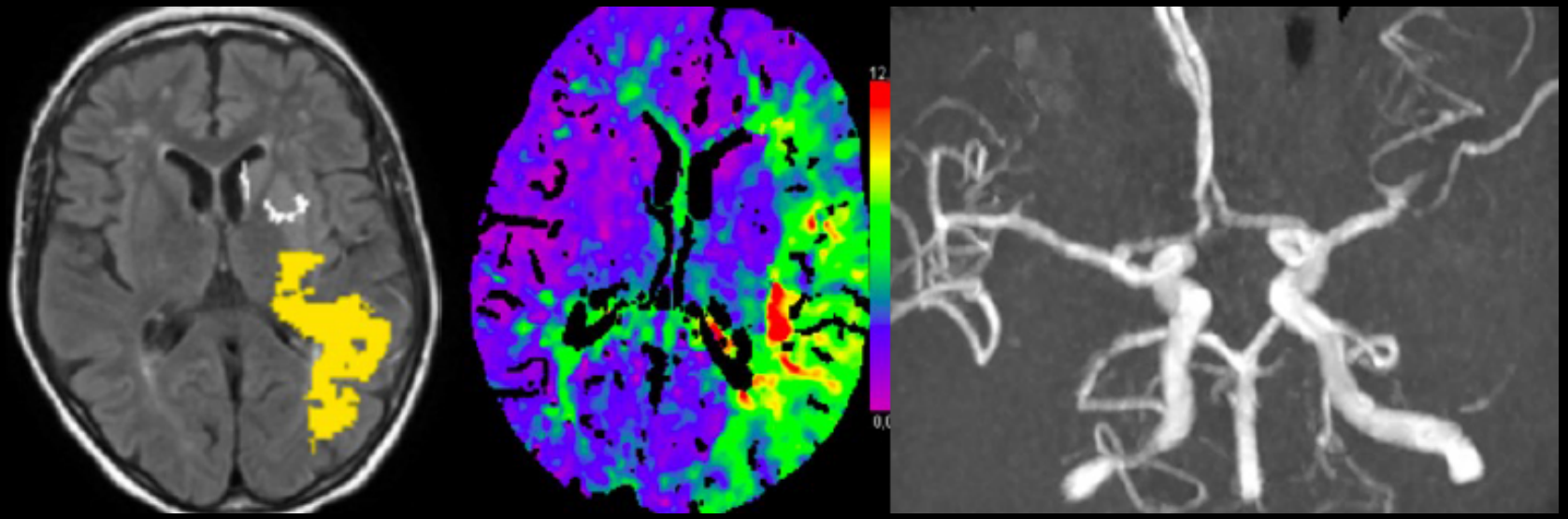
EPU de Neuroradiologie et d'Imagerie Tête et Cou

IRM cérébrale multimodale à la phase aiguë de l'AVC : ce qu'il faut retenir en 2019

Xavier Leclerc, Jérôme Hodel, Sébastien Verclytte, Jean-Pierre Pruvo



Université de Lille

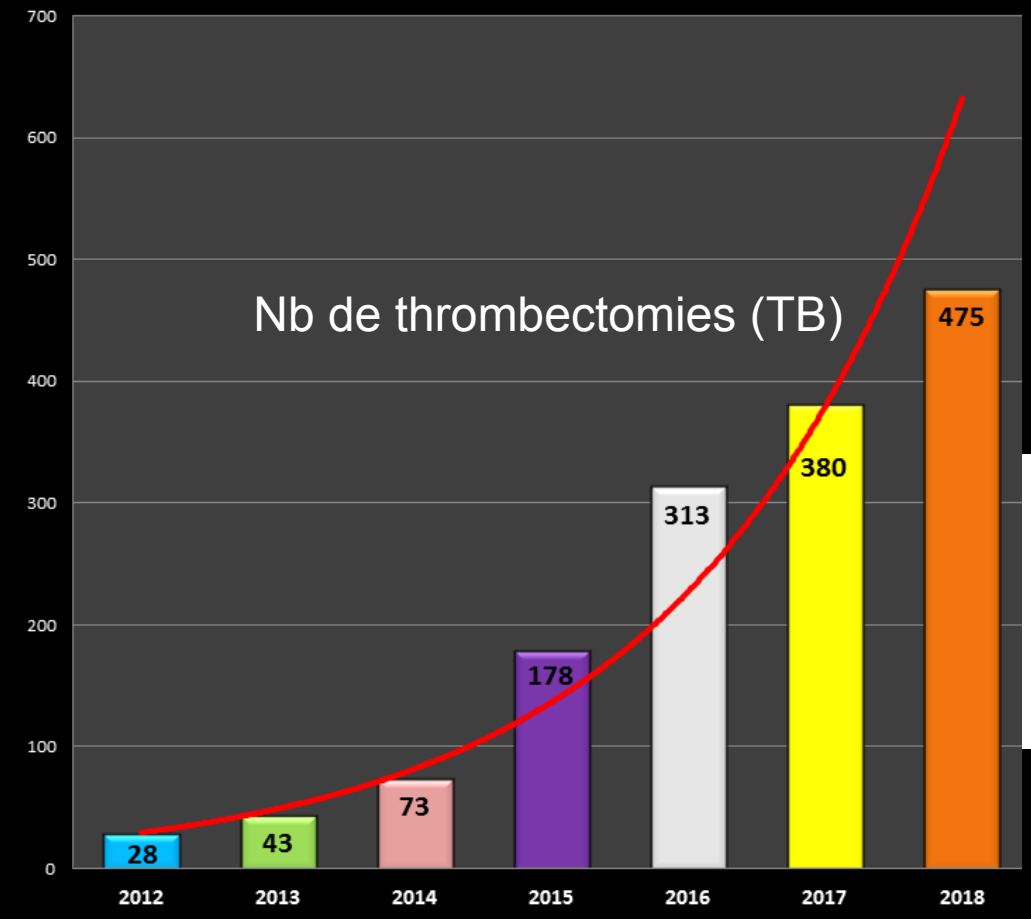
FACULTÉ DE MÉDECINE Henri Warembourg

CHU LILLE

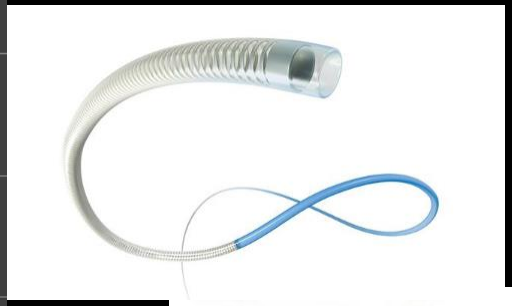
Objectif

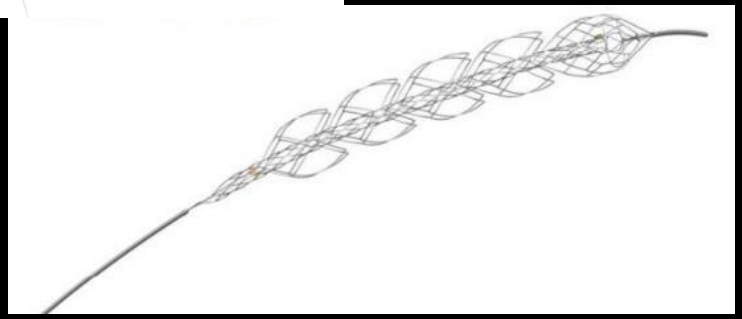
- La stratégie d'exploration et de prise en charge des AVC a évolué ces dernières années en raison des indications croissantes de la thrombectomie (TB)
- L'imagerie occupe une place majeure pour le diagnostic et la prise de décision.
- Discuter le protocole IRM et préciser l'apport de chaque séquence illustré par des cas cliniques

CHU Lille



MRI = examen de première intention avant TB





MrClean, Extend-IA, Escape, Swift, Thrace, Dawn, Defuse III

IRM et AVC aigu

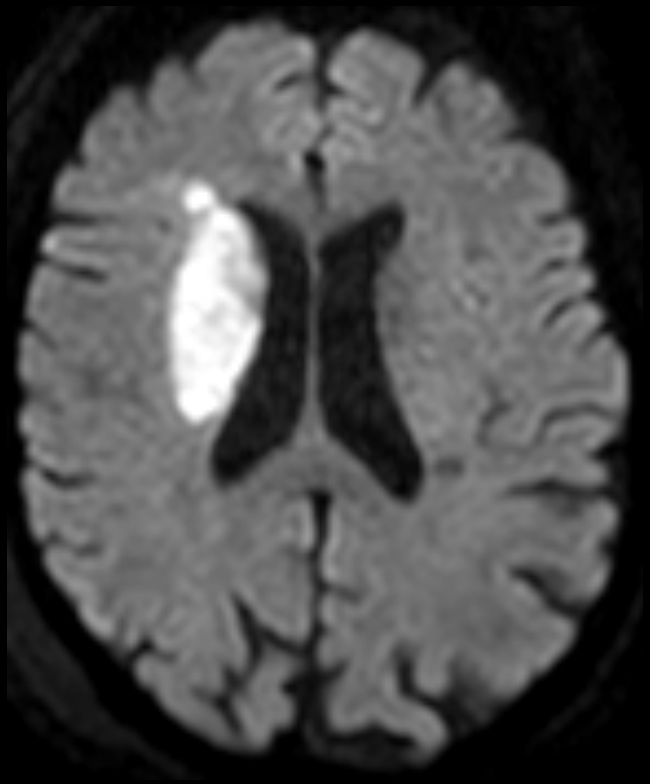
	Scanner	IRM
Hemorragie	+	+
Volume de l'infarctus	+	+++
Pénombre ischémique	+	+
Vx cervico-encéphaliques	+++	+
Stroke mimics	-	++
Fosse postérieure	-	++
Infarctus lacunaire	-	++
TA et accès	++	-

