Prevalence, Screening, Prevention Strategies and Imaging Modalities for Carotid Artery Disease and Abdominal Aortic Aneurysm

Ratna Kunasani, MD
Stroke

- Someone in the US has a stroke about once every 40 seconds.
- Stroke accounts for 1 of every 20 deaths in the US.
- Stroke kills someone in the US about every 4 minutes.
- When considered separately from other cardiovascular diseases, stroke ranks No. 5 among all cause of death in the US, killing nearly 133,000 people a year.
- From 2004 to 2014, stroke death rate decreased 28.7 percent, and the actual number of stroke deaths declined 11.3 percent.
- Each year, about 795,000 people experience a new or recurrent stroke. Approximately 610,000 of these are first attacks, and 185,000 are recurrent attacks.

Stroke is a leading cause of serious long-term disability in the US.
- In 2013, worldwide prevalence of stroke was 25.7 million, with 10.3 million people having a first stroke.
- Stroke was the second-leading global cause of death behind heart disease in 2013, accounting for 11.8 percent of total deaths worldwide.

Cardiovascular disease is the leading global cause of death, accounting for more than 17.3 million deaths per year in 2013, a number that is expected to grow to more than 23.6 million by 2030.
- In 2013, cardiovascular deaths represented 31 percent of all global deaths.
- In 2010, the estimated global cost of cardiovascular disease was $863 billion, and it is estimated to rise to $1044 billion by 2030.

AHA and American stroke Association – statistics 2017
85% of the strokes are ischemic, and 15% hemorrhagic. Ischemic- 45% are due to extracranial carotid disease, and 55% are due to cardioembolic causes.
## Degree of ICA Stenosis in Doppler US*

**Consensus Criteria – NASCET criteria**

<table>
<thead>
<tr>
<th>ICA stenosis (%)</th>
<th>ICA PSV cm/sec</th>
<th>ICA EDV cm/sec</th>
<th>PSV ratio ICA/CCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt; 125</td>
<td>&lt; 40</td>
<td>&lt; 2.0</td>
</tr>
<tr>
<td>&lt; 50%</td>
<td>&lt; 125</td>
<td>&lt; 40</td>
<td>&lt; 2.0</td>
</tr>
<tr>
<td>50 – 69%</td>
<td>125 – 230</td>
<td>40 – 100</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>&gt; 70%</td>
<td>&gt; 230</td>
<td>&gt; 100</td>
<td>&gt; 4.0</td>
</tr>
<tr>
<td>Near occlusion</td>
<td>variable</td>
<td>variable</td>
<td>variable</td>
</tr>
<tr>
<td>Total occlusion</td>
<td>undetectable</td>
<td>undetectable</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

* Diameter reduction

CTA - severe carotid stenosis
3D MRA with gad Left prox SCA stenosis
Moderate carotid stenosis-DSA
<table>
<thead>
<tr>
<th></th>
<th>Duplex Sono</th>
<th>CTA</th>
<th>TOF MRA</th>
<th>MRA + Gd</th>
<th>DSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICA Stenosis</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Morphology</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Fair</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Evaluation of</td>
<td>Good</td>
<td>Good</td>
<td>Fair</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Proximal artery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intracranial</td>
<td>None</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Visualization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance by</td>
<td>Fair</td>
<td>Excellent</td>
<td>Good</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Surgeons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>None</td>
<td>Low</td>
<td>None</td>
<td>Very Low</td>
<td>Low – Moderate</td>
</tr>
<tr>
<td>Cost</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++++</td>
<td>+++++++</td>
</tr>
</tbody>
</table>
Factors influencing decision to recommend intervention:

1. **Life expectancy**: At least 3-5 y in asymptomatic pts to benefit from intervention ACAS, ACST.
   Symptomatic trial: NASCET, ECST: only pts with >5 y life expect were enrolled

2. **Age**: In CREST: (At 64y – CAS was = to CEA). After 64 y CEA was better than CAS – vessels tortuousity, more plaque instability in elderly.

3. **Gender**: Men benefit more. Women - more postop stroke, but CEA still beneficial in 70-99% stenosis

4. **Functional status**: Baseline functional ability.

5. **Cardiac**: Peri op cardiac events are associated with late mortality: In symptomatic: cardiac risk assessment with H & P, in asymptomatic – full cardiac workup

6. **Renal**: Moderate – severe renal insufficiency decreases life expectancy and increases complication rates after both CEA and CAS: ? plaque instability

7. **Contralateral carotid occlusion (CCO)**: Slightly increased stroke postop with CEA vs CAS (3.15% vs 2.1% - NS).
Factors influencing choice of intervention:

1. **Presence of neuro symptoms**: CAS inferior to CEA in sympt pts. In sub analysis of CREST- Benefit of CEA over CAS in sympt pts esp great in the 1st week after stroke- postop stroke- 2.8% vs 9.4%: Hazard Ratio- 3.4

2. **Hostile neck**: Stoma, recent radiation, Neck dissection.
   CEA can be done in necks with remote radiation- inc cranial N injury.

