Recanalization of Chronic Carotid Artery Occlusion
Objective Improvement Of Cerebral Perfusion

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ICA stenting

- Proven to be an alternative to CEA in ICA stenosis to prevent artery-to-artery embolism
- But the application of endovascular intervention in cervical ICA occlusion (ICAO) has never been explored, which comprise 15% of patients with ipsilateral TIA or infarction
- “The risk of stroke is minimal with ICAO, because there is no flow to carry the emboli”, but is it true?

Prognosis and pathophysiology of ICAO

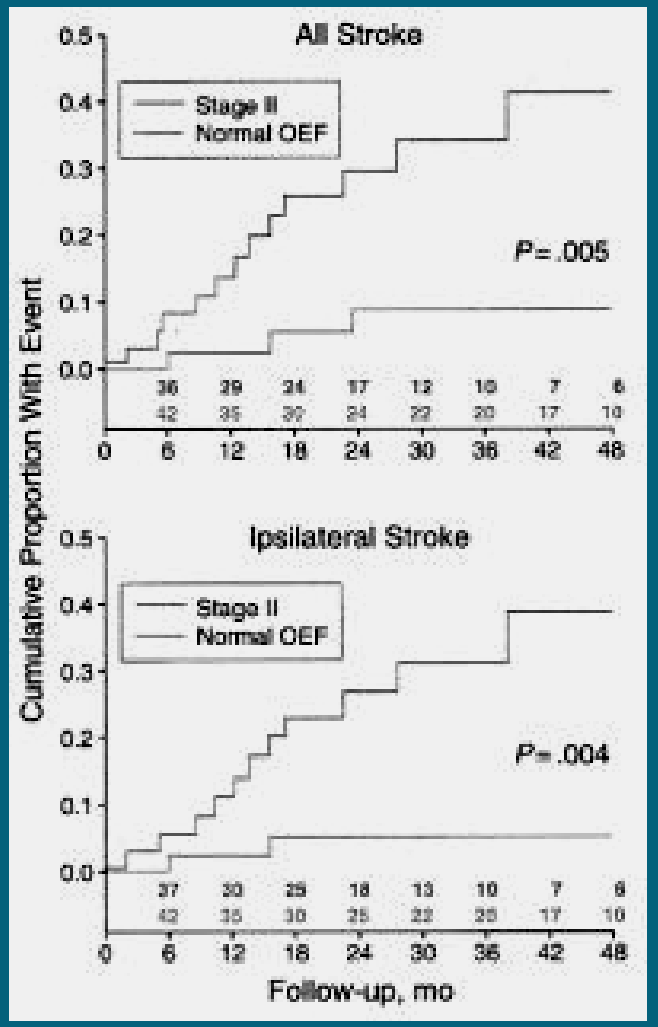
- Cervical ICAO is an important cause of TIA and cerebral infarction and should not be neglected
  - Annual risk of ipsilateral stroke in symptomatic ICAO is 6-20%
  - Annual risk of ipsilateral stroke in asymptomatic ICAO is 2-5 %
- Pathophysiology of symptoms
  - Emboli arising from ECA/CCA via collaterals
  - Emboli arising from ICA stump via collaterals (Stump syndrome)
  - Emboli arising from trailing thrombi distal to the occlusion
  - Hypo-perfusion (hemodynamic insufficiency)

Treatment options for ICAO

- Medical
  - The recommended treatment at present, but may be insufficient for certain patients
- Surgery
  - CEA
  - Stump ligation/exclusion
  - EC/IC bypass
  - Can be very technically demanding with high periprocedural complications
  - All failed to reduce ipsilateral stroke and are not recommended to ICA CTO in general

Identify the right patient to revascularize

- 81 ICAO patients with old ipsilateral stroke or TIA, evaluated with PET and followed for 3 years
- Stroke occurred in 12/39 and 3/42 (p=0.005, age-adjusted RR= 6) patients with and without stage 2 perfusion failure, ipsilateral stroke in 11/39 and 2/42 (p=0.004, age-adjusted RR= 7.3)



JAMA. 1998;280:1055–1060

NTUH ICAO experience

- Endovascular recanalization was attempted in 75 patients with ICAO from October 2002 to Dec 2007, out of 480 (15.6%) ICA stentings in the same period
- ICAO was documented by ultrasound, CTA, or MRA
- All patients were followed clinically for at least 2 months after the diagnosis of ICAO by in dependent neurologist/cardiologist
- Enrollment criteria
  - Progression or recurrence of ipsilateral neurological deficit, or
  - Objective ipsilateral hemispheric ischemia

Acknowledged work

Interventional Cardiology

Feasibility of Endovascular Recanalization for Symptomatic Cervical Internal Carotid Artery Occlusion

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Objectives This study sought to report technical details and clinical results of the first series of endovascular recanalization for cervical internal carotid artery (ICA) occlusion.

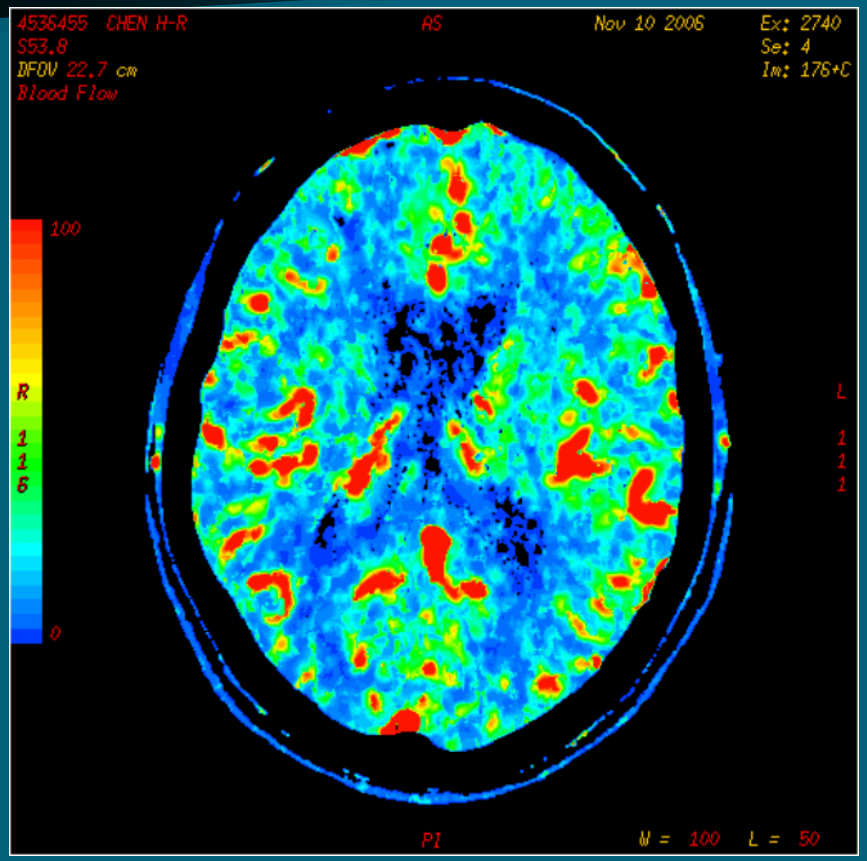
Background Cervical ICA occlusion is associated with impaired cerebral perfusion, which may lead to ischemic cerebral symptoms and hemodynamic infarcts. Neither surgical nor endovascular revascularization has been shown to benefit this population.

