

# ACUTE STROKE INTERVENTIONS & CAROTID STENTING

How to prevent hyperperfusion syndrome and intracranial bleeding after carotid stenting -  
Patient selection, procedural aspects and post-procedural care

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# Disclosure

Speaker name: Piotr Pieniazek

I have the following potential conflicts of interest to report:

 Consulting

- ☐ Employment in industry
- ☐ Stockholder of a healthcare company
- ☐ Owner of a healthcare company
- ☐ Other(s)
- ☐ I do not have any potential conflict of interest

## In 2018 !!!

- Era of new meshstents ( Roadsaver, CGuard)
- New generation of independent filters
- Common use of proximal protection
- Double filter protection ( Paladin device ) in high risk patient
- Risk of distal embolization below 0.5%!!

Unresolved problem is Hyperperfusion Syndrom

### Comorbidity/medication

- Diabetes mellitus
- Longstanding hypertension
- Pre-existing hypertensive microangiopathy
- Minor stroke in the presenting history
- Age  $\geq 72$  years
- Recent (<3 months) contralateral CEA
- High-grade carotid artery stenosis

### Flow related

#### Preoperative

- Poor collateral flow
- Contralateral carotid occlusion
- Incomplete circle of Willis
- Preoperative hypoperfusion
- Diminished cerebrovascular reactivity or reserve
- Intracerebral steal (decrease of CBF after acetazolamide challenge)

#### Perioperative or postoperative

- Increased intraoperative CBF after clamp release
- Intraoperative distal carotid pressure of  $\leq 40$  mm Hg (measured through shunt)
- Persistence of hyperperfusion longer than several days postoperative
- Systemic hypertension

#### Miscellaneous

- Use of (high doses of) volatile halogenated hydrocarbon anaesthetics
- Use of anticoagulants or antiplatelet therapy
- Periprocedural cerebral infarction

## Potential risk factors:

best proven risk factor  
mean SBP of 164 mmHg  
(95% (CI) 150 - 178  
mmHg)

postoperatively in pts  
who develop CHS  
no published cases of  
CHS below a SBP of  
<135 mmHg

van Mook W Lancet Neurol 2005,  
S. Bouri et al. Eur J Vasc Endovasc Surg (2011)



# Cerebral Hyperperfusion

## Symptoms:

- throbbing ipsilateral frontotemporal, periorbital or diffuse headache
- nausea, vomiting
- eye, face pain
- aphasia
- psychotic disorders
- confusion
- macular oedema
- visual disturbances
- focal motor seizures with frequent secondary generation
- hemiparesis, hemiplegia
- focal neurologic deficits
- intracerebral or subarachnoid hemorrhage

mild



life threatening  
fatal

Mean onset time:

- 5.8 postoperative day in patients who undergo CEA vs. 1.5 days in those after CAS ( $p < 0.0001$ )

• Ogasawara et al. JNeurosurg 2007

Our experience : all 8 fatal ICH 2 – 8 mean 4hr after CAS procedure

## Cerebral Hyperperfusion Incidence:

	Cerebral Hyperperfusion	Intracranial Haemorrhage
Carotid Endarterectomy	1.9% (range, 0.4% to 14%)	0.37% (range, 0% to 1%)
Carotid Artery Stenting	1.16% (range, 0.44% to 11.7%)	0.74% (range, 0.36% to 4.5%)

In the metaanalysis of 13 studies on 4689 CEA pts and 9 studies on 4446 CAS pts (*Moulakakis KG et al. JVascSurg 2009*)

### Our experience:

- severe CHS that resulted in **fatal ICH** : **0.24% out of 1252 CAS** procedures
- insignificantly more often in pts > 75 years old 0.1% vs 0.01% in the younger (p=0.07)

*Dzierwa K. Pieniazek P et al: Catheter Cardiovasc Interv. 2013 Nov. 1; 82(5).*

Severe CHS that resulted in **fatal ICH** : **0.34% out of 2015 CAS** procedures.

# Pathophysiology

- combination of increased CBF with impaired cerebro-vascular autoregulation may play a key role in the expression of CHS
  - carbon dioxide and cerebral autoregulation maintain cerebral perfusion over the range of systemic blood pressures 60 -160 mmHg

Chronic ischaemia → Dilation of the resistance arteries and arterioles



Endothelial changes



Diabetes, hypertension

Nitric oxide

**We need to spend more time to discuss how to prevent hyperperfusion syndrome after CAS !!!**

Endothelial damage

Breakthrough of autoregulation

Baroreceptor reflex breakdown (CEA)

