Carotid Artery Stenting: Technical Approach

Sheldon Goldberg MD, FACC, FSCAI
Hahnemann University Hospital
Philadelphia, PA
Stroke: Scope of the Problem

• # 1 cause of morbidity
• # 3 cause of mortality
• ≈ 800,000 strokes per year
• 40% – 60% due to carotid disease
• Approximately 175,000 CEA annually
• Estimated # of patients with carotid disease and “pending stroke” untreated: 250,000

– Heart and Stroke Statistical Update, AHA Website
Stroke Risk in CAS

Chambers and Norris et al. NEJM 1986;315:860-865
Invasive Angiography
Moniz illustrates the first cerebral angiogram to the medical faculty at the University of Lisbon

Normal Cerebrovascular Anatomy

Lesions Classification and Stenosis Quantification

ECST = European Carotid Surgery Trial; NASCET = North American Symptomatic Carotid Endarterectomy Trial; CC = Common Carotid

% Stenosis = \( \frac{c - a}{c} \times 100 \)

% Stenosis = \( \frac{b - a}{b} \times 100 \)

% Stenosis = \( \frac{d - a}{d} \times 100 \)
CEA in Asymptomatic CAS

ACAS JAMA 1995;273:1421-1428
ACST JAMA 2004;363:1491-1502

\[ P = 0.004 \quad P = <0.0001 \]

[Bar chart showing comparison between CEA and Med Rx for ACAS (n=1662) and ACST (n=3120) with statistical significance marked.]
CEA in Asymptomatic CAS

P = 0.004

P = <0.0001

ACST JAMA 2004;363:1491-1502
ACAS JAMA 1995;273:1421-1428
Carotid Angiography step by step

- Pigtail catheter in ascending aorta for arch aortogram-20cc per sec for 2 sec-LAO projection
- 5 Fr hydrophilic catheter in common carotid arteries below level of bifucation
- Angio of carotid bifurcation
- Intracerebral angiography in AP cranial and lateral views
Assessing Arch Anatomy

Type A

Type B

Type C
Arch Aortogram- 45 degree LAO projection 20cc/sec for 2 sec

Increasing elongation, increasing difficulty
Arch Anatomy

Using the origin of the left subclavian artery as a landmark, the arch curvature can be classified into three levels.

- **Type A**  Straightforward
  - The great vessels arise *at or above the horizontal line* drawn across the origin of the left subclavian or the peak of the arch, whichever is highest.
• **Type C**  Most Difficult
  - The great vessels arise well below the horizontal line or deeper than two CCA diameters
Aortic Arch Variants & Anomalies

A: common origin of innominate (IA) and left common carotid Artery (LCCA)
B: LCCA originating from the IA (“bovine arch”)
C: left vertebral artery originating directly from aortic arch
D: aberrant right subclavian artery (RSA), distal and posterior to origin of LSA
Aortic Arch: Variations

65% usual pattern
27% left common carotid from innominate
3% separate origin of left vertebral
1% right subclavian as most distal vessel
4% various other patterns
Diagnostic Catheters to Engage Common Carotid

- Vitek (VTK)
- Simmons/Sidewinder 1
- Benson-Hanafee-Wilson 1
- Angled taper
Type A Arch Without Elongation

- Almost any catheter will do
- Reverse curve not required
- Access major arch vessels with Angled taper, Benson
Bovine Arch

- Common trunk
- LCCA as branch of innominate
- Shape Simmons catheter in left subclavian
- Prolapse into aorta
- Engage LCCA during withdrawal
Bovine Arch

- More curve, or reverse curve required

VTK

SIM1

SIM2

HS
It’s Not Just The Arch That Gets Longer!