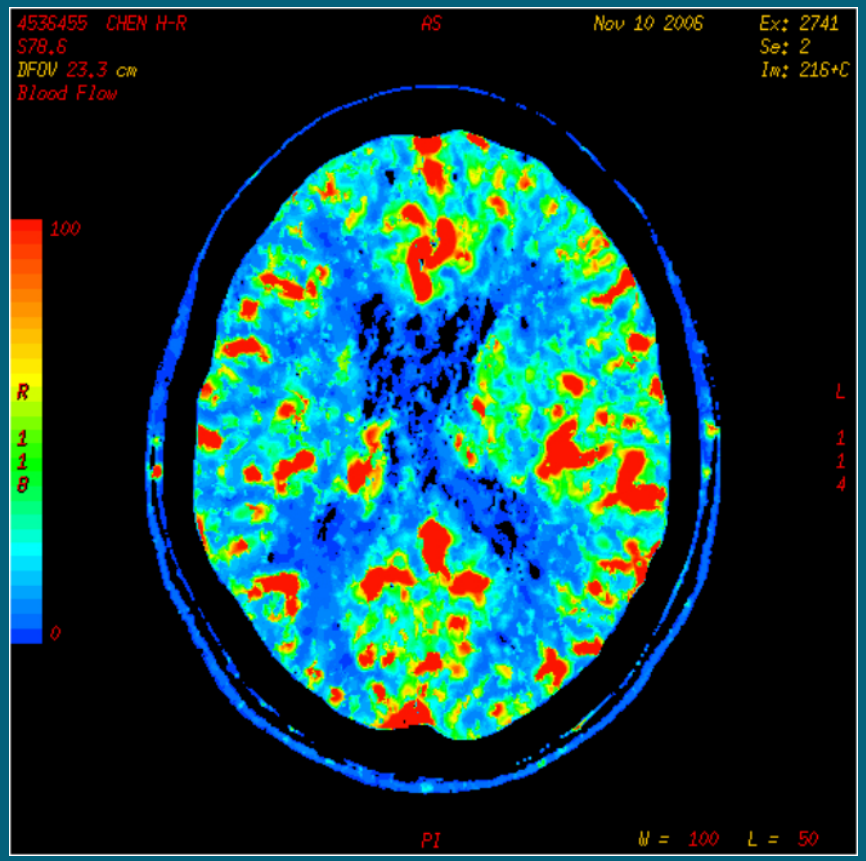
Methods Endovascular recanalization was attempted in 30 patients with ICA occlusions (27 men; age 72.1 ± 8.0 years, range 48 to 85 years). Recurrent neurologic deficit or cerebral ischemia by perfusion study, after known ICA occlusion, was noted in all patients. Strategies and devices for coronary occlusion intervention were applied, including microcatheter-supported tapered-tip stiff coronary guidewires. Contralateral ICA stenosis was found in 9 patients (30%). All patients underwent independent neurologic and duplex ultrasound follow-up.

Results The overall technical success rate was 73% (22 of 30). No neck hematoma, intracranial hemorrhage, or hyperperfusion was noted. One (3.3%) fatal brainstem infarction occurred 1 day after a successful ICA procedure, with angiographically proven acute basilar artery occlusion and patent ICA stent. Baseline ophthalmic artery flow was reversed in 15 of the 22 successfully recanalized patients, and was normalized in 12 after the procedure. There was no new cerebral ischemic event or neurologic death for a mean follow-up of 16.1 ± 18.5 months.

Conclusions Endovascular recanalization for cervical ICA occlusion is feasible with acceptable midterm clinical results.
(J Am Coll Cardiol 2007;49:765–71)

Exemplary case: 64M with old RMCA infarct





Baseline **Diamox stress**

Flow

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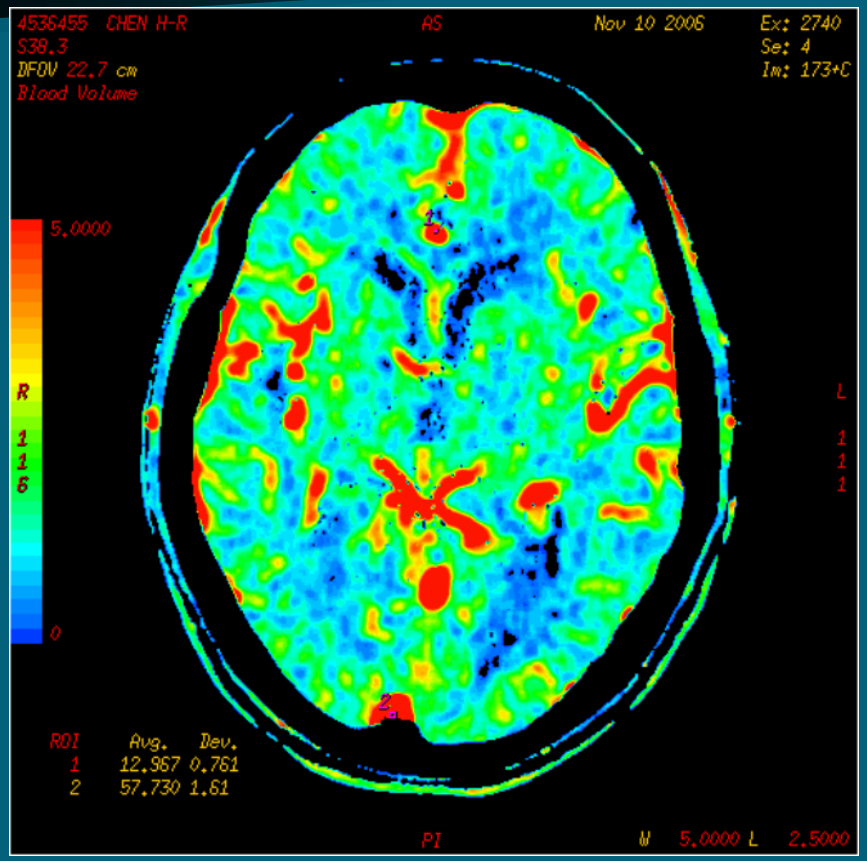
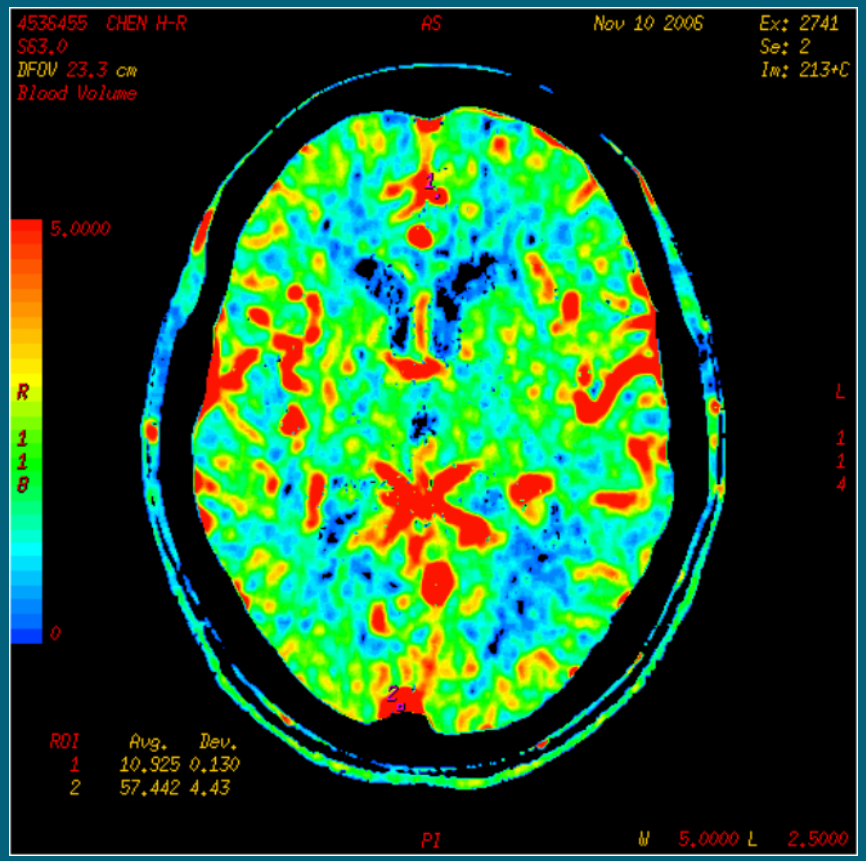
Perfusion CT imaging for objective ischemia