DWI et AVC ischémique aigu

Rôle clé dans la prise de décision

- < 70 mL = évolution clique favorable chez les patients traités par TB

- > 100 mL = Pas de bénéfice de la TB et risque augmenté d'hémorragie intracrânienne

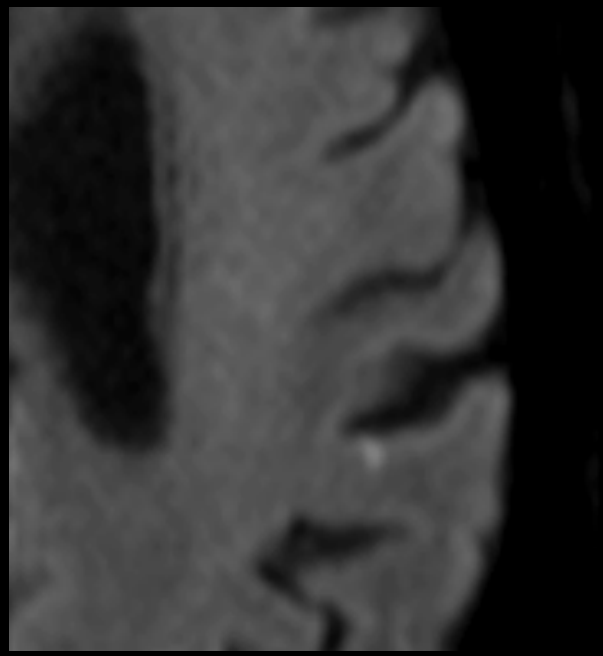


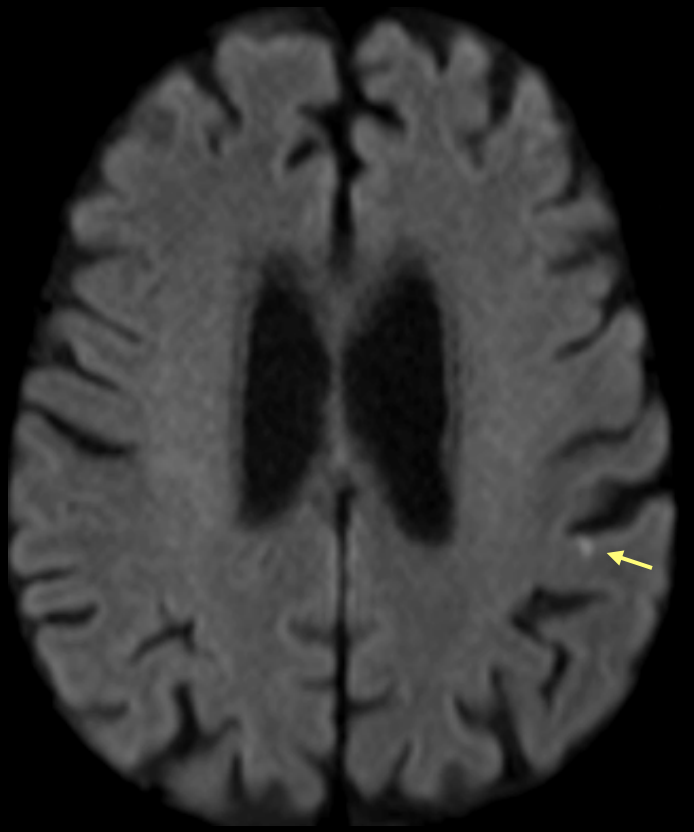
Yoo AJ et al. Infarct volume is a pivotal biomarker after intra-arterial stroke therapy. Stroke 2012;43:1323-30.

DWI et AVC ischémique aigu

Technique très sensible

- 90% dès la première heure après début des signes

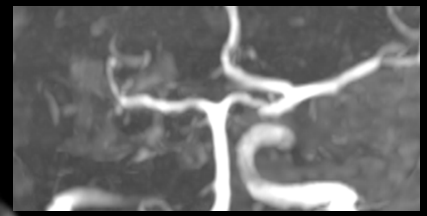




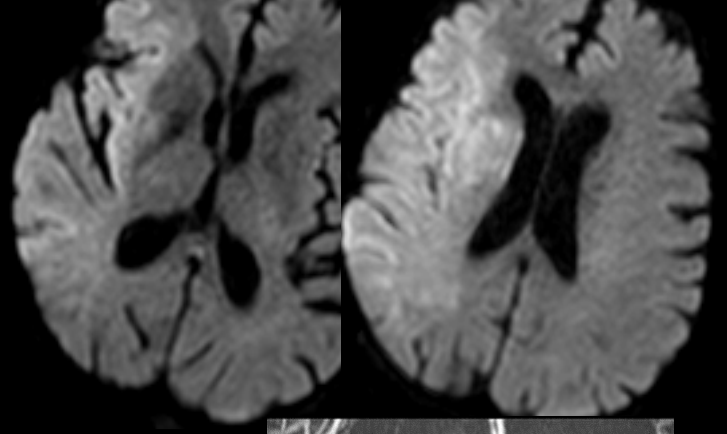
Aphasie transitoire

Schaefer PW et al. Diffusion-weighted MR imaging of the brain. Radiology 2000;217:331-45

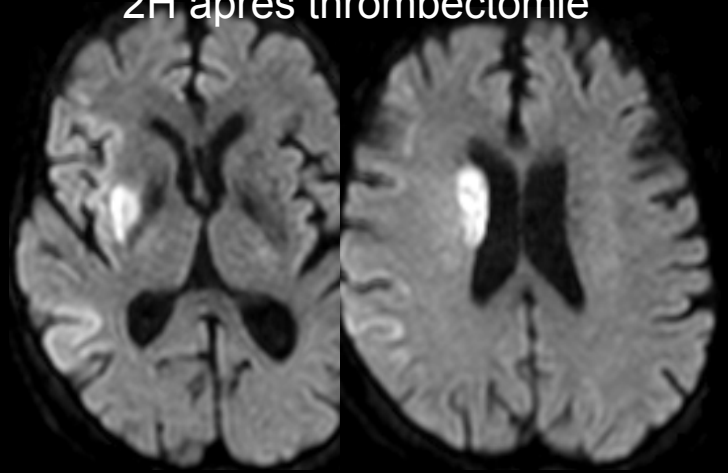
DWI et AVC ischémique aigu



1H après début des signes



2H après thrombectomie



Reversibilité des anomalies en diffusion après TB

- Reperfusion très précoce (< 3 H)
- Réversibilité partielle le plus souvent
- Parfois majeure si la diffusion est réalisée précocément après TB (pseudonormalisation)

Labeyrie MA, Turc G, Hess A, et al. Diffusion lesion reversal after thrombolysis: a MR correlate of early neurological improvement. Stroke 2012;43:2986–91.

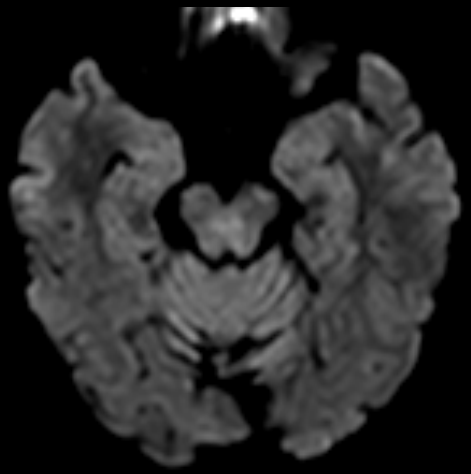
DWI et AVC ischémique aigu

Diffusion normale

- Diffusion précoce
- Infarctus de petite taille
- Infarctus du tronc cérébral
- Accident ischémique transitoire
- Stroke mimics

DWI et AVC ischémique aigu

Diffusion normale



H 5

- Diffusion précoce
- Infarctus de petite taille
- Infarctus du tronc cérébral
- Accident ischémique transitoire
- Stroke mimics