Tortuous Right Common Carotid
Implications from angiography

Tortuous Right Common Carotid
Imaging Carotid Bifurcation

- Multiple views
- Digital subtraction
- 10” or smaller field of view
- Collimation
Intracranial Circulation

- AP and lateral
- 10-12” field of view
- Must be subtracted
- Assessment of intracranial disease
- Assessment of collateral circulation
Invasive Angiography — Advantages

• Excellent spatial resolution and coverage
• Aortic arch anatomy
• Intracranial anatomy: collateral circulation, aneurysms
• Lesion morphology: discrete, eccentric, calcific, ulcerated (high stroke risk)
• Delineates vessel anatomy beyond the lesion to assist with selection of embolic protection devices: size, tortuosity, collaterals, etc.
Microembolic signals during intra-arterial cerebral angiography

Contrast injection

Probing of CCA

Lancet Neurol 2006; 5: 364–72
Hostile Aortic Arch
DWI lesions after carotid angiography

Lancet Neurol 2006; 5: 364–72
Permanent Neurological Complications of Cerebral Angiography
Carotid Endarterectomy
CEA

- First successful CEA was done in 1953
- By the 1980s CEA was the most frequently performed vascular surgery
- Late 1980s & early 1990s, six randomized trials were established to demonstrate the efficacy of CEA over medical therapy
- Today, CEA is the standard revascularization therapy against which CAS is compared
# CEA Data for Symptomatic Patients

<table>
<thead>
<tr>
<th>Trial</th>
<th>No.</th>
<th>Stenosis</th>
<th>Primary EP</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Med Rx</td>
<td>CEA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NASCET</td>
<td>659</td>
<td>≥ 70%</td>
<td>26%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>858</td>
<td>50–69%</td>
<td>22.2%</td>
<td>15.7%</td>
</tr>
<tr>
<td></td>
<td>1,368</td>
<td>≤ 50%</td>
<td>18.7%</td>
<td>14.9%</td>
</tr>
<tr>
<td>ECST</td>
<td>554</td>
<td>≥ 70%</td>
<td>ARR was 21.2%</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td></td>
<td>646</td>
<td>50–69%</td>
<td>ARR was 5.7%</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>1,808</td>
<td>≤ 50%</td>
<td>ARR was 1.3%</td>
<td>NS</td>
</tr>
</tbody>
</table>
## CEA Data for Asymptomatic Patients

<table>
<thead>
<tr>
<th>Trial</th>
<th>No.</th>
<th>Stenosis</th>
<th>Primary EP</th>
<th>P-Value</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Med Rx</td>
<td>CEA</td>
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<tr>
<td>ACAS</td>
<td>1,659</td>
<td>$\geq 60%$</td>
<td>11%</td>
<td>5.1%</td>
</tr>
<tr>
<td>ACST</td>
<td>3,120</td>
<td>$\geq 60%$</td>
<td>11.8%</td>
<td>6.4%</td>
</tr>
</tbody>
</table>
CEA Trials & Real World

In-Hospital Outcomes

Guidelines

CEA Acceptable Morbidity and Mortality *

Symptomatic: < 6%

Asymptomatic: < 3%

* Ad Hoc Committee, AHA.
# High-Risk Criteria for CEA

<table>
<thead>
<tr>
<th>Anatomical Criteria</th>
<th>Medical Comorbidities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesion at C-2 or higher</td>
<td>Age &gt; 80 yrs</td>
</tr>
<tr>
<td>Lesion below clavicle</td>
<td>Class III/IV congestive heart failure</td>
</tr>
<tr>
<td>Prior radical neck surgery or radiation</td>
<td>Class III/IV angina pectoris</td>
</tr>
<tr>
<td>Contralateral carotid occlusion</td>
<td>Left main / ≥ 2 vessel coronary disease</td>
</tr>
<tr>
<td>Prior Ipsilateral CEA</td>
<td>Urgent (&lt; 30 days) heart surgery</td>
</tr>
<tr>
<td>Contralateral laryngeal nerve palsy</td>
<td>LV ejection fraction ≤ 30%</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>Recent (&lt; 30 days) myocardial infarction</td>
</tr>
<tr>
<td></td>
<td>Severe chronic lung disease</td>
</tr>
<tr>
<td></td>
<td>Severe renal disease</td>
</tr>
</tbody>
</table>
Carotid Artery Stenting
Patient post-carotid surgery

