Cerebral Revascularization
Microsurgical Approach on Stroke Prevention

16 May 2017
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Neurosurgery Tuen Mun Hospital
Carotid Endarterectomy and EC-IC bypass

CEREBRAL REVASCULARIZATION
Carotid Endarterectomy

CAROTID STENOSIS
Landmark paper

The New England Journal of Medicine

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Volume 325  AUGUST 15, 1991  Number 7

BENEFICIAL EFFECT OF CAROTID ENDARTERECTOMY IN SYMPTOMATIC PATIENTS WITH HIGH-GRADE CAROTID STENOSIS

North American Symptomatic Carotid Endarterectomy Trial Collaborators*
• SJ Peerless
  – Professor and Chairman of the Division of Neurosurgery in the Department of Clinical Neurological Sciences

• GG Ferguson
  – Chief of Neurosurgery at University Hospital, Professor of Neurosurgery and Medical Biophysics

• University of Western Ontario
  (University Hospital and St Joseph’s Heath Center)
The term ‘carotid’ derived from Greek word ‘karos’ meaning deep sleep.
Carotid stenosis

- Cerebral ischemia /infarction due to carotid stenosis:
  - Embolism with platelet aggregates, thrombi or fragments from atheroma plagues at carotid bifurcation
  - Flow reduction because of the arterial narrowing/occlusion
2 SYMPTOMATIC CASES
M/54
HT, DM

Transient left side weakness and Left homonymous hemianopia

MRI: Acute infarct over right watershed and occipital region

Medical Rx
Aspirin, plavix, insulin, zocor

Recurrent symptoms within a week and readmitted
M/54
DSA revealed severe stenosis
LHCS M/54
CEA under GA
Intra-operative monitor:
EEG
SSEP
Uneventful surgery
The procedure

CAROTID ENDARTERECTOMY
Clips application in sequence: ICA, CCA, ECA
Arteriotomy and endarterectomy
Backflow from ICA
Clips off sequence: ECA, CCA, ICA
EEG monitoring in Carotid endarterectomy (G.A.)

Raw EEG

Compressed Spectral Array (CSA)

Density Spectral Array (DSA)
Changes at clamping

Clamps on
Clamps off
Clamps on
Clamps off
SSEP summary
No significant change throughout the procedure
CEA (G.A.)
EEG signal changed after cross clamping
EEG signal changed after cross clamping, required shunting/ by-pass
Shunt if EEG/SSEP depressed in clamping

Shunt placement

A shunt helps keep blood flowing during the procedure.
SECOND CASE
M/69
Chronic smoker
Good past health
Sudden onset left side weakness
MRI: acute infarct over MCA territory
Medical Rx
Antiplatelet, antilipid
Power improved over 4 weeks
MBI: 67->88
ADLi
M/69
Tight stenosis at proximal ICA
CEA under RA
BENEFICIAL EFFECT OF CAROTID ENDARTERECTOMY IN SYMPTOMATIC PATIENTS WITH HIGH-GRADE CAROTID STENOSIS

NORTH AMERICAN SYMPTOMATIC CAROTID ENDARTERECTOMY TRIAL COLLABORATORS*
Benefit of CEA in symptomatic patients in North American Symptomatic Carotid Endarterectomy Trial

<table>
<thead>
<tr>
<th>% stenosis</th>
<th>Nonsurgical Stroke risk</th>
<th>Surgical Stroke risk</th>
<th>Absolute risk reduction</th>
<th>NNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-69%</td>
<td>22.2%</td>
<td>15.7%</td>
<td>6.5% at 5 years</td>
<td>20</td>
</tr>
<tr>
<td>70-99%</td>
<td>26%</td>
<td>9%</td>
<td>17% at 2 years</td>
<td>8</td>
</tr>
</tbody>
</table>
Severe symptomatic carotid stenosis

Any Ipsilateral Stroke, 70–99% Stenosis

Proportion without Events

P \leq 0.001

NO. AT RISK

Surgical therapy: 300, 290, 281, 264, 247, 224, 174, 111
Medical therapy: 275, 249, 230, 218, 207, 192, 151, 73
Moderate symptomatic carotid stenosis
Risk of stroke in moderate vs severe stenosis
Surgical performance of the study

