Learning Objectives

1. Review devices available to monitor CNS status during CV surgery
2. Discuss perioperative interventions that can impact outcome

In the following section the following tables will be used to discuss the three cases

Risk factors CVA and cognitive issues:

- Age > 75 years
- Hypertension
- Carotid disease
- Aortic atheroma
- Diabetes mellitus
- Prior cerebral vascular disease
- Post CPB hypotension
- Post op arrhythmias
- CPB hemodynamic instability

Risk factors for CVA

- Complex procedures
- Emergency surgery
- Dialysis
- Vascular disease
- Anemia
- CPB > 2 hours

Risk factors for cognitive issues

- Cerebral hypotension during CPB
- Brain hyperthermia during rewarming from CPB

Cerebral monitoring

- Brain temperature
- EEG/ processed EEG
BIS
Evoking potentials
Transcranial Doppler
NIRS
CPP
Jugular oximetry

**Perioperative interventions that can impact outcome**

Monitoring
Pharmacology
Glucose control
Alpha stat vs ph stat
Temperature control
Emboli elimination
Perfusion
Inflammation

**Case 1**

50 year old 100 kg farmer presents for emergency repair of acute aortic dissection on Christmas eve. History is significant for hypertension on beta blockers. CT scan reveals dissection extending in both carotids and subclavian arteries and extends to the femoral arteries. Surgeon plans reconstruction of all thoracic vessels and repair of the ascending aorta.

The patient presents to the operating room combative, disorientated blueish in color. He has a large head and a short thick neck. BP 170/110 HR 100 Resp 24 slightly labored.

What else would you want to know?

How would you monitor the CNS?

- EEG
- NIRS
- TCD
- TEE

Any problems with using these monitors in this case?

What can the surgeon do to protect the brain?

- Cannulation techniques?
- Cerebroplegia?
- Hypothermia?
- Ph stat / alpha stat?
Rate of cooling?

What would you do to protect the brain?
- Barbs?
- Steroids?
- Propofol?
- Isoforane?
- Ketamine?
- Lidocaine?
- Calcium channel blockers?
- Magnesium?

The repair has a circulatory arrest time of 3.5 hours. Does this concern you?

The cross clamp time is 5 hours and CPB time is 6.5 hours. What concerns do you have?

How fast do you rearm?
- Ph stat /alpha stat

What do you think the outcome should be? Why?

**Case 2**

89 year old 40 kg lady with severe calcific aortic stenosis with a valve area of 0.3 cm$^2$ presents for aortic valve replacement. The patient is on no meds and does not have any significant past medical history.

- How would you monitor the CNS?
- How would you protect cerebral protection here?
- What should the surgeon do?

Intraoperative TEE reveals an ascending aortic dilatation at 4.5 cm. The descending aorta reveals severe atheroma extending into the distal arch.

- How does this affect your management?
- How may this affect the surgeon’s management?

- Cannula, type, where?
Case 3

54 year old male insulin dependent with end stage renal disease on hemodialysis for off pump coronary artery bypass grafting.

Other information you would like?

How would you monitor this patient?
- NIRS
- TCD
- EEG
- SSEP
- CPP

How would you manage glucose control?

How would you protect the CNS?
- Barbs?
- Propofol?

Evidence-Based Classes of Recommendations.

Classifications

Class I: Always acceptable, proven safe, and definitely useful. Sufficient evidence from multiple high quality trials.

Class IIa: Acceptable, safe, and useful. Reasonably prudent physicians can choose. Considered the intervention of choice by majority of physicians. A number of studies of good quality with positive results.

Class IIb: Acceptable, safe, and useful. Considered optional or alternative treatment by most experts. Low to intermediate level of evidence. Only a few studies of fair quality support intervention.

Class III: No evidence of benefit. Supportive evidence lacking or evidence suggests harm.

Class Indeterminate: Intervention can be used but insufficient evidence to support efficacy. Some evidence may be available but studies have shortcomings.
Summary of cerebral protection evidence-based recommendations.

This is based on the analysis by C Hogue and JM Murkin in their book chapters and lectures.

A membrane oxygenator and an arterial line filter ($\leq 40$ _M_) should be used for CPB. Class I (Level A)

Epiaortic ultrasound for detection of atherosclerosis of the ascending aorta. Class I (Level B)
  - To detect nonpalpable plaque Class I, level A
  - For detection of cerebral emboli Class IIa, Level B

Hyperthermia should be avoided during and after CPB. Class I (Level B); Class IIa, Level B

A single cross-clamp technique should be used for patients at risk for atheroembolism. Class IIa (Level B)

During CPB in adults _-stat_ pH management should be considered. Class IIa (Level A), Class I (Level A) add moderate hypothermia

Arterial line temperature during CPB rewarming should be limited to 37°C. Class IIa (Level B)

NIRS monitoring should be considered especially in high-risk patients. Class IIb (Level B)

Arterial blood pressure should be kept $> 70$ mmHg during CPB in high risk patients. Class IIb (Level B)

Serum glucose should be kept $< 140$ mg/dL with an infusion of insulin. Class IIb (Level C) Class I Level B institutions normal level

It is reasonable to consider processing cardiotomy suction aspirate with a cell-saver device. Class IIb (Level B); Class I (Level B)

Blood cell processing and filtration may be considered to decrease the effects of reinfuse RBCs. Class II b, Level B

Transfusion of packed red blood cells should be considered in high risk patients when hemoglobin is $\leq 7$ g/dL or higher depending on other patient specific considerations.
Class IIb, (Level C)

Effort to reduce hemodilution including reduction of pump prime (avoid pRBC transfusions)
Class I, Level A

Reduction of CPB circuit surface area and use of biocompatible circuits to decrease SIRS response to CPB
Class II a, Level B