Patient post-carotid angioplasty and stent (no neck incision)
### Markers of Increased Risk During Carotid Stenting

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
</tr>
<tr>
<td>Advanced age</td>
<td>Age $\geq 80$ years</td>
</tr>
<tr>
<td>Decreased cerebral reserve</td>
<td>- Prior large stroke</td>
</tr>
<tr>
<td></td>
<td>- Multiple lacunar infarcts</td>
</tr>
<tr>
<td></td>
<td>- Intracranial microangiopathy</td>
</tr>
<tr>
<td></td>
<td>- Dementia</td>
</tr>
<tr>
<td><strong>Angio-graphic</strong></td>
<td></td>
</tr>
<tr>
<td>Excessive tortuosity</td>
<td>$\geq 2$ $90^\circ$ bends within 5 cm of the lesion</td>
</tr>
<tr>
<td>Heavy calcification</td>
<td>Concentric calcification; width $\geq 3$ mm</td>
</tr>
</tbody>
</table>

$\geq 2$ risk factors $\sim$ high risk for complications

Carotid Angioplasty and Doppler Flow: Pre- and Post-PTA

Elective Stenting of the Extracranial Carotid Arteries

Jay S. Yadav, MD; Gary S. Roubin, MD, PhD; Sriram Iyer, MD; Jiri Vitek, MD; Peter King, MD; William D. Jordan, MD; Winfield S. Fisher, MD
Methods

- March 1994–Nov 1995
- 77% excluded from NASCET, ACAS
- Symptomatic Patients > 70% stenosis
- Asymptomatic Patients > 60% (after ACAS)
- Stents:
  - Palmaz medium biliary stents (J&J) 69%
  - Flex-Stents (Cook Inc) 20%
  - Wallstents (Schneider) 11%

Results at 30 Days

Why Use Embolic Protection in Carotid Artery Stenting?

The main cause of complications is . . .

Cerebral Embolization
Silent cerebral ischaemia
hidden fingerprints of invasive medical procedures

Martin Bendszus, Guido Stoll
DWI lesions and Cerebral ischemia

- Most periprocedural DWI lesions do not cause an obvious neurological deficit
- Asymptomatic DWI lesions have the same characteristics on imaging as symptomatic lesions
- Primarily, the lesion location determines the extent of neurological deficits
- Small periprocedural DWI lesions, if located in an eloquent brain area, can cause severe neurological deficits
- Persistent ischaemic cerebral deficits have not been described in patients without DWI lesions
- These findings apply to patients who develop strokes independently from a diagnostic or therapeutic procedure
Cortical DWI lesions with and without clinical symptoms

Lancet Neurol 2006; 5: 364–72
Carotid Stenting Trials

- CAVATAS
- SAPPHIRE
- CREST
- BEACH
- CABERNET
- ARCHER
- MAVERIC
- SECURITY
- CARESS
- SPACE
- EVA 3S
SAPPHIRE TRIAL

>50% stenosis if symptomatic
>80% stenosis if asymptomatic
High risk for CEA

**CONSENSUS**

**SURGICAL REFUSAL**

STENT REGISTRY 409

**INTERVENTIONAL REFUSAL**

**RANDOMIZED**

307

Stenting = 156  CEA = 151

**SURGICAL REGISTRY**

7

Courtesy of Sheldon Goldberg, M.D.
SAPPHIRE

Endpoints

• Primary:
  - At one month: Death, Stroke, and MI
  - At one year: 30-day MACE plus Death and Ipsilateral Stroke between 31 days and 1-year post-procedure

• Secondary:
  - Patency (< 50% restenosis) by US at:
    - 48 hours, 6 months, 1, 2, and 3 years
  - Disabling stroke at 30 days and 6 months
  - Composite of MACE at 6 months, 1, 2, and 3 years
  - Safety assessment of the ANGIOGUARD XP
## Randomized Patients
### 30-Day Events