Hydrostatic forces

BP uncontrolled

Brain blood barrier breakthrough

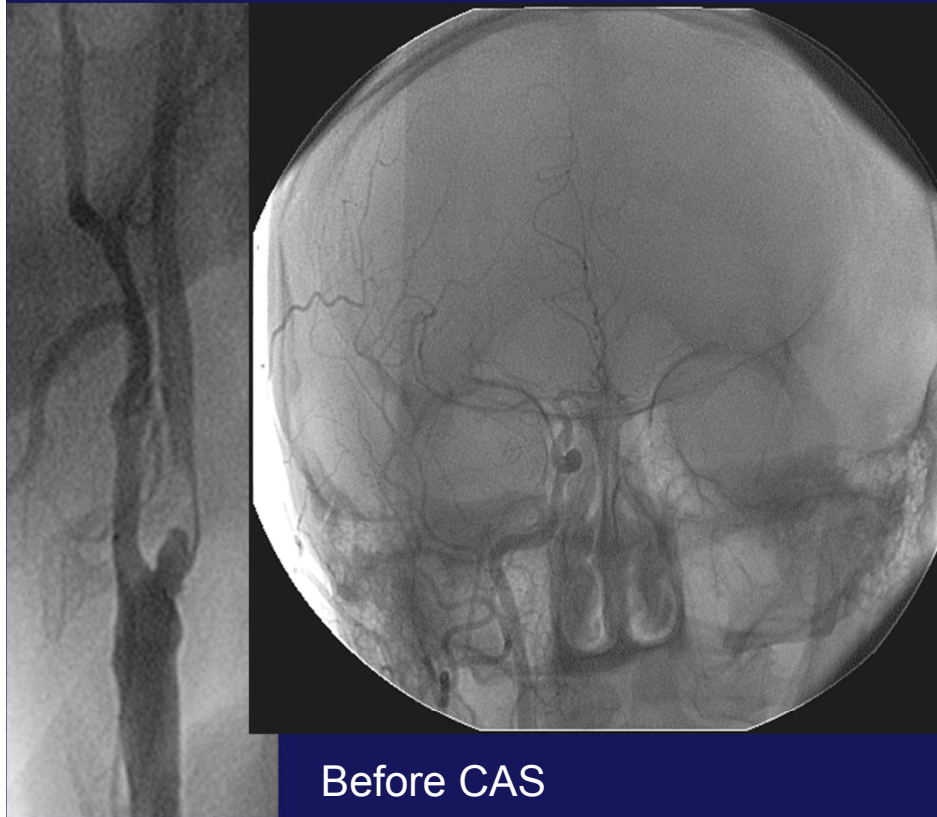
oedema

haemorrhage

regulation

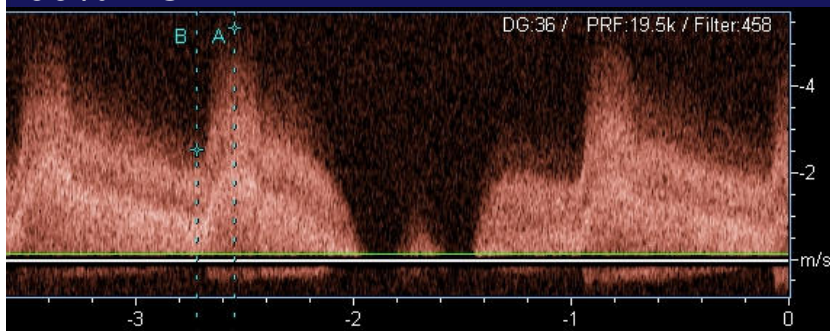
increase in blood flow (hypertensive pts)

Pt. age 76, with LICA occlusion & 99% RICA stenosis .

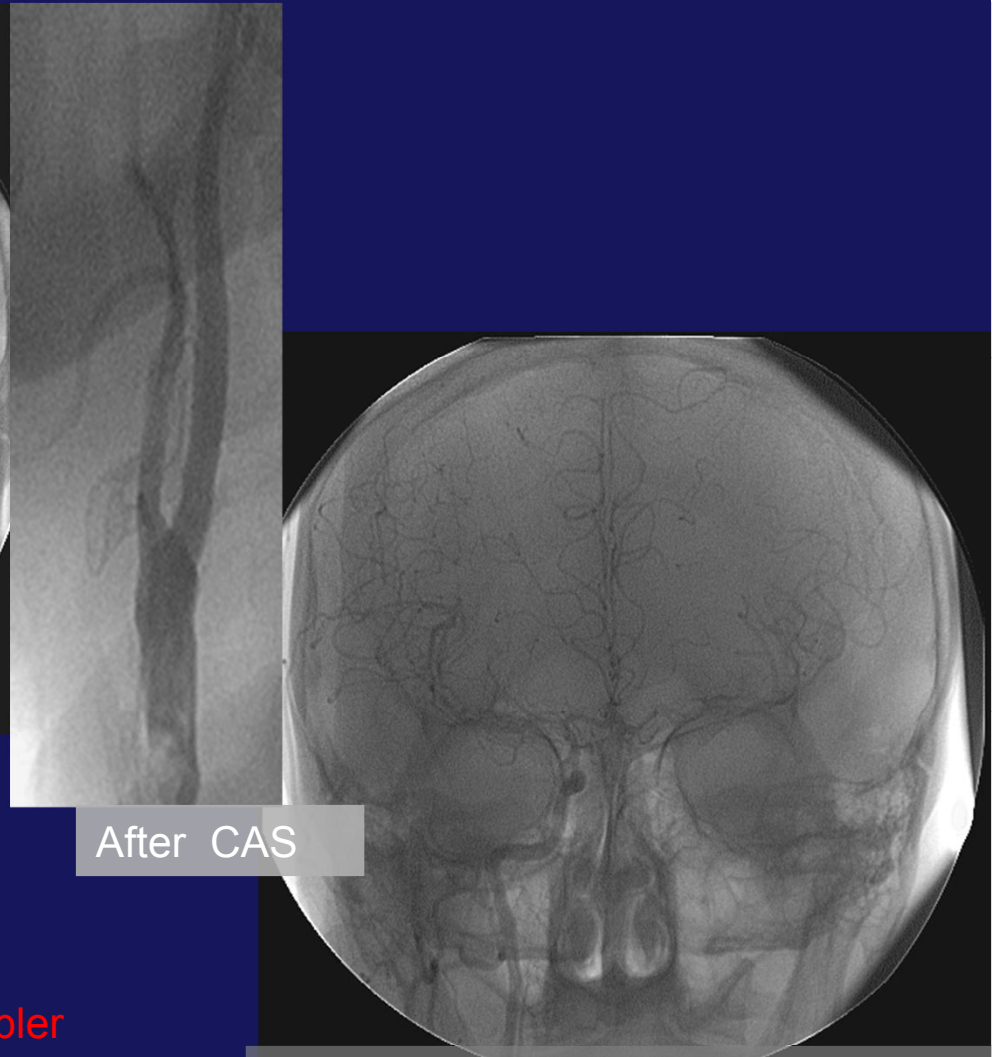


Before CAS

99%RICA



Doppler  
4.7/2.3 m/s



After CAS

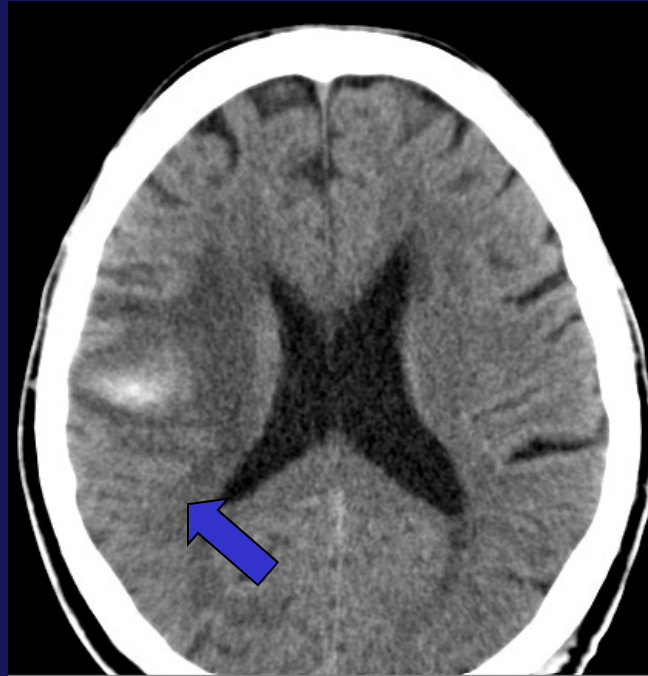
Intra cranial angiography after CAS –  
significant improvement of inflow to  
both haemispheres