• Centers with 50 CEA cases performed in 24 months
• Surgeons with <6% peri-operative complication rate
  – Performance of surgeons continuously evaluated by principal surgical investigators
• Majority done under GA
• Surgical time 2-2.5 hours
• 40% shunt rate
• Median unshunted clamp time: 32min
• Majority of arteriotomy closed by simple closure
Recommedations from American Stroke Association

• Indication of Carotid endarterectomy in **symptomatic** stenosis:
  – Severe carotid stenosis **70-99%**
  – Recent TIA or ischemic stroke within 6 months
  – Perioperative mortality and morbidity <6%
  – Moderate carotid stenosis 50-69% with favorable patient **factors**: age, gender, comorbidities, and severity of initial symptoms

• Operation ideally done within 2 weeks
Asymptomatic patients?
Asymptomatic carotid stenosis

Advancement of current medical therapy reducing stroke risk in asymptomatic stenosis patients improved over years.

Fig. 1. Decreasing trends in the risk of ipsilateral stroke seen in patients with asymptomatic carotid artery stenosis randomized to medical therapy in ACAS and ACST. Data obtained from Naylor.30

Fig. 2. Change in the 5-year and annual risk of any stroke over time among patients receiving medical therapy alone in ACAS and ACST. Data obtained from Naylor.30
Identification of high risk patients in asymptomatic stenosis

- Silent infarct on CT/MRI
- Cerebrovascular reserve
- Progressive stenosis on FU
- Contralateral carotid occlusion
- Microemboli on transcranial doppler
- Plaque related factors
  - Severe stenosis
  - Lipid rich
  - Intra-plaque hemorrhage
Asymptomatic carotid stenosis

• Indications of CEA
  – High risk patients with severe stenosis >70%
  – Performed by centers with <3% morbidity and mortality
CEA in recent 8 years (2009-2016) in Tuen Mun Neurosurgery Department

- 63 patients Age: 53-81
- M:F 55:8
- GA: RA 24:39 (1 from RA to GA)
- Shunt bypass: 6 (9.5%)
- Peri-operative complications:
  - 1 transient ischemia*(1.6% 30 day peri-operative risk)
  - 2 wound haematoma
  - 1 transient hoarseness
- 1 TIA (8 months after CEA)
- No recurrent stroke
- No re-stenosis (carotid doppler, CTA)
- 4 mortality unrelated to stroke (1 Ca rectum, 1 Ca lung, 1 HCC, 1 pneumonia)
- No myocardial infarct
Alternative intervention

• Carotid stenting
  – Radiation induced stenosis
  – Poor medical condition
  – Restenosis after CEA
  – Prior radical neck surgery
  – Contralateral ICA occlusion
Stenosed irregular lumen
# Natural history of carotid stenosis

<table>
<thead>
<tr>
<th>Natural History</th>
<th>Risk of stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic &lt;70%</td>
<td>0.5%/ year</td>
</tr>
<tr>
<td>Symptomatic ≥70%</td>
<td>10% first 3 months, 5-6%/year</td>
</tr>
<tr>
<td>Asymptomatic ≥ 70%</td>
<td>3-3.5%/year</td>
</tr>
<tr>
<td>Asymptomatic carotid stenosis with contralateral occlusion</td>
<td>5-6%/ year</td>
</tr>
<tr>
<td>Progressive asymptomatic stenosis</td>
<td>4-5%/ year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trial Data-Intervention Risk of Stroke</th>
<th>CREST, ICSS, NEJM, Neurology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angioplasty</td>
<td>4.7-7.7%</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>2.3-5.5%</td>
</tr>
</tbody>
</table>
Guidelines for performance of Carotid Endarterectomy

• Appropriate patients
  – Symptomatic 70-99% stenosis

• Uncertain patients
  (careful patient selection + low perioperative risk center)
  – Symptomatic 50-69% stenosis
  – Asymptomatic 60-99% stenosis

• Inappropriate patients
  – <50% symptomatic stenosis
  – <60% asymptomatic stenosis
  – Unstable medical or neurological status
  – Recent large cerebral infarction
  – Decreased level of consciousness
  – Surgically inaccessible stenosis
CEREBRAL REVASCULARIZATION

Extracranial-Intracranial (EC-IC) bypass
M/72
Chronic smoker
Chronic drinker
Right eye blind
Sudden onset of left side weakness with partial recovery
Limb side limb power Gr 4
ADL independent
Carotid doppler revealed severe right cervical ICA occlusion/stenosis
DSA: right cervical ICA occlusion
EC-IC bypass