<table>
<thead>
<tr>
<th>Events</th>
<th>Stent (n = 156) [95% CI]</th>
<th>CEA (n = 151) [95% CI]</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death:</td>
<td>0.6% [-0.6%, 1.9%]</td>
<td>2.0% [-0.2%, 4.2%]</td>
<td>0.36</td>
</tr>
<tr>
<td>Stroke:</td>
<td>3.8% [0.8%, 6.9%]</td>
<td>5.3% [1.7%, 8.9%]</td>
<td>0.59</td>
</tr>
<tr>
<td>Major Ipsilateral</td>
<td>0.0%</td>
<td>1.3%</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Major Non-Ipsilateral</td>
<td>0.6%</td>
<td>0.7%</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Minor Ipsilateral</td>
<td>3.2%</td>
<td>3.3%</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Minor Non-Ipsilateral</td>
<td>0.6%</td>
<td>0.0%</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>MI (Q or NQ):</td>
<td><strong>2.6% [0.1, 5.0%]</strong></td>
<td><strong>7.3% [3.1%, 11.4%]</strong></td>
<td>0.07</td>
</tr>
<tr>
<td>Q Wave MI</td>
<td>0.0%</td>
<td>1.3%</td>
<td>0.24</td>
</tr>
<tr>
<td>Non-Q Wave MI</td>
<td>2.6%</td>
<td>6.0%</td>
<td>0.16</td>
</tr>
<tr>
<td>Death/Stroke:</td>
<td>4.5% [1.2%, 7.7%]</td>
<td>6.6% [2.7%, 10.6%]</td>
<td>0.46</td>
</tr>
<tr>
<td>Death/Stroke/MI:</td>
<td><strong>5.8% [2.1%, 9.4%]</strong></td>
<td><strong>12.6% [7.3%, 17.9%]</strong></td>
<td><strong>0.047</strong></td>
</tr>
</tbody>
</table>
SAPPHIRE: One-Year Outcome

1 Year Data
Randomized Patients (Per Protocol)

Cumulative Percentage of MAE

- Nitinol Stent
- Carotid Endarterectomy

CEA: 19.9%
P = 0.048

Stent: 11.9%

Time after Initial Procedure (days)

0 30 60 90 120 150 180 210 240 270 300 330 360

– Yadav JS. TCT 2003
Results at One Year

All Patients

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEA</td>
<td>20.1</td>
</tr>
<tr>
<td>Stent</td>
<td>12.2</td>
</tr>
<tr>
<td>Stent Registry</td>
<td>16</td>
</tr>
</tbody>
</table>

P = 0.05
SAPPHIRE

Conclusion

In patients with severe carotid artery stenosis and co-existing morbid conditions, carotid artery stenting with embolic protection is not inferior to carotid endarterectomy.
Prospective, multicenter registry to assess:
- Safety of carotid stenting by physicians with varying levels of experience
- Unexpected device-related complications

The primary endpoint:
- Composite of death, any stroke, or myocardial infarction within 30 days post-procedure

Evaluates the outcomes of CAS in the “real world”
Death, Stroke, and MI

DSMI by Physician Level by Symptomatic Status

Physician Specialty Mix (n=353)

- Intervventional Cardiologist (n=194) 55%
- Vascular Surgeon (n=77) 22%
- Intervventional Radiologist (n=53) 5%
- Neurosurgeon (n=14) 4%
- Interventional Neuroradiologist (n=15) 4%
EXACT and CAPTURE 2: Outcomes at 30 Days

- Prospective data on post-market surveillance studies
- Multicenter (280 United States sites, 672 operators),
- High-surgical risk patients
- Pre- and post-procedure neurologic evaluation and independent adjudication of neurologic events
Death and Stroke @ 30 Days
Two Prospective, Multicenter, High Surgical Risk Registries

EXACT (n = 2145)  CAPTURE 2 (n = 4175)
4.1  3.4

Gray WA; Chaturvedi S and Verta P
Circulation: Cardiovascular Interventions March 6, 2009
Death and Stroke @ 30 Days in Octogenarians

