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# RECANALIZATION OF CAROTID CTO -INDICATION AND METHOD FOR A CONTROVERSIAL PROCEDURE-

# What's the controversy?

- Endarterectomy and stenting have been proven in preventing stroke in patients with carotid stenosis
- But revascularization for carotid CTO is “contra-indicated” in the current guideline
- In fact, carotid CTO carries high subsequent stroke rates (5-7% per year)

Hankey GJ, et al. Cerebrovasc Dis 1991;1:245

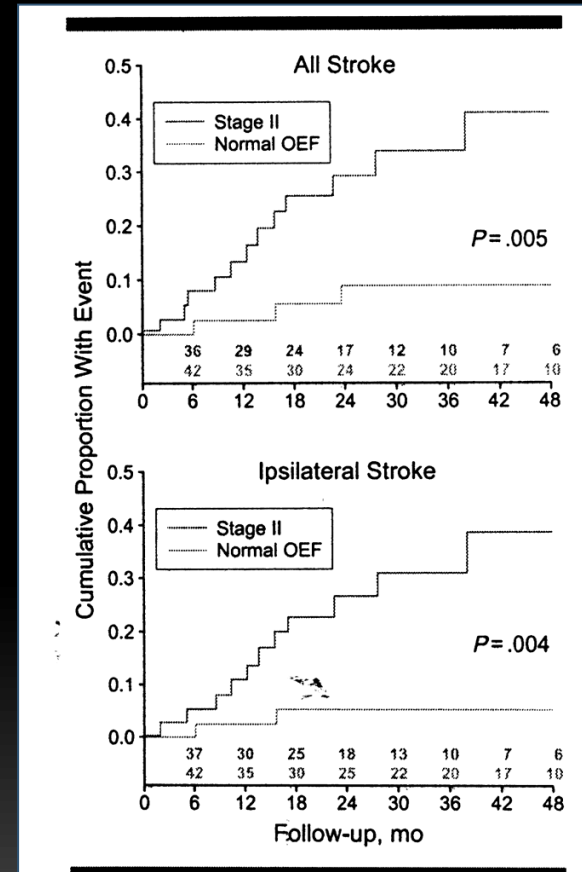
Derdeyn CP, et al. Neurology 1999;53:251

# Myths about carotid CTO

- With cessation of antegrade flow, the risk of embolic stroke is low
- Surgical bypass failed to show benefit
- It is rare, and endovascular recanalization is difficult and dangerous

# Cerebral hypoperfusion

- Severe carotid stenosis or occlusion leads to **cerebral hypo-perfusion**
- Annual **stroke risk** is as high as 20% with objective cerebral ischemia



Klijn CJ, et al. Stroke 1997;28:2084

Grubb RL Jr, et al. JAMA 1998;280:1055

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# Why surgeons failed in carotid CTO?

- Endarterectomy is not possible as the distal end of the occlusion is often located high
- Extracranial-intracranial bypass failed to yield benefit in the EC-IC trial, due to high surgical complication and poor patient selection

EC/IC Bypass Study Group. N Engl J Med 1985;313:1191

- COSS (Carotid Occlusion Surgery Study) currently undergoing

Grubb RL Jr, et al. Neurosurg focus 2003;14(3):e9

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# Incidence of carotid CTO

- CS program started in Apr 1998 in NTUH
- 1128 CS done so far, with 160 CAO attempts since Feb 2002
- Roughly 14% CTO in all CS cases
- Majority of the referred carotid CTO were symptomatic/ischemic (91%, 160/176)
- Feasibility and safety has been reported

JACC 2007;49:765-771

Circ Cardiovasc Intervent 2008;1:119-125



# NTUH CTO data

N=160		
CCA diameter (mm)	$7.9 \pm 0.6$	
ICA diameter (mm)	$5.0 \pm 0.6$	
Occlusion length (mm)	$49 \pm 21$	
Wire crossing success	110	69%
Final residual DS	$4 \pm 7$	
Technical success	109	68%