• The STA–MCA bypass is the procedure first successfully performed by M. G. Yasargil in the treatment of occlusive cerebrovascular disease in 1967

• In late 1960s, EC-IC bypass widely performed in ischemic stroke
A and B, Anatomical relationships of the superficial temporal artery and middle cerebral artery. C, Intraoperative view showing completed anastomosis prior to closure of the dura, replacement of the bone flap, and closure of the soft tissues. The temporalis fascia, periosteum, subcutaneous fat, and dura are not depicted.
EC-IC bypass

- In mid 1980s, Barnett (EC-IC bypass Trial) questioned the true efficacy of the bypass procedure to decrease the risk of ischemic stroke
- A small subgroup of patients despite having optimal medical treatment still have ischemic symptoms referable to the vascular territory with underperfused and poor collateral supply
- More sophisticated investigations to select patient for revascularization
Circle of Willis
Figure 1. Cerebral arterial circulation. (A) Extracranial arterial collateral circulation. Shown are anastomoses from the facial (1), maxillary (2), and middle meningeal (3) arteries to the ophthalmic artery, and dural arteriolar anastomoses from the middle meningeal artery (4) and occipital artery through the mastoid foramen (5) and parietal foramen (6). Intracranial arterial collateral circulation in frontal (B) and lateral (C) views. Shown are the posterior communicating artery (1); leptomeningeal anastomoses between anterior and middle cerebral arteries (2) and between posterior and middle cerebral arteries (3); the tectal plexus between posterior cerebral and superior cerebellar arteries (4); anastomoses of distal cerebellar arteries (5); and the anterior communicating artery (6).
Assessment of collateral circulation

Anatomical Imaging
- Cerebral Angiogram
- CT Angiogram
- MR Angiogram

Physiologic imaging
- CT Perfusion
- MR Perfusion
- Positron Emission Tompography (PET)
CT perfusion

Perfusion maps calculated by computer software after rapid bolus of iodinated contrast injection

Mean transit time, MTT
Time taken for blood to traverse a given brain region; sec

Cerebral blood flow, CBF
Volume of blood traversing a brain region per unit time; ml/100g/min

Cerebral blood volume, CBV
Total amount of blood flowing through a brain region at any one time: ml/100g
Cerebral vascular reserve
Cerebral vasodilator
Acetazolamine

Example:
CTP revealed poor left cerebral perfusion and reserve

Left STA-MCA bypass Sep2011

FU CTP showed marked improvement
## CT perfusion interpretation

<table>
<thead>
<tr>
<th>CT perfusion parameters</th>
<th>Normal</th>
<th>Stenosis/occlusion with good collateral</th>
<th>Oligemic tissue that likely to survive</th>
<th>Oligemic tissue at risk</th>
<th>Tissue irreversibly damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTT</td>
<td>Normal</td>
<td>Prolonged</td>
<td>Prolonged</td>
<td>Prolonged</td>
<td>Marked prolonged</td>
</tr>
<tr>
<td>CBF</td>
<td>Normal</td>
<td>Normal</td>
<td>Mild Reduction</td>
<td>Marked reduction</td>
<td>Severely reduced</td>
</tr>
<tr>
<td>CBV</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal/Mild reduction</td>
<td>Moderate reduction</td>
<td>Severely reduced</td>
</tr>
<tr>
<td>Intervention</td>
<td>Not indicated</td>
<td></td>
<td>Acetazolamide challenge</td>
<td>Most useful</td>
<td>Not useful</td>
</tr>
</tbody>
</table>
Anatomical localization

- Cervical ICA occlusion
- Intracranial arterial occlusion/stenosis
  - Petrous or cavernous ICA occlusion
  - Supraclinoid ICA stenosis or occlusion
  - MCA stenosis or occlusion
- Moyamoya Disease
- Vertebrobasilar insufficiency
Cervical ICA occlusion

- >80% tolerate unilateral occlusion without suffering a significant ischemic event
- Small percentage become symptomatic during hypotension or high hemodynamic stress
- Older
- Symptoms due to watershed hypoperfusion
- Carotid Occlusion Surgery Study Trial
Carotid Occlusion Surgery Study

Extracranial-Intracranial Bypass Surgery for Stroke Prevention in Hemodynamic Cerebral Ischemia
The Carotid Occlusion Surgery Study Randomized Trial
Carotid Occlusion Surgery Study

• ECIC bypass + Medical Rx vs Medical Rx only
• Patients with symptomatic atherosclerotic internal carotid artery occlusion (AICAO) and hemodynamic cerebral ischemia
Results

- The trial was terminated early for futility.