Gray WA; Chaturvedi S and Verta P
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Death and Stroke @ 30 Days
Two Prospective, Multicenter, High Surgical Risk Registries

Gray WA; Chaturvedi S and Verta P
Circulation: Cardiovascular Interventions March 6, 2009
Death and Ipsilateral Stroke with and without CPD

“Data From the SPACE Trial”

P 0.40

% Death and Ipsilateral Stroke with and without CPD

Unprotected (n=418) 6.5

Protected (n=145) 8.3

Stroke 2009;40;841-846;
Symptomatic Carotid Stenosis >60%

n = 527

Death/ CVA @ 30 days

- CEA: 3.9
- CAS: 9.6

n = 259

Death/ CVA @ 6 mon

- CEA: 6.1
- CAS: 11.7

n = 261

P = 0.01

P = 0.02

Mas JL NEJM 2006;355:1660
EVA 3 S

Symptomatic Carotid Stenosis >60% (n = 527)

Mas JL NEJM 2006;355:1660r
EVA 3S and SPACE trials

Death/ CVA @ 30 days
- CEA: 3.9
- CAS: 9.6
- P = 0.01

Death/ CVA @ 6 mon
- CEA: 6.1
- CAS: 11.7
- P = 0.02

Symptomatic Carotid Stenosis >60%
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- Protected (n=145): 8.3
- P = 0.40

Mas JL NEJM 2006;355:1660
Stroke 2009;40;841-846;
Carotid Artery Stent Trials
(Registries & Randomized)

One Month Outcomes
Death/MI/Stroke

D J McCormick, Review in press - Vasc Medicine Management
Carotid Intervention Step by Step
Common Carotid Sheath Access Technique

Guidewires

Wholey
Magic Torque
Amplatz (1 and 6 cm transition tip) Terumo .035 and .038 in.

90 cm Sheaths

Cook Shuttle (5–7 F)
Cordis Brite-Tip (6–7 F)
ArrowFlex (6–7 F)

Special Guide Catheters

Simmons 2
AL
JR
Shuttle Sheaths

5 Fr with JB1 Slipcath to Lead Sheath

6 Fr with Dilator
Aortic Arch Elongation

Increasing elongation, increasing difficulty
Increasing elongation, increasing difficulty
Aortic Arch Elongation

Increasing elongation, increasing difficulty
Arch Anatomy

Using the origin of the left subclavian artery as a landmark, the arch curvature can be classified into three levels.

- **Type A** Straightforward
  - The great vessels arise *at or above the horizontal line* drawn across the origin of the left subclavian or the peak of the arch, whichever is highest.
- Type B  Difficult
  - The great vessels arise below the horizontal line but within 2 CCA diameters from the peak. AC
• **Type C** Most Difficult
  
  – The great vessels arise well below the horizontal line or deeper than two CCA diameters
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- **Type A** Straightforward
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MRI Brain w/o contrast
Technical Steps

- Image carotid bifurcation with 5 Fr hydrophilic diagnostic catheter
- 0.035” Terumo wire through it and into external carotid
- Place diagnostic catheter into external carotid; remove Terumo
- Place supportive wire eg. Long transition Amplatz, Magic Torque, Wholey into external carotid; remove diagnostic catheter
- Place Shuttle Sheath into common carotid
- Remove wire and dilator
- If external carotid stenosis, use supportive wire eg. Short transition Amplatz in common carotid
Shuttle Sheath

6 Fr with Dilator
Guide wire in external carotid artery

View separates internal from external carotid
Technical Steps (cont’d)

• Place distal protection device in petrous portion or straight segment of internal carotid—make sure of adequate landing zone
• Predilate with 4 x 30 mm balloon
• Place self expanding stent
• Post dilate with 5 x 20 mm balloon
• Recapture filter or use aspiration catheter if balloon occlusion device used
• Final carotid and cerebral angiography
Death and Stroke With and Without CPD

“A Systematic Review of the Literature”

