CEA and cerebral protection

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VA Hospital
7/26/2012
63 year old male presents for the vascular evaluation s/p TIA in January 2012

PMH: HTN, long term active smoker, Hep C

PSH: None

Labs: Cholesterol 153; Triglyceride 460; HDL 40; LDL 21

Meds: Valsartan, Simvastatin, ASA

Physical: Bruit on the Left carotid. Neurologically: intact
CT angio neck (neurology workup): 6.5 mm distal to the bifurcation there is a 13 mm segment of severe narrowing (70%-90%) the left internal carotid artery.
- Left carotid endarterectomy on 7/16/2012.
- Cross-clamp time: 26 min
- Cerebral oximetry applied for cerebral flow monitoring
- Patient has uneventful post-op course and was discharge home on post-op day #2.
Cerebral monitoring and protection during CEA
Cerebrovascular disease is the second leading cause of death worldwide

750,000 stokes occur annually in the United States

Clear benefit of CEA in symptomatic patients with high-grade (70% to 99%) carotid stenosis

First successful carotid surgery performed in 1954 by Eastcott, Pickering, and Rob
• Brain receives approximately 15 to 20% of the cardiac output and consumes approximately 20% of the total body O2

• At a CBF of 25 mL / 100g / min – Cerebral impairment

• At a CBF between 15 to 20 mL / 100g / min – Flattening of the EEG

• At a CBF of < 10 mL / 100g / min – Irreversible brain damage and neuronal death

• Interruption of O2 supply for:– 10 seconds can result in unconsciousness
  – 3 to 8 minutes results in ATP depletion
What Are the Risks?

- Neurological complications following surgery & anesthesia are a cause of significant morbidity & mortality

- Cerebral hypoxemia may lead to residual neurological damage
  - Significantly prolongs hospitalization
  - Requires long term skilled nursing care

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How Do We Monitor / Manage Cerebral Blood Flow and Oxygenation?

• Monitored and managed using indirect parameters of adequate brain blood flow and oxygenation
  – Heart rate
  – Blood pressure
  – ETCO2
  – Peripheral oxygenation

● The brain is the target organ of general anesthesia……but it is the least monitored
Intraoperative Interventions that May Improve Cerebral Oxygenation

- Adjust head position
- Increase anesthetic depth
- Decrease temperature
- Increase inspired oxygen
- Increase Pa CO2 (MV)
- Increase MAP / cardiac output
- Increase Hct
The use of intravascular shunts for cerebral protection:

- routine nonuse of shunts
- selective use of shunts
- routine use of shunts
The routine use of carotid shunts

- Placing a shunt in the setting of severe ischemia decreases the stroke rate.

- Carotid shunting diminishes the inflammatory response of ischemic brain injury

Halsey Jr JH at al, Stroke 1992
Parsson HN at al, Eur J Vasc Endovasc Surg 2000
Thompson demonstrated results over a 15-year period, with a stroke rate of 1.4% in 1107 CEAs.

Hertzer and colleagues reported a series of over 1900 CEAs at the Cleveland Clinic, with a perioperative stroke rate of 1.8%.

Hamdan and associates published a series of 1001 patients with a combined stroke and death rate of 1.6%.

Hertzer NR at al, J Vasc Surg 1997
Hamdan AD at al, Arch Surg 1999
Javid or Pruitt-Inahara shunt
An absolute requirement for safe shunt placement is that the superior end of the plaque be positively identified and adequately exposed through the arteriotomy.
Cerebral Monitoring

- Stump pressure
- Somato-sensory evoked potentials (SSEP)
- Trans-cranial doppler
- Electroencephalogram
- Cerebral oximetry
The Role of Monitoring Techniques during Carotid Surgery*

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*CBF, cerebral blood flow; EEG, electroencephalography; ICA, internal carotid artery; SSEP, somatosensory evoked potential; TCD, transcranial Doppler.
Stump pressure monitoring
6% of patients with stump pressure higher than 50 mm Hg had ischemia by EEG criteria.

Stump pressure lower than 50 mm Hg had a positive predictive value of only 36%.

Stump pressure did not correlate well with ischemia by TCD criteria in patients with postoperative deficits.

Kelly at all, Arch Surg 1979
Harada at all, Am J Surg 1995
Finocchi at all, Stroke 1997
Intraoperative EEG monitoring is the most widely used method of intraoperative cerebral monitoring.

Standart criteria for intraoperative ischemia are:

- At least a 50% decrease in fast background activity
- Increase in delta wave activity
- Complete loss of EEG signals
The EEG is positive in 10% to 40% of patients with unilateral carotid disease and positive in as many as 69% with bilateral carotid disease.

Postoperative strokes observed in only 9% of patients with abnormal EEG findings in whom shunts were not placed.

5% of patients with postoperative deficits showed EEG changes only late in the operation, when shunting was no longer feasible.

