Treatment of Carotid Artery Disease

Maria Litzendorf, MD
Assistant Professor of Clinical Surgery
Division of Vascular Diseases and Surgery
The Ohio State University's Wexner Medical Center

Stroke

- **Ranks third as leading cause of death behind heart disease and cancer**
- **Annual stroke occurrence in the United States around 795,000**
- **Current American Heart Association data suggest that every 40 seconds someone in the United States is having a stroke**

Roger V, Go A, Lloyd-Jones D, et al: Heart Disease and Stroke Statistics—2011 Update: a report from The American Heart Association Statistics Committee and Stroke Statistics Committee. *Circulation* 2011; 123:e18-e209.

Objectives

- **Stroke Epidemiology and risk factors**
- **Review indications for carotid revascularization**
- **Choosing between endarterectomy and stenting: outcomes**
- **Timing of revascularization**

Stroke Epidemiology

- **Significant gender and racial differences**
- **Strokes occur in 55,000 more women than men**
- **African-Americans have almost twice the stroke risk of whites**
- **Mexican Americans have also been shown to have an increased incidence of stroke**

Incidence and Prevalence: 2006 Chart Book on Cardiovascular and Lung Diseases. Bethesda, Md: National Heart, Lung, and Blood Institute; 2006.

Stroke Sequelae

- 70% of stroke survivors do regain functional independence
- 15% to 30% become permanently disabled
- 3 months after stroke, up to 20% will continue to require long-term care

Asplund K, Stegmayr B, Peltonen M. From the twentieth to the twenty-first century: a public health perspective on stroke. In: Ginsberg MD, Bogousslavsky J, eds. Cerebrovascular Disease Pathophysiology, Diagnosis, and Management. Malden, Mass: *Blackwell Science*;1998:2.

Cost

- In 2007, the total cost of stroke exceeded 40 billion dollars in U.S.
- projections of future costs of stroke from 2005 to 2050
  - $1.52 trillion for whites
  - $313 billion for Hispanics
  - $379 billion for African-Americans

Roger V, Go A, Lloyd-Jones D, et al: Heart Disease and Stroke Statistics—2011 Update: a report from The American Heart Association Statistics Committee and Stroke Statistics Committee. Circulation 2011; 123:e18-e209.

Stroke Sequelae

- Among ischemic strokes at 6 months after the initial insult for patients who are $\geq$ 65 years old the following deficits exist:
  - 50% had some hemiparesis
  - 30% required some assistance with walking
  - 26% could not perform activities of daily living independently
  - 19% had aphasia
  - 26% were institutionalized

Kelly-Hayes M, Beiser A, Kase CS, Scaramucci A, D'Agostino RB, Wolf PA. The influence of gender and age on disability following ischemic stroke: the Framingham study. *J Stroke Cerebrovasc Dis*. 2003;12:119–126.

Risk Factors

- Modifiable risk factors for stroke mimic those for cardiovascular disease in general
- Smoking, diabetes and hypertension
- Atrial fibrillation independently increases the risk for stroke by a factor of 5

Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke*. 1991;22:983–988.

Risk Factors

- Age
- Gender
  - women aged 45-84 have a lower risk than men
  - women aged greater than 85 have higher risk then men
- Race

Petrea RE, Beiser AS, Seshadri S, Kelly-Hayes M, Kase CS, Wolf PA. Gender differences in stroke incidence and poststroke disability in the Framingham Heart Study. *Stroke*. 2009;40:1032–1037.

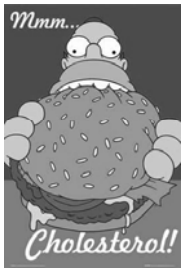
Risk Factors

- TIA
- 3% to 10% risk of stroke at 2 days following TIA
- 9% to 17% risk of stroke at 90 days after TIA
- TIA related mortality at 1 year is up to 25%

Kleindorfer D, Panagos P, Pancioli A, et al: Incidence and short-term prognosis after transient ischemic attack in a population based study. *Stroke* 2005; 36:720-723.