## 8h. after CAS severe headache, and left hemiparesis



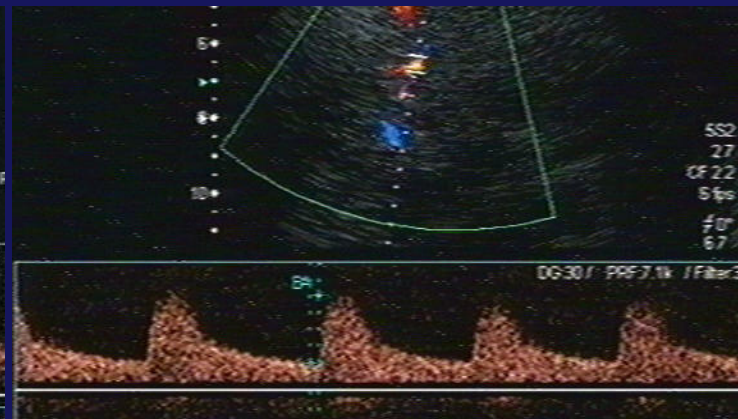
Normal Angio CT before CAS



Intracranial bleeding

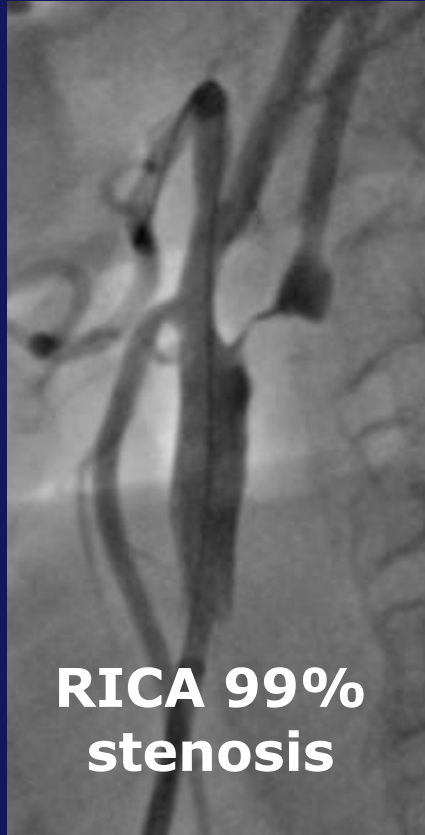


Doppler US – normal  
in-stent flow



2.7- time  
higher flow in  
RMCA

**Male 54 y.o. recently symptomatic RICA, 4 episodes of TIA within 24hr.**



**5 hours after CAS,**  
symptoms of right hemispheric  
stroke, seizures, headache,  
apnea requiring mechanical  
ventilation

**A successful  
Cristallo 6-9x40mm  
stent implantation**

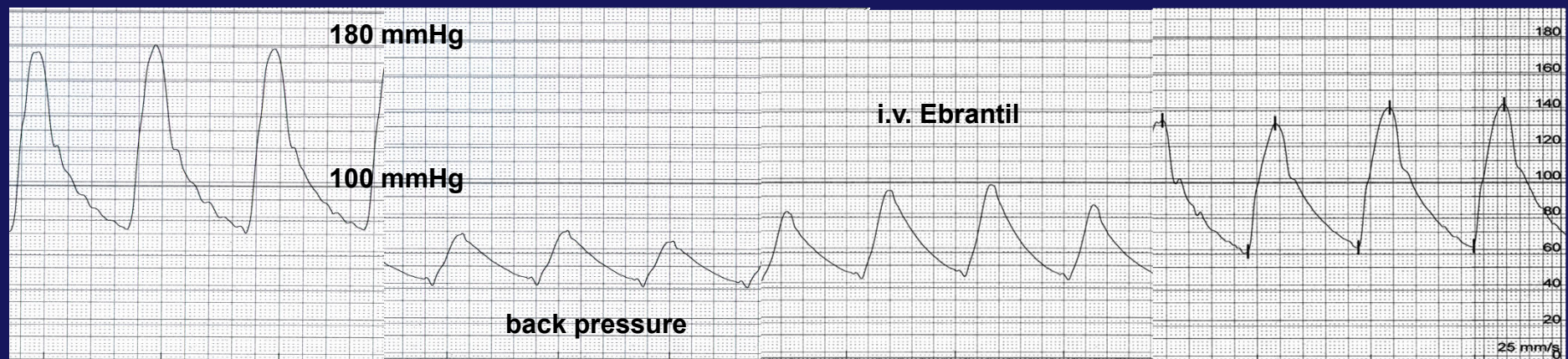
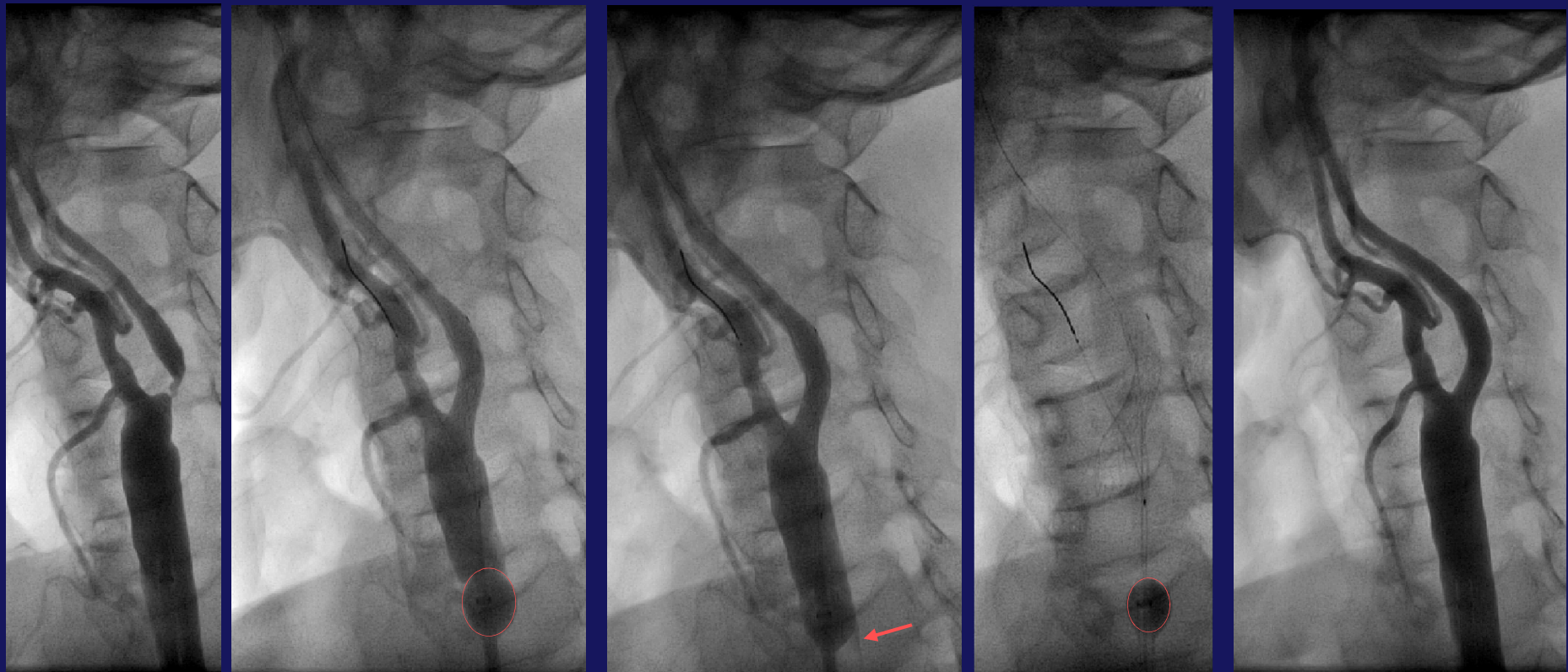
**Cerebral hyperperfusion syndrome – rare but severe, often  
fatal complication of CAS**



