Brachiocephalic and Cerebral Vascular Anatomy
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and
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Goals

1. Appreciate the angiographic anatomy of extracranial and intracranial cerebral vessels
2. Understand the location of the intracranial vessels relative to CNS tissue
3. Understand the location of the carotid and vertebral arteries relative to the skull base
4. become familiar with angiography
GOALS

5. Appreciate the importance of perforators vessels
6. Understand collateral circulation and the Circle of Willis
7. Understand Carotid dissection
8. Appreciate the Venous Anatomy of the Brain
9. Identify vascular pathology using neuroimaging
Goals

10. Understand CT perfusion and its utility in acute stroke therapy
11. Appreciate the utility of endovascular therapy in Acute Stroke
VENOUS VASCULAR ANATOMY
SINUS THROMBOSIS
Perforators
Perforators
Lenticulostriates
0.21 MICROCATHER RUN occluded prox ICA
Circle of Willis

• 4 vessels that feed brain
• 2 carotid arteries
• 2 vertebral arteries
• Usually incomplete circle
Origins of Cerebral Collaterals

- Anterior Communicator
- Posterior Communicator
- Ethmoidal - Retrograde Ophthalmmic
- Pial
ARTERIAL DISSSECTIONS
Fibromuscular Dysplasia
What Is Stroke?

Stroke is the death of brain Cells
There are two types of stroke:
Ischemic and Hemorrhagic
Transient ischemic attack (TIA) is a temporary stroke with symptoms that last less than 24 hours. The blood clot eventually dissolves and the artery reopens.

The severity of TIA depends on the portion of the brain that is denied blood.

Often, brain imaging fails to demonstrate any abnormal findings. Typically, embolic stroke is the cause of TIA.
Sources Embolic Stroke

- Heart
  - Clots
  - Structural Defects
- Atheroma Aortic Arch
- Atheroma Brachiocephalic and or Intracranial vessels
- Clotting Disorders
- Small vessel disease
- Vasculitis
- Trauma
MI vs. Stroke

Heart attacks kill muscle cells that decrease the ability of the heart to pump blood

When brain cells die they may sub serve a unique function, resulting in permanent loss of motor function, speech, vision, intellectual function etc.
TOOLS OF THE TRADE

SOPHISTICATED IMAGING MAKES ALL THE DIFFERENCE
Time vs bleeding
Two million brain cells die every minute during a stroke. Therefore, every second counts. Time is brain
Ischemic Stroke
Brain Viability
Ischemic Penumbra
STROKE THERAPY
Like Plumbing

• Stroke therapy either
• opens blocked arteries (ischemic stroke)
• repairs burst blood vessels (hemorrhagic)
STROKE THERAPY
Like Plumbing

• Clogged Pipe
  • Drano - IV tPA
  • Snake - clean out pipe - Catheters

• Broken Pipe Leaking
  • Patch Pipe - stent
  • Fill Defect – coils or glue
  • Bypass or clip – open surgery
Major symptoms of stroke

• Weakness, numbness, or paralysis of the arms or legs, especially on one side of the body
• Inability to hold arm upward
• Facial droop, inability to smile
• Unexplainable worst headache of life, light is bothersome, neck stiffness
• Severe dizziness, loss of balance
• Loss of normal vision
• Confusion and problems with speech - can not think of a word, can not say a word
Variable factors that you can control

• High blood pressure (hypertension)
• High cholesterol (hypercholesterolemia)
• Peripheral vascular disease
• Heart disease, especially atrial fibrillation (irregular heart beat)
• Smoking
• Diabetes mellitus
• Poor diet: high fat, high cholesterol, high salt
• Lack of exercise
• Obesity
• Alcohol abuse
• Drug abuse
• Prior stroke or TIA
Fixed factors that you cannot control

Age
- your chance of stroke doubles every 10 years after the age of 55 for both men and women

Hereditary
(family history) because some strokes may be caused by genetic disorders

Gender
women who smoke and use birth control pills have increased risk of stroke, especially after age 35