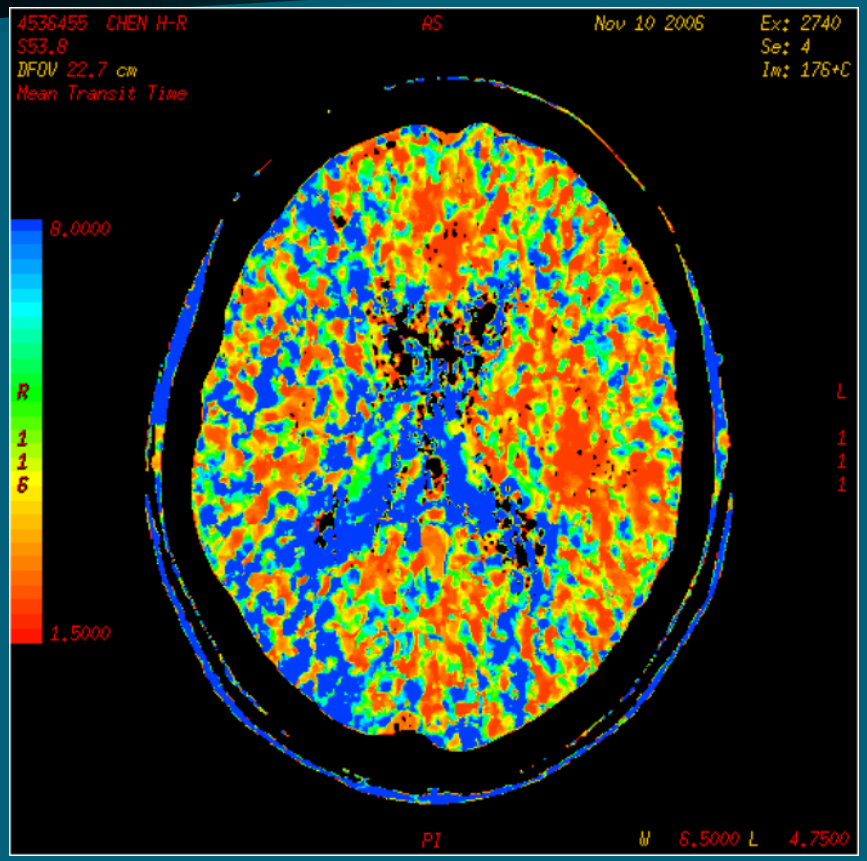


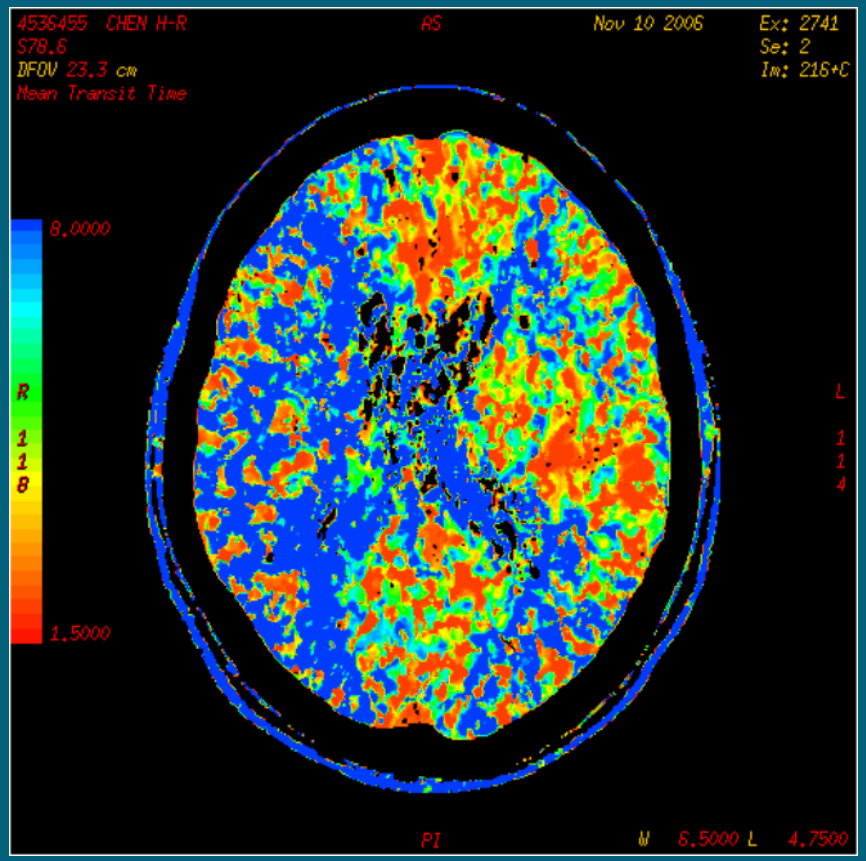


Baseline **Diamox stress**

Volume

Perfusion CT imaging for objective ischemia





Baseline **Diamox stress**

Transit Time

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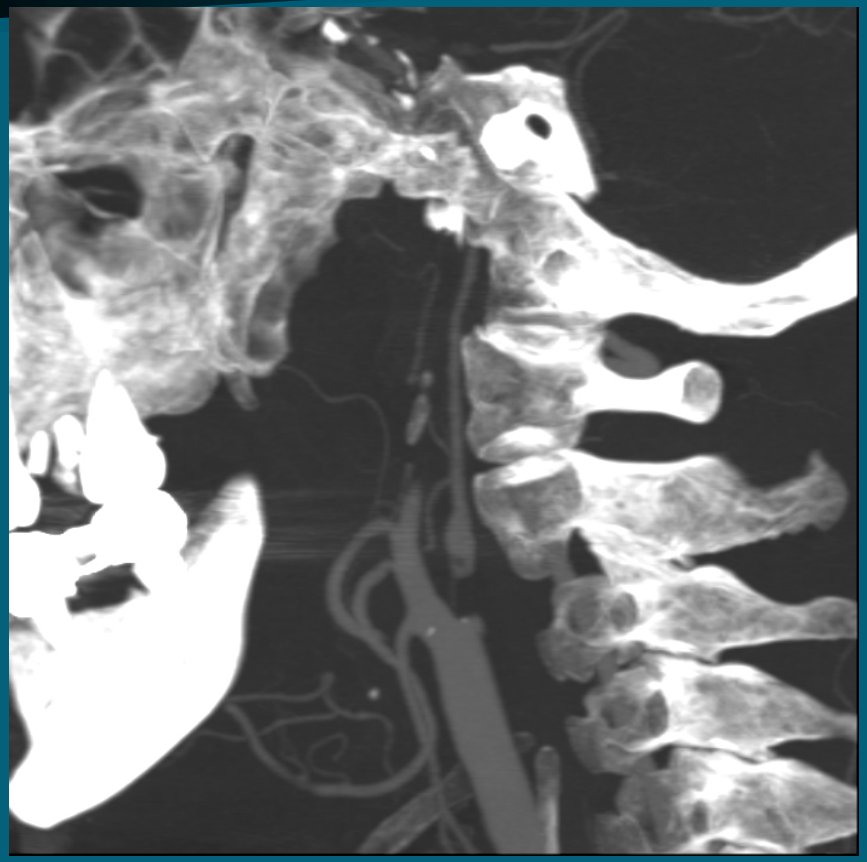
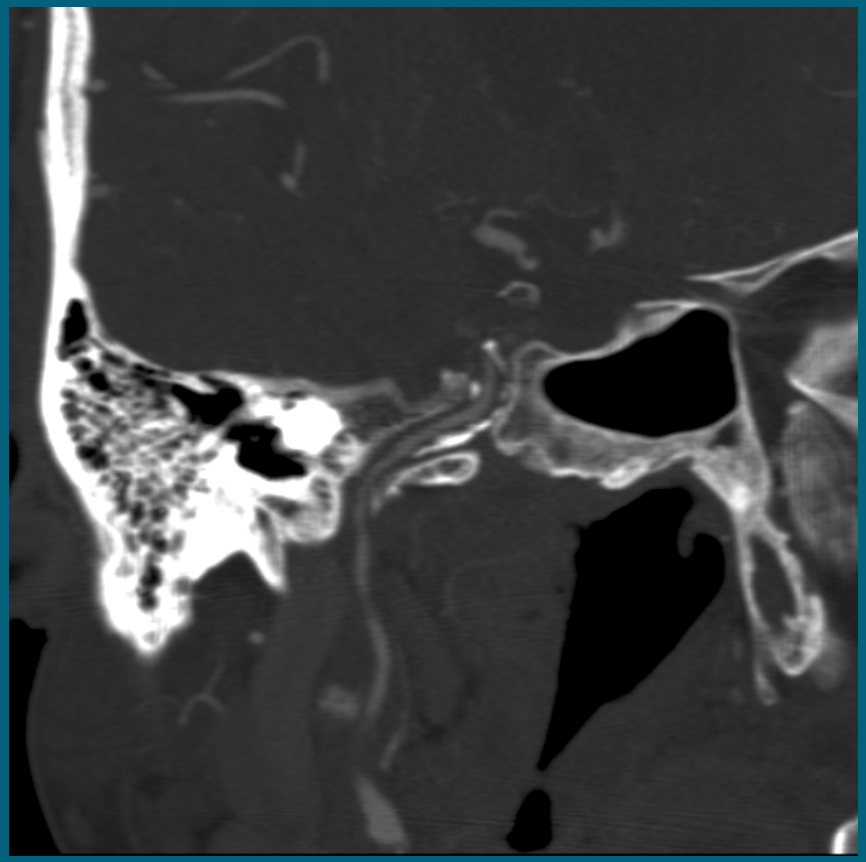
CT angiography for path finding