3. **Lesions outside the cervical carotid**: Proximal CCA, intracranial ICA

4. **Vessel Tortuosity**: Aortic arch and carotids

5. **Lesion Character**: More echolucent- more embolicogenic with CAS
   Long (>15mm length), preocclusive, calcified, fresh thrombus: Increase stroke after CAS
Carotid kink
Treatment options for carotid bifurcation stenosis:

1. Risk factor reduction and medical management: HTN is the most imp factor for stroke: should be controlled AFTER the 1st 24 hrs.
   - DM is an independent predictor of recurrent stroke: 9%
   - EC coated Aspirin is assoc with incr resistance – hence suggest Noncoated low dose aspirin
   - In severe carotid stenosis: CEA + BMT has an additive benefit to BMT alone in stroke reduction
     (ie in asymp >60% by angio, or >70% by US)

2. Carotid endarterectomy

3. Carotid stenting
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Goal</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiplatelet therapy</td>
<td>Either single or dual drug acceptable</td>
<td>Reduces both stroke rate and overall MACEs</td>
</tr>
</tbody>
</table>
| Antihypertensive therapy | Decrease BP by 10 mm Hg systolic/5 mm Hg diastolic or to 120/80 mm Hg in hypertensive patients | Reduces stroke recurrence  
|                    |                                           | Treat all patients regardless of baseline BP, after first 24 hr          |
| Diabetes mellitus  | Aim for HgbA<sub>1c</sub> < 7            | Reduce overall stroke rate, no benefit in tight control                  |
| Smoking cessation  | Total abstinence                          | Reduces stroke and MACEs                                                 |
| Statin therapy     | Reduce LDL by 50% or <70 mg/dL           | Treat hyperlipidemia and normolipemic patients with H/O stroke, may be beneficial before CEA/CAS |
| Alcohol            | Avoid excessive consumption               |                                                                          |
With medical Rx alone

NASCET:
- 70-99%: 24% stroke at 2 y
- 50-69%: 14.6% at 2 y

ACAS: 11% at 5 y

ACST: 11.8 at 5 y
### Perioperative

<table>
<thead>
<tr>
<th>Trial</th>
<th>Indication</th>
<th>CVA/Death</th>
<th>Risk Reduction</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASCET</td>
<td>Sx: &gt;70%</td>
<td>5.8%</td>
<td>16.5% / 2 years</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Sx: 50%-69%</td>
<td>6.7%</td>
<td>10.1% / 5 years</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>ECST</td>
<td>Sx: 70%-99%</td>
<td>7.5%</td>
<td>9.6% / 3 years</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ACAS</td>
<td>Asx: &gt;60%</td>
<td>2.3%</td>
<td>5.9% / 5 years</td>
<td>0.004</td>
</tr>
<tr>
<td>ACST</td>
<td>Asx: &gt;60%</td>
<td>3.1%</td>
<td>5.4% / 5 years</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

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Patel SG, et al: Outcome, observer reliability, and patient preferences if CTA, MRA, or Doppler ultrasound were used, individually or together, instead of digital subtraction angiography before carotid endarterectomy. *J Neurol Neurosurg Psychiatry* 73:21–28, 2002.
Post CAS
<table>
<thead>
<tr>
<th>Complication</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stent thrombosis</td>
<td>Immediate conversion to carotid endarterectomy</td>
</tr>
<tr>
<td>Kinking at endpoints</td>
<td>Observation vs. additional stent</td>
</tr>
<tr>
<td>Carotid dissection</td>
<td>Observation, balloon apposition vs. additional stent</td>
</tr>
<tr>
<td>Visualized distal embolization</td>
<td>Neurorescue techniques, catheter-directed thrombolysis (recombinant tissue plasminogen activator or urokinase) vs. intravenous or arterial glycoprotein IIb/IIIa inhibitor, thrombus maceration, aspiration thrombectomy, capture and removal of embolus</td>
</tr>
<tr>
<td>Bubble emboli</td>
<td>No treatment</td>
</tr>
<tr>
<td>Carotid spasm</td>
<td>No treatment vs. nitroglycerin</td>
</tr>
<tr>
<td>Stop flow due to debris-full filter</td>
<td>Cautious closure of embolic protection device and retrieval</td>
</tr>
<tr>
<td>Hyperperfusion</td>
<td>Hypotensive drugs</td>
</tr>
</tbody>
</table>