# NTUH CTO data

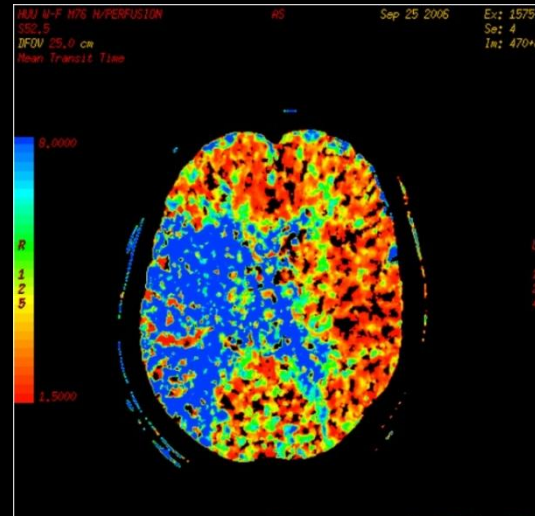
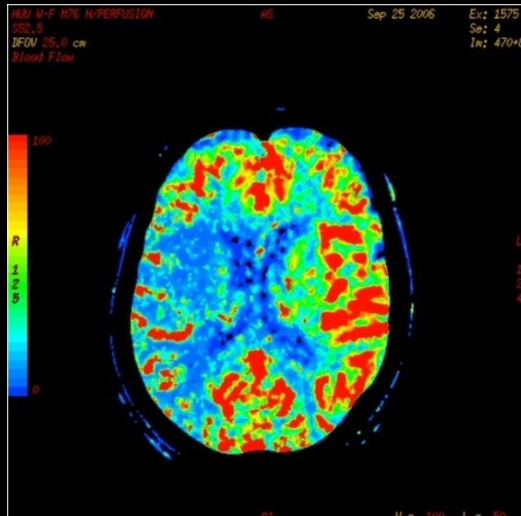
	30d (%), N=160	31d-1y (%), N=155
Death	1 (0.6)	3 (1.9)
Neurological	1 (0.6)	1
Other cause	0	2
Non-fatal ischemic stroke	2 (1.3)	2 (1.3)
Major ipsi.	0	0
Major non-ipsi.	0	1
Minor ipsi.	2	1
Minor non-ipsi.	0	0
Non-fatal ICH	2 (1.3)	0
ICA injury without event	5 (3.1)	1 (0.6)
Restenosis (DS>50%)	--	21 (13.5)

# Indications for recanalization

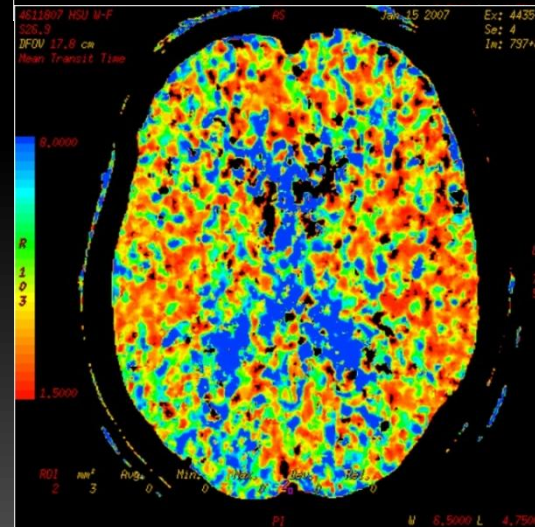
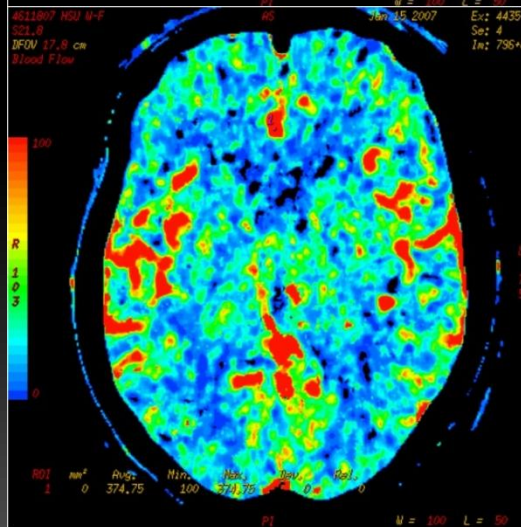
- Current indications at NTUH (consensus between neurologist, radiologist, and interventionist)
  - Symptomatic on optimal medical treatment after documentation of CAO, or
  - Objective ischemia by CTP, MRP, or PET

# Example CTP images

*baseline*



*post stenting*



*stress blood flow*

*stress mean transit time*

# Interventional techniques

- 8F femoral approach using JR<sub>4</sub> GC
- Bi-plane machine with DSA capability
- Bilateral injection sometimes needed for contouring the variable cervical ICA course
- Intra-luminal wiring vs. STAR technique
- Kao-Leong scoring system