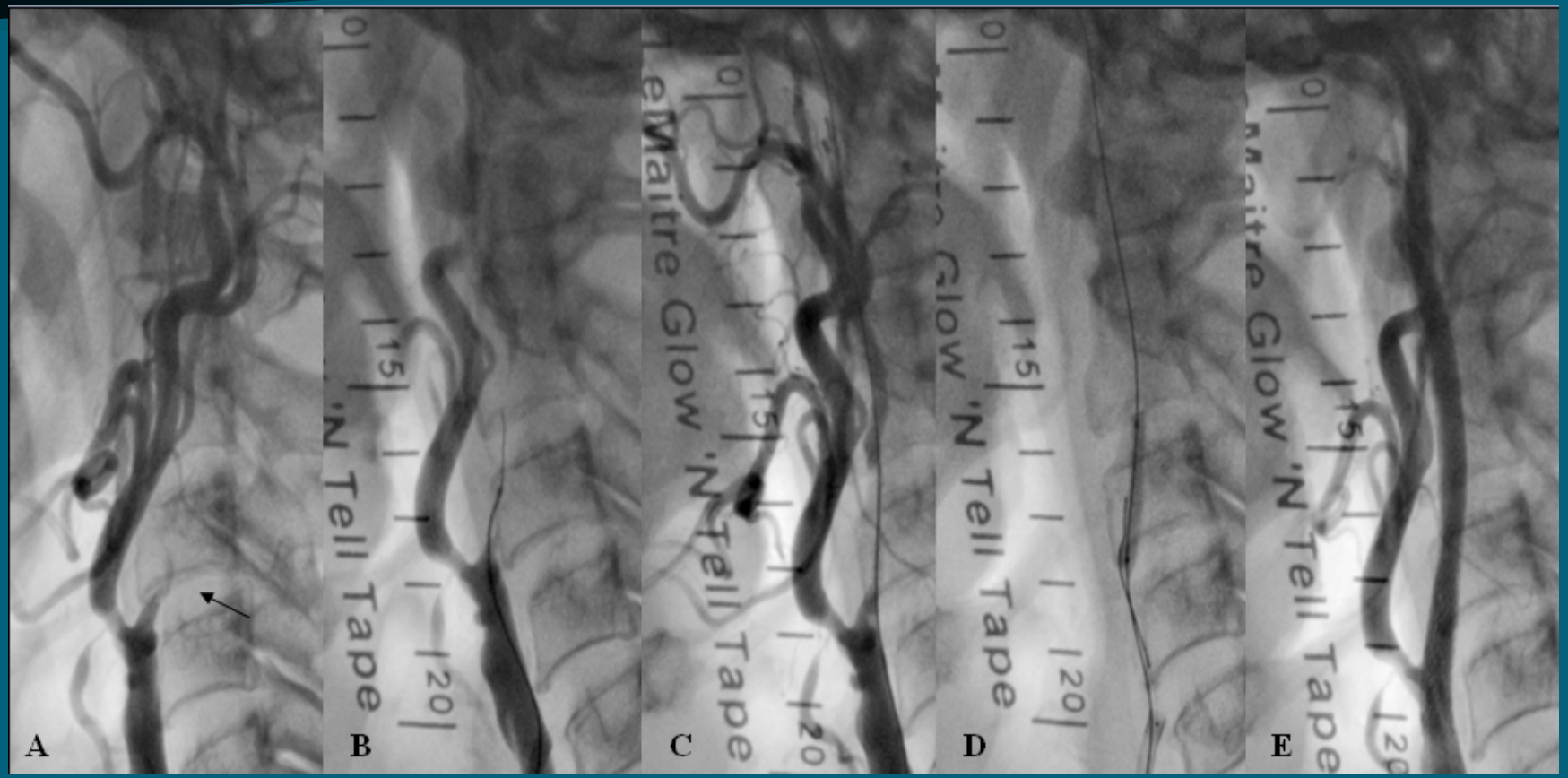


Cervical ICA

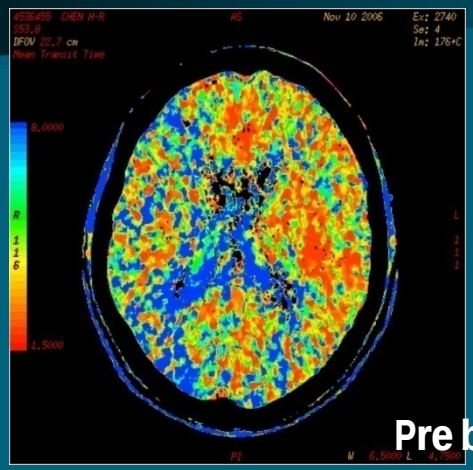


Carotid canal

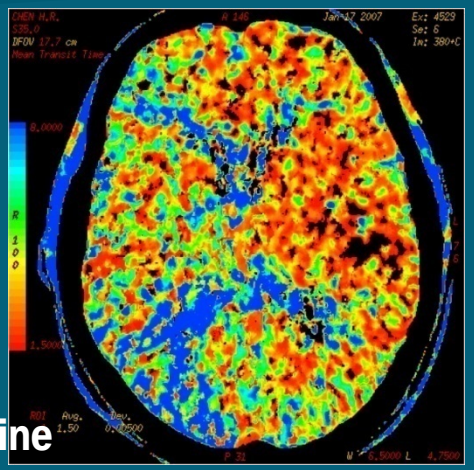
Wiring example



Partial recovery of perfusion CT at 1 month

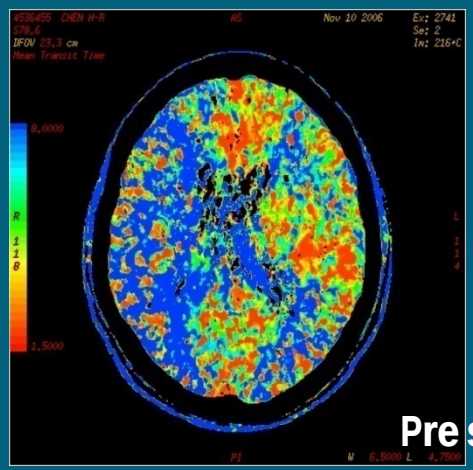


Transit time

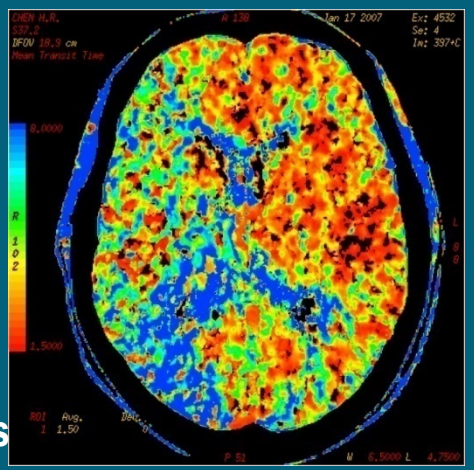


Pre baseline

Post baseline

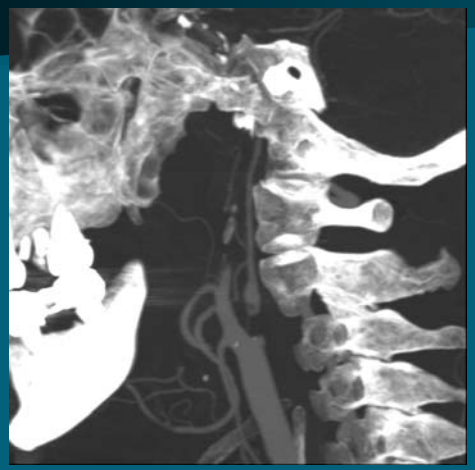


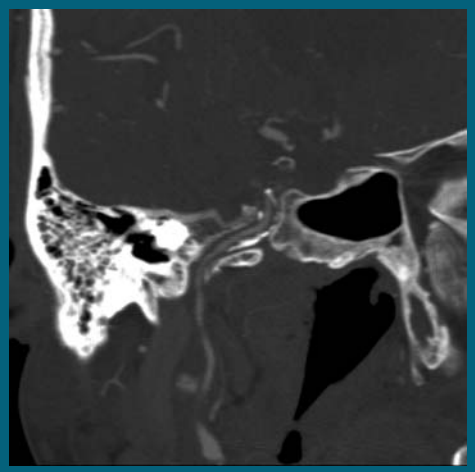
Pre stress



Post stress

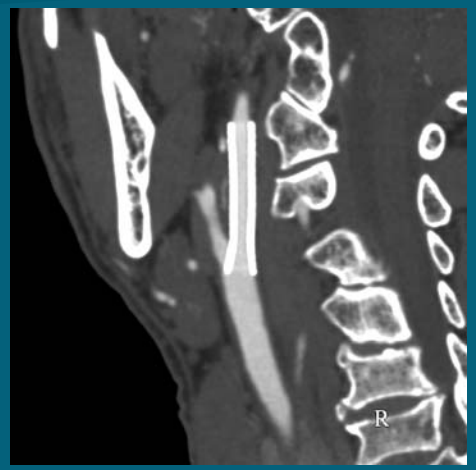