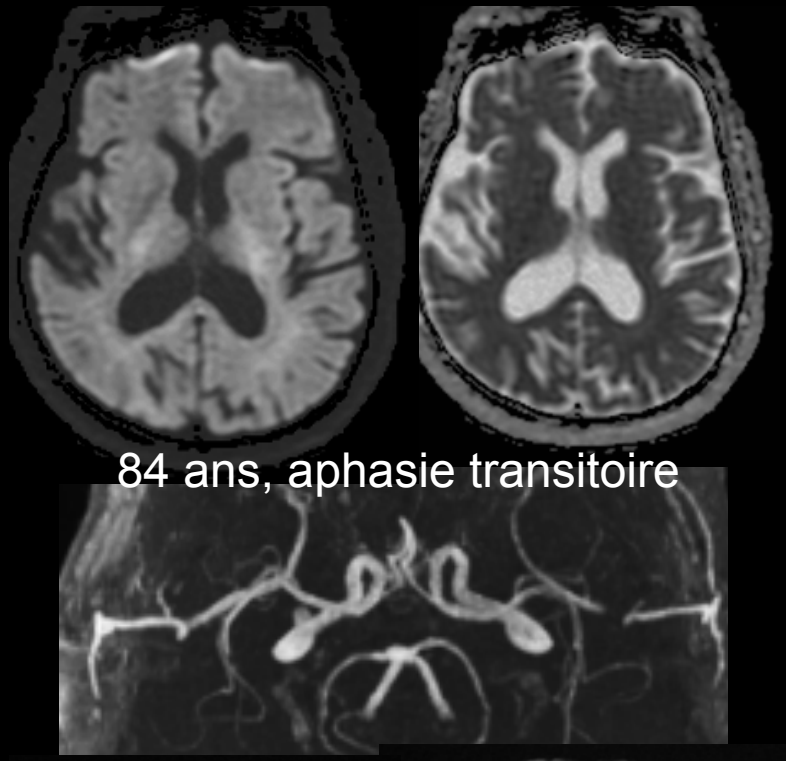
Diplopie binoculaire

H 10

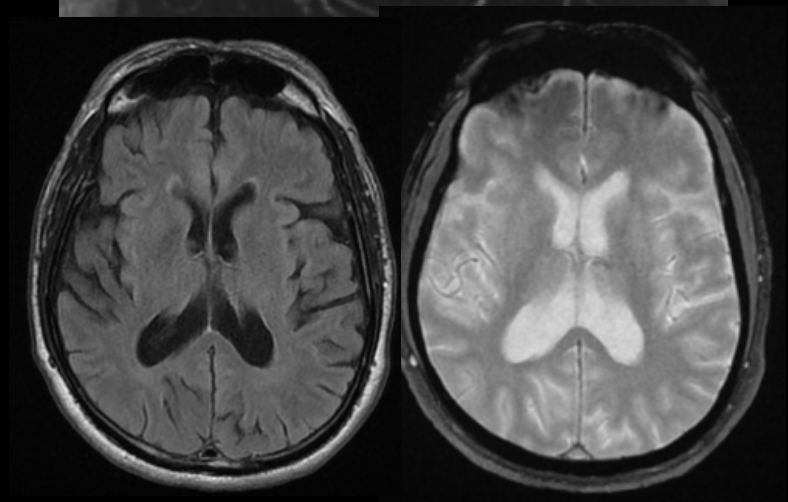
DWI et AVC ischémique aigu

Diffusion normale

- Diffusion précoce
- Infarctus de petite taille
- Infarctus du tronc cérébral
- Accident ischémique transitoire
- Stroke mimics



84 ans, aphasie transitoire

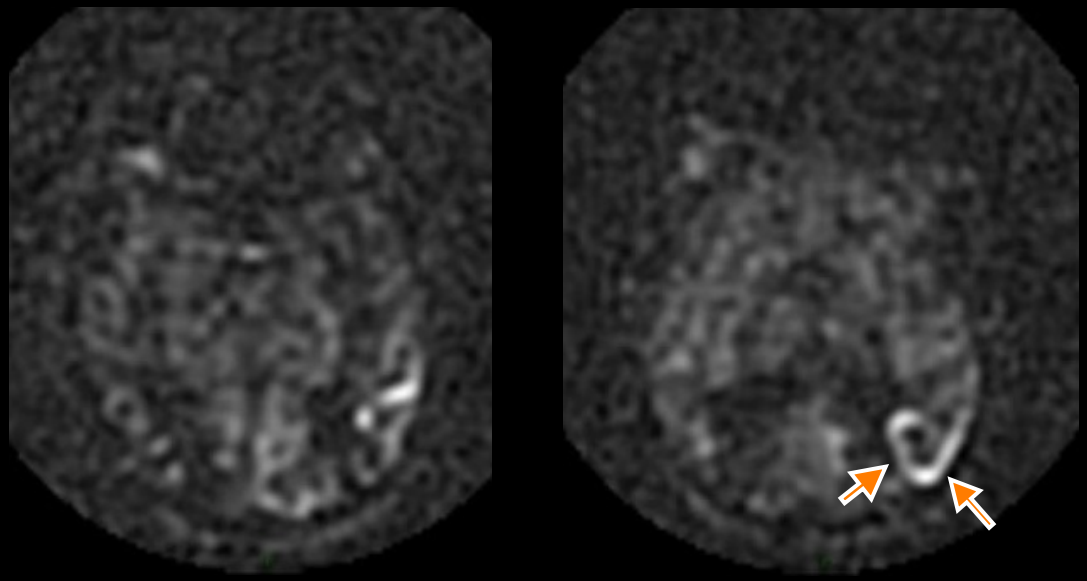


ASL

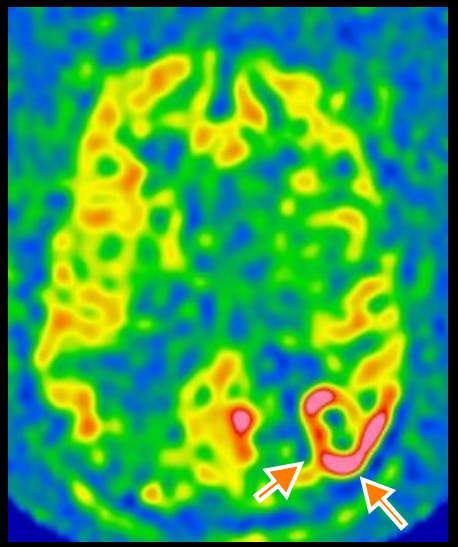
Ralentissements circulatoires artériels

« Arterial Transit Artifact » (ATA)

ASL raw data



CBF color map



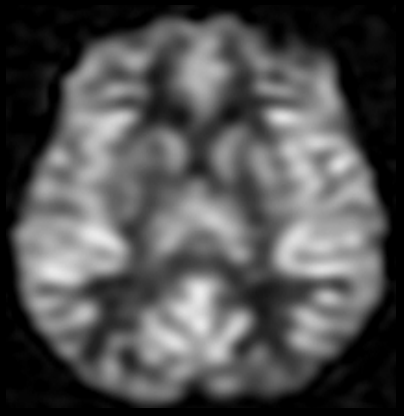
Zaharchuk Greg at al. Arterial Spin Label Imaging of Acute Ischemic Stroke and Transient Ischemic AttackR imaging of the brain. Neuroimaging Clin N Am 2011;21: 285–301

ASL (Arterial Spin Labeling)

Marquage des spins artériels

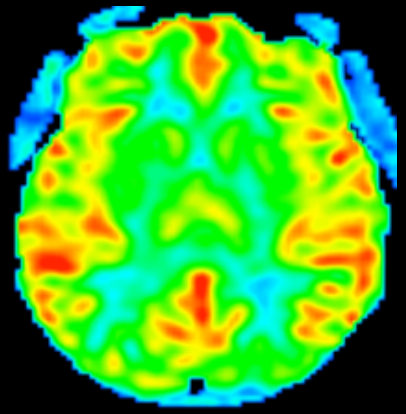
Quantification du débit sanguin (CBF)