**CT scan: massive intracranial haemorrhage**



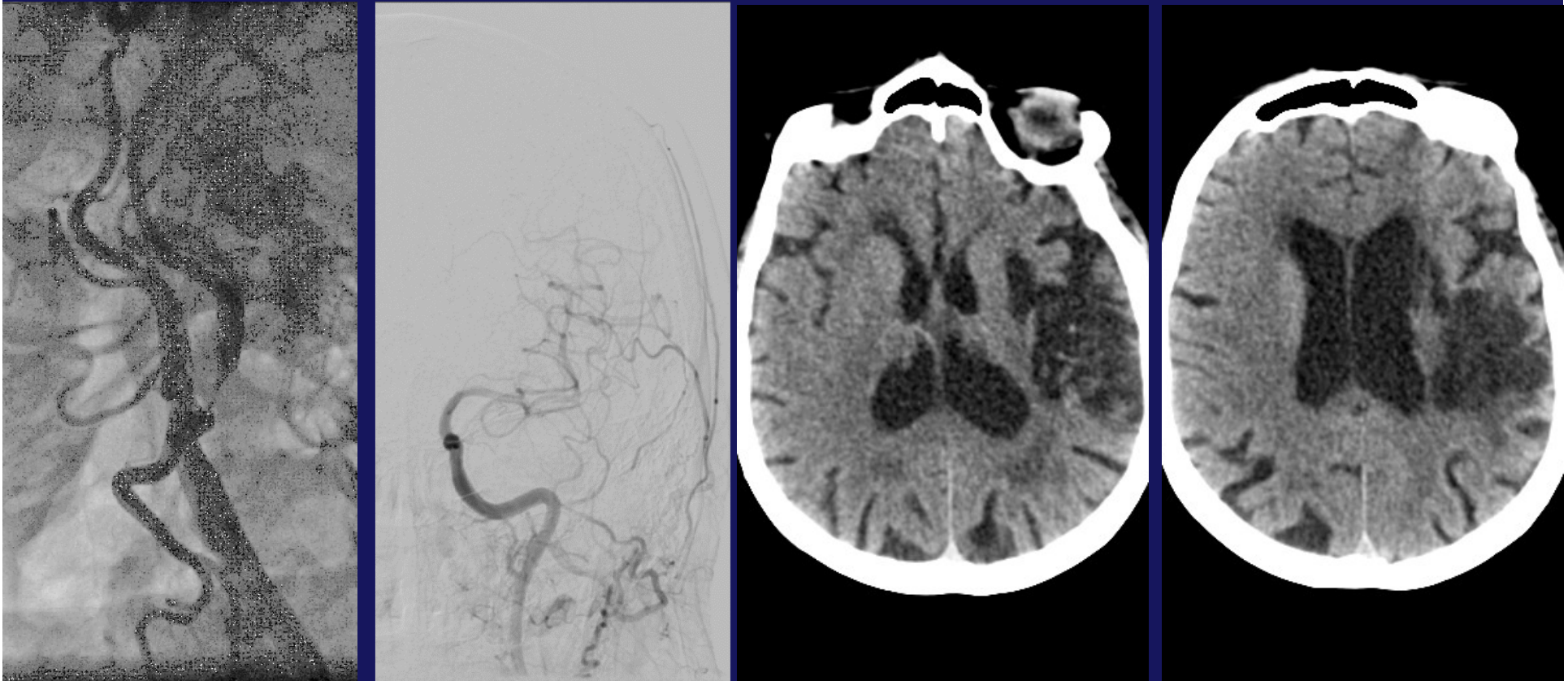
## Slow 'restitution' of ICA flow under BP control....



might reduce risks of 'bombarding' the brain with sudden and rapid ICA flow.

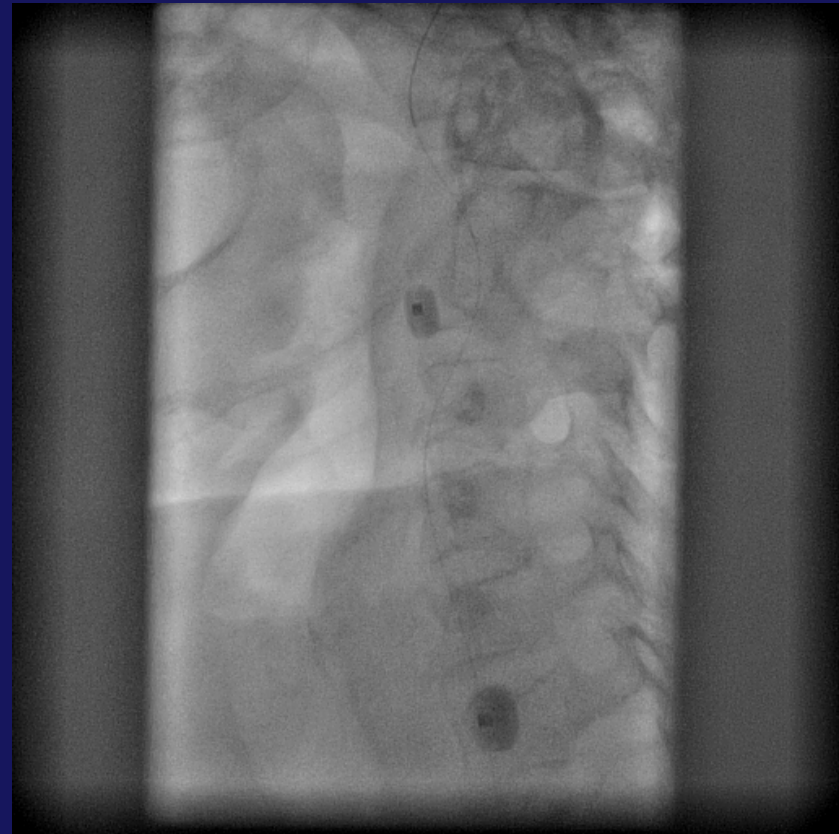


Pt of high risk for hyperperfusion syndrome !!!  
Recent major stroke with large cerebral scare  
Tight ICA stenosis with slow flow.