Race
high blood pressure and sickle cell anemia are more prevalent amongst African Americans. Hispanics also posses a higher risk of stroke
Endovascular Therapy for Ischemic Stroke with Perfusion-Imaging Selection
March 12, 2015

- MR CLEAN
- IV tPA and Endovascular therapy
- Most Patients were within 60 of stroke center with endovascular capability
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Alteplase-Only Group (N = 35)</th>
<th>Endovascular-Therapy Group (N = 35)</th>
<th>Adjusted</th>
<th>Effect Size (95% CI)†</th>
<th>P Value</th>
<th>Unadjusted</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary outcomes</strong></td>
<td></td>
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<tr>
<td>Median reperfusion at 24 hr (IQR) — (%)‡‡</td>
<td>37 (-0.5 to 96)</td>
<td>100 (100 to 100)</td>
<td>4.7 (2.5 to 9.0)</td>
<td>&lt;0.001</td>
<td>4.9 (2.5 to 9.5)</td>
<td>&lt;0.001</td>
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<tr>
<td>Early neurologic improvement — no. (%)§§</td>
<td>13 (37)</td>
<td>28 (80)</td>
<td>6.0 (2.0 to 18.0)</td>
<td>0.002</td>
<td>6.8 (2.3 to 20)</td>
<td>&lt;0.001</td>
<td></td>
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<td><strong>Secondary outcomes</strong></td>
<td></td>
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<tr>
<td>Score on the modified Rankin scale at 90 days¶¶</td>
<td></td>
<td></td>
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<tr>
<td>Median score (IQR) on ordinal analysis</td>
<td>3 (1 to 5)</td>
<td>1 (0 to 3)</td>
<td>2.0</td>
<td>0.02</td>
<td>2.1 (1.2 to 3.8)</td>
<td>0.006</td>
<td></td>
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<tr>
<td>Independent outcome — no. (%)</td>
<td>14 (40)</td>
<td>25 (71)</td>
<td>4.2 (1.4 to 12)</td>
<td>0.01</td>
<td>3.8 (1.4 to 10.0)</td>
<td>0.009</td>
<td></td>
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<tr>
<td>Excellent outcome — no. (%)</td>
<td>10 (29)</td>
<td>18 (51)</td>
<td>2.4 (0.87 to 6.6)</td>
<td>0.09</td>
<td>2.6 (1.0 to 7.1)</td>
<td>0.05</td>
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<td><strong>Safety — no. (%)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Death</td>
<td>7 (20)</td>
<td>3 (9)</td>
<td>0.45 (0.1 to 2.1)</td>
<td>0.31</td>
<td>0.38 (0.1 to 1.6)</td>
<td>0.18</td>
<td></td>
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<tr>
<td>Symptomatic intracerebral hemorrhage</td>
<td>2 (6)</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>-6 (-13 to 2)</td>
<td>0.49</td>
<td></td>
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<tr>
<td>Parenchymal hematoma</td>
<td>3 (9)</td>
<td>4 (11)</td>
<td>NA</td>
<td>NA</td>
<td>3 (-11 to 17)</td>
<td>0.99</td>
<td></td>
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<td><strong>Tertiary outcomes</strong></td>
<td></td>
<td></td>
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<tr>
<td>Reperfusion of &gt;90% at 24 hr without symptomatic intracerebral hemorrhage — no. (%)</td>
<td>12 (34)</td>
<td>31 (89)</td>
<td>27.0 (5.5 to 135.0)</td>
<td>&lt;0.001</td>
<td>15.0 (4.0 to 52.0)</td>
<td>&lt;0.001</td>
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<tr>
<td>Recanalization at 24 hr — no. (%)‡‡†‡</td>
<td>15 (43)</td>
<td>33 (94)</td>
<td>29.0 (5.4 to 155.0)</td>
<td>&lt;0.001</td>
<td>22.0 (4.5 to 106.0)</td>
<td>&lt;0.001</td>
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<tr>
<td>Median infarct growth at 24 hr (IQR) — ml†††</td>
<td>35.3</td>
<td>10.9</td>
<td>-0.44</td>
<td>0.007</td>
<td>NA</td>
<td>NA</td>
<td></td>
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<tr>
<td>Median home time (IQR) — days¶¶</td>
<td>15 (0 to 69)</td>
<td>73 (47 to 86)</td>
<td>64 (28 to 90)</td>
<td>0.001</td>
<td>58 (17 to 90)</td>
<td>0.006</td>
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</tbody>
</table>
STENT RETRIEVER FOR ACUTE STROKE CASE
Different Types of Hemorrhagic Stroke by Location
Hemorrhagic Stroke
TREATMENT OF CEREBRAL ANEURYSM Sub Arachnoid Hemorrhage, SAH
Trauma is the Number one cause of SAH 50% of reported cases
History