Pas de mesure du CBV, Tmax ou MTT



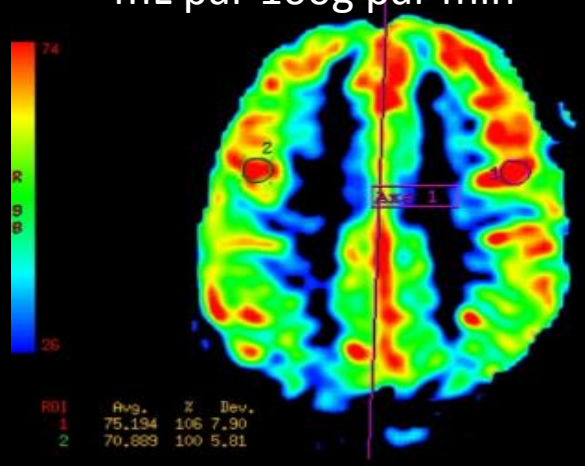
ASL raw data

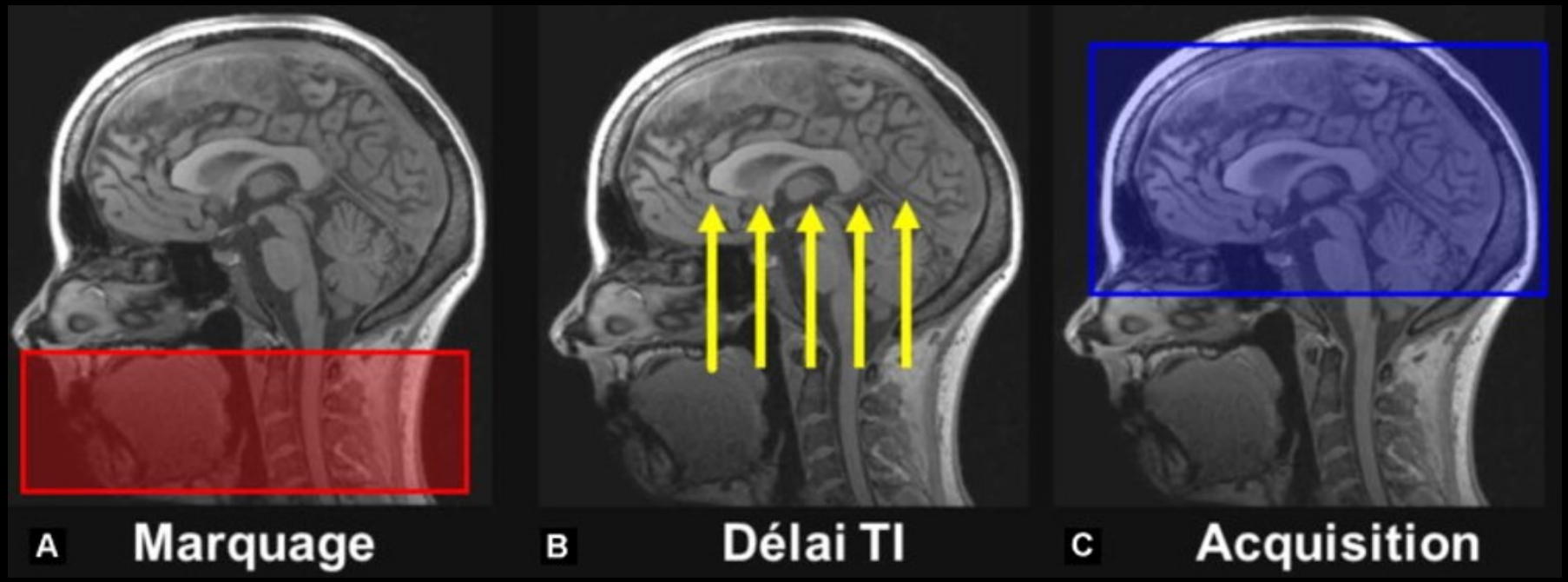
model



CBF color map

mL par 100g par min

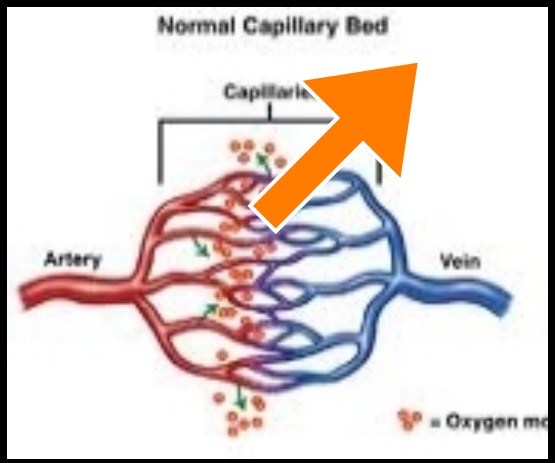




POST LABEL DELAY
Temps d' inversion

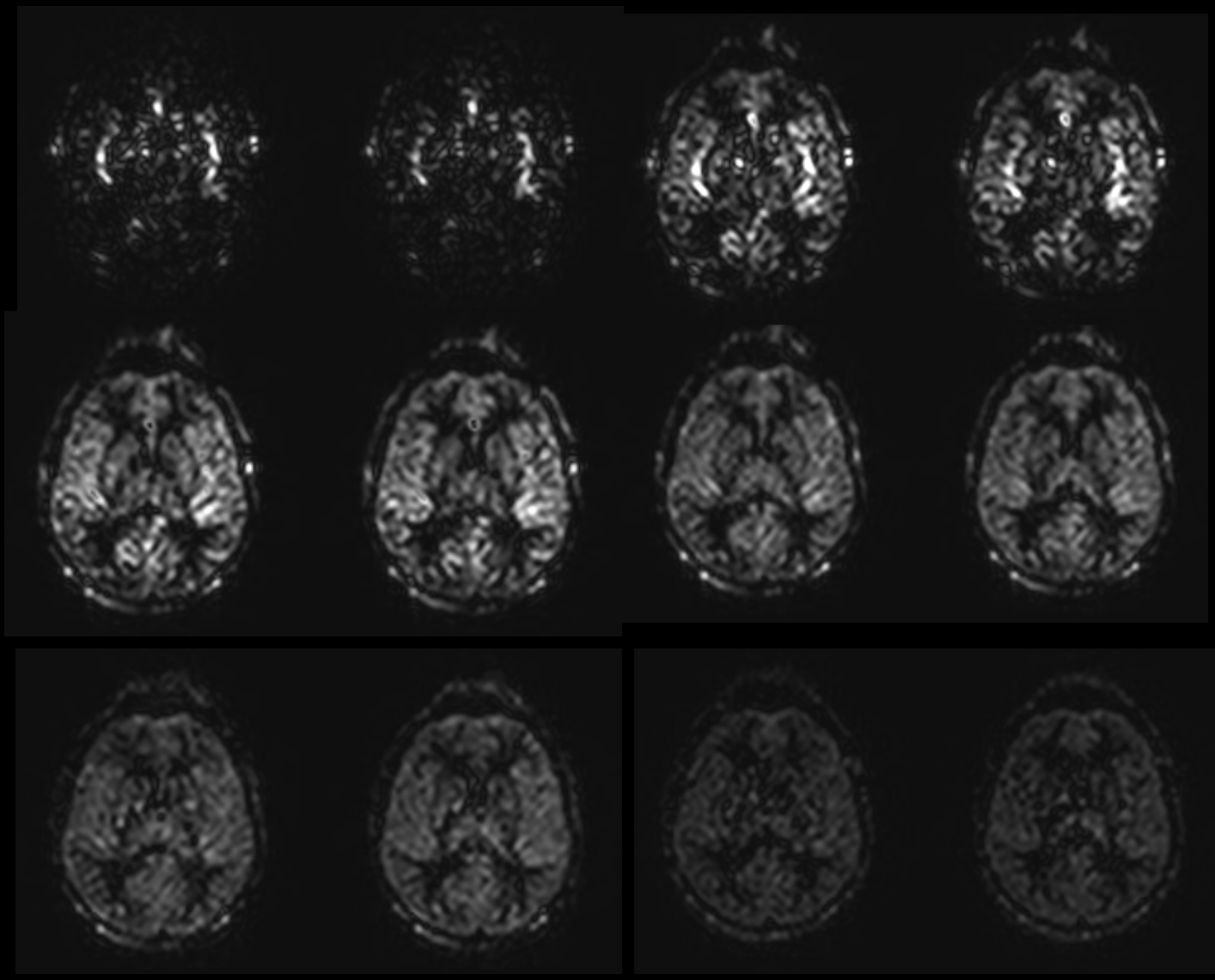
1.5 sec – 2500 sec

Qualité de l' image



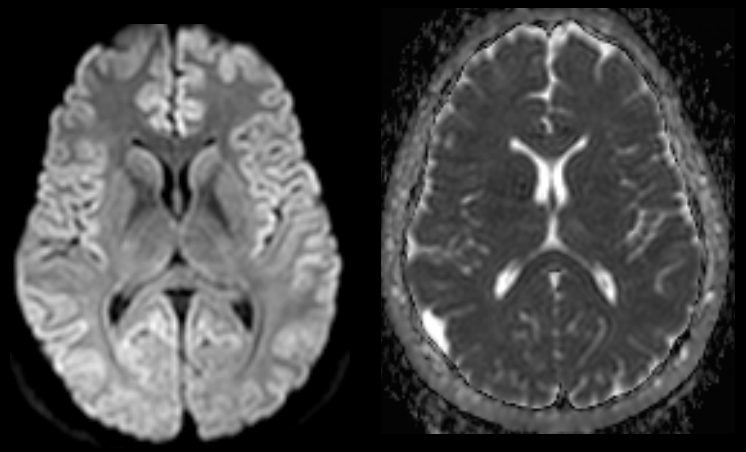
Dans les conditions normales, l'eau artérielle marquée est extraite au niveau du lit capillaire