Risk Factors

- Hypercholesterolemia?
- Statin drugs decrease stroke risk even in patients without hypercholesterolemia



Mackey, W. Cerebrovascular Considerations. In: Cronenwett J, Johnston K, editors. *Rutherford's Vascular Surgery*. Philadelphia: Elsevier; 2010:1386-1399.

Carotid Stenosis

- Stroke risk is directly related to the degree of carotid disease
- 1115 patients from the Asymptomatic Carotid Stenosis and Risk of Stroke (ACSRS) group
- Asymptomatic internal carotid artery stenosis greater than 50% followed for a mean of 37 months
- Linear relationship between stroke and degree of carotid stenosis

Nicolaides AN, Kakkos SK, Griffin M, et al: Severity of asymptomatic carotid stenosis and risk of ipsilateral hemispheric ischaemic events: results from the ACSRS study. *Eur J Vasc Endovasc Surg* 2005; 30:275-284.for the Asymptomatic Carotid Stenosis and Risk of Stroke (ACSRS) Study Group

Carotid Stenosis

- 296 carotid arteries in 293 patients were followed for an average of 46 months
- Either less than 75% stenosis or greater than 75% stenosis
- Patients with greater than 75% stenosis were found to have higher risk of both TIA and stroke
- Plaque morphology

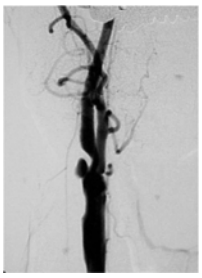
O'Holleran LW, Kennelly MM, McClurken M, Johnson JM: Natural history of asymptomatic carotid plaque. *Am J Surg* 1987; 154:659-662.

Treatment Modalities

- Medical therapy
- Carotid endarterectomy
- Carotid artery stenting

Carotid Artery Disease

20 to 30% of strokes are caused by atherosclerotic carotid artery disease



- Carotid artery disease increases the risk for stroke:
- by plaque or clot breaking off from the carotid arteries and blocking a smaller artery in the brain
- by narrowing of the carotid arteries due to plaque build-up
- by a blood clot becoming wedged in a carotid artery narrowed by plaque

Executive Committee for the Asymptomatic Carotid Atherosclerosis Study. *Endarterectomy for Asymptomatic Carotid Artery Stenosis*. JAMA 1995;273:1421

Medical Treatment

- Advantages
  - Good option for those with short life expectancy (i.e. benefits of endovascular or surgical therapy does not outweigh the risks)
  - Does not require hospitalization
- Disadvantages
  - Risk of stroke may be higher
  - Risk of hemorrhage
  - Regular lab monitoring

Natural History of Asymptomatic Carotid Disease

- **Asymptomatic Carotid Atherosclerosis Study (ACAS)**
- **European Asymptomatic Carotid Surgery Trial (ACST)**
- **Overall stroke risk in medically managed asymptomatic patients is about 2% per year**

Indications

- **Largely independent of method of revascularization**
- **Symptomatic disease**
- **Asymptomatic disease**
- **Vertebral or posterior fossa disease**
- **External carotid disease**
- **3% rule (ACAS 2.3% stroke/death)**

Results of Asymptomatic Trials

	Medical (%)	Surgical (%)
ACAS (ipsilateral stroke risk)	11	5.1
ACST (any stroke risk)	11.8	6.4

Asymptomatic Disease

- **> 60%**
- **ACAS 5 year follow up**
  - **11% stroke risk in medical arm**
  - **5.1% stroke risk in surgical arm**
  - **lesser benefit in women**
- **Consider limiting to men, > 80%, contralateral occlusion or high grade stenosis, ulcerated lesions**
- **No increased benefit with increasing degrees of stenosis**

Symptomatic Disease

- 70 – 99%
- NASCET 2 year follow up
  - 26% stroke risk in medical arm
  - 9% stroke risk in surgical arm
  - especially benefits males > 75