- Worst HA of life
- Thunderclap onset
- Sustained headache
- Nuchal rigidity
- Photophobia
- If trauma – did they fall and bleed or bleed then fall
SAH Incidence

MORTALITY
APPROX 0.5%
5-10/100,000
Death from initial bleed 40-50%
APPROXIMATELY 25-35% OF PATIENTS WHO PRESENT TO ER WITH SAH ARE SENT HOME WITHOUT IMAGING
REBLEED RATE
4% in first 24 hours
1% per day for 14 days
The best method for reducing rebleeding within the first 24hrs is BP control.

Both hypotension and hypertension must be avoided.
Stent-coil
MCA Surgery Videos
Intracranial Atherosclerotic Disease
WASID- Warfarin vs Aspirin for Symptomatic Intracranial Disease

806 patients followed 3 years, 60 centers
TIA or Ischemic stroke <90 days due to ≥ 50% stenosis of a major intracranial artery
Warfarin (INR 2-3) vs Aspirin 1300 mg/d

1° endpoint- stroke or vascular death

2° endpoint- ipsi lateral territory ischemic stroke, vascular death, MI, major hemorrhage

Establish a prospective natural history to compare to other therapies.
WASID FINAL

- 4.3% rate of death in the aspirin group and a 9.7% rate in the warfarin group (P=0.02);
- 3.2% rate of major hemorrhage in the aspirin group and a 8.3% rate in the warfarin group (P=0.01);
- 2.9% rate of myocardial infarction or sudden death in the aspirin group vs. a 7.3% rate in the warfarin group (P=0.02).
Diamox Spect Scan
Brain Stress Test
Asymptomatic Disease
No Clear Data
Intracranial Atherosclerosis

- Antiplatelet therapy alone or in combination
- If Symptomatic

Angioplasty Alone
Angioplasty Stent
No treatment
Rcca pre filter
RCCA post plasty
Stent deployment
Capture of filter
EPI
3D Angio pre and post
TREATMENT OF INTRACRANIAL STENOSIS WITH ANGIOPLASTY
MASS EFFECT
Cerebral AVM AVF
HEMICRANIECTOMY

- Hamlet Trial
  - Patients randomized up to 96 hours
  - Patients did best before 48 hours
  - 10% all strokes end up with malignant MCA syndrome
  - These patient should have hemicraniectomy
  - Large MCA infarctions 50-80% death rate
  - Hemicraniectomy 50% risk reduction
HEMICRANIECTOMY

- One year after hemicraniectomy mRS 4 increased, less mRS 5, mRS \( \frac{3}{4} \) increased 60% MRS 2 14%
- Size hemicraniectomy > 12cm
- No change in outcome right vs left
- All data age < 60 yrs
Pharmaceutical Division

ARTERIAL SYSTEM

Internal carotid artery system

1 — Internal carotid artery
2 — Ophthalmic a.  a — supraorbital a.
   b — dorsal nasal a.
   c — retinal choroid plexus
3 — Posterior communicating a.
4 — Anterior choroidal a.*