# Devices

- Micro-catheter support: Finecross, Corsair
- Hydrophylic wire for micro-channel probing and/or STAR maneuver: Fielder FC, XT
- CTO wire for controlled puncture: Conquest Pro
- Workhorse wire for intracranial wiring: Sion, Runthrough
- Long-shaft balloon for pre-dilatation: Ikatzuchi
- IC stent: Driver, Tsunami, Omega
- Cervical stent: Carotid Wallstent

# Kao-Leong score

Independent Variables	Status	Coefficient	Scores
Symptom Duration	< 6m	0.903	0
	>6m		1
	Asx		2
Stump Angulation	<45°	1.591	0
	>45°		2
Visible Distal Flow	Ipsilateral	0.738	0
	Contralateral		1
	Not visible		2
Lesion Length	< 30cm	2.226	0
	> 30cm		3

# Kao-Leong score

KL Score	Success Rate
0-2	94.87%
3-4	70.59%
5-6	39.47%
>6	33.33%

Will be presented in EuroPCR '13



# Example case of techniques



76y man with left hemi  
for 2ys

Neck Duplex: R't CAO  
with reversed OA flow

OMT

# Ischemia documented



Worsening mentality for 1y but no recurrent "carotid sx"

Significant right hemisphere ischemia by CTP

# Neurology consult



Duplex: same findings

ADAS 8 → 14

MMSE 20 → 15

# Angiography



Cervical R't CAO 2cm  
from orifice

Reverse OA flow into  
distal ICA

Willis circle intact

KL score 5

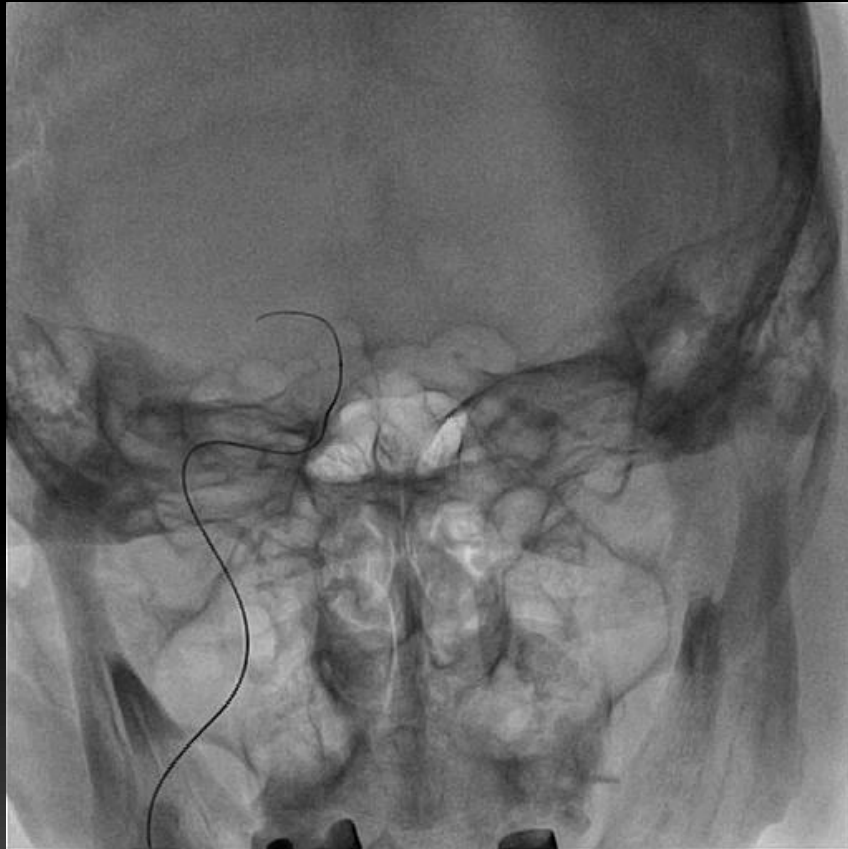
# Wiring cervical/petrous ICA



Fielder FC in Finecross,  
advanced into distal ICA  
just proximal to OA take-  
off