ASL 3D Multi TI

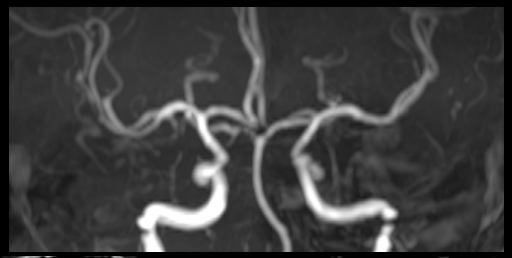


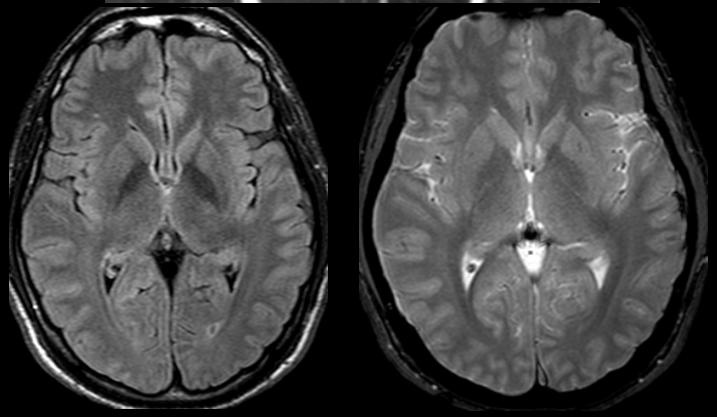
DWI et AVC ischémique aigu

Diffusion normale



39 ans, hémiparésie droite brutale.
IRM 2H après le début des signes

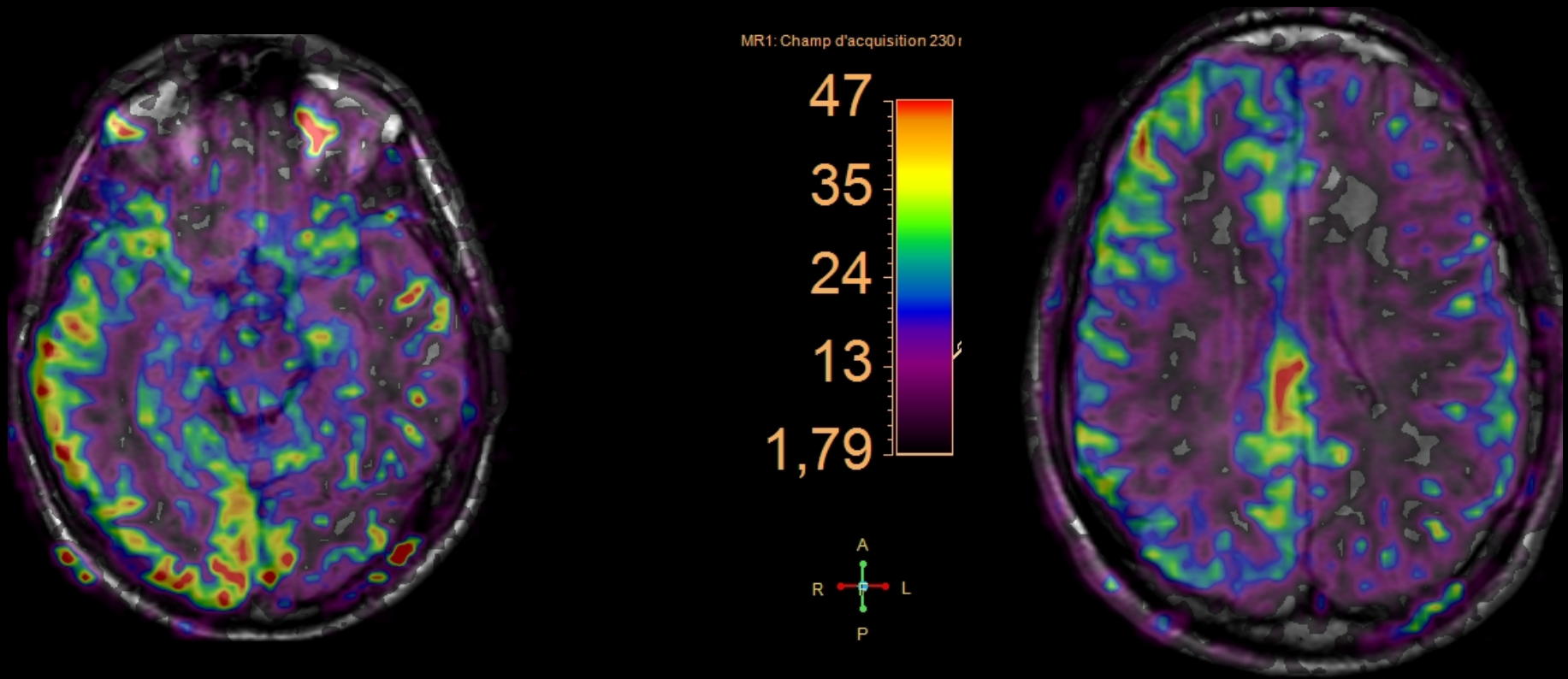




- Diffusion précoce
- Infarctus de petite taille
- Infarctus du tronc cérébral
- Accident ischémique transitoire
- Stroke mimics

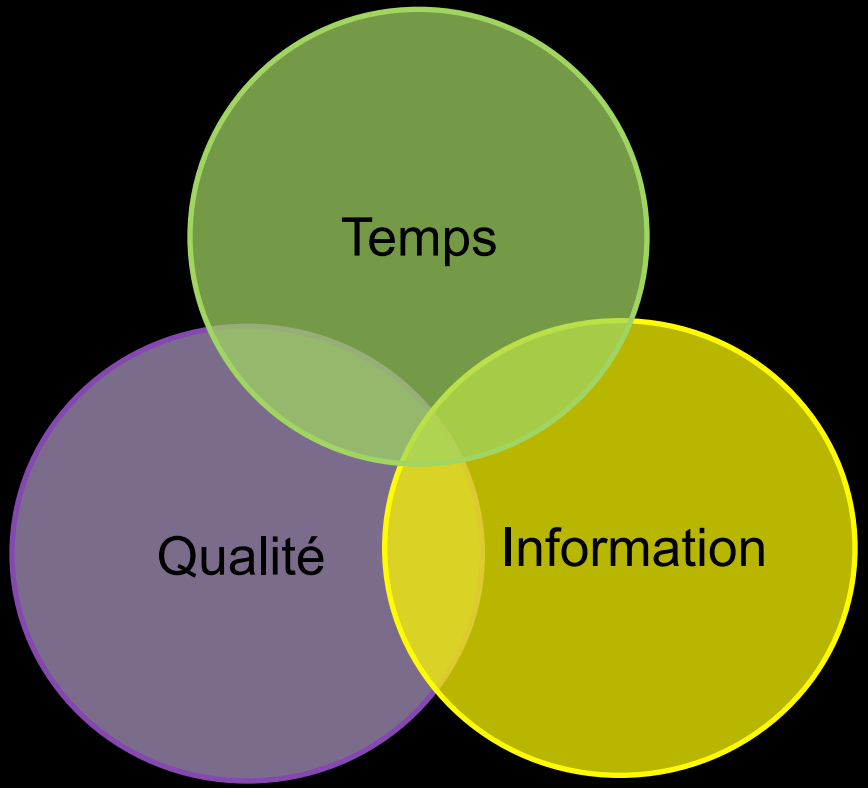
ASL

Hypoperfusion hémisphère gauche *(migraine)*



Protocole IRM - AVC ≤ 6 H

1. Diffusion (DWI)
2. FLAIR
3. T2* ou SWI
4. TOF



Guidelines for the Early Management of Patients With Acute Ischemic Stroke. AHA Guidelines. Stroke 2018

Protocole IRM - AVC ≤ 6 H

1. Diffusion (DWI)
2. FLAIR
3. T2* ou SWI
4. TOF

TA < 10 min

Systems should be established so that brain imaging studies can be performed within 20 minutes of arrival in the ED in at least 50% of patients who may be candidates for IV alteplase and/or mechanical thrombectomy.	I

Guidelines for the Early Management of Patients With Acute Ischemic Stroke. AHA Guidelines. Stroke 2018