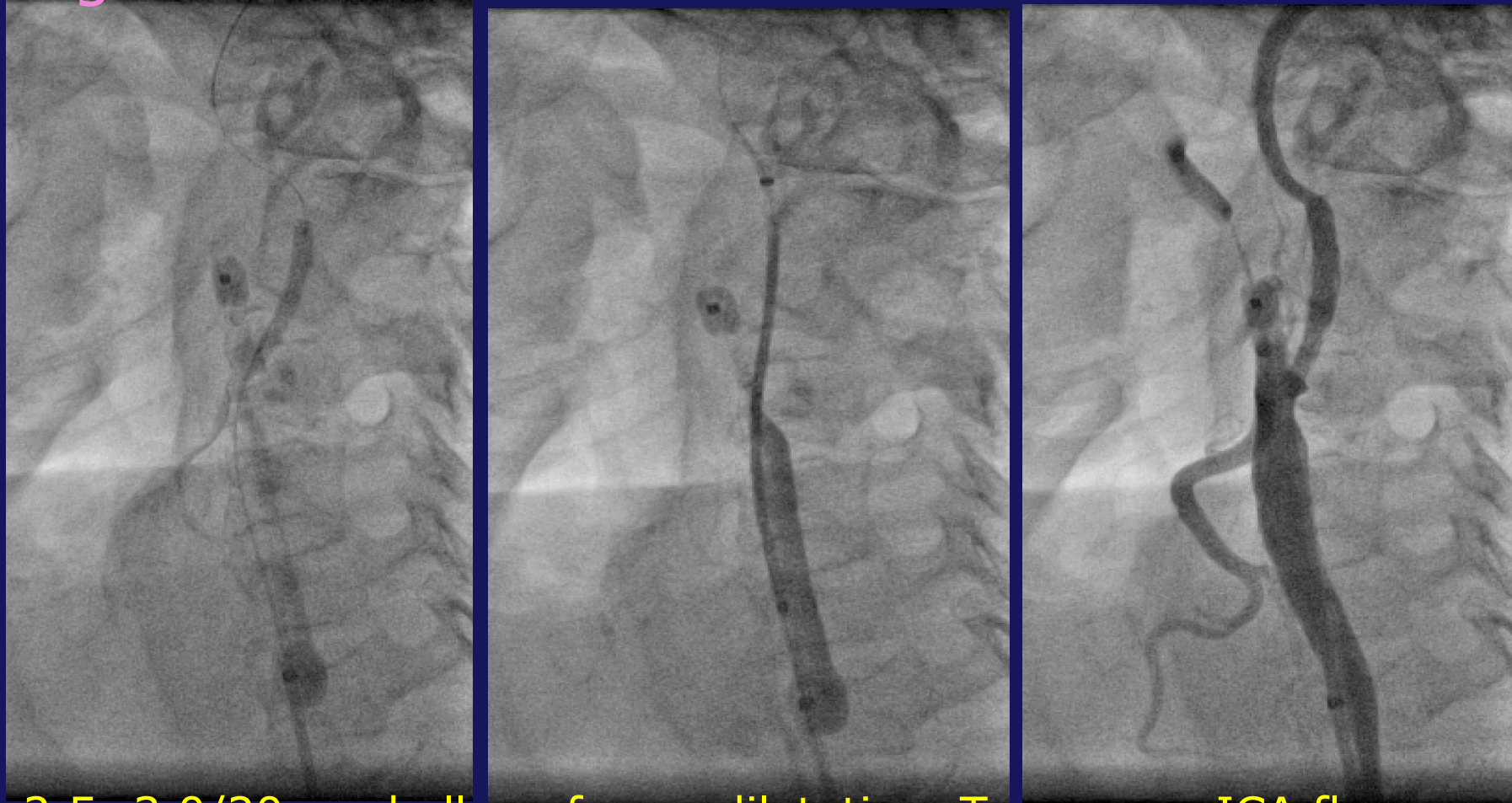
How to prevent hyperperfusion syndrome ????

Pt of high risk for hyperperfusion syndrome !!!  
Recent major stroke with large cerebral scare  
Tight ICA stenosis with slow flow.



How to prevent hyperperfusion syndrome ????

Pt of high risk for hyperperfusion syndrome !!!  
Recent major stroke with large cerebral scare.  
Tight ICA stenosis with slow flow.



2.5 -3.0/20mm balloon for predilatation. Temporary ICA flow restoration for 10 min for intracranial artery precondition before massive inflow after postdilatation. Roadsaver is a very safe stent in this CAS strategy



Pt of high risk for hyperperfusion syndrome !!!  
Recent major stroke with large cerebral scare.  
Tight ICA stenosis with slow flow.

