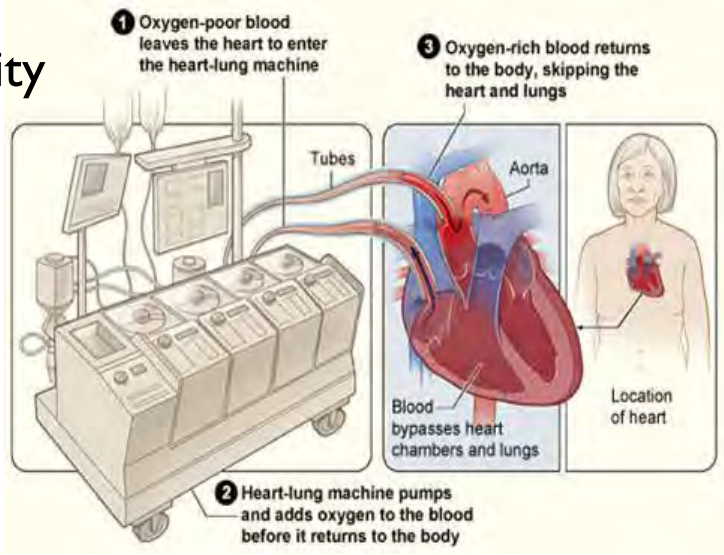
Etiology: Anesthesia

- Prolonged exposure →
  - Gene expression
  - Brain synthesis
  - Cognitive function
- Sevoflurane ≠ POCD



Etiology: CPB Technique

- Cardiopulmonary Bypass (CPB) technique:
  - Off-pump
    - Immobilization
    - NO CPB
  - On-pump
    - Increases blood brain barrier permeability
    - Micro/Macroemboli
  - Duration
    - ≥ 114 minutes → Neurologic event



Risk Factors

- Preoperative
  - Age
  - Education
  - Previous Disease
  - Lower socioeconomic status
- Intraoperative
  - Embolization
  - Surgical procedure duration
  - Arterial pressure
  - Inflammation
  - Hyperglycemia
  - Temperature
  - Metabolic abnormalities
  - Anemia
  - Multiple transfusions
- Postoperative
  - Hypoxia

Preoperative Factors: Age

- Increased age
- Unknown mechanism
  - Atherosclerosis → Cardiovascular disease
  - Embolization
  - Vasculature alterations
  - Cerebral blood flow alterations
  - Pharmaceuticals (agents)
  - Cognitive function reduction

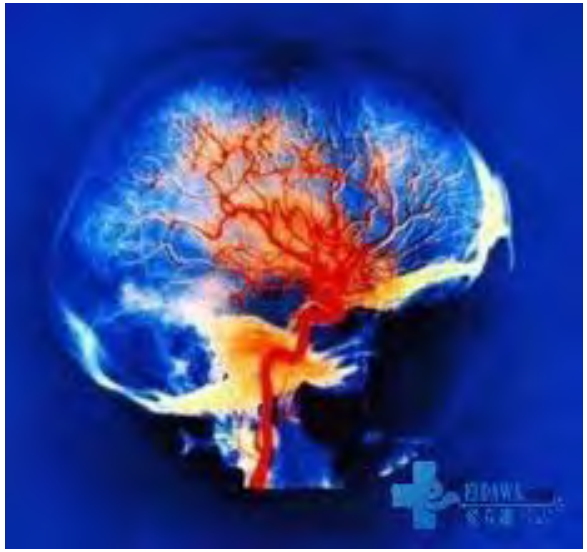
Preoperative Factors: Education

- Protective effect
- Number of school years
  - Cognitive reserve
  - Evaluation ability improvement
  - Increase neuronal homeostasis
  - Neuronal injury resistant

- Unknown mechanism
  - Education → Increase neocortex synaptic density → Increase neuronal communication → Minimize cognitive & functional impairment S/S