Protocole IRM - AVC ≤ 6 H

1. Diffusion (DWI)
2. FLAIR
3. T2* ou SWI
4. TOF

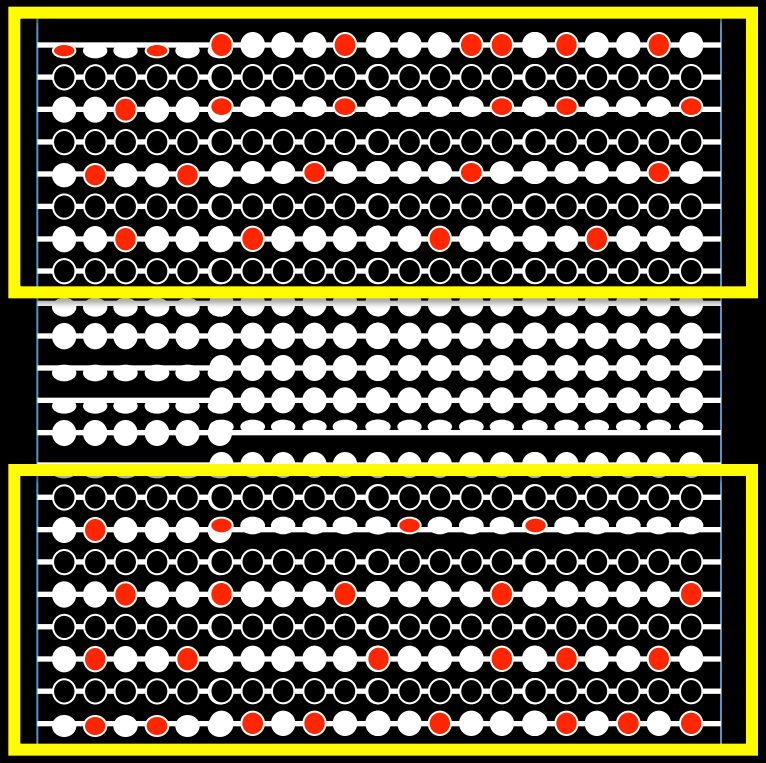
TA < 10 min

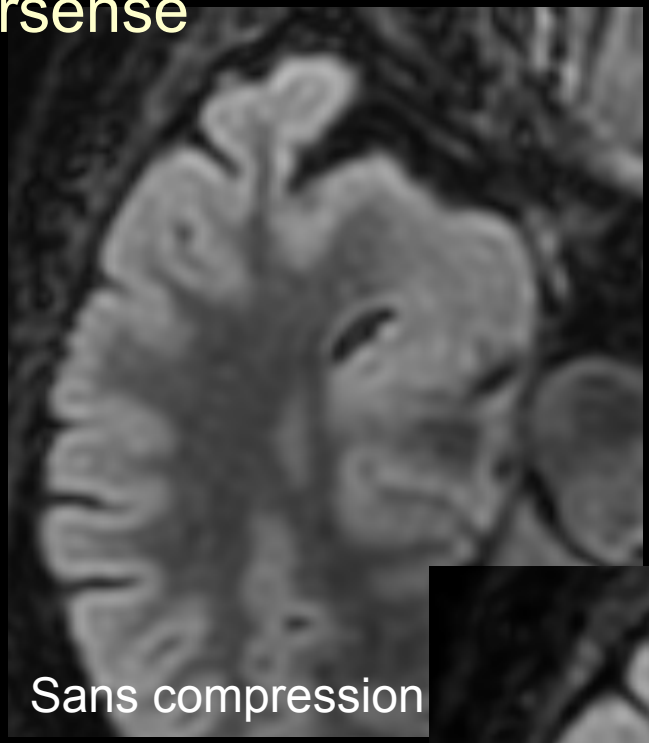
Techiques d'accélération

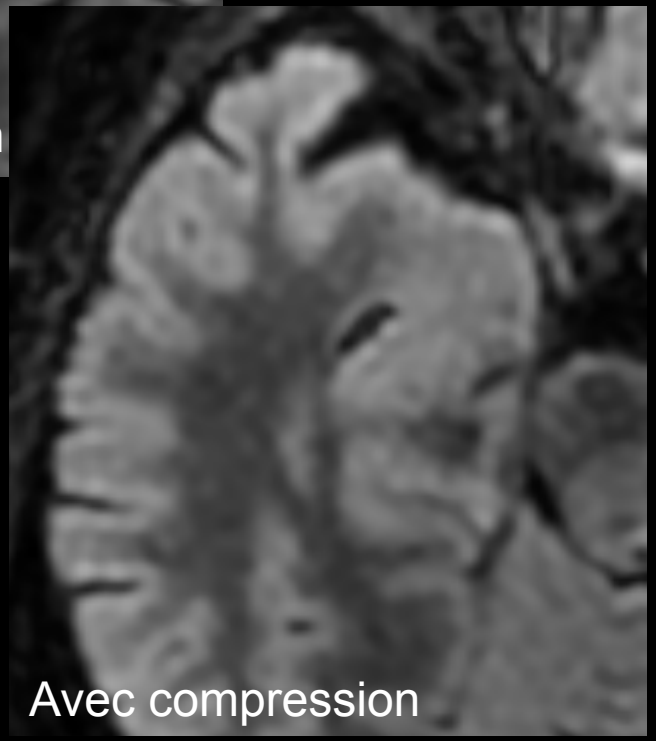
- EPI
- Parallel imaging
- Compressed sensing
- Multiband acquisition

Nael K et al. Six-minute MRI protocol for evaluation of AIS. Pushing the boundaries. Stroke 2014;45:1985-91

Compressed Sensing/Hypersense



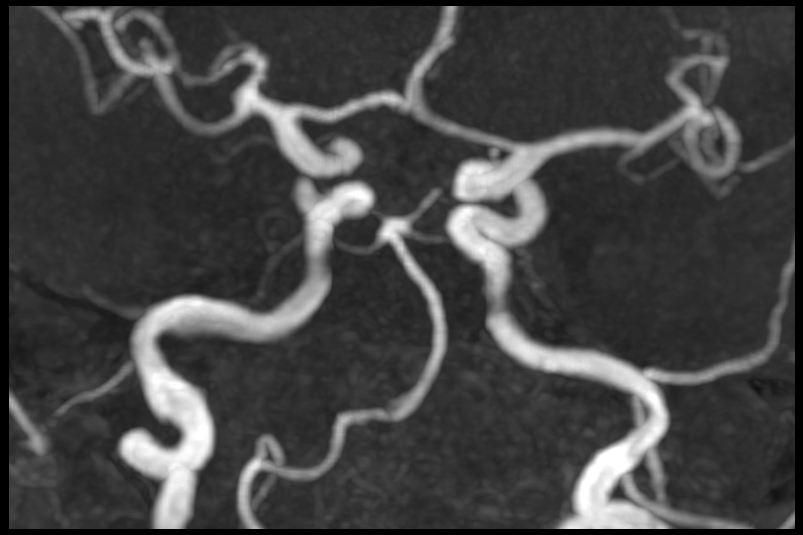




Moins d'échos acquis dans les hautes fréquences spatiales de l'espace k
= Flou de l'image ?

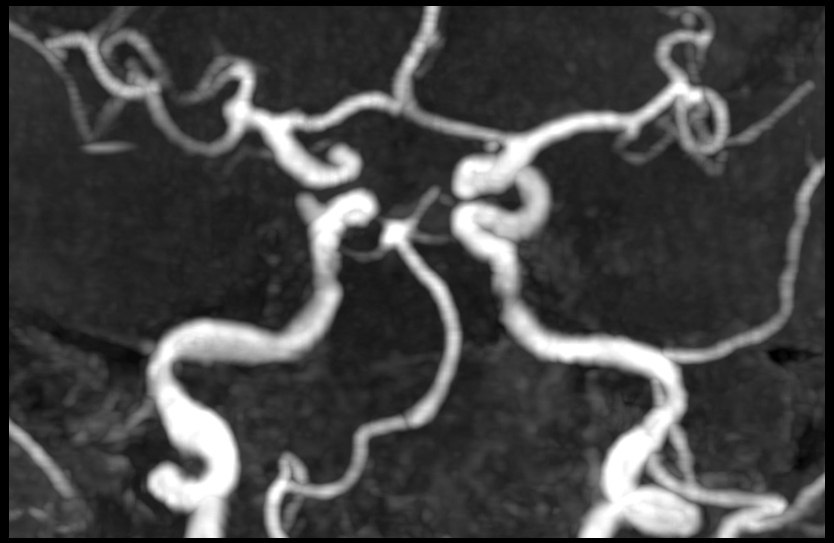
ARM temps de vol (TOF)

Image basée essentiellement sur le contraste
(peu de données spatiales)