Comparison of CTA at 1 month

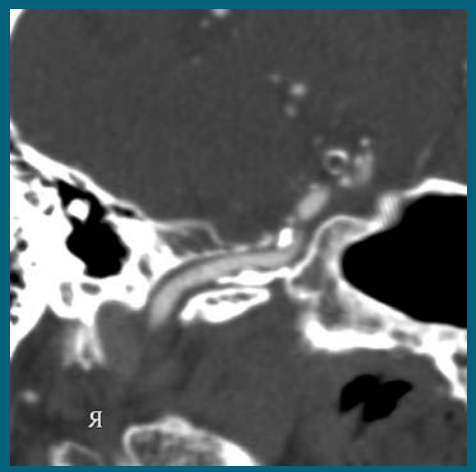




Pre

Post





Demographics (Oct '02 - Aug '07)

Male sex	48	89%
Age (y)	69.2 ±9.8	
Hypertension	43	80%
Diabetes mellitus	19	35%
Hyperlipidemia	29	54%
Smoking	28	52%
Prior ipsilateral stroke	35	65%
Ipsilateral TIA	15	28%
Amaurosis fugax	4	7%
Contralateral ICA stenosis >50%	19	35%
Progression or recurrence of neurologic deficit after known ICA occlusion	37	69%

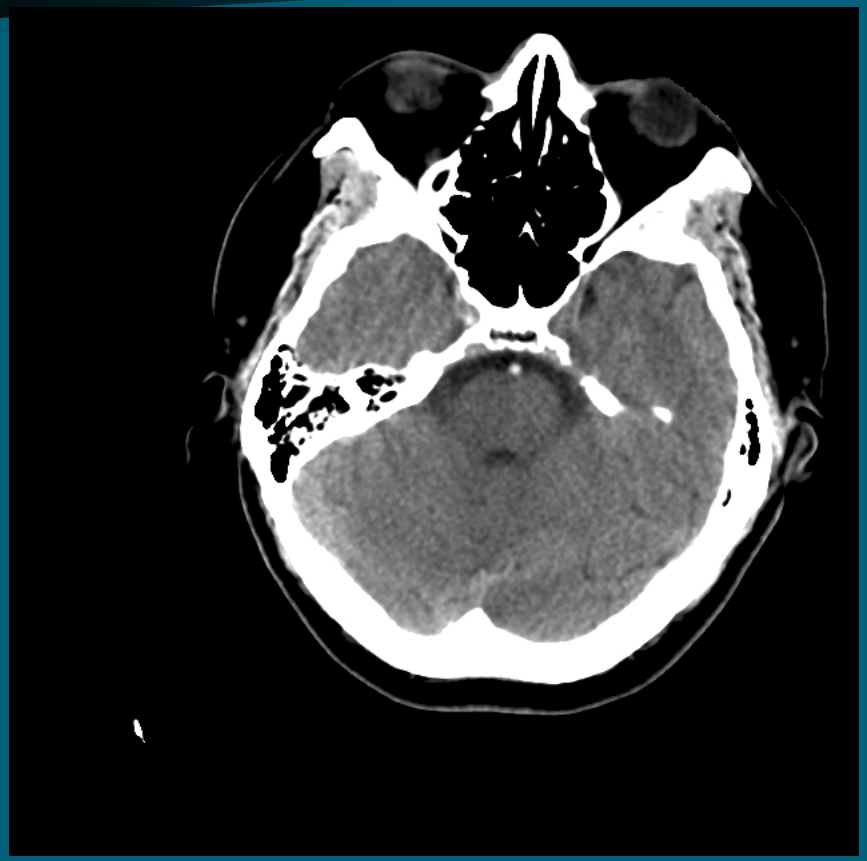
Procedural results (Oct '02 - Aug '07)