References:


Improved cerebral protection through replacement of residual intracavitral air by carbon dioxide: a porcine model using diffusion-weighted magnetic resonance imaging S Martens, MD, A Theisen, DVM, J O Balzer, MD, M Dietrich, MD, K Graubitz, MD, M Scherer, MD, C Schmitz, M Doss, MD, A Moritz, MD, PhD Volume 127, Issue 1, Pages 51-56 January 2004


Deep Hypothermic Circulatory Arrest in Patients With High Cognitive Needs: Full Preservation of Cognitive Abilities
Andrew Percy, Shannon Widman, John A. Rizzo, Maryann Tranquilli, and John A. Elefteriades

Cognitive outcomes in elderly high-risk patients 1 year after off-pump versus on-pump coronary artery bypass grafting. A randomized trial
Birte Østergaard Jensen, Lars S. Rasmussen, and Daniel A. Steinbrüchel

Brain Protection by Using Innominate Artery Cannulation During Aortic Arch Surgery
Shangyi Ji, Jianan Yang, Xiaoqing Ye, and Xiaolei Wang

No improvement in neurocognitive outcomes after off-pump versus on-pump coronary revascularisation: a meta-analysis
Silvana F. Marasco, Lisa N. Sharwood, and Michael J. Abramson

Does Intensive Management of Cerebral Hemodynamics and Atheromatous Aorta Reduce Stroke After Coronary Artery Surgery?
Masanori Nakamura, Fumiyuki Okamoto, Katsuhiko Nakanishi, Ryushi Maruyama, Akira Yamada, Satoshi Ushikoshi, Shunsuke Terasaka, Satoshi Kuroda, Keisuke Sakai, and Tetsuya Higami

Carbon Dioxide Field Flooding Reduces Neurologic Impairment After Open Heart Surgery
Sven Martens, Katrin Neumann, Christian Sodemann, Heinz Deschka, Gerhard Wimmer-Greinecker, and Anton Moritz

Intraoperative Hyperglycemia and Cognitive Decline After CABG
James C. Halstead, Christian Etz, D. Matthias Meier, Ning Zhang, David Spielvogel, Donald Weisz, Carol Bodian, and Randall B. Griepp

Effects of pH Management During Selective Antegrade Cerebral Perfusion on Cerebral Microcirculation and Metabolism: Alpha-Stat Versus pH-Stat
Invited commentary
Marshall L. Jacobs

Does retrograde cerebral perfusion via superior vena cava cannulation protect the brain?
Andreas Künzli, Patrick O. Zingg, Gregor Zünd, Boris Leskosek, and Ludwig K. von Segesser

An evidence-based review of the practice of cardiopulmonary bypass in adults: A focus on neurologic injury, glycemic control, hemodilution, and the inflammatory response

Randomized Controlled Trial of Pericardial Blood Processing With a Cell-Saving Device on Neurologic Markers in Elderly Patients Undergoing Coronary Artery Bypass Graft Surgery
Michel Carrier, André Denault, Joel Lavoie, and Louis P. Perrault

Magnesium as a neuroprotectant in cardiac surgery: A randomized clinical trial

Single crossclamp improves 6-month cognitive outcome in high-risk coronary bypass patients: The effect of reduced aortic manipulation
John W. Hammon, David A. Stump, John F. Butterworth, Dixon M. Moody, Kashemi Rorie, Dwight D. Deal, Edward H. Kincaid, Timothy E. Oaks, and Neal D. Kon
Attempted control of hyperglycemia during cardiopulmonary bypass fails to improve neurologic or neurobehavioral outcomes in patients without diabetes mellitus undergoing coronary artery bypass grafting

John Butterworth, Lynne E. Wagenknecht, Claudine Legault, Daniel J. Zaccaro, Neal D. Kon, John W. Hammon, Jr, Anne T. Rogers, B. Todd Troost, David A. Stump, Curt D. Furberg, and Laura H. Coker

Optimal pH strategy for selective cerebral perfusion

James C. Halstead, David Spielvogel, Dieter M. Meier, Donald Weisz, Carol Bodian, Ning Zhang, and Randall B. Griepp

Neuroprotection in Cardiac Surgery

William A. Baumgartner

Brain Injury and Neuropsychological Outcome After Coronary Artery Surgery Are Affected by Complement Activation

Christophe Baufreton, Philippe Allain, Alain Chevailler, Frédérique Etcharry-Bouyx, Jean Jacques Corbeau, Didier Legall, and Jean Louis de Brux

Risk factors for cognitive dysfunction after coronary artery bypass graft surgery in patients with type 2 diabetes

Yuji Kadoi, Shigeru Saito, Nao Fujita, and Fumio Goto

The Impact of Aortic Manipulation on Neurologic Outcomes After Coronary Artery Bypass Surgery: A Risk-Adjusted Study

Emmanouil I. Kapetanakis, Sotiris C. Stamou, Mercedes K.C. Dullum, Peter C. Hill, Elizabeth Haile, Steven W. Boyce, Ammar S. Bafi, Kathleen R. Petro, and Paul J. Corso

Hypothermic circulatory arrest with and without cold selective antegrade cerebral perfusion: impact on neurological recovery and tissue metabolism in an acute porcine model

Christian Hagl, Nawid Khaladj, Sven Petersss, Klaus Hoeffler, Michael Winterhalter, Matthias Karck, and Axel Haverich

The effect of leucocyte-depleting arterial line filters on cerebral microemboli and neuropsychological outcome following coronary artery bypass surgery
Donald C. Whitaker, Stanton P. Newman, Jan Stygall, Chris Hope-Wynne, Michael J.G. Harrison, and Robin K. Walesby