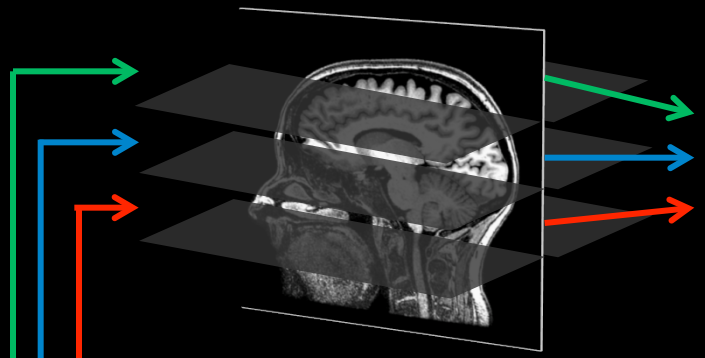
ARM TOF
1 mm, 156 slices
TA : 3.56 min

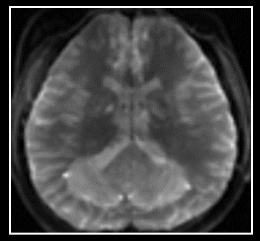
-28%



ARM TOF
1 mm, 156 slices
TA : 2.50 min

Multiband - Hyperband

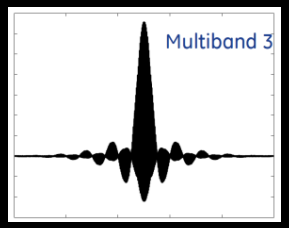


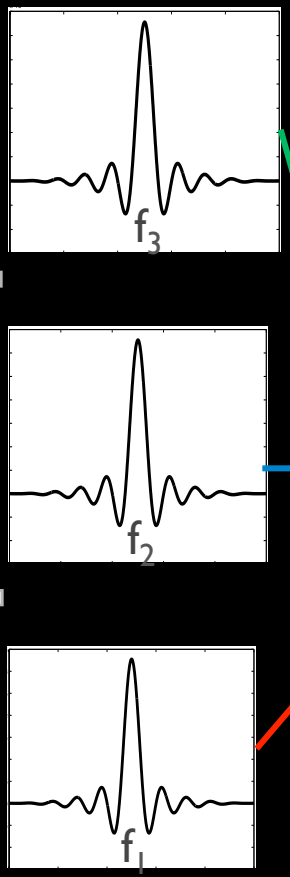


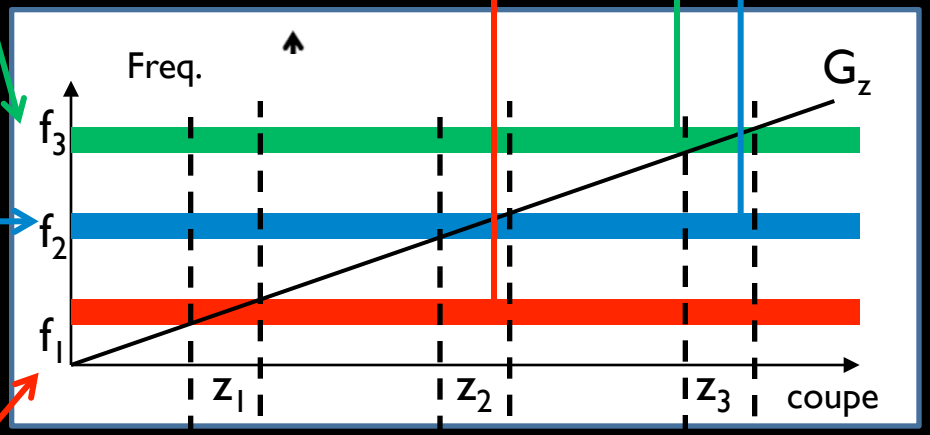
Repliement

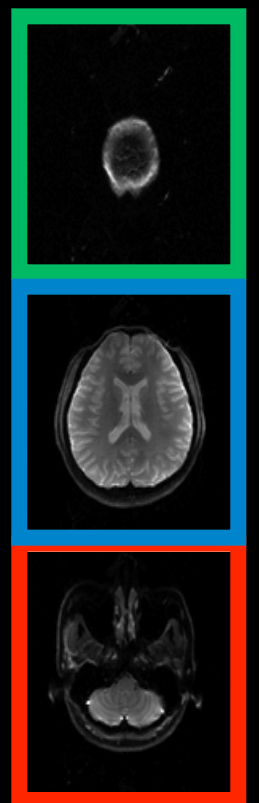
Reconstruction

Excitation
Multi-coupes
(Nb = 3)



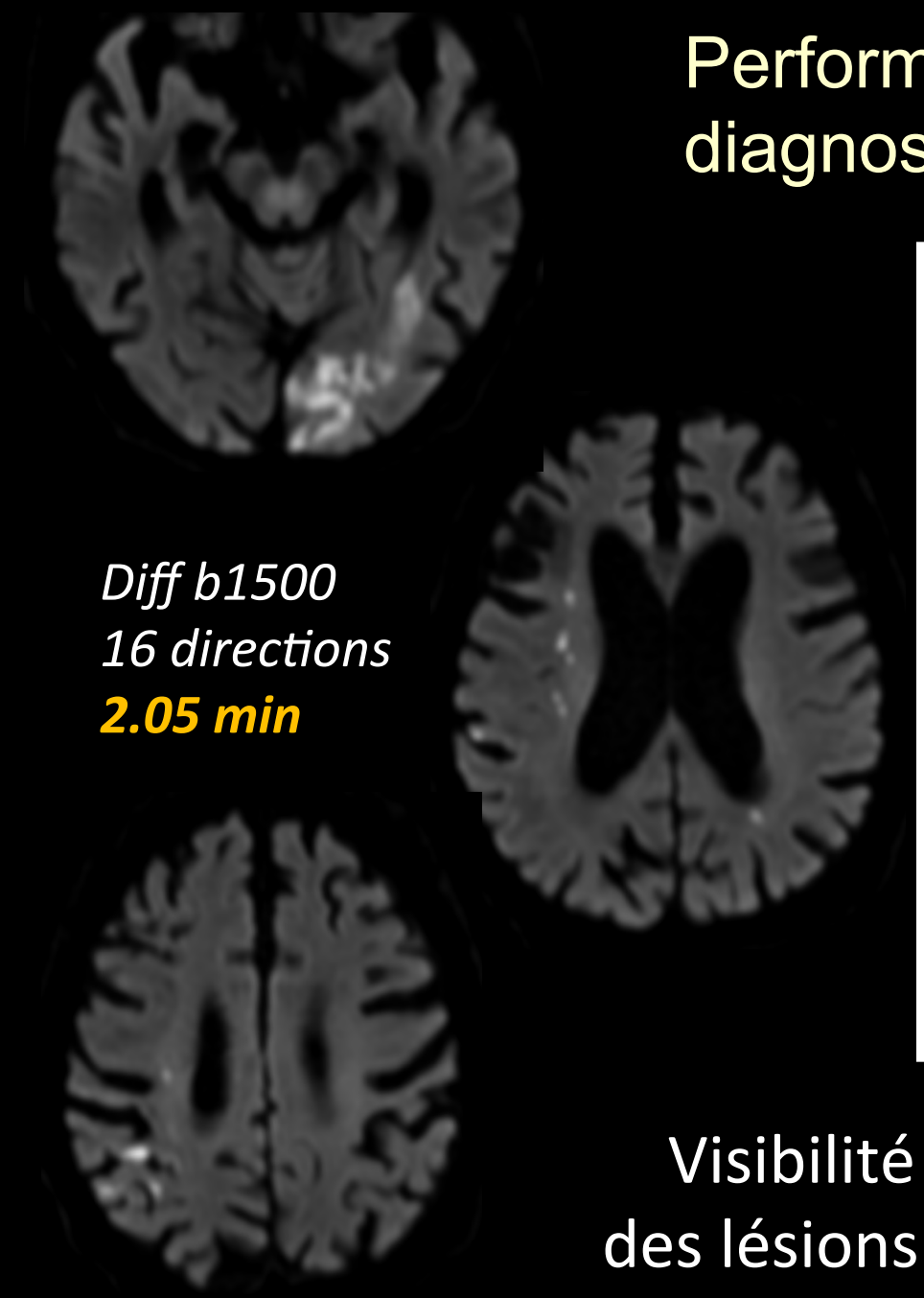




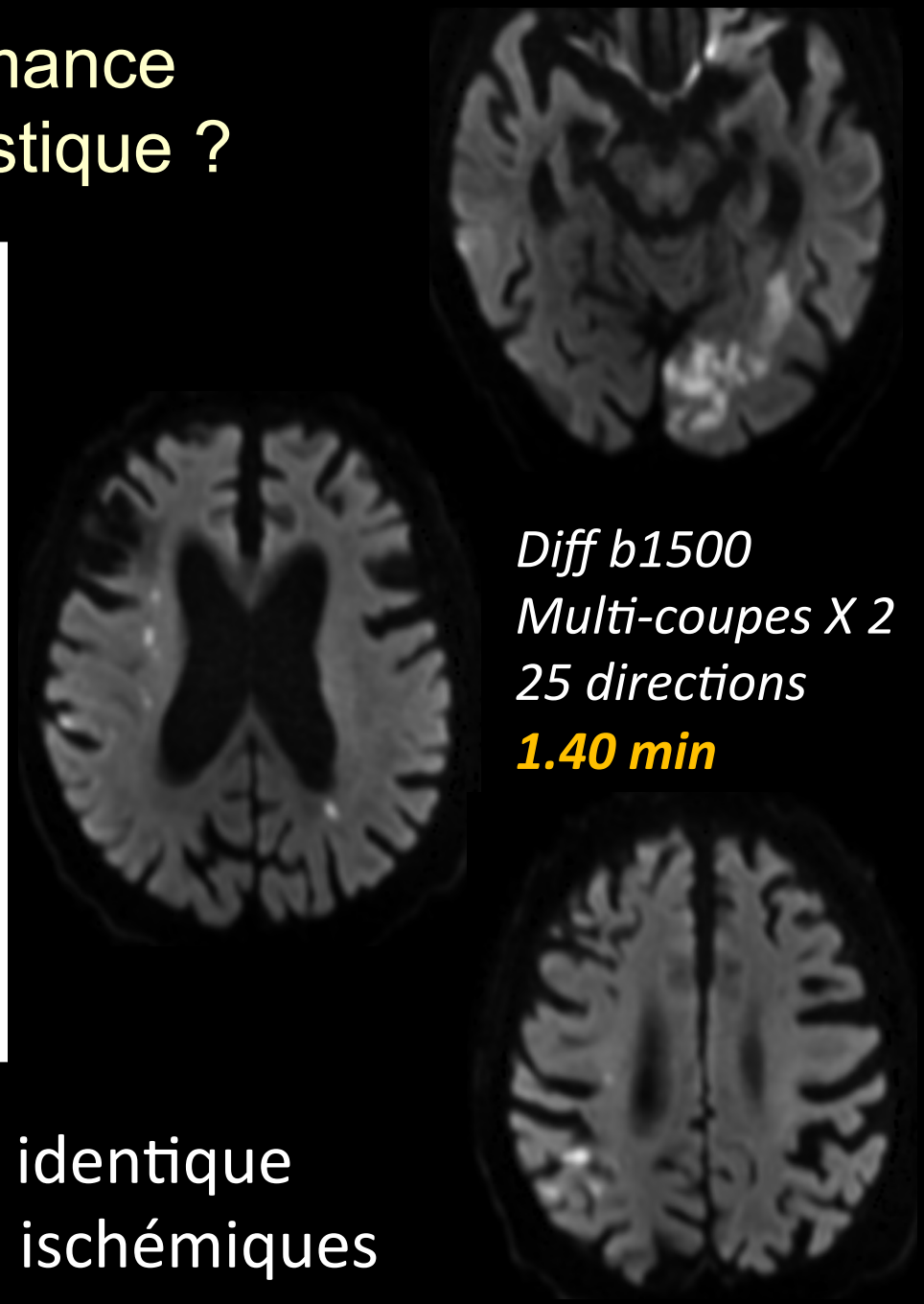


Acquisitions multi-coupes
1 excitation =
Plusieurs fréquences
Plusieurs coupes

Performance diagnostique ?