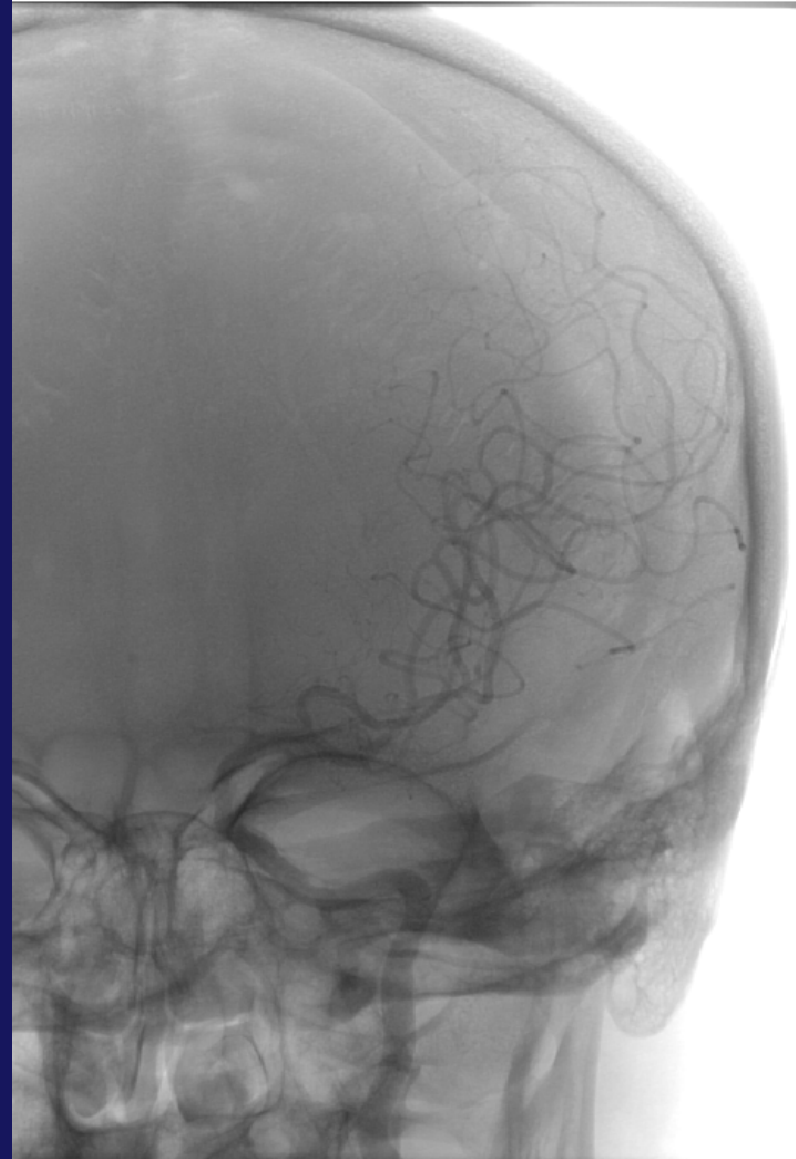


After aggressive postdilatation – normalization of intracranial circulation

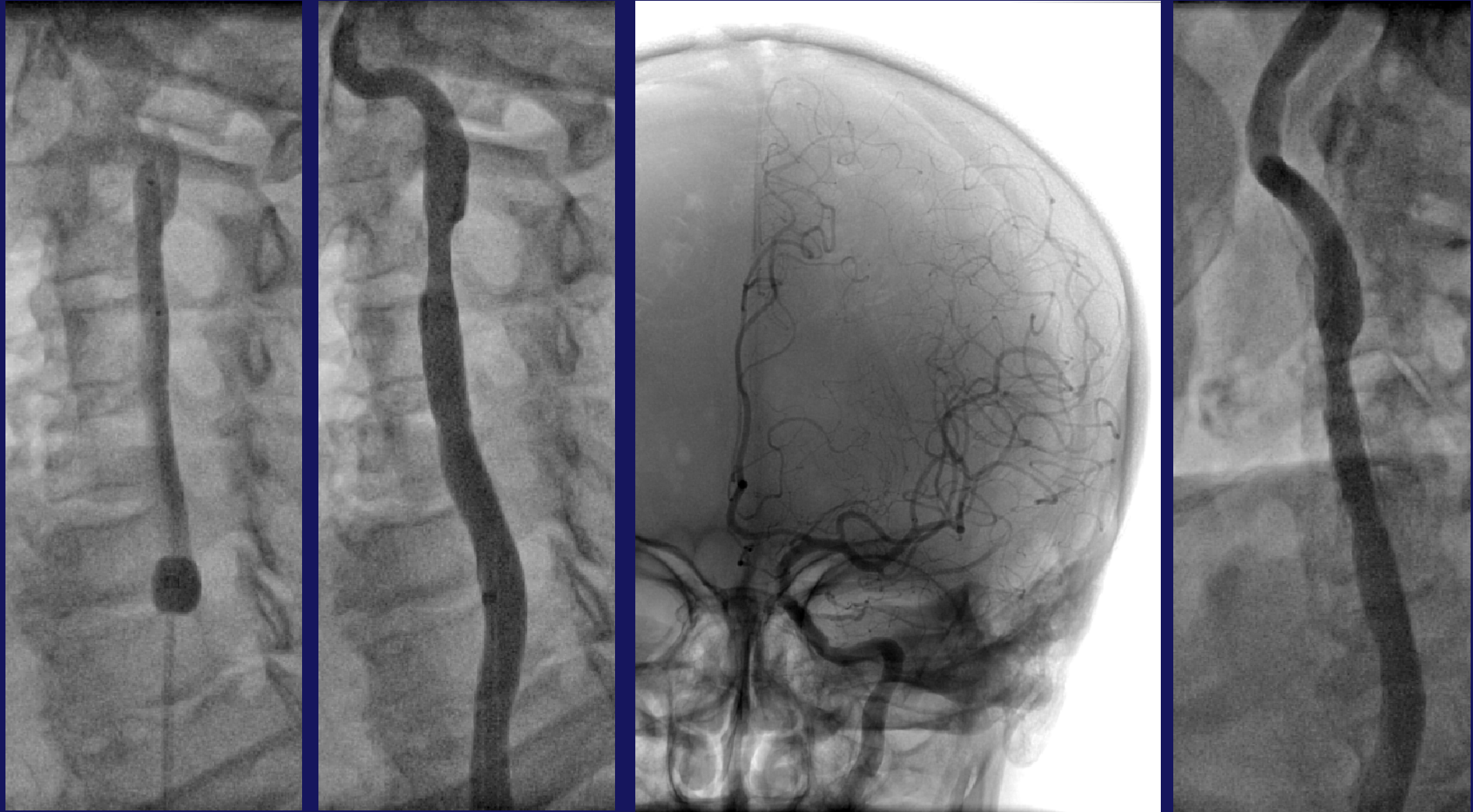
Small aneurysm on left AIA represents additional risk of intracranial bleeding after CAS

Patient with recurrent TIA within prior 48 h  
(right haemiparesis and slurred speech).

Procedure strategy to prevent hyperperfusion



High risk for hyperperfusion Mono-MoMa **suboptimal** CAS procedure  
**predilatation** with 3.5/20 balloon!! and Carotid Wallstent implantation **without**  
**posdilatation** !!!!!!!



3 m follow up. Improved angiographic result

**Don't always try to optimize CAS procedure as PCI ( eg. soft, high symptomatic lesion ).**



# The role of TCD to predict HPS after CAS

J Endovasc Ther. 2010 Aug;17(4):556-63. doi: 10.1583/09-2980.1.

## Predictors of cerebral reperfusion injury after carotid stenting: the role of transcranial color-coded Doppler ultrasonography.

Kablak-Ziembicka A<sup>1</sup>, Przewlocki T, Pieniazek P, Musialek P, Tekieli L, Rosławiecka A, Motyl R, Zmudka K, Tracz W, Podolec P.

### ⊕ Author information

#### Abstract

**PURPOSE:** To evaluate the possible role of transcranial color-coded Doppler ultrasonography (TCD) in predicting cerebral reperfusion injury (CRI) in patients undergoing carotid artery stenting (CAS) for internal carotid artery (ICA) stenosis.

**METHODS:** TCD was obtained in 210 patients (149 men; mean age 64.2 $\pm$ 8.4 years, range 44-83) who underwent CAS for ICA stenosis averaging 86.7% $\pm$ 8.4%. Contralateral ICA occlusion or near occlusion (stenosis >90%) was present in 67 (31.9%) patients. TCD was performed before and 24 hours after CAS with assessment of peak systolic velocities (PSVs) in the ipsilateral middle cerebral artery (iMCA) and contralateral middle cerebral artery (cMCA). PSV ratios (PSVR) in the iMCA and cMCA were calculated from the PSVs before and after CAS.