* The arterial bed was simplified to choroid plexus.
Numerous parenchymal branches were omitted
for the sake of comprehensibility.
5 — Anterior cerebral artery  a — precommunicating  
               b — postcommunicating segment
6 — Anterior communicating a.
7 — Pericallosal a.
8 — Medial frontobasal (medial orbitofrontal) a.
9 — Frontopolar a.
10 — Callosomarginal a.
11 — anteromedial frontal branch
12 — mediomedial frontal branch
13 — posteromedial frontal branch
14 — Paracentral a.
15 — Precuneal (superior internal parietal) a.
16 — Parietooccipital (inferior internal parietal) a.
17 — Anteromedial central (lenticulostriate medial perforating, 
       recurrent Heubner’s) a.
18 — Middle cerebral artery  a — sphenoid segment  
               b — insular segment  
               c — opercular segment  
               d — terminal segment
19 — Lateral frontobasal (lateral orbitofrontal) a.
20 — Operculofrontal (prefrontal) a.
21 — Precentral sulcal (pre-Rolandic) a.
22 — Central sulcal (Rolandic) a.
23 — Postcentral sulcal (post-Rolandic, anterior parietal) a.
24 — Posterior parietal a.
25 — Artery of the angular gyrus
26 — Temporal polar a.
27 — Anterior temporal a.
28 — Middle temporal a.
29 — Posterior temporal a.
30 — Temporooccipital a.
31 — Insular aa.

32 — Anterolateral central (lenticulostriate lateral perforating, Charcot’s) aa.

Vertebrobasilar system

33 — Posterior cerebral artery

34 — Anterior temporal branch (inferior anterior temporal a.)
35 — Posterior temporal branch (inferior posterior temporal a.)
36 — Occipitotemporal branch
37 — Calcarine (internal occipital) a.
38 — Posterior pericallosal a.
39 — Parietooccipital a.
40 — Posteromedial central (anterior thalamoperforate) aa.
41 — Posterolateral central (posterior thalamoperforate) aa.
42 — Medial posterior choroidal a.
       Lateral posterior choroidal a.
43 — Paramedian aa.
44 — Short circumferential aa.
45 — Long circumferential aa., Mesencephalic aa.
46 — Posterior inferior cerebellar a.
47 — Anterior inferior cerebellar a.
48 — Superior cerebellar a.
49 — Anterior spinal a.
50 — Posterior spinal a.
51 — Muscular branches
52 — Vertebral a.
53 — Basilar a.
VENOUS SYSTEM

I. Ascending (superior) cerebral veins

1 — Frontal vv.
2 — Precentral (frontoparietal, v. of Trolard) vv.
3 — Parietal (central, v. of Roland) vv.
4 — Occipital vv.
5 — Posterior cerebral vv.
6 — Petrosal (v. of Dandy) v.

II. Descending (inferior) cerebral veins

7 — Middle cerebral (Sylvian fossa) v.
8 — Temporooccipital (v. of Labbé) v.
9 — Ophthalmic v.
10 — Superior sagittal (longitudinal) sinus
11 — Inferior sagittal (longitudinal) sinus
12 — Rectus (straight) sinus
13 — Transverse sinus
14 — Sigmoid sinus
15 — Sphenoparietal sinus
16 — Cavernous sinus
17 — Petrosal sinus
18 — Confluens sinuum (torcular Herophili)
19 — Falcotentorial confluens sinuum
20 — Vein of Galen
21 — Venous angle of Monro
22 — Basilar venous confluens
23 — Septal v.
24 — Thalamostriate v.
25 — Internal cerebral v.
26 — Basal v. (of Rosenthal)
27 — Caudate vv.
28 — Insular vv.
29 — Hippocampal v.
30 — Lenticulostriate vv.
31 — Pontine v.
32 — Occipital internal v. (calcarine and parietomedial branch)
33 — Orbital vv. and vein of olfactory gyrus
34 — Posterior callosal (splenial) v.
35 — Jugular v.
36 — Superficial pontine vv.
37 — Peduncular and central pontine vv.
38 — Mesencephalic v. (of lateral mesencephalic sulcus)
39 — Precentral cerebellar v.
40 — Vermian cerebellar v.
41 — Superior cerebellar vv.
42 — Inferior cerebellar vv.
43 — Tentorial vv.
44 — Choroidal v.