Vertebral Disease

- Carotid reconstruction first if there is concomitant carotid and vertebral disease in the presence of posterior fossa symptoms

Symptomatic Disease

- 50 – 69%
- NASCET 5 year follow up
  - 22.7% stroke risk in medical arm
  - 15.7% stroke risk in surgical arm

External Carotid Disease

- Ipsilateral hemispheric TIA (not amaurosis) in the setting of ipsilateral ICA occlusion and contralateral ICA stenosis – contralateral ICA revascularization
- Ipsilateral amaurosis in the setting of ipsilateral ICA occlusion and ipsilateral ECA stenosis – ipsilateral ECA revascularization
- Ipsilateral TIA in the setting of patent contralateral carotid system, ipsilateral ICA occlusion, and ipsilateral ECA stenosis – ipsilateral ECA revascularization

Endarterectomy vs. Stenting

- High risk for endarterectomy – CMS criteria
- Endarterectomy outcomes
- Stenting outcomes

High Risk for Endarterectomy

- COPD
- Anatomically inaccesible lesion
- Cervical immobility
- Prior neck dissection
- Tracheostomy
- Contralateral cranial nerve injury

High Risk for Endarterectomy

- NYHA III or IV CHF
- EF < 30%
- Unstable angina
- Recent MI
- Contralateral occlusion
- Recurrent stenosis
- Radiation

Endarterectomy Outcomes

- Symptomatic
  - 0.6 – 1% death
  - 5 – 7% stroke/death
- Asymptomatic
  - 2.3% stroke/death

Endarterectomy Outcomes

- Cranial nerve injury: 4 – 7%
- Hemorrhage: 3%
- MI: 1 – 2.6%
- Hyperperfusion syndrome/intracranial hemorrhage: 1%
- Restenosis: 3 - 6%
- Infection: 0.3 – 0.8%

Stenting Outcomes

Trial	CEA Stroke/ death	CAS stroke/ death	CEA restenosis	CAS restenosis
CAVATAS 2001	9.9%	10%	10.5%	30.7%
SAPPHIRE 2004	20.1%	12.2%		
EVA-3S 2006	3.9%	9.6%		
SPACE 2006	6.3%	6.8%	4.6%	10.7%

Stenting Outcomes

- Randomized trials plagued by
  - bias
  - operator inexperience
  - aberrant CEA outcomes
  - Non-standardized EPD
  - angioplasty without stent

ICSS (n = 1,713)

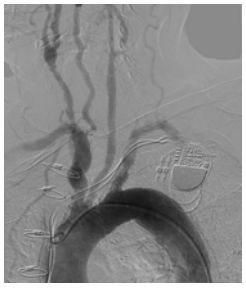
	Stroke	Stroke/death/MI
CEA	4.1%	5.2%
CAS	7.7%	8.5%

Carotid Revascularization Endarterectomy versus Stenting Trial (CREST)

- Only NIH sponsored, prospective, randomized, controlled, multi-center trial; normal risk patients
- Long enrollment period
- Rigorous operator training and credentialing
- Best medical therapy regimen used
- Independent neurologist evaluation
- Crossovers discouraged
- New devices now

CREST

- Primary endpoint of any stoke, MI or death during the periprocedural period or ipsilateral stroke for up to 4 years occurred in 7.2% of CAS patients and 6.8% of CEA patients
- Better outcomes were seen with patients aged ≤ 70 who underwent CAS
- Patients aged > 70 did better with CEA



CREST

- 2502 patients
- Symptomatic disease ≥50% by angiography, ≥ 70% by ultrasound, CTA or MRA,
- Asymptomatic ≥60% stenosis by angiography, or >70% by ultrasound or >80% by CTA of MRA

CREST sub analysis of MI and stroke

	CEA	CAS
MI	2.3%	1.1%
Stroke	2.3%	4.1%

- Postprocedure analysis demonstrated greater impact on the patients who had suffered a stroke rather than an MI