Technical success	35	65%
Lesion location, right/left	27/27	50%/50%
CCA diameter (mm)	7.9±0.6	
ICA diameter (mm)	5.1±0.5	
Occlusion length (mm)	27.9±16.2	
Wire crossing successful	37	69%
Distal protection device used after crossing	27	73%
PercuSurge/FilterWire	17/10	63%/37%
Post-dilatation balloon diameter (mm)	4.5±1.7	
Post-dilatation pressure (atm)	6.8±2.9	
ECA orifice covered by stent	34	92%
Final residual diameter stenosis (%)	9±7	

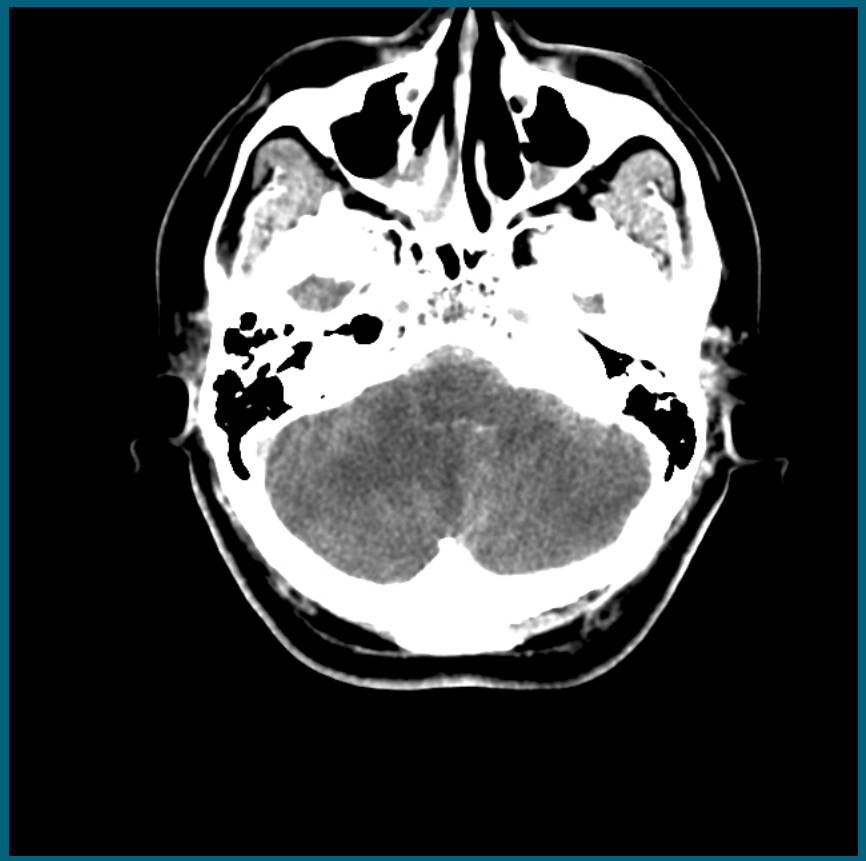
Clinical outcome (Oct '02 - Aug '07)

	In-hospital , n (%)	3-m follow-up, n (%)
Death	1 (1.9)	1 (1.9)
Fatal stroke	1 (1.9)	1 (1.9)
Other cause	0	0
Stroke	2 (3.7)	2 (3.7)
Major ipsi.	0	0
Major non-ipsi.	1 (1.9)	1 (1.9)
Minor ipsi.	1 (1.9)	1 (1.9)
Minor non-ipsi.	0	0
TIA	0	0
ICH/hyperperfusion	0	0
Restenosis	--	4/35 (11.4)

The only mortality



Baseline

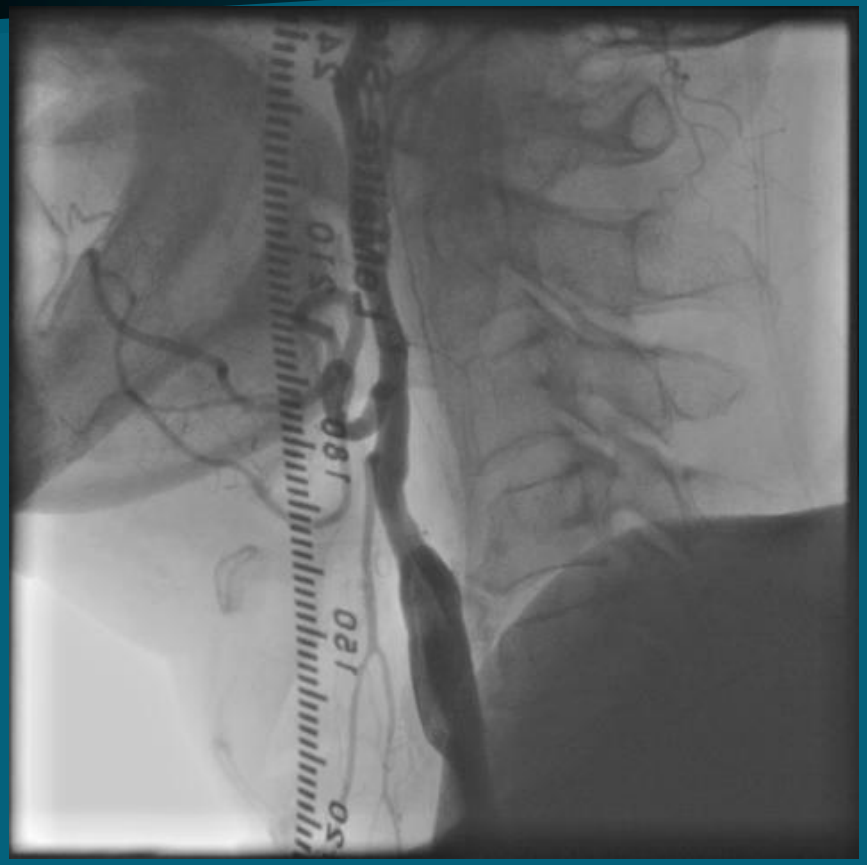


Emergent

Cerebral functional assessments

- CT
  - CTA
  - Perfusion CT: rest/Diamox stress
- MRI
  - MRA
  - Infarction (DWI)
  - CBF measurements (PWI): rest/Diamox stress
- Brain ^{18}F-FDG PET (SPM quantification)
  - Brain glucose metabolism