<table>
<thead>
<tr>
<th></th>
<th>ECIC+Medical Rx</th>
<th>Medical Rx only</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 years stroke rate</td>
<td>21%(20 events)</td>
<td>22.7(20 events)</td>
</tr>
<tr>
<td>30 days ischemic stroke</td>
<td>14.4%(14/97)</td>
<td>2.0%(2/98)</td>
</tr>
</tbody>
</table>

- Two-year rates for the primary end point were 21.0% (95% CI, 12.8% to 29.2%; 20 events) for the surgical group and 22.7% (95% CI, 13.9% to 31.6%; 20 events) for the nonsurgical group ($P = .78$, Z test), a difference of 1.7% (95% CI, -10.4% to 13.8%).
- Thirty-day rates for ipsilateral ischemic stroke were 14.4% (14/97) in the surgical group and 2.0% (2/98) in the nonsurgical group, a difference of 12.4% (95% CI, 4.9% to 19.9%).
The primary end point is defined in the footnote to Table 3. The number of participants who remained event free and available for follow-up evaluation at each 90-day interval is shown. EC-IC indicates extracranial-intracranial.
Comments on COSS

• High peri-operative morbidity
  – 14.4% in COSS
  – 0% in the Japanese EC-IC bypass Trial (JET)

• Outcome at 2 years are not significantly different, a continuation of the curves could result in a crossover benefiting surgery

• Mean time from symptoms to enrollment in COSS was about 72 days, the enrollees were more stable patients

• PET failed to identify the right candidates for bypass
The primary end point is defined in the footnote to Table 3. The number of participants who remained event free and available for follow-up evaluation at each 90-day interval is shown. EC-IC indicates extracranial-intracranial.
<table>
<thead>
<tr>
<th>Stroke rate</th>
<th>Medical</th>
<th>Surgical early</th>
<th>Surgical late per yr</th>
<th>Surgical 2 years risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSS 2010</td>
<td>11,4% per yr</td>
<td>15%</td>
<td>3% per yr</td>
<td>21%</td>
</tr>
<tr>
<td>JET</td>
<td>14,2%</td>
<td>0%</td>
<td>5,1%</td>
<td>10,2%</td>
</tr>
<tr>
<td>Masaryk HS</td>
<td>7,5%</td>
<td>1,1% per yr</td>
<td></td>
<td>9,7%</td>
</tr>
<tr>
<td>Sames, 2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zurich</td>
<td>15% per yr</td>
<td>0%</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>Yonekawa, 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>15% per yr</td>
<td>0%</td>
<td></td>
<td>8,7%</td>
</tr>
<tr>
<td>Sharma, 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ECIC bypass evolution in the world 1967-2017

- Barnett 1985
- COSS 2010
- Specialized centers

Yasargil, Donaghy
CVRC
PET-OEF
EC-IC bypass in TMH (2008-2016)

• 37 procedures (3 patients with bilateral procedures)
• Age: 22-77
• M:F 24:10
• Pre-operative Ix: All symptomatic with DSA+CTP
• Pathology:
  – Atherosclerosis: 31 (6 with RT)
  – Moya Moya Disease: 6
• Anatomic locations:
  – Extracranial ICA 22
  – Intracranial arterial stenosis 13
  – Posterior circulation 2
EC-IC bypass in TMH (2008-2016)

• 30 days peri-operative complications:
  – 2 (5.4%) cerebrovascular events: 1 (2.7%) new cerebral infarct, 1 IVH at D26
  – 4 epilepsy
  – 2 subdural hematoma (treated conservatively)
  – 1 pseudomeningocele (LP)

• Cerebrovascular events beyond 30 days:
  – 4 more cases: 3 TIA, 1 IVH(MMD)

• 4 mortality unrelated to stroke (1 Ca lung, 1 HCC, 2 pneumonia)

• Bypass patency confirmed in 27 cases
• CT perfusion improved in 20 cases
## Results