Timing of Revascularization

- Emergent
  - immediate thrombosis after CEA or CAS
- Urgent
  - crescendo TIA
  - stroke in evolution

Post-Procedure Stroke

- If patient awakens with neurologic deficit – return to OR
- Neurologic deficit within 24 hours – return to OR
- Neurologic deficit after 24 hours – head CT to rule out hemorrhage first

Timing of Revascularization

- 6 weeks
  - significant fixed deficit
  - large infarct volume
- 4 weeks
  - moderate fixed deficit
  - moderate infarct volume
- < 2 weeks
  - mild fixed deficit or no fixed deficit
  - small or undetectable infarct volume

Carotid Artery Disease

Mounir Haurani, MD
Department of Surgery
Division of Vascular Diseases and Surgery
The Ohio State University's Wexner Medical Center

Standard Risk Patients

Age < 70

CAS or CEA with equivalent composite stroke/MI/death rates

- **CAS: ↑stroke risk ↓MI risk**
- **CEA: ↑ MI risk ↓stroke risk**

Stent or Endarterectomy?

High Surgical Risk

Symptomatic high-grade stenosis

- **Stent**

Asymptomatic high-grade stenosis

- **Stent (through a trial)**
- **Continued Medical Management**

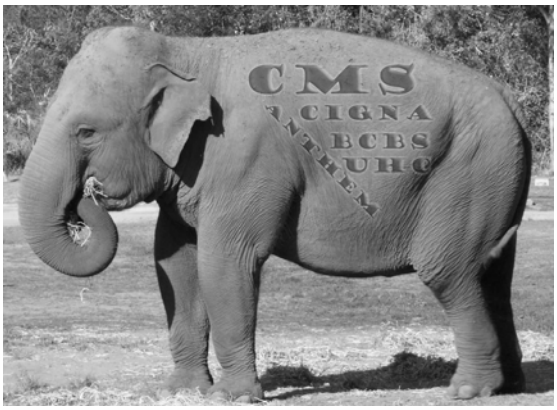
Standard Risk Patients

Age> 70

CEA (lower periprocedural stroke risk)

Medical management

1. **Antiplatelet therapy**
2. **Statin**
3. **Management of hypertension**
4. **Smoking Cessation**



Elephant Picture Courtesy of http://www.freenaturepictures.com/elephant-pictures.php

Cardiac Complications

- MI is responsible for 25% to 50% of perioperative deaths
- Late deaths are due to myocardial infarction
- Surgically correctable CAD was identified in 20%

National Coverage Determination for PTA (20.7)

- ONLY High-Risk, Symptomatic, >70% stenosis
- Otherwise has to be part of a trial
- Not covered if embolic protection not used
- Not covered if facility not Medicare approved

https://www.cms.gov/MedicareApprovedFacilitie/CASF/list.asp

Preoperative Management

Eagle or Goldman / Detsky index used to determine need for further workup.

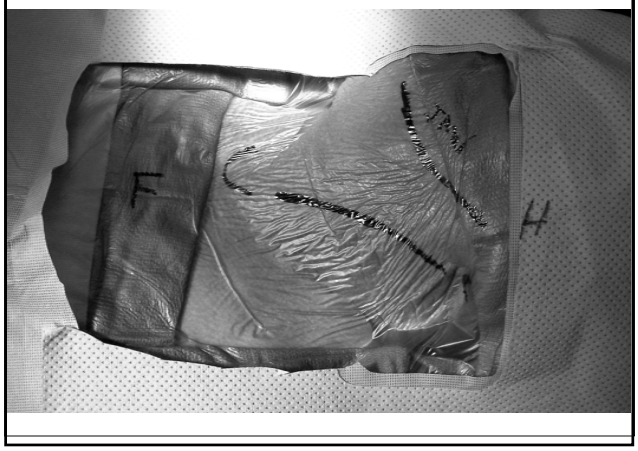
Minor predictors do not warrant cardiac testing.