Transcranial Doppler During CAS

- **Emboli**
- **Inflated**
- **Deflated**
Therapeutic Options:
Current Embolic Protection Categories

Distal Occlusive Devices

Distal Filters

Proximal Occlusion and Flow Reversal
Interventional Emboli
(Clinical Need)

Control vs. PercuSurge
SAFER ~50% reduction
(SVG)

* Al-Mubarak et al., 2001
Microembolic Profile During CAS and New (DW) MR Lesions After CAS

Selection of EPD

- Filter devices
- Distal balloon occlusions
- Proximal protection
Current DPDs in Use

- Accunet
- Guardwire
- SPIDER
- Angioguard
- FilterWire EZ
- Emboshield
- Balloon Sheath & Dilator
- Balloon Wire
- External Filter
- Fibernet
- Gore Device
GuardWire — PercuSurge EPD

GUARDWIRE®
Temporary Occlusion and Aspiration System

Prep and Use Pocket Guide
Balloon Occlusion Devices

Advantages

• Easy to cross lesion
• Compatible with devices
• Aspirate large and small particles
• Reliably trap debris
• Easy device retrieval

Disadvantages

• No antegrade flow
• 5–8% are intolerant
• Balloon-induced injury
• Not as steerable as PTCA wires
• Difficult to image during the procedure
Drops of blood

External carotid artery

Flow goes from the external into the internal carotid artery

Internal carotid artery

9 Fr sheath with balloon inflated

Balloon on a 0.018” wire

Back-flow from the internal carotid artery into the sheath is created by opening the valve at the end of the sheath.

Drops of blood
# Distal Embolic Protection Devices

## Filter Devices

### Advantages
- Preserve antegrade flow
- Contrast imaging is possible throughout the procedure

### Disadvantages
- May not capture all debris
- Filters may clog, cause spasm
- Delivery catheters may cause embolization before filter deployment
- Retrieval sheath may snag on stents
GORE FLOW REVERSAL SYSTEM

- Balloon Sheath & Dilator
- Balloon Wire
- External Filter
EMPiRE: A Multicenter Registry Evaluating Neuroprotection During Carotid Stenting with a Novel Flow Reversal System

L. Nelson Hopkins, MD
Daniel Clair, MD

For the EMPiRE Investigators
EMPiRE Major Adverse Event Rates by Subgroup (Stroke, Death, MI)

- Asymptomatic (n=167): 3.6%
- Symptomatic (n=78): 3.8%
- Octogenarians (n=38): 2.6%
Flow Reversal

**Advantages**
- Not dependent on distal ICA anatomy
- Theoretic reduced risk for embolization during guide wire/filter crossing crossing
- No problem with retrieval sheaths

**Disadvantages**
- Increased complexity
- 9Fr system
30-Day Events (TIA, Stroke, and Death)

<table>
<thead>
<tr>
<th>Comparison</th>
<th>RR</th>
<th>95% CI</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td><strong>Proximal occlusion vs. filter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Unadjusted</td>
<td>1.52</td>
<td>0.75–3.13</td>
<td>1.00</td>
</tr>
<tr>
<td>• Adjusted for RF, ST</td>
<td>1.59</td>
<td>0.71–3.10</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Distal occlusion vs. filter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Unadjusted</td>
<td>2.72</td>
<td>0.71–10.51</td>
<td>0.96</td>
</tr>
<tr>
<td>• Adjusted for RF, ST</td>
<td>3.38</td>
<td>0.55–10.87</td>
<td>0.54</td>
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<tr>
<td><strong>Distal vs. proximal occlusion</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• Unadjusted</td>
<td>1.79</td>
<td>0.40–7.96</td>
<td>1.00</td>
</tr>
<tr>
<td>• Adjusted for RF, ST</td>
<td>1.79</td>
<td>0.40–7.96</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Eccentric vs. concentric filter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Unadjusted</td>
<td>0.59</td>
<td>0.38–0.92</td>
<td>0.04</td>
</tr>
<tr>
<td>• Adjusted for RF, ST</td>
<td>0.76</td>
<td>0.47–1.22</td>
<td>0.51</td>
</tr>
</tbody>
</table>
Balloon/stent inflation
Heart rate