Management of Carotid Artery Stenting neurologic complications
<table>
<thead>
<tr>
<th>AHA</th>
<th>CEA for 50%-99% stenosis, CAS as an alternative in patients at low risk of CAS associated complications or when CEA is high risk if complication rates are 4%-6%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVS</td>
<td>CEA preferred in patients 50%-99%, CAS in hostile neck and severe uncorrectable cardiac conditions</td>
</tr>
<tr>
<td></td>
<td>CEA in good risk patients with 60%-99% stenosis and 3-5 yr life expectancy with complication rates &gt;3%. Insufficient data to support CAS outside trials, may be used by selected Interventionalists with established complication rates &lt;3%. High risk patients should have BMT alone</td>
</tr>
<tr>
<td>ESC</td>
<td>CEA for 70%-99% Stenosis, CAS for high surgical risk</td>
</tr>
<tr>
<td></td>
<td>CEA for 60%-99% stenosis with complications &lt;3% and 5-year survival, CAS as an alternative in high volume centers with complications &lt;3%</td>
</tr>
</tbody>
</table>
Timing of intervention after acute stroke: As long as there is no hemorrhagic component and < 1/3rd of hemispheric involvement – suggest CEA within 1-2 weeks

Recurrent stenosis: 5-8% with both CAS and CEA. Can do recurrent CEA as long as the mortality/stroke risk is <3%. If recurrent stenosis due to CAS – can do CEA: However repeat interventions - Both CAS and CEA – are associated with increased risk

Radiation induced carotid stenosis: Radiation accelerates atherosclerosis. If remote RT to neck and no previous neck surgery, can do CEA with good wound healing and better durability than CAS (CAS – increased recurrence)
Conclusions:

Stroke is the 2\textsuperscript{nd} cause of death and the 1\textsuperscript{st} cause of disability with significant economical impact.

Thrombolysis and stroke units are a major contribution to stroke Rx advancements

Risk factors reduction and BMT – for all pts, pts at increased risk for intervention, or asymp /moderate disease

CEA: Better durability in >70 yrs age group, symptomatic >50\% and asymptomatic good risk moderate stenosis or severe stenosis.

CAS : In symptomatic pts who are at high risk for CEA: due to anatomic or patient factors
AAA is defined as an aortic diameter at least one and one-half times the normal diameter at the level of the renal arteries, which is approximately 2.0 cm.

Every year, 200,000 people in the U.S. are diagnosed with an abdominal aortic aneurysm (AAA). Aortic aneurysms constitute the 15th leading cause of death in the United States and the 10th leading cause of death in men older than 55.

Each year in the United States, AAA rupture causes 4500 deaths, with an additional 1400 deaths resulting from the 45,000 repair procedures performed to prevent rupture. Ruptured aneurysm are estimated to cause 4% to 5% of sudden deaths.

An estimated 15,000 seniors die from abdominal aortic aneurysm rupture each year.
Predisposing factors

Age

Ethnicity

Gender

Family History

Smoking: Smoking has been found to be a major risk factor for aneurysm formation

Other


Symptoms:

None

Abdominal/back pain

**Ruptured aneurysm**
cause 4% to 5% of sudden deaths

Harris LM, Faggioli GL, Fiedler R, Curl GR, Ricotta JJ.
RISK OF RUPTURE

Aneurysm size

- Less than 4.0 cm in diameter – 0%
- 4.0 cm to 4.9 cm in diameter – 0.5% to 5%
- 5.0 cm to 5.9 cm in diameter – 3% to 15%
- 6.0 cm to 6.9 cm in diameter – 10% to 20%
- 7.0 cm to 7.9 cm in diameter – 20% to 40%
- 8.0 cm in diameter or greater – 30% to 50%