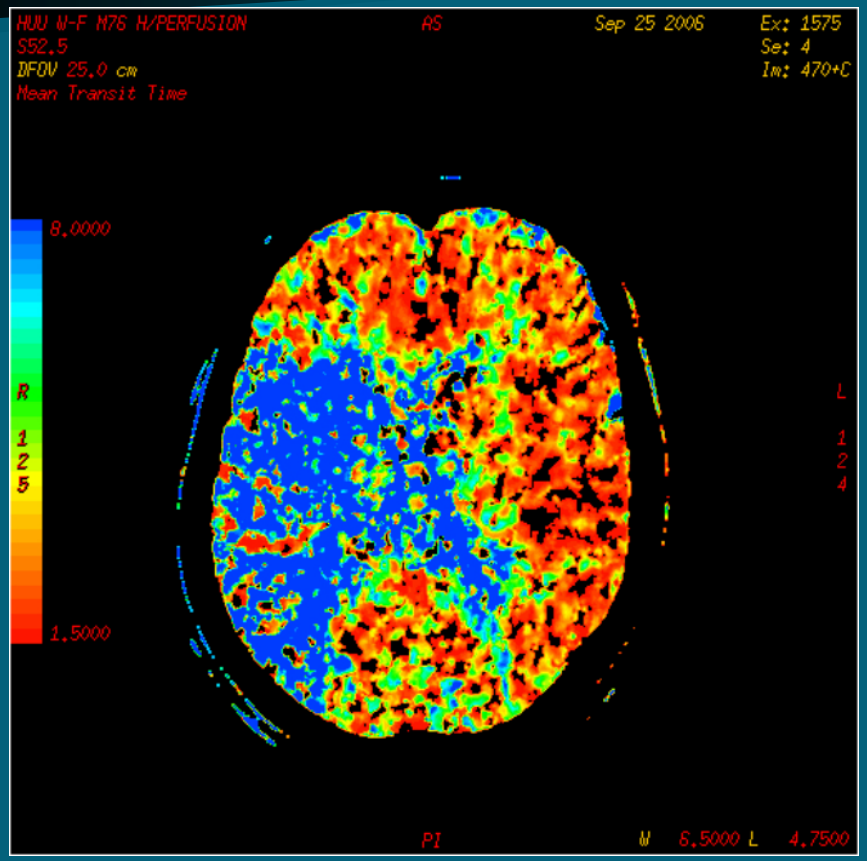
Safety issues



Baseline

Recanalized

Delayed pseudoaneurysm



Recurrent ischemia

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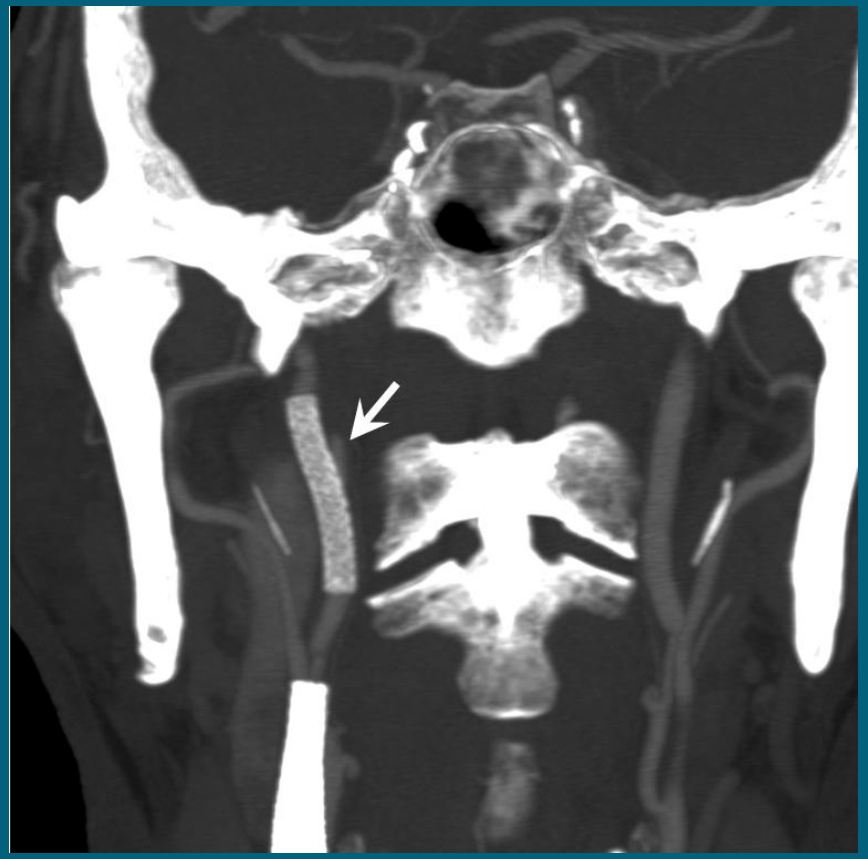
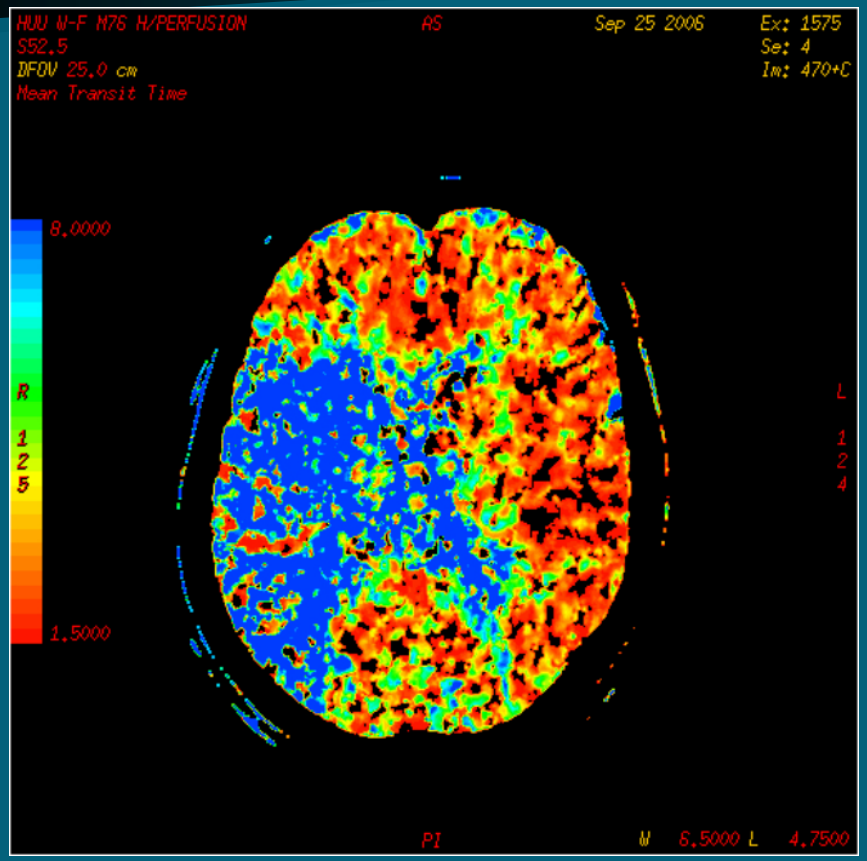
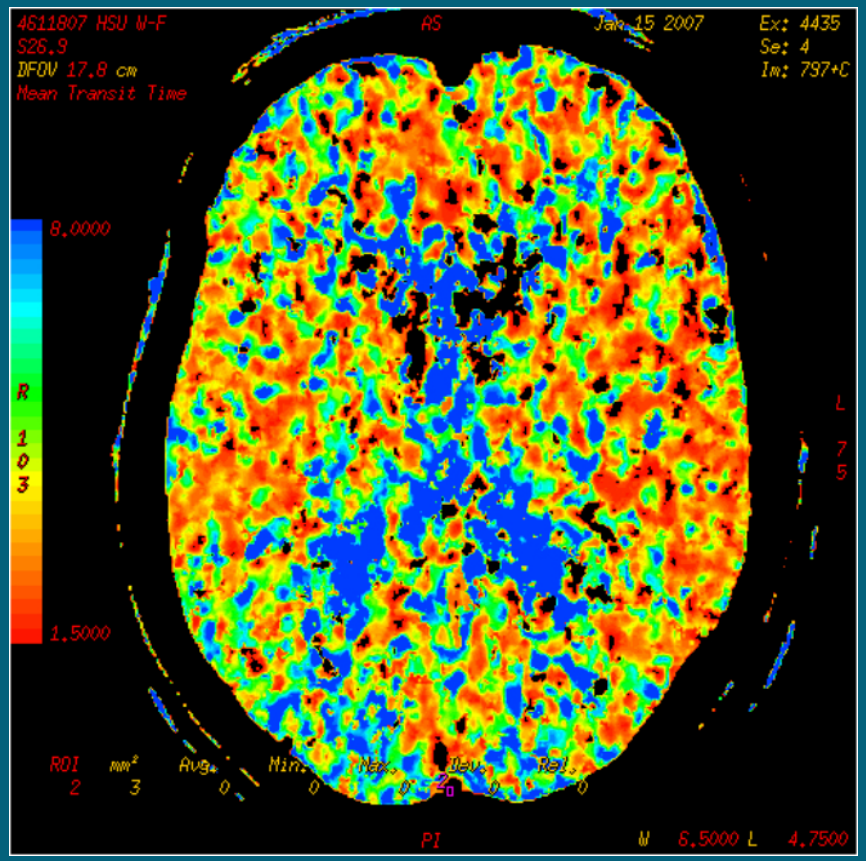
BMS across pseudoaneurysm