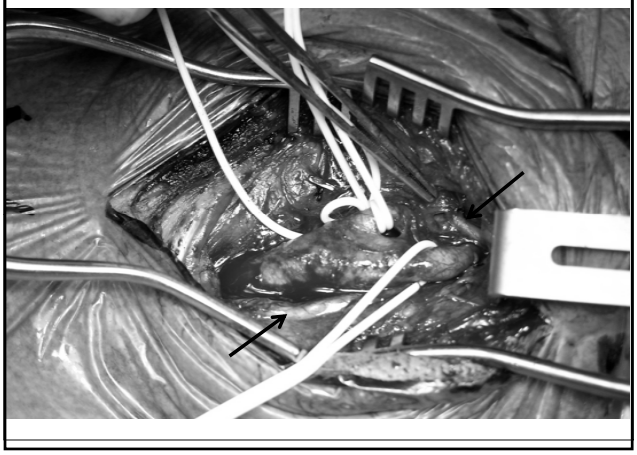
No further workup:

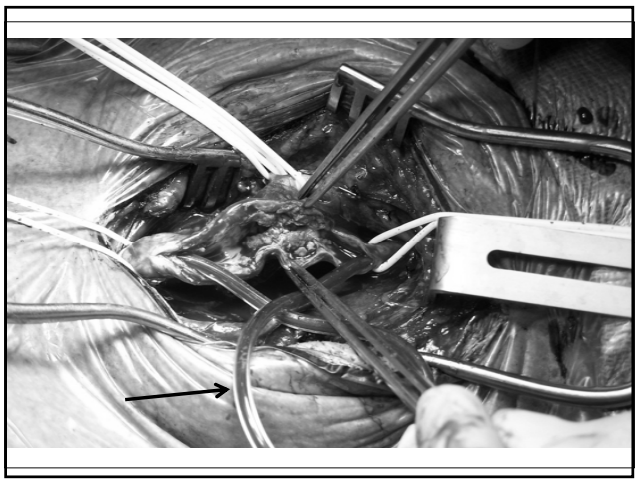
- Recent coronary revascularization within 5 years
- Negative coronary angiography or cardiac stress testing within 2 years.

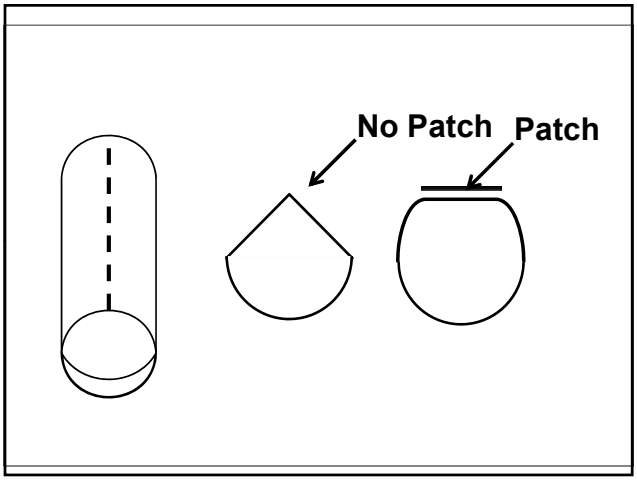
Anesthetic Choice

- General
  - Need to have monitoring of brain activity
  - Routinely shunt
- Local cervical block








No Patch
Patch

CN Injury

Hypoglossal Nerve

- **Tongue weakness and deviation to the affected side**
- **Unilateral hypoglossal nerve injury is rarely serious**

CN Injury

Vagus Nerve

- **Recurrent laryngeal branch - Paralysis of the ipsilateral vocal cord**
- **hoarseness and loss of an effective cough mechanism**
- ***Superior Laryngeal Nerve* - loss of tensioning of the ipsilateral vocal cord**