• Bradycardia common, asystole isn’t
• Usually brief
• Routine pacing not required
• Initial response dictates final inflation strategy
• Usual treatment: none
• Severe or persistent drop: atropine 1mg
  ➢ Don’t confuse a dry mouth with slurred speech
Placing and Deploying Stent

- Start to deploy
- Withdraw to intended position
- Fully deploy
Placing and Deploying Stent

- Watch protection device as you advance
- Beware of stent pushing guide or sheath down
- Go just beyond intended landing zone
- Ask: what will happen to vessel kink?
- Aspirate shuttle sheath
Carotid Stenting: General Principles

- 30-40 mm length
- Mostly 8-10 mm diameter
- Size to CCA (with exceptions…)
- Stent placed across bifurcation and ECA origin, into distal CCA
- ‘No price to pay’ for over-stenting, but falling short…
Does Carotid Stent Cell Design Matter?

European Registry

Martin Schillinger, MD; Manfred Gschwendtner, MD; Bernhard Reimers, MD; Johannes Trenkler, MD; Luc Stockx, MD; Johann Mair, MD; Sumaira Macdonald, MD; Franz Karnel, MD; Kurt Huber, MD; Erich Minar, MD

FDA approved stents

Acculink®, Guidant

Wall Stent

Precise, Cordis

Xact®, Abbott Vascular Device

Protege®, ev3
Basic Principle of Open Versus Closed Cell
Free Cell Area of Available Stent Designs . . .
Stroke and Death Rates


![Graph showing stroke and death rates](image-url)

- **Day 0 to 30**
  - CC: 3.1
  - OC: 2.4
  - Day 0:
    - CC: 2.6
    - OC: 1.3

- *p=0.079*
- *p=0.38*
Post Procedural Care

- Routine overnight stay in neuro ICU
- Exam by same neurologist as pre procedure
- Frequent neuro checks (initially q 15 min)
- Hypotension
  - Usually just observe if asymptomatic
  - First treatment: fluids
  - Neosynephrine or dopamine infusions
Post Procedural Care

- Discharge following day
- ASA plus Plavix, 6 wks minimum
  - DO NOT STOP PLAVIX FOR BLEEDING
  - Use integrin for pts requiring CABG, load with Plavix post op
- F/U generally at 1 month with duplex
- Routine f/u 6 months, 12 months, and yearly thereafter
- Consider intervention for:
  - New lesions
  - Critical restenosis
Wire ECA, placement of long 6-7F interventional sheath
Guide wire in external carotid artery

View separates internal from external carotid
“Set Up” Angio

- Note bony landmarks
- Lesion clearly visualized
- “Landing zone” for protection
- Don’t move table

Internal Carotid Stenosis
Carotid Artery Stenting — Step by Step
From Initial Access to Final Result
Right ICA

- 59 YO with h/o CABG and St. Jude AVR
- RCEA 6 years ago
- Amaurosis fugax despite therapeutic INRs
FDA approval and CMS coverage

- Carotid stenting has been approved by the FDA for high-risk CEA pts:
  - Symptomatic (>50%) or
  - Asymptomatic (>80%)

- CMS has restricted CAS to pts high risk for CEA:
  - Symptomatic >70%
  - Asymptomatic (>80%) high risk patients who are enrolled in prospective clinical studies
CAS Outcomes Tied To . . .

ANATOMY
- Difficult Arch
- Angulation/
  Tortuosity
- Lesion anatomy

PATIENT
- Symptoms
- Octogenarians
- Comorbidities
- Vasc fragility
- Prior Stroke

OPERATOR
- Sub-optimal training
- Early learning curve
- Procedure length
- Case selection
- Stubborn persistence

DEVICE SELECTION
- Catheters/Balloons
- Predilation
- Stent design
- Cerebral protection