Further advancement  
impossible

# Wiring cavernous/clinoid ICA



Fielder FC exchanged to  
Conquest Pro

With careful and delicate  
manipulation Conquest  
Pro entered MCA

# Wire exchange and ballooning

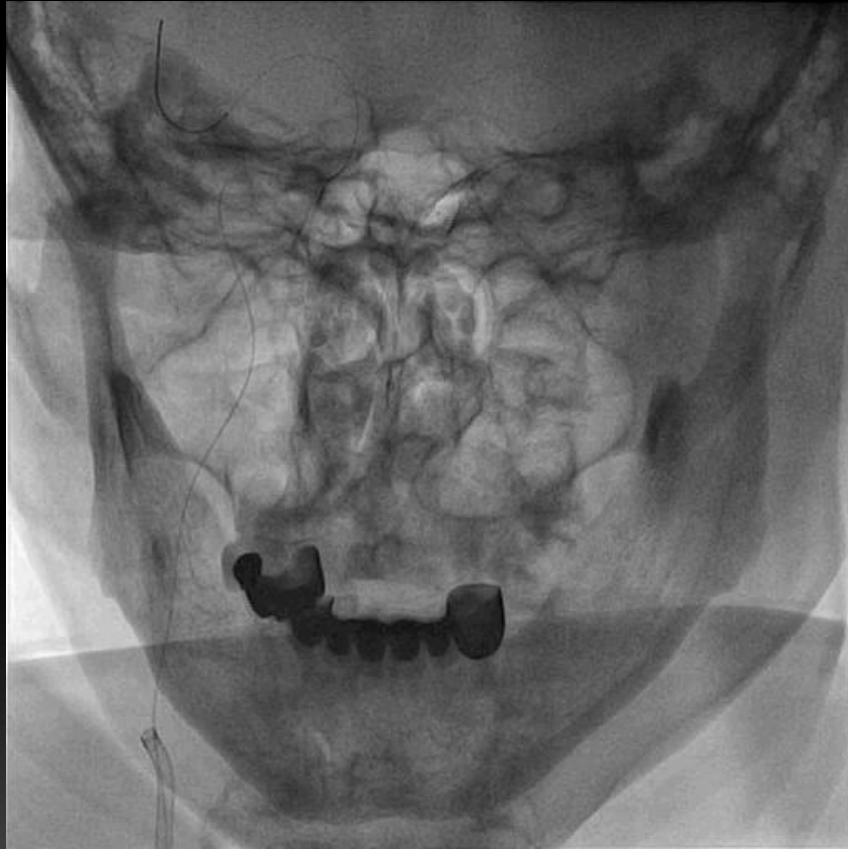


Runthrough NC Floppy  
exchanged through  
Finewire into M<sub>3</sub> branch

1.25x10 Ottimo at 6atm,  
2.5x15 Ottimo at 6atm



# Stenting preparation



Recanalization achieved

SBP lowered to  
140mmHg by  
nitroglycerin iv

ACT checked at 240''