**RESULTS:** CRI syndrome occurred in 3 (1.4%) patients (2 intracranial bleedings, 1 subarachnoid hemorrhage). The mean iMCA and cMCA PSVRs were 2.66 $\pm$ 0.19 and 4.16 $\pm$ 2.77, respectively, in CRI patients, while the PSVRs in CAS patients without neurological sequelae were 1.56 $\pm$ 0.46 and 1.21 $\pm$ 0.39, respectively (both  $p < 0.001$ ). The combination of iPSVR > 2.4 and cPSVR > 2.4 occurred in 4 patients with bilateral ICA disease; 3 (75%) of them developed CRI (100% sensitivity and 99% specificity for CRI prediction). The following independent CRI predictors were identified: combined iPSVR > 2.4 and cPSVR > 2.4 (RR 2.06, CI 1.89 to 2.24;  $p < 0.001$ ), high cMCA PSV after CAS (RR 1.23, CI 1.13 to 1.34;  $p < 0.001$ ), and contralateral ICA occlusion (RR 1.13, CI 1.03 to 1.23;  $p = 0.007$ ).

**CONCLUSION:** TCD is an important tool in CRI risk evaluation. The combination of iPSVR > 2.4 and cPSVR > 2.4 is an independent CRI risk factor, along with contralateral ICA occlusion and high cMCA PSVs after CAS.



Our CAS strategy for prevention HPS works

From 2014 to 2018 – 1400 CAS procedures

TWO DEATHS DUE TO HPS AND ICH

0.15 % !!!!!

probably can not come down below this value

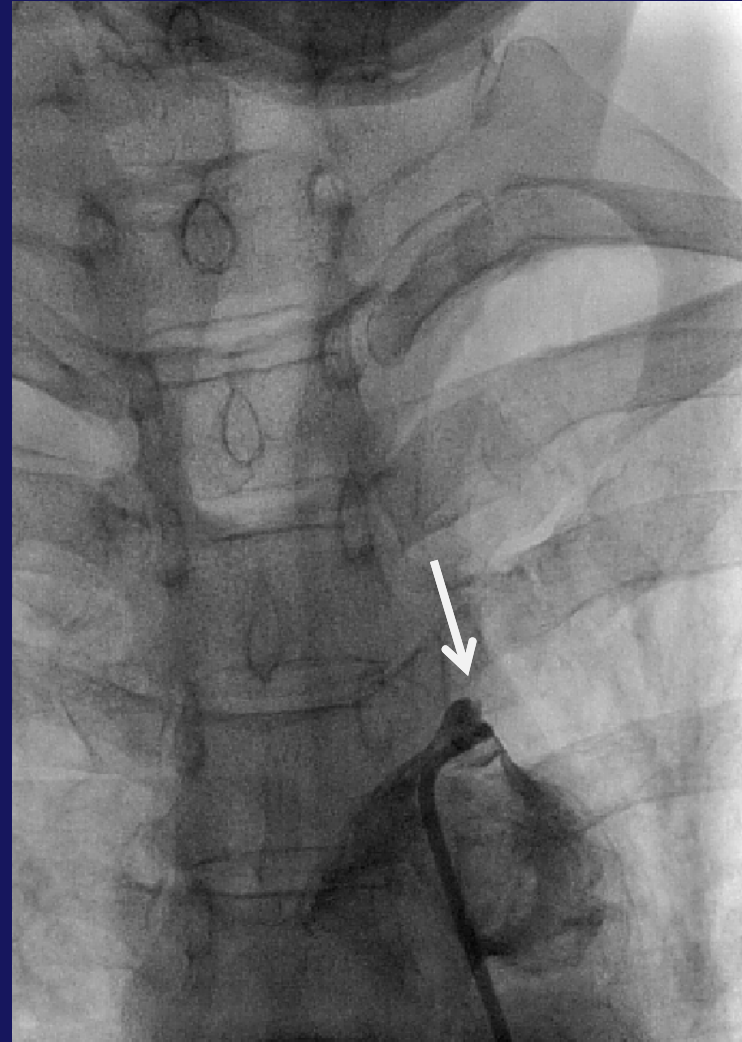
## 56 y.o. women with Takayasu Syndrome.



RICA-occlusion



LICA-occlusion



LSA-occlusion : severe ataxia ,  
vertigo,diplopia



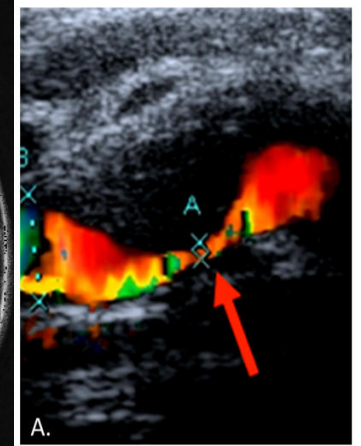
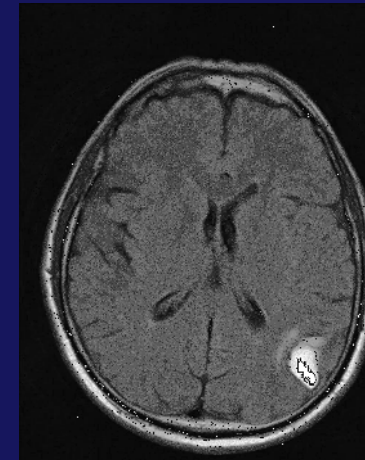
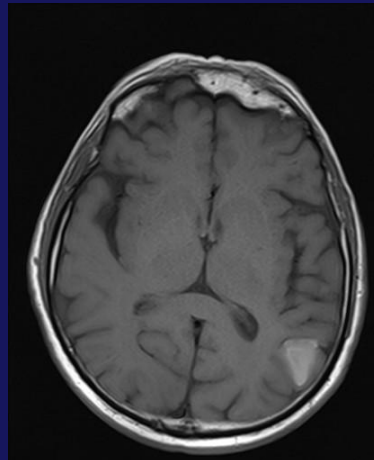
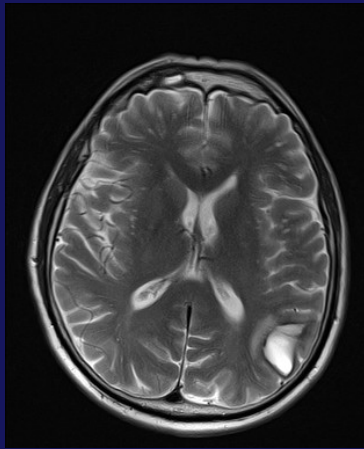
Hyperperfusion not only  
after CAS or CEA