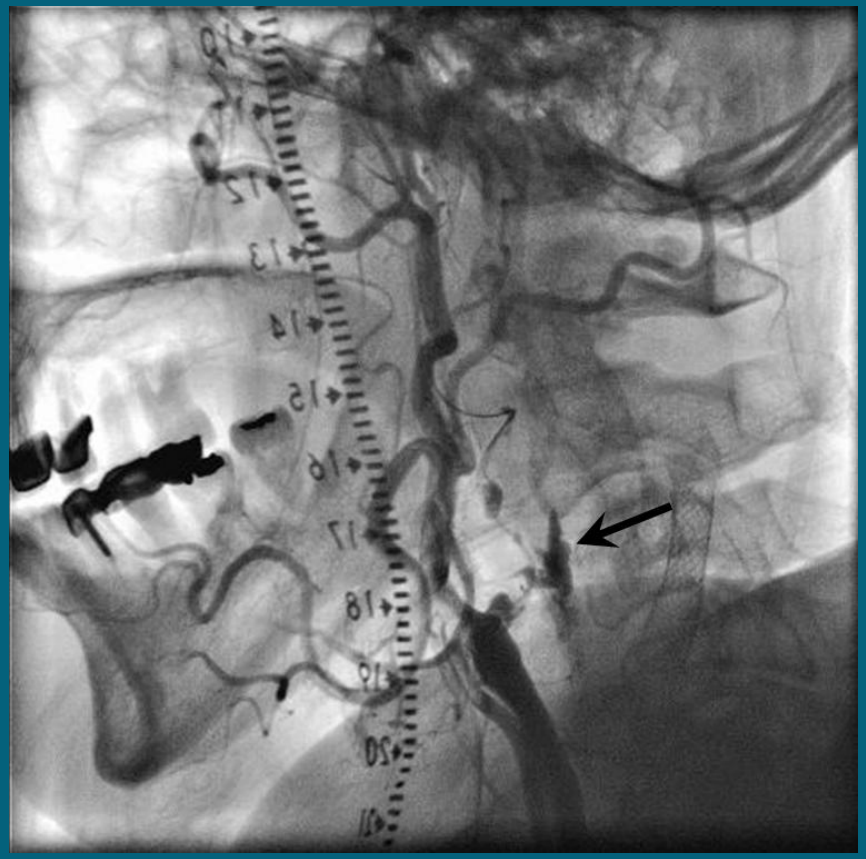
Ischemia relieved





Extravasation

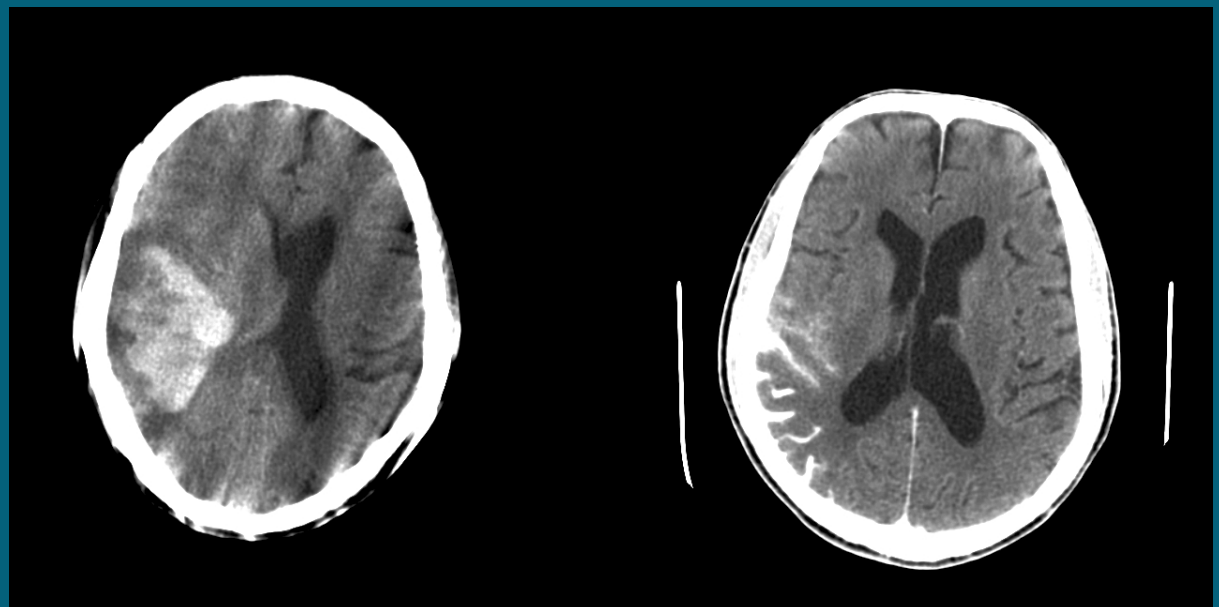
Carotid-cavernous fistula



Local hematoma

Post-procedural care

- All patients stented were monitored in CCU overnight
- No post-procedural anticoagulation, but aspirin and clopidogrel are maintained for at least 3 months
- Continuous BP monitoring, clamping SBP within 100-140mmHg using NTG/dopamine



Endpoints for ICAO intervention

- Physiological and functional endpoints are important
  - Neuro-cognitive evaluation
- Perfusion imaging
  - Perfusion CT: rest/Diamox stress
  - MRI CBF measurements (PWI): rest/Diamox stress
  - Brain ^{18}F-FDG PET (SPM quantification): brain glucose metabolism

Conclusions

- Endovascular recanalization of ICAO is feasible and safe, and knowledge of cprpnary CTO equipments and techniques is essential

- Future prospective studies with larger patient numbers evaluating functional endpoints are mandatory to establish the benefit and indication of ICAO recanalization

It's never too late to open a closed door, because the room behind may be full of surprises