- Rough comparison with COSS

<table>
<thead>
<tr>
<th></th>
<th>ECIC+Medical Rx</th>
<th>Medical Rx only</th>
<th>TMH ECIC</th>
<th>ECIC (- MMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 years stroke rate</td>
<td>21%(20 events)</td>
<td>22.7(20 events)</td>
<td>4.8% (1 event)</td>
<td>6.67%(1/15)</td>
</tr>
<tr>
<td>30 days ischemic stroke</td>
<td>14.4%(14/97)</td>
<td>2.0%(2/98)</td>
<td>2.7% (1/37)</td>
<td>3.2%(1/31)</td>
</tr>
</tbody>
</table>

- Cannot directly compare the 2 year stroke rate: 13 patients not reached 2 years FU, only 21 patients included
The Procedure

STA-MCA BYPASS
Superficial temporal artery – middle cerebral artery (STA-MCA) bypass

1. Isolate STA
2. Craniotomy and identify the MCA branch
3. Anastomosis
MCA segment temporary clipped
Arteriotomy on MCA
MCA lumen irrigated
End to side anastomosis
Patency checked after anastomosis

ICG angiography  Anastomosis completed
Cervical ICA Occlusion
M/72
Chronic smoker
Chronic drinker
Right eye blind
Sudden onset of left side weakness with partial recovery
Limb side limb power Gr 4
ADL independent
Carotid doppler revealed severe right cervical ICA occlusion/stenosis
DSA: right cervical ICA occlusion
M/72
CTP: impaired right cerebral perfusion and reserve
Right STA-MCA bypass Dec2011
Postop CTP revealed improved perfusion and reserve
No ischemic event, ADLi, Walks unaided
Anatomical localization

- Cervical ICA occlusion
- Intracranial arterial occlusion/stenosis
  - Petrous or cavernous ICA occlusion
  - Supraclinoid ICA stenosis or occlusion
  - MCA stenosis or occlusion
- Moyamoya Disease
- Vertebrobasilar insufficiency
Supraclinoid ICA stenosis or occlusion

• Younger
• Pathology often dissection rather than atherosclerotic
• Bypass is extremely effective especially occlusion is above the Pcom origin
Distal ICA Occlusion

M/55

Chronic smoker
Sudden onset right side weakness and aphasia with partial recovery
Residual limb weakness and expressive dysphasia
Right limb power Gr4
Walks unaided with hemiparetic gait
DSA revealed occlusion of terminal ICA
Supraclinoid ICA occlusion
M/55

CTP revealed poor left cerebral perfusion and reserve

Left STA-MCA bypass Sep2011

FU CTP showed marked improvement
M/55

Postop DSA: STA hypertrophy
Anatomical localization

• Cervical ICA occlusion
• Intracranial arterial occlusion/stenosis
  – Petrous or cavernous ICA occlusion
  – Supraclinoid ICA stenosis or occlusion
  – MCA stenosis or occlusion
• Vertebrobasilar insufficiency

Moyamoya Disease
MCA stenosis or occlusion

- Dangerous
- Collateral only from leptomenigeal vessels from ACA and PCA
- Older patient; MCA occlusion or stenosis either cause severe injury or adequate collateral
- Young patients due to acute or subacute dissection with fluctuating ischemic symptoms; good candidate for bypass
Bilateral MCA stenosis
F/50

Construction site worker
EX-smoker
Hx of transient right side weakness and slurring speech 4 years ago
Transient left side weakness
Expressive dysphasia
Limb power normal
MRI, MRA revealed left parietal old infarct; Right MCA stenosis and left MCA occlusion
MCA occlusion
F/50

DSA confirmed the MRA findings; early Moyamoya phenomenon
F/50

CTP revealed decreased perfusion in bilateral MCA territories and inadequate reserve
Left STA-MCA bypass Mar2011
Postop CTP: improvement in left MCA and impaired right MCA perfusion and reserve
F/50

Postop DSA: Patent left STA-MCA bypass; Right MCA occlusion and moyamoya phenomenon
F/50

CTP revealed decreased perfusion in bilateral MCA territories and inadequate reserve
Bilateral EC-IC performed
Postop CTA: patent bilateral bypass
Moyamoya disease

