Carotid Artery Stenting: Basics of Intervention

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Symptomatic vs. Asymptomatic High-Risk Patient
FDA Approval Guidelines

Symptomatic? [Yes/No]

- Yes: CAS candidate if other criteria are met
- No: Not a CAS candidate

≥80% stenosis? [Yes/No]

- Yes: CAS candidate if other criteria are met
- No: Not a CAS candidate

≥50% stenosis? [Yes/No]

- Yes: CAS candidate if other criteria are met
- No: Not a CAS candidate
Stenosis Evaluation

NASCET Stenosis measurement protocol

- A is normal vessel diameter distal to stenosis
- B is diameter at greatest site of narrowing
- Percent stenosis = (A-B)/A*100
- Always Look at PSV and EDV
CEA High-Risk Criteria – Class I Comorbidities*

The following conditions significantly increase the perioperative risk for complications during CEA. Any single criterion listed classifies the patient as a high surgical risk for CEA:

– Unstable angina
– Congestive heart failure – Class III or IV
– Left ventricular ejection fraction less than 30%
– Chronic obstructive pulmonary disease (COPD) with a forced expiratory volume (FEV) less than 30%
– Requirements for staged and scheduled coronary artery bypass graft (CABG) or valve replacement procedures less than 30 days following the procedure
– Age 80 years or more

CEA High-Risk Criteria – Class II Comorbidities*

The following conditions significantly increase the perioperative risk for complications during CEA. Any two criteria listed classify the patient as a high surgical risk for CEA:

– Age 75 years or more
– Recent myocardial infarction more than 72 hours and less than 30 days
– Two or more major diseased coronary arteries that require revascularization

CEA High-Risk Criteria – Anatomical High Risks*

The following conditions significantly increase the perioperative risk for complications during CEA. Any criterion listed classifies the patient as a high surgical risk for CEA:

- Surgically inaccessible lesions above C-2 or below the level of the clavicle
- Contralateral carotid artery occlusion
- Restenosis after a previous ipsilateral CEA
- Previous head/neck radiation therapy or surgery that included the area of stenosis
- Ipsilateral radical neck dissection for the treatment of cancer
- Obese/short neck
- Fibromuscular dysplasia
- Spinal immobility of the neck due to cervical arthritis
- Presence of laryngeal palsy
- Presence of a tracheostoma

Patients should be excluded as candidates for the CAS procedure if any of the following general conditions exist:

- Patients with a life expectancy of less than one year due to existing disease
- Patients whose lesions might require more than two stents
- Pregnant patients
- Patients unable to follow physician instructions post-procedure (dementia)
- National Institutes of Health Stroke Scale (NIHSS) score $\geq 15$ within seven days of procedure

Patients should be excluded as candidates for the CAS procedure if any of the following general conditions exist:

- Stroke history within three weeks of the procedure
- Myocardial infarction within 72 hours of the procedure
- Severe renal insufficiency precluding safe use of contrast agents
- Severe peripheral vascular disease which precludes safe vascular access

CAS Exclusion Criteria – Angiographic Screening Criteria

A secondary screening phase is performed during the diagnostic angiography. Patients are assessed for angiographic and anatomical eligibility. Exclusions include:

- Total occlusion of the target carotid artery treatment site
- Severe tortuosities and angulations of the carotid arteries
- Heavy calcifications within and around the lesion
- Thrombus at the lesion site or distal to it
- Subtotal occlusions of the ICA, called the “string sign”
- Severely tortuous and atheromatous aortic arch and arch vessels that make access difficult

Lesions $\leq 50$ percent are generally not treated and medical therapy is considered most appropriate.
Contraindications

Contraindications associated with angioplasty must be considered when using any Nitinol Stent. These include but are not limited to:

- Patients in whom anticoagulant and/or antiplatelet therapy is contraindicated
- Patients with severe vascular tortuosity or anatomy that would preclude the safe introduction of the guide catheter / introducer sheath
- Patients with a known hypersensitivity to nickel-titanium
- Patients with uncorrected bleeding disorders
- Lesions in the ostium of the common carotid artery
Anatomical Considerations: Aortic Arch

Evaluate

- Aortic arch type
- Variant anatomy
- Calcification
Anatomical Considerations: Aortic Arch Type

- Type I – Least difficult because of linear approach
- Type II – Moderately difficult because of curved approach
- Type III – May be considered a contraindication for CAS
Anatomical Considerations: Challenges of Complex Arches

Type I (Ideal Arch)  Type III (Challenging Arch)
Anatomical Considerations: Challenges of Complex Arches

Variant Anatomy

- Curved approach
- Difficult to track stiff catheters
- Catheters can kink
- Must maintain guide catheter/sheath position during procedure
  - Prolapse of guide catheter/sheath may pull an open filter into the stent or lesion

Left CCA off Innominate
Anatomical Considerations: Challenges of Complex Arches
Anatomical Considerations: Aortic Arch Calcification