Successful LSA  
recanalization

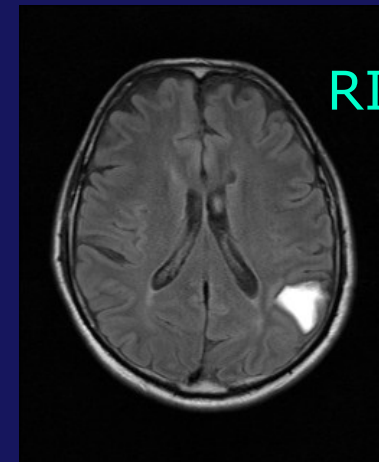
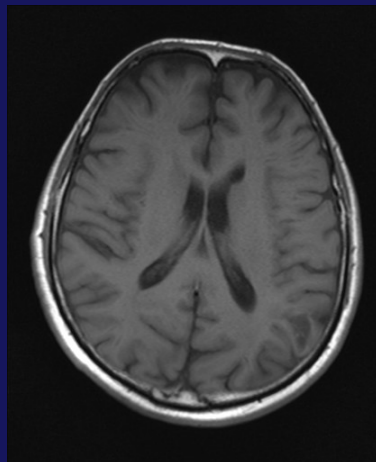
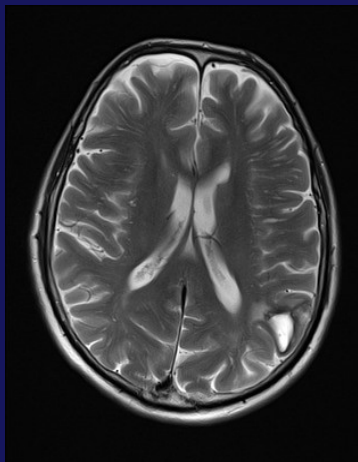


Intracranial  
bleeding due  
to Hyperperfusion  
Syndrome

No consensus between neurologists  
How to treat this patients  
with persistent hematoma & ipsilateral tight carotid artery stenosis



Stroke due to RICA 85% stenosis MRI LH-hematoma after rTPA therapy



RICA-stenosis

PSV-3,1m/s  
ESV -0.9m/s

RICA 85% stenosis MRI 5 monts later still LH – hematoma (no neurological symptoms)



# Conclusion

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- ❖ We need wide multidisciplinary discussion how to prevent hyperperfusion syndrome after CAS - the most severe complication !!!!!
- ❖ Patients after Trombolysis due to ischaemic stroke require special attention and always brain MRI before CAS procedure.
- ❖ Suboptimal angiografic effect in high risk pts for Hyperperfusion Syndrome can be effective and safe.
- ❖ The key issues : periprocedural blood pressure monitoring and intracranial circulation preparation/preconditionig !!!

# ICCA STROKE

**Warsaw 20-21.04.2018**

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**Kenneth Snyder, MD**, neurosurgeon, University at Buffalo, Buffalo, USA

It is a great honour to meet such outstanding interdisciplinary specialists and experts and debate for two days about future of CAS procedures and intracranial interventions !!

Everyone who want to do CAS and intracranial interventions should attend this course

# Hyperperfusion syndrome is the life threatening complication....

LICA



RICA



RICA stenting...



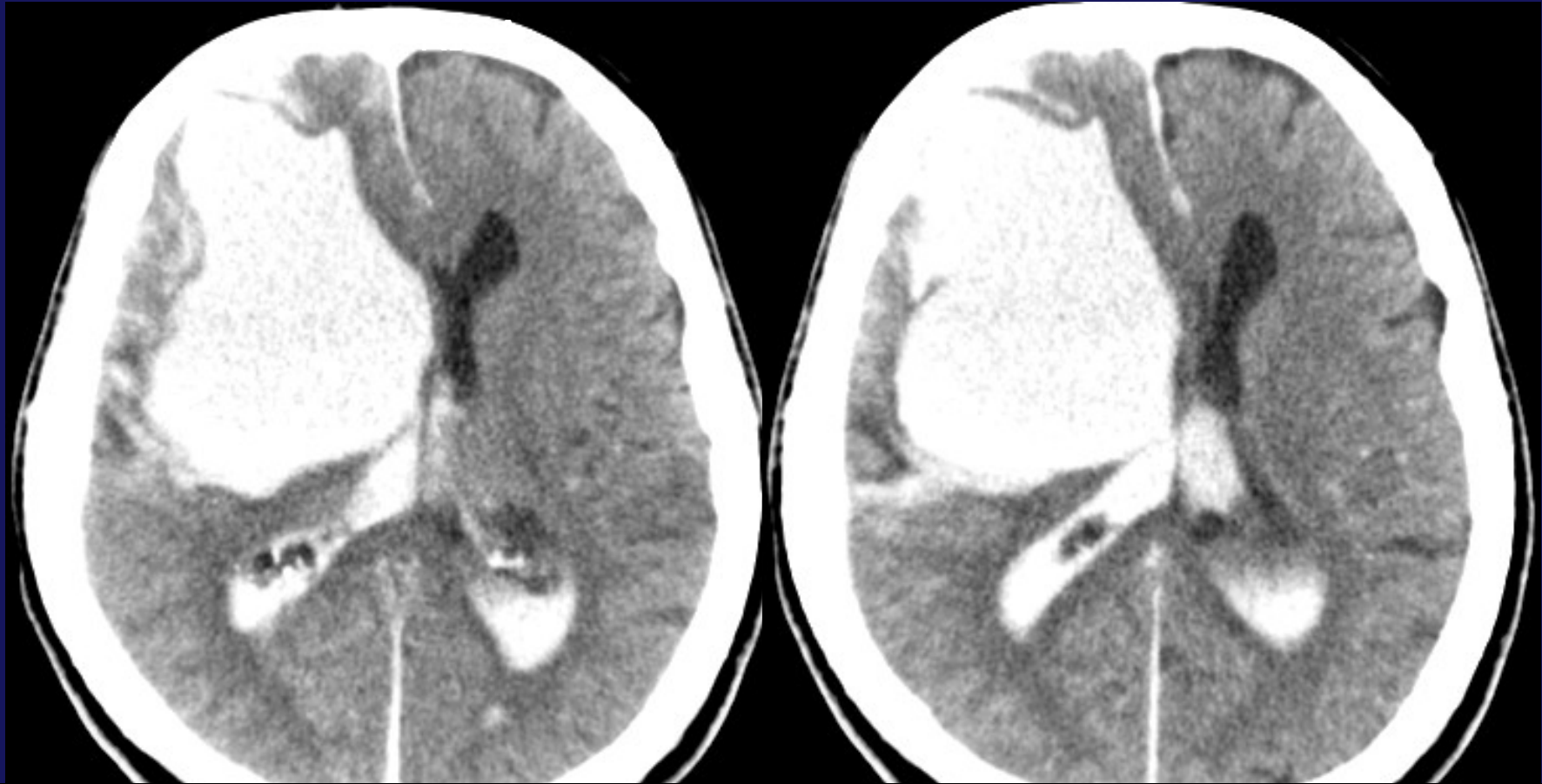
Still not resolve the problem !!!!!



Hyperperfusion syndrome is the life threatening complication....

3 hour later

Hyperperfusion syndrome is the life threatening complication....



Pt dyed during intubation just after CT scan....

Always take protamin to CT laboratory if you suspect HPS and intracranial bleeding