- Classically affecting young children and young adults
- All ages and all ethnic group
- Direct/indirect bypass
Moya Moya Disease
F/22
Sudden onset of headache and collapse in England
Found to have ventricular hemorrhage and hydrocephalus
Resuscitated with ventricular drainage and managed in London
Transferred back to HK after 2 months

Good neurological recovery with full GCS
Right side limb weakness
F/22

CTP and DSA showed Moya Moya Disease and impaired perfusion

Bilateral STA-MCA bypass

Good recovery in limb power
Back to full time job 4 months later
Right hemisphere post-ECIC

Right ECA

Right ICA
F/22
Bilateral STA-MCA bypass

Good recovery in limb power
Back to full time job 4 months later
Left hemisphere post-ECIC

Left ECA

Left ICA
Anatomical localization

- Cervical ICA occlusion
- Intracranial arterial occlusion/stenosis
  - Petrous or cavernous ICA occlusion
  - Supraclinoid ICA stenosis or occlusion
  - MCA stenosis or occlusion
- Moyamoya Disease
- Vertebrobasilar insufficiency
Vertebrobasilar disease

• Old patients with severe atherosclerotic disease
• Cervical vertebral artery with angioplasty and stenting
• Bypass: OA-PICA, STA-SCA, STA-PCA bypass
Vertebral artery occlusion
Bilateral VA Occlusion
M/59
Ex-smoker, ex-drinker
NPC RT 2001
Old TB
Recurrent generalized weakness and dizziness for months
Bilateral deafness
Impaired gag reflex
Impaired tandem gait
Limb power normal
MRI/MRA: pontine infarct, left vertebral artery occlusion, right VA and basilar artery stenosis
M/59

DSA: Complete occlusion of both VA, right PICA supplied by muscular branches at C1 level
Posterior circulation supplied by anterior circulation through Pcom
What next?
M/59
Left occipital artery – PICA bypass
Oct2011
CTA: patent bypass
Dizziness improved
Conclusion

• Neurosurgery plays a significant role in management of ischemic stroke
• New imaging techniques useful in selecting suitable candidates for surgery
• Microsurgical procedures, endarterectomy and EC-IC bypass, are feasible and safe for preventing major strokes
Thank you
TUEN MUN HOSPITAL
Ischemic Stroke

M/47
History of infective endocarditis
Sudden left hemiplegia
Deteriorating conscious level:
GCS15->13
Ischemic Stroke

M/47
History of infective endocarditis
Sudden left hemiplegia
Deteriorating conscious level:
GCS15->13

Decompressive craniectomy and duroplasty
Right CEA
Baseline, left > right perfusion

Bipolar EEG - EEG
Density spectral array

Rt
Lt

Compressed spectral array

Density spectral array
SSEP baseline
Lt stim 20mA, Rt stim 30mA
The procedure: Carotid endarterectomy
M/61
Chronic smoker
Repeated LOC
No limb weakness
PE: Left carotid bruit
Carotid doppler revealed bilateral carotid stenosis
DSA revealed bilateral carotid stenosis, more on the left side
M/61
Left carotid endarterectomy  Nov2011
Postop CTA significant R ICA stenosis
No symptom after left CEA
What next?
M/61
CTP revealed impaired cerebrovascular perfusion and reserve over right side watershed region
Right CEA Aug 2012
Remain asymptomatic
F/81
DM, HT
Recurrent left TIA
Admitted for right side weakness and slurring speech in 2009
DSA: bilateral proximal carotid severe stenosis(>90%)
F/81

Left CEA performed under RA
Intra-operative finding:
strong adhesion of plaque to ECA
orifice preventing atheroma removal
at ECA

Noticed to have decreased conscious
level and increased right side
weakness shortly after operation

Urgent DSA: ECA occlusion, patent ICA
F/81

Urgent DSA: left middle cerebral artery thrombo-embolism

Urgent intra-arterial thrombolysis performed with successful recanalization

Power and conscious level returned to pre-morbid state

No recurrent TIA/ stroke on FU(2014)
## Factors Influencing Risk & Benefit of CEA