Hewett R M , Stewart G E J Neurol Neurosurg Psychiatry 2011;82:376-377

CN Injury

Facial Nerve: Marginal Mandibular Branch

- **Drooping of the ipsilateral lower lip**
- **Injury is usually due to excessive stretch**

Antonia Kolokythas, J Oral Maxillofac Res 2010 (Jul-Sep);1(3):e1

Hyperperfusion

- Related to loss of cerebral autoregulation
- Usually acute but may present delayed
- Risks:
  - Hypertension and recent contralateral carotid
  - Very tight stenosis preop
- Headaches and Hypertension
  - May result in cerebral hemorrhage / death

CN Injury

Glossopharyngeal and Spinal Accessory Nerves

- Exceedingly rare
- Glossopharyngeal -mild dysphasia to recurrent aspiration
- Spinal accessory nerve - shoulder droop, scapular winging, and difficulty abducting the shoulder

Recurrent Stenosis

- Meta-analysis - 6% to 14%
- 10% within the first year, 3% in the second, and 2% in the third year
- Usually from intimal hyperplasia
- Some regress over time
- Closure with a patch reduces recurrent stenosis

Follow-Up Schedule for Duplex

20-49% - an annual study

50-79% - every six months

80-99% - every 6 months if surgery not performed

Filter Wires

- Set wires and catheters
- Cross lesion before protected

Follow-Up Schedule for Duplex

After carotid endarterectomy

Ipsilateral/unilateral examinations

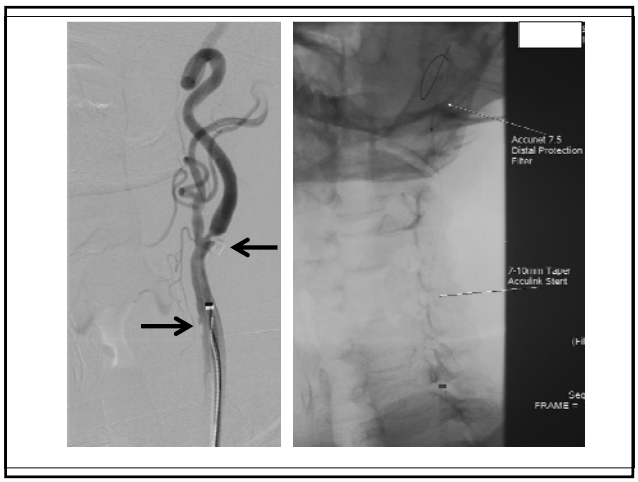
- at six weeks
- six months
- one year

Bilateral study

- symptoms or previously disease in the contralateral carotid

Flow Reversal

- Closer to how it is done in CEA
- Can use different wire and catheters
- "Belt and Suspenders" with filter in ICA



Complications

- Hyperperfusion syndrome
  - Headache and hypertension
  - Focal motor seizures and intracerebral hemorrhage
  - 1.1 % incident
- Myocardial infarction
  - 1 to 4 %

Complications

- Renal dysfunction
  - Contrast-induced nephropathy
  - Atheroemboli
  - Hypoperfusion
  - Risk greatest in moderate to severe renal insufficiency and diabetes

Complications

- Access-related complications
  - Hematoma
  - Bleeding
  - Pseudoaneurysm
  - Atheroembolization
    - Purple discoloration of the toes or gangrene
    - Marbled pattern (livedo reticularis)
    - Extremely Painful

Follow Up

- Dual Antiplatelet Therapy
  - Aspirin 325mg for life
  - Plavix 75mg 6 weeks or longer
- Statin
- Smoking Cessation
- BP control

Complications

- Carotid restenosis
  - Acute thrombosis in 0.5 to 2 %
  - Early restenosis due to neointimal hyperplasia, 6 % 1 year
- Stent fracture
  - As high as 29 percent
  - Clinical significance unknown as of yet

Carotid Duplex

- Normal criteria probably overestimate degree of stenosis
- Related to decreased compliance from stent
- Those in trials will have defined follow up
- Otherwise similar to CEA for ultrasound