Expansion rate
Three-dimensional CT reconstructions allow for accurate, inline measurement of aortic lengths and true cross-sectional diameter.
Computed tomography angiography (CTA) of a patient with a right pelvic kidney (arrow) with renal artery arising from the distal infrarenal abdominal aorta. This patient was deemed an unacceptable candidate for conventional endovascular aneurysm repair because of inevitable coverage of the right renal artery without the ability to preserve the right renal artery.
Axial images and three-dimensional CTA reconstructions demonstrating challenging aneurysm anatomy including a short, angled neck, bilateral common iliac artery aneurysms and left external iliac artery occlusion.
Three-dimensional CT reconstruction showing an abdominal aortic aneurysm with tortuous proximal aorta and tortuous bilateral iliac artery aneurysms.
Axial images and three-dimensional CTA reconstructions demonstrating challenging aneurysm anatomy including a circumferential thrombus and a narrow calcified distal aorta.
Axial CTA image showing visceral involvement in a type IV thoracoabdominal aortic aneurysm
Abdominal aortic aneurysm (AAA) rupture in a patient previously treated with endovascular aneurysm repair (EVAR) seen with Type V endoleak, which had been followed for 2 years for ongoing AAA sac growth without definable focal endoleak. This patient then was seen with acute onset of abdominal and back pain after experiencing several weeks of flank pain and malaise and computed tomographic angiography demonstrated AAA rupture. The patient was successfully converted to open AAA repair.
a | Ultrasonography showing a transverse view of the distal aorta showing the diameter of the vessel. b | Ultrasonography showing a transverse view showing the aortic bifurcation; left and right iliac artery. c | Preoperative and d | postoperative 3D CTA reconstruction for a patient with AAA. e,f | Two postoperative 3D MRA reconstructions for a patient with AAA. g | IVUS demonstrating incomplete expansion of a stent graft in an AAA. Reprinted from Lee, J. T. & White, R. A. Basics of intravascular ultrasound: an essential tool for the endovascular surgeon. Semin. Vasc. Surg. 17, 110–118, Copyright 2004, with permission from Elsevier. h | IVUS demonstrating standard measurement of the aorta at the level of the renal arteries. Reprinted from Marrocco, C. J. et al. Intravascular ultrasound. Semin. Vasc. Surg. 25, 144–152, Copyright 2012, with permission from Elsevier. Abbreviations: AAA, abdominal aortic aneurysm; CTA, computed tomography angiography; IVUS, intravascular ultrasound; MRA, magnetic resonance angiography.
Zenith Fenestrated aortic endograft (Cook Medical, Bloomington, IN) with bilateral renal artery fenestrations, covered renal artery stents, and a superior mesenteric artery scallop.
Surgical repair versus endovascular repair

The short-term technical success rate for endovascular aneurysm repair is more than 95%. Thirty-day mortality **after elective surgical repair in major randomized trials** ranges from 2.7% to 5.8%.

30-day all-cause mortality was significantly lower with endovascular repair compared with surgical repair (1.6% versus 4.8%). For patients who are at high risk for surgery, the short-term mortality rate is significantly lower with endovascular repair.


Various guidelines have been issued regarding screening for AAA. The United States Preventive Services Task Force (USPSTF) makes the following recommendations:

- Men between 65 to 75 years of age who have ever smoked should be screened once for AAAs by abdominal USG. The USPSTF found little benefit to repeat screening in men who have a negative USG and who are older than 75 years of age.
- The USPSTF does not make any recommendation for men 65 to 75 years of age who have never smoked.
- The USPSTF recommends against screening women for AAA.

The American College of Cardiology/American Heart Association (ACC/AHA) guidelines issued in 2005 regarding screening of patients for AAA recommended that men 60 years of age or older who are either siblings or offspring of patients with AAAs should undergo a physical examination and USG screening for the detection of AAA. As well, the guideline recommended that men 65 to 75 years of age who have ever smoked should undergo a physical examination and one-time ultrasound screening for detection of AAAs.

The 2005 ACC/AHA guidelines recommended that aneurysms 3.0 cm to 4.0 cm in diameter should be monitored by USG every two to three years, and those with a diameter ranging from 4.0 cm to 5.4 cm should be monitored by USG or CT every six to 12 months.

The SAAAVE Act

Abdominal aortic aneurysm rupture is one of the leading causes of death in the U.S. and an estimated 15,000 seniors die from abdominal aortic aneurysm rupture each year. Now, for the first time, new Medicare beneficiaries at risk for abdominal aortic aneurysm will have the opportunity to be screened.

The Screening Abdominal Aortic Aneurysms Very Efficiently (SAAAVE) Act, which was enacted by Congress and signed into law by President Bush, effective January 1, 2007.

This abdominal aortic aneurysm screening will be available for men who have smoked at least 100 cigarettes and men and women with a family history of abdominal aortic aneurysm. In order to be reimbursed, this screening must be part of the Welcome to Medicare physical.
CONCLUSION

AAAs are mostly asymptomatic and found incidentally. The incidence of AAA is higher in Caucasian men, individuals older than 60 years of age and smokers. Diagnosis is usually reached using imaging modalities.

Aneurysm rupture is a medical emergency and risk of aneurysm rupture increases with increasing diameter, rapid expansion, symptomatic aneurysm and history of smoking. Surgical intervention is recommended for all symptomatic aneurysms and asymptomatic aneurysms greater than 5.5 cm in diameter.

Regular surveillance through imaging studies should be conducted in asymptomatic aneurysms 3 cm to 5.5 cm in size.

Medical management with beta-blockers, cessation of smoking and management of risk factors, such as dyslipidemia and hypertension, may be helpful in patients with small- to medium-sized aneurysms that are not treated surgically.