<table>
<thead>
<tr>
<th>Factors favoring CEA</th>
<th>Factors favoring medical treatment</th>
</tr>
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<tbody>
<tr>
<td>Hemispheric TIA</td>
<td>Amaurosis fugax</td>
</tr>
<tr>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Recent symptoms(&lt;30 days)</td>
<td>Remote symptoms</td>
</tr>
<tr>
<td>Comorbidities well controlled</td>
<td>Comorbidities uncontrolled</td>
</tr>
<tr>
<td>Severe stenosis(&gt;80%)</td>
<td>Advanced age</td>
</tr>
<tr>
<td>Ulceration or intraluminal thrombus</td>
<td>Asymptomatic</td>
</tr>
<tr>
<td>Silent ipsilateral infarct</td>
<td></td>
</tr>
<tr>
<td>Contralateral stenosis/occlusion</td>
<td></td>
</tr>
<tr>
<td>Intracranial (tandem) atherosclerosis</td>
<td></td>
</tr>
</tbody>
</table>
Carotid endarterectomy by neurosurgeon

- NASCET cases primarily performed by neurosurgeons
- Dedicated team in awake surgery (Awake craniotomy)
- Routine electro-physiological monitoring in GA cases
- Procedure performed under microscope
- Intensive post-operative neurological monitoring and management
- Close cooperation with neuro-radiological interventional team
- Cerebrovascular perfusion study in equivocal cases
M/72

Chronic smoker
Chronic drinker
Right eye blind
Sudden onset of left side weakness with partial recovery
Limb side limb power Gr 4
ADL independent
Carotid doppler revealed severe right cervical ICA occlusion/stenosis
DSA: right cervical ICA occlusion
Cervical ICA occlusion
CREST

- No significant difference between CEA vs Stenting
  - Periprocedural stroke
  - Myocardial infarction
  - Death
  - Ipsilateral stroke
  - Postprocedural stroke

Long-Term Results of Stenting versus Endarterectomy for Carotid-Artery Stenosis

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Figure 2. Subgroup Analyses of the Primary Composite End Point and the End Point of Stroke or Death.

Hazard ratios and associated 95% confidence intervals are shown for the primary composite end point of any stroke, death, or myocardial infarction during the periprocedural period plus ipsilateral stroke within 10 years after randomization (Panel A) and for any stroke or death during the periprocedural period plus ipsilateral stroke within 10 years after randomization (Panel B). Severe stenosis was defined as stenosis of at least 70% of the diameter of the artery, and moderate stenosis as less than 70%. The sizes of the boxes are proportional to the numbers of patients in the strata, and horizontal lines indicate 95% confidence intervals.
<table>
<thead>
<tr>
<th>End Point</th>
<th>Periprocedural Period plus 10-Yr Follow-up</th>
<th>Periprocedural Period Only</th>
<th>Postprocedural Period Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Events</td>
<td>Rate (95% CI)</td>
<td>Hazard Ratio (95% CI)</td>
</tr>
<tr>
<td>---------------------------------------</td>
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<td>-----------------------</td>
</tr>
<tr>
<td><strong>Primary composite end point</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting</td>
<td>108</td>
<td>11.8</td>
<td>(9.1–14.8)</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>97</td>
<td>9.9</td>
<td>(7.9–12.2)</td>
</tr>
<tr>
<td><strong>Stroke or periprocedural death</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting</td>
<td>98</td>
<td>11.0</td>
<td>(8.5–13.9)</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>71</td>
<td>7.9</td>
<td>(5.9–10.0)</td>
</tr>
<tr>
<td><strong>Myocardial infarction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting</td>
<td>95</td>
<td>10.8</td>
<td>(8.3–13.7)</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>71</td>
<td>7.9</td>
<td>(5.9–10.0)</td>
</tr>
<tr>
<td><strong>Major</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenting</td>
<td>24</td>
<td>3.5</td>
<td>(1.8–5.6)</td>
</tr>
<tr>
<td>Endarterectomy</td>
<td>15</td>
<td>2.0</td>
<td>(0.9–3.5)</td>
</tr>
</tbody>
</table>
Periprocedure stroke
- more in stenting

Myocardial infarction
- more in endarterectomy
Carotid Occlusion Surgery Study

• Patients with symptomatic atherosclerotic internal carotid artery occlusion (AICAO) and hemodynamic cerebral ischemia are at high risk for subsequent stroke when treated medically.

• Objective To test the hypothesis that extracranial-intracranial (EC-IC) bypass surgery, added to best medical therapy, reduces subsequent ipsilateral ischemic stroke in patients with recently symptomatic AICAO and hemodynamic cerebral ischemia.