# Intracranial stenting



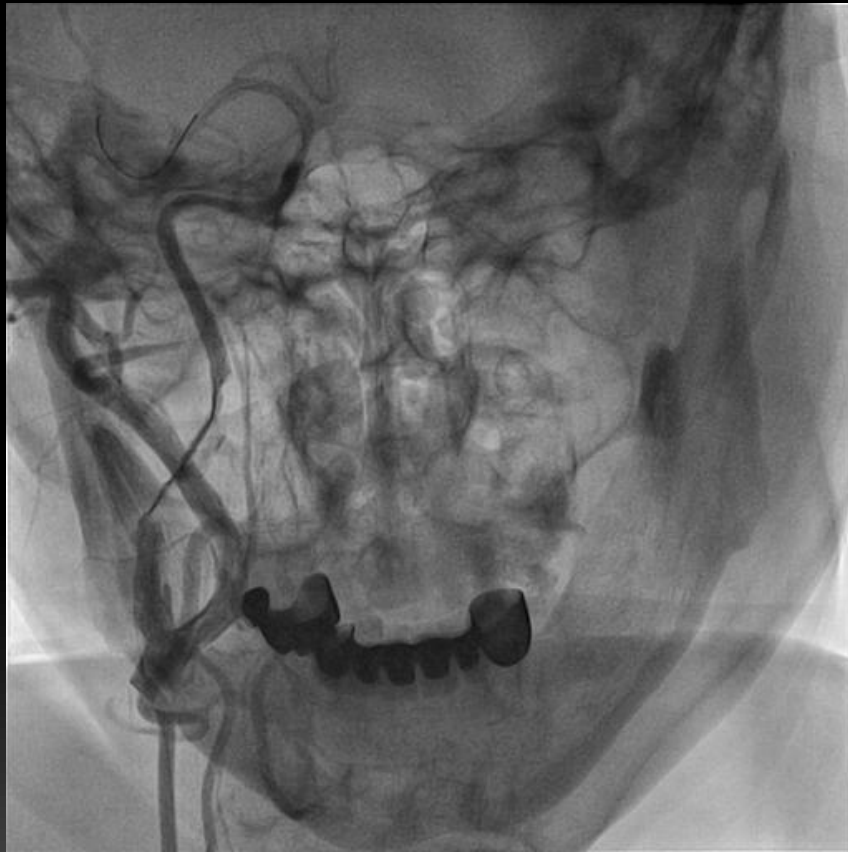
- Tsunami 3.0x25 implanted at 10atm

# Distal cervical stenting



- Tsunami 3.5X30 implanted at 10atm

# After balloon-expandable stents



1 long self-expanding stent needed to cover the whole occlusion segment

# Proximal cervical stenting



Carotid Wall stent 8x29  
deployed and post-  
dilated with 4x15  
Maverick at 10atm

# Final image



CCU overnight  
hemodynamic  
management

No post-procedure  
anticoagulation

DAPT for 3m

# Post-stenting course



Discharged D3

Recovery of R't  
hemisphere ischemia by  
CTP at 3m

ADAS 14 → 5

MMSE 15 → 26

# Effect on cognitive function

- Impaired cerebral perfusion impairs **cognitive function**

Stroke 2003;34:1491-1424

J Neurol 2003;250:1340-1347

Ann Intern Med 2004;140:237-247

- Our results demonstrated cognitive improvement after carotid stenting, and its correlation to cerebral perfusion, not only in CTO cases but also in “asymptomatic” patients

Stroke 2011;42:2850-2854

Int J Cardiol 2012;157:104-107

JACC published online April 10, 2013  
doi:10.1016/j.jacc.2013.02.059

# Improved cognition in successful cases

	Successful			Unsuccessful		
	baseline	3m	p	baseline	3m	p
ADAS	7.7±8.9	5.7±7.1	0.024	8.7±9.7	9.7±11.1	0.268
MMSE	25.8±3.8	27.7±2.7	0.015	24.7±5.6	25.7±4.9	0.422
Color trail A	123.2±68.6	99.3±51.5	0.017	141.3±101.0	138.3±103.7	0.799
Color trail B	196.2±99.3	175.1±85.5	0.169	176.8±82.1	182.0±92.3	0.397
Verbal fluency	26.3±14.0	27.3±10.2	0.937	27.5±9.4	25.3±6.5	1.0
NIHSS	0.6±0.9	0.4±0.7	0.157	0.6±0.8	0.6±0.8	
Barthel index	97.5±8.7	98.8±4.3	0.317	95.7±7.3	97.1±3.9	0.310



# Correlation with cerebral perfusion

	Ischemia(+) failed			Ischemia(+) success			Ischemia(-) success		
	Baseline	3m	p	Baseline	3m	p	baseline	3m	p
NIHSS	0.17±0.4 1	0.17±0.4 1	1.0	0.24±0.5 6	0.12±0.3 3	0.32	0	0.18±0.6 0	0.32
BI	99.2±2.0	99.2±2.0	1.0	100	99.4±2.4	0.32	100	100	1.0
ADAS	5.2±1.7	4.7±2.1	0.52	6.2±3.6	4.9±2.8	0.033	6.5±4.8	5.6±5.1	0.07
MMSE	26.7±2.1	27.8±2.3	0.066	25.8±3.8	27.4±3.5	0.007	27.1±3.1	27.4±2.7	0.73
Color A	97.2±67. 4	110.0±63 .9	0.17	120.4±73 .9	95.8±57 6	0.004	82.7±51.3	84.0±58.7	0.66
Color B	168.0±74 .4	169.3±8 8.2	0.83	193.1±10 4.3	184.6±95 .2	0.352	135.3±70. 2	136.6±78 .1	0.96
Verbal	32.5±8.0	29.2±6.7	0.34	25.7±8.5	27.1±6.9	0.92	30.4±10. 0	33.6±7.5	0.08

# Conclusions 1

- Recanalization is feasible for carotid CTO, improves cerebral perfusion and cognitive function
- The proposed indications are: persistent sx or objective viable ischemia
- The techniques are mostly adapted from coronary CTO intervention

# Conclusions 2

- A scoring system may help the beginner to start with more feasible cases
- Carotid intervention not only prevents embolic stroke, but also correct cerebral ischemia and improve mental functions
- The term “asymptomatic” needs serious re-consideration