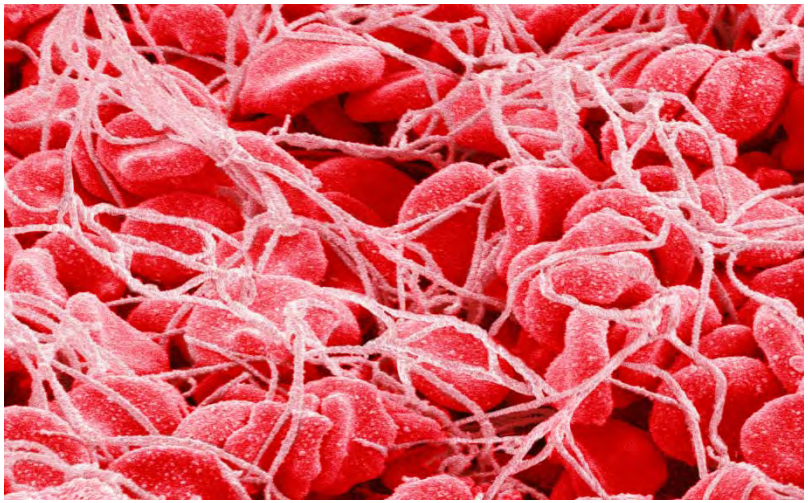
Preoperative Factors: Previous Diseases

- Diabetes Mellitus (DM)
  - Cerebral blood flow alteration
- Systemic Arterial Hypertension (SAH)
  - Cerebral blood flow alteration
  - Cerebral artery hardening
  - Atherosclerotic disease
- Chronic Renal Failure (CRF)
- Atrial fibrillation
- Left ventricular ejection fraction (EF) ≤ 30%



Intraoperative Factors: Embolization

- Emboli formation:
  - Aortic wall
  - Aggregated platelets
  - Air bubbles
  - Heart chambers



- Micro vs. Macroemboli
  - Microemboli → POCD
  - Gaseous microemboli
    - Most probable source
    - Origin:
      - 1. Oxygenator
      - 2. Cooling process
      - 3. Opening heart chambers

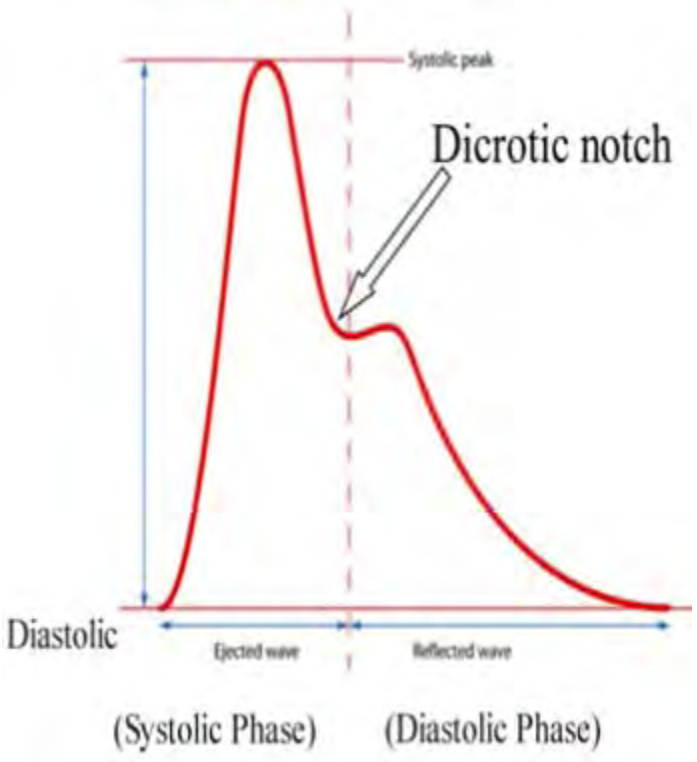
Intraoperative Factors: Surgical Procedure Duration

- Cardiopulmonary bypass (CPB)
  - Greater microvascular obstructions
- Surgical procedure duration
  - Greater microvascular obstructions



Intraoperative Factors: Arterial Pressure

- Hypertension
  - Neurological impairment
- Hypotension
  - Neurological impairment
- Mean arterial pressure (MAP)
  - Maintain



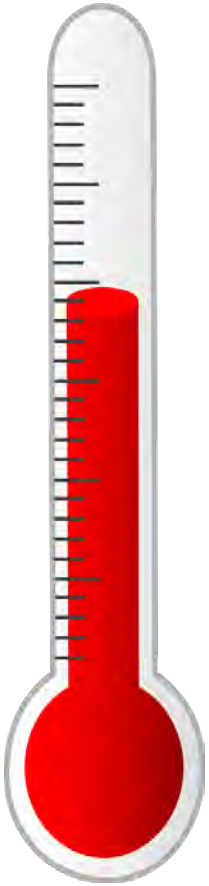
Intraoperative Factors: Hyperglycemia

- Hyperglycemia
  - Blood sugar > 200 mg/dL
  - Cerebral metabolism
    - Anaerobic metabolism
      - Increase lactate production
      - Ischemic process
  - Increase excitatory amino acids
    - Inflammatory response
    - Corticosteroid production