- Interventional devices increase risk of plaque emboli
- Risk of emboli is greater in calcified complex anatomy
- CAS may be more challenging in patients with very heavily calcified aortic arches
Anatomical Considerations: Common Carotid Artery

Evaluate

- Ostial stenosis
- Tortuosity
- Calcification
CCA – Ostial Stenosis

Challenges

• May limit access into vessel
• Embolization can occur
• Guide catheter/sheath can occlude
• May affect long term patency of stent

Image courtesy of Mark Wholey, M.D.
CCA – Tortuosity

Challenges

• Difficulty gaining access with guide catheter/sheath

• Movement of bend cephalad

• Maintaining guide catheter/sheath position during procedure
  – Prolapse of guide catheter/sheath may pull an open filter into the stent or lesion
CCA – Calcification

Challenges

- Embolization
- Vessel occlusion with guide catheter/sheath
- May affect long term patency of stent
Anatomical Considerations: External Carotid Artery

Evaluate

- Occluded or patent
- Degree of calcification
- Ability to accommodate stiff wire
- Tortuosity
External Carotid Artery

Normal

Diseased

Occluded
Anatomical Considerations: Internal Carotid Artery

Evaluate
- Takeoff angle
- Degree of stenosis
- Tortuosity
- “Landing zone” for EPD
ICA - Takeoff

Considerations

• Trackability of EPD
• Balloon and stent trackability
• Risk of EPD movement
• Stent may kink in severely angled takeoff
• EPD ease of recovery
Challenges of Angulated ICA Takeoff

Linear

Angulated
Internal Carotid Artery

Linear

Angulated
ICA – Degree of Stenosis

Will EPD cross through lesion?
- Profile 3-4F
- Takeoff angle can affect crossing
- Transition from guide wire tip to filter basket
ICA – Landing Zone for EPD

Area in the vessel where the EPD can be safely and effectively placed

– Tortuosity
– Calcification
– Vessel diameter
– Room for PTA and stent deployment
ICA – Tortuosity

- May hinder advancement of EPD, balloon and/or stent
- Can impact apposition of EPD
- Can lead to kink or movement of bends with stent placement
- Can make EPD recovery difficult
Anatomic Features

- **Iliofemoral Arteries** - small caliber or systemic arterial disease could limit access size
- **Aortic arch** – general cannulation considerations for difficult arch anatomies
- **Cervical**
  - Proximal tortuosity
  - CCA and ECA size
  - Origin of ECA branch vessels
  - Bifurcation angle - stent interaction risk increases
- **Intracranial** – Non-patent Circle of Willis
Proximal Tortuosity

• Difficult to navigate

• Poor proximal balloon landing zone
Vessel size

Large ECA and CCA vessels contraindicated for proximal protection systems:

- ECA vessel diameter less than or equal to 6 mm
- CCA diameters from 6 - 12 mm.
A Challenging ECA

• Occlude as much as possible, focus on stability of the PPD in the ECA.

• Aspiration can overcome collateral flow.
  – Has the potential to increase signs of intolerance as pressure in the MCA is reduced.

  • Options
    – Inflate PPD further
    – Reposition PPD
Anatomy Concerns

- Can’t exclude ECA branch vessels (Superior Thyroid and maybe Lingual).

- Angle between Stent and PPD
  - Past experience shows that this angle can increase the potential for PPD/Stent interaction and entanglement – especially in open cell stents.
Incomplete Circle of Willis

- Occurs in >50% of cases due to disease or anatomic variation
  - can result in loss of collateral supply
Anatomical Considerations: Target Lesion

Evaluate

- Presence of thrombus in lesion
- Severe circumferential calcification
- Lesion Type
  - Type A
  - Type B
  - Type C
**Target Lesion - Thrombus**

- Look for “filling defect”
- High-risk for CAS
- Danger of embolization
Target Lesion - Calcification

- Severe circumferential calcification
- Challenges
  - Difficult to treat with PTA/stent
  - Possible incomplete expansion of stent
- May interfere with EPD removal

Image courtesy of Chet Jarmolowski, M.D.
Low Risk

Type A lesion
- Short < 1 cm
- Non-ulcerative
- Concentric
- < 85% stenosis

Wholey et al. JVIR 2003;14:1-10
Moderate Risk

Type B lesion
- 1-2 cm in length
- Frequently eccentric
- Ulcerative
- May involve the ostium with extension of the bifurcation
- 85-95% stenotic

Wholey et al. JVIR 2003;14:1-10
High Risk

Type C lesion
• > 2 cm in length
• Major ulceration
• Bifurcation involvement
• Question of clot vs. plaque
• 95% or greater stenosis

Image courtesy of Mark Wholey, M.D.

Wholey et al. JVIR 2003;14:1-10
Summary

Success of CAS is directly related to:
- Physician experience
- Careful patient selection
  - Complete medical history
  - Thorough evaluation of anatomy
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