Facco E at al, Neurophysiol Clin 1992
Blume W at al, Stroke 1986
Tempelhoff R, Neurosurgery 1989
Somatosensory evoked potentials (SEPs or SSEPs) are a useful, noninvasive means of assessing somatosensory system functioning.

The meta-analysis of 15 studies, found that SSEP monitoring is not a reliable means of detecting ischemia and predicting neurologic outcome.

Schwartz, Panetta at al, Cardivascular Surg 1996
Wober C at al, J Clin Neurophysiol 1998
Transcranial Doppler was introduced by Schneider and coworkers in 1988.

Transcranial TCD has the unique advantage of detecting microemboli intraoperatively, which may alert the surgeon to avoid further manipulation that may cause a stroke.

TCD (as well as stump pressure) was not accurate in predicting cerebral ischemia.

Belardi P ad al, Eur J Vasc Endovasc Surg  2003
Cerebral Oximetry

- Uses the variation in light absorption at 2 different wavelengths to determine O2 Hgb and Hgb

- Hgb absorbs light at 660 nm (visible wavelength)
- O2 Hgb absorbs light at 940 nm (infrared wavelength)

- Estimates the arterial O2 saturation based on ratio of O2 Hgb to Total Hgb:

\[
\frac{O2 \text{ Hgb}}{(O2 \text{ Hgb} + \text{Hgb})}
\]
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Anatomy of Cerebral Oximetry
CASMED Fore-Sight

- Uses **LASER** light at 4 wavelengths: 690, 780, 805 & 850nm

- It measures actual **Cerebral Tissue Oxygen Saturation (S_{ct}O_2)**
  - Considered an **absolute** cerebral oxygenation monitor
  - Referred to as **Quantitative**
Advantages of Cerebral Oximetry

- Non invasive and requires no specialize training
- Can be used at the bedside
- No radioactive tracers
- Real time oxygenation status of region of brain being monitored
- By measuring predominately venous versus arterial saturation provides information about oxygen demand and supply balance
Limitations of Cerebral Oximetry

- Does not measure global oxygenation
  - Limited depth of penetration
  - Large area of the brain is not monitored

- Measures only intravascular oxygenation
  - Not a true reflection of intracellular oxygen availability

- It cannot differentiate the cause of neurologic dysfunction

- Electrocautery can cause interference

- Does not measure oxygen saturation but measures changes or trends in the rSO2. There is no “normal” value
Performing CEA under RA is the most reliable method of predicting the need for selective shunting.

Shunt rates are consistently lower than with other modalities, on the order of 5% to 15%.

A cost analysis found that RA saved more than $3000 per case by avoiding EEG measurements.

Calligaro KD at al, J Vasc Surg 2005
GALA trial, the definitive study of RA versus GA in CEA that included more than 3500 patients in Europe, failed to show any significant benefit of performing CEA under RA.

The disadvantages of RA are that not all anesthesiologists, surgeons, or patients are comfortable with performing CEA under RA.

*General anaesthesia versus local anaesthesia for carotid surgery (GALA), Lancet 2008*
Conclusions

- No optimal method for intraoperative cerebral perfusion monitoring exist

- Despite variety of techniques and approaches CEA has low mortality and stroke rate and is a “gold standard” procedure for carotid disease
Accepted guidelines for shunting during CEA include all of the following EXCEPT:

A. Routine shunting in all cases
B. Selective shunting in a stroke patient based on intraoperative electroencephalographic changes
C. Selective shunting based on ICA stump pressure
D. Selective shunting in an awake patient based on whether hemiplegia on carotid clamping develops
E. Selective shunting on asymptomatic patient based on changes on intracranial Doppler ultrasonography
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E. Selective shunting on asymptomatic patient based on changes on intracranial Doppler ultrasonography
Indications for CEA include all of the following EXCEPT:

A. 55% left ICA stenosis with right arm and leg transient attack
B. Asymptomatic 85% right ICA stenosis
C. 100% right ICA occlusion with right eye amaurosis fugax
D. 75% left ICA stenosis with transient aphasia
E. 99% right ICA stenosis with left sided hemiparesis
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A. 55% left ICA stenosis with right arm and leg transient attack
B. Asymptomatic 85% right ICA stenosis
C. **100% right ICA occlusion with right eye amaurosis fugax**
D. 75% left ICA stenosis with transient aphasia
E. 99% right ICA stenosis with left sided hemiparesis
Thirty minutes after arriving in the recovery room after a right CEA, the patient develops left hemiparesis. The most appropriate next step would be:

A. Immediate operative re-exploration of the carotid artery
B. Tissue plasminogen activator infusion
C. Cerebral angiography
D. Carotid duplex ultrasound scan
E. Head CT
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"Hey. When he wakes up, how 'bout I talk but you make the faces."