Alteration in:
Glycolysis
Protein Synthesis
Homeostasis
Enzymatic Functions
Other cell processes

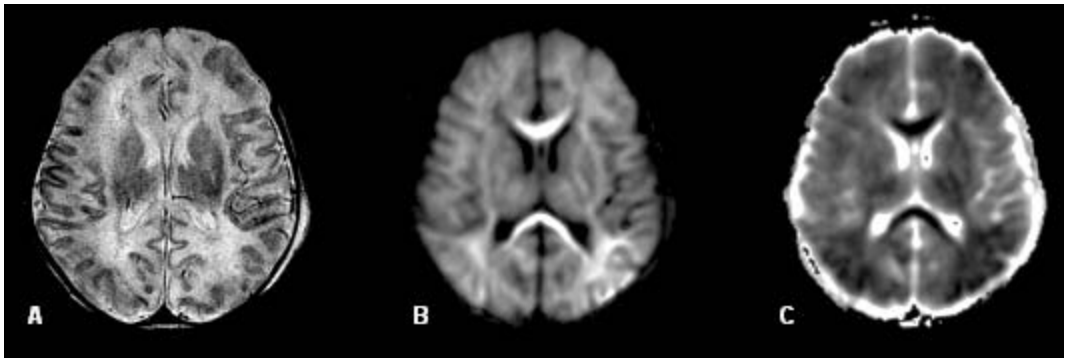
Intraoperative Factors: Temperature

- Hyperthermia
  - Neurotransmitter release
    - Toxic amounts
  - Free radical release
  - Increase blood-brain barrier permeability
  - Ischemic area enlargement
    - Increase ischemic depolarization
  - Increase morbidity & mortality rates
- Hypothermia
  - Reduces energy consumption → cell integrity
  - Improves cerebral & myocardial tolerance
- Rewarming
  - Speed → jugular desaturation



Postoperative Factors: Hypoxia

- Cerebral hypoxia
  - Hippocampus alterations
  - CPB consequence



Prevention

- Assessment:
  - Hemodynamic stability
- Temperature
  - Hypothermia
  - Slow rewarming

- Minimal surgical invasiveness
- Mechanical devices
  - Intra-aortic filter
  - Ultrafiltration
  - Leukocyte depletion

Pharmacotherapy

- Aprotinin
  - Serine protease inhibitor
  - Anti-inflammatory
- Heparin
  - Decrease inflammatory reponse
- Barbiturates
  - Neuroprotection
  - Controversial
- Xenon
  - Neuroprotection
  - N-methyl-D-aspartate (NMDA) antagonist
- Steroids
  - Inhibit ischemia-reperfusion injury
  - Anti-inflammatory



Future Research

- Quality of life
- Intervention strategies
- Reverse impact/incidence
- Treatment strategies
- Core neuropsychological testing
- Volatile anesthetics

Review Questions

1. Preoperative predisposing risk factors for POCD include all the following EXCEPT:
   a. Increased age
   b. Previous diseases
   c. Increased education level
   d. Diabetes

2. The use of the anesthetic gas, Sevoflurane, has been shown to increase the incidence of POCD.
   True
   False

3. Cardiopulmonary bypass (CPB) time greater than or equal to _____ minutes significantly increases the risk of a neurologic event.
   114

The End!


Situation where the "5 second" rule doesn't apply...
It's still good!
Heart Surgery.
10
JW ©07

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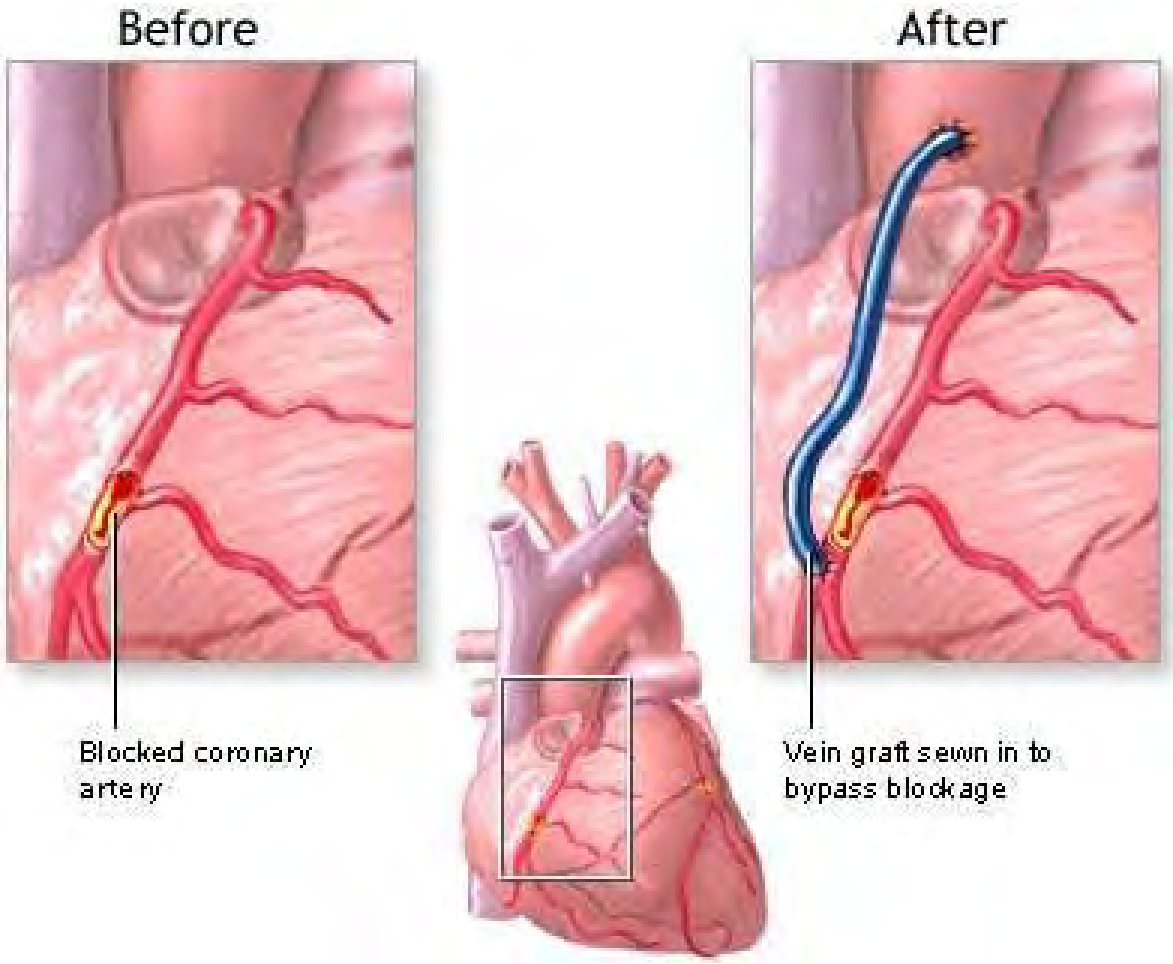
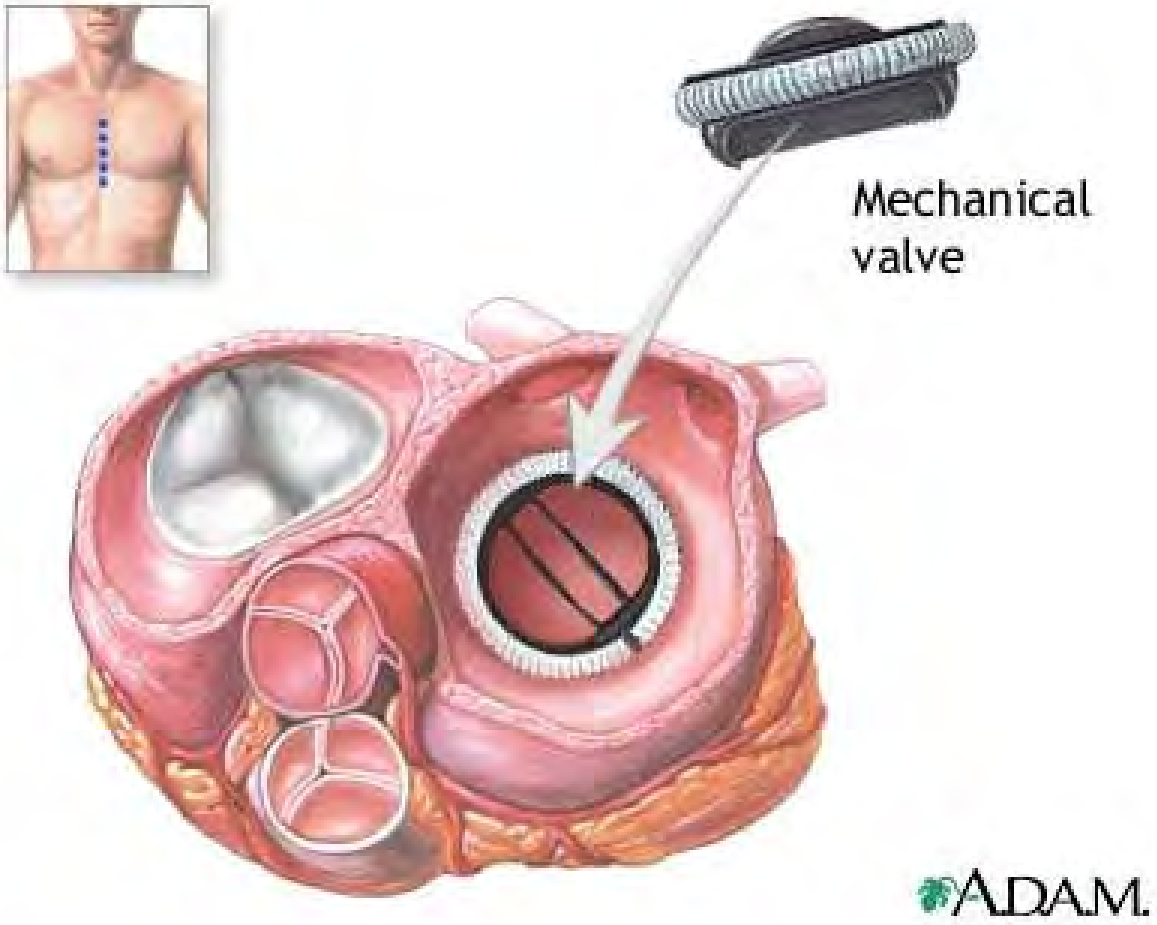
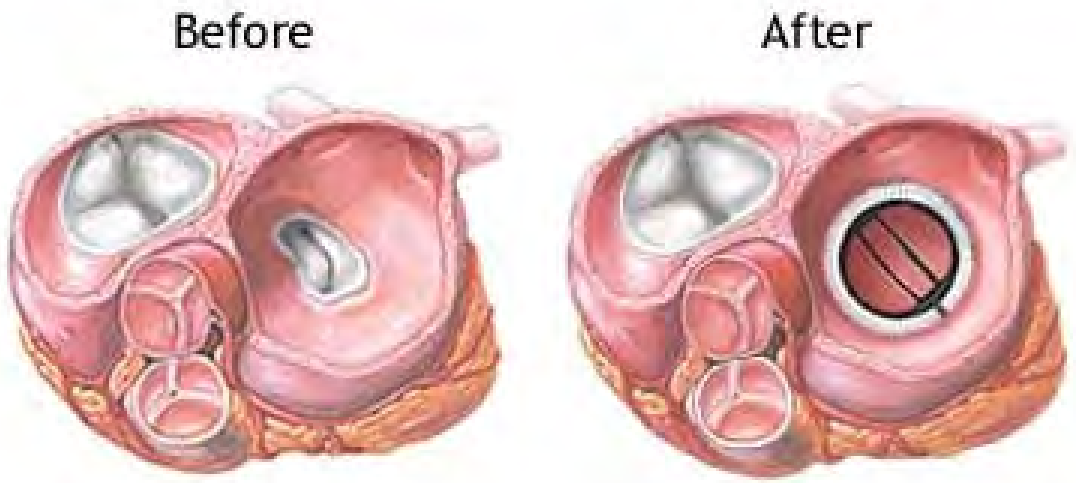

Before
After
Blocked coronary artery
Vein graft sewn in to bypass blockage

Biological valve
(human or porcine)

Mechanical valve


Mechanical
valve
A.D.A.M.


Before
After