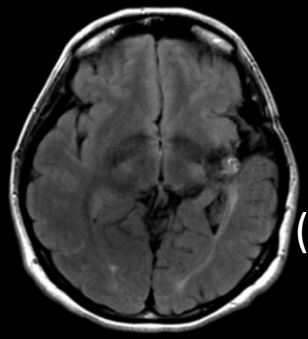
Diff b1500
16 directions
2.05 min



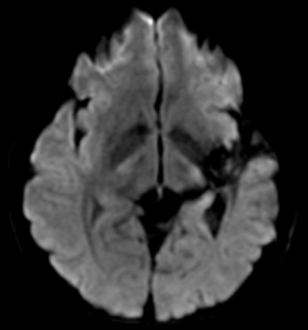
Diff b1500
Multi-coupes X 2
25 directions
1.40 min

Visibilité identique
des lésions ischémiques

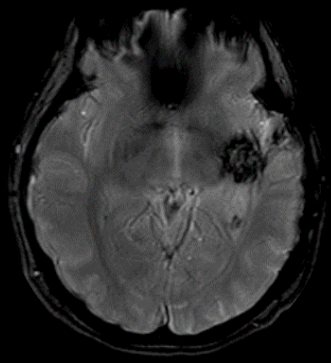
3:40 min



T2 FLAIR
Propeller
(TA 1:48 min)

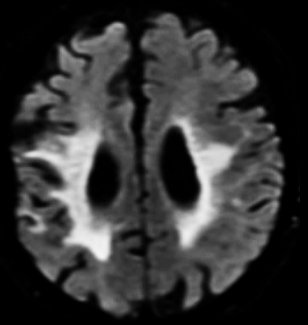


Diffusion
b1000
(TA 14 s)

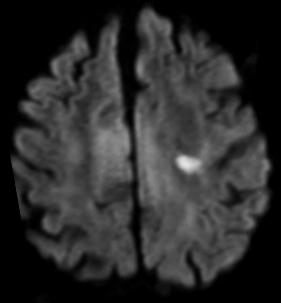


T2* GRE
(TA 1:02 min)

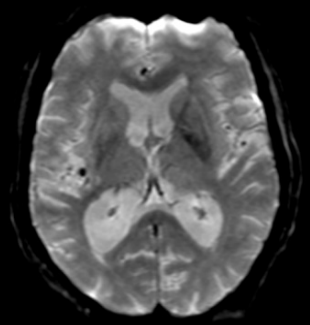
45 sec



T2 FLAIR
EPI
(TA 28 s)



Diffusion
b1000 1 dir
(TA 9 s)



T2* EPI
(TA 8 s)

Protocoles automatisés dits "push button" (ViosWorks, GoBrain)

Protocole IRM - AVC ≤ 6 H

1. Diffusion (DWI)
2. FLAIR
3. T2* ou SWI
4. TOF

- ± ARM Gd si TB envisagée

In patients who are potential candidates for mechanical thrombectomy, imaging of the extracranial carotid and vertebral arteries, in addition to the intracranial circulation, is reasonable to provide useful information on patient eligibility and endovascular procedural planning.	IIa

Guidelines for the Early Management of Patients With Acute Ischemic Stroke. AHA Guidelines. Stroke 2018

Protocole IRM - AVC ≤ 6 H

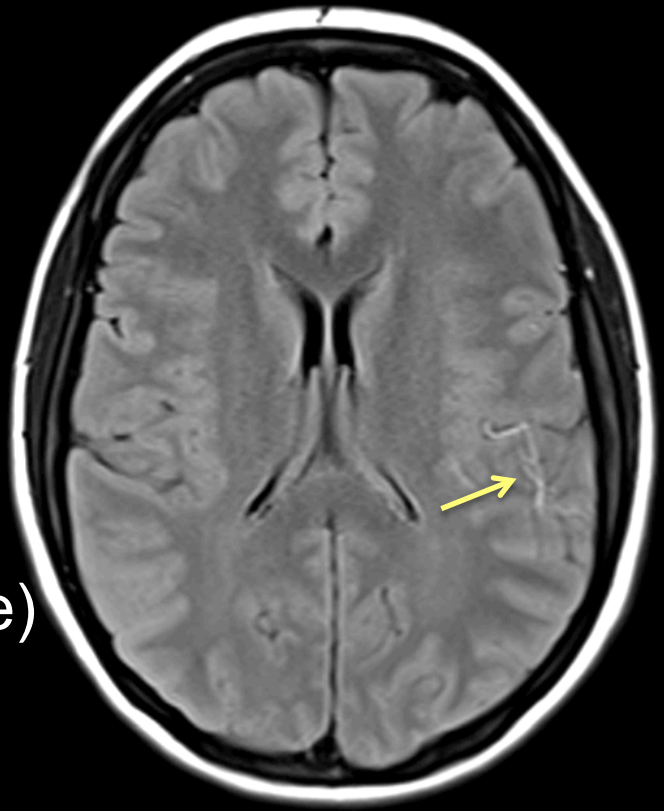
1. Diffusion (DWI)
2. FLAIR
3. T2* ou SWI
4. TOF

- Pas de perfusion ++

Additional imaging beyond CT and CTA or MRI and magnetic resonance angiography (MRA) such as perfusion studies for selecting patients for mechanical thrombectomy in <6 hours is not recommended.	III: No Benefit

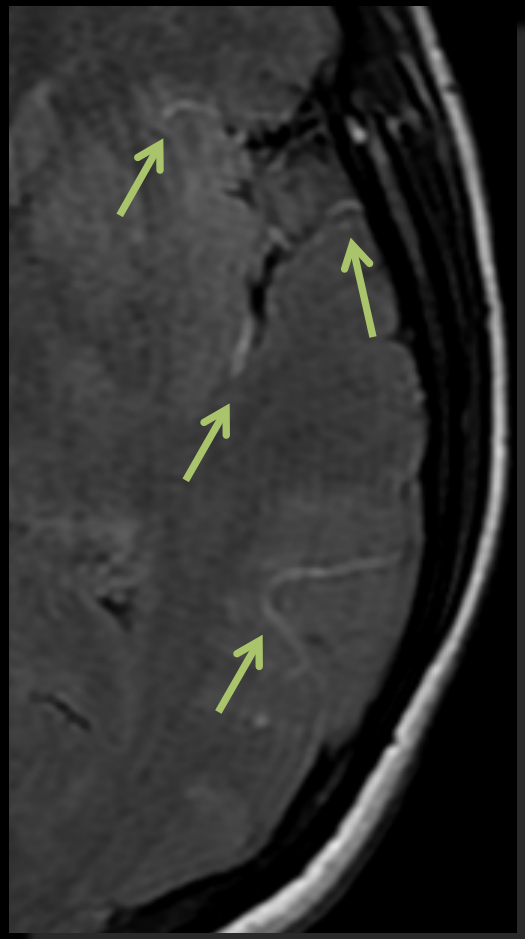
Guidelines for the Early Management of Patients With Acute Ischemic Stroke. AHA Guidelines. Stroke 2018

FLAIR



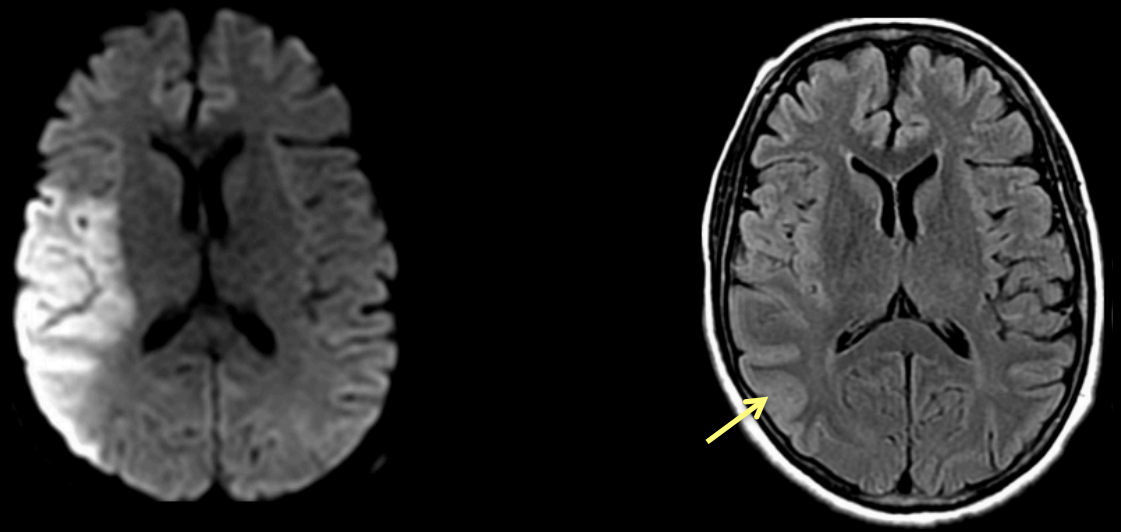
- Diagnostic différentiel
- AVC ancien
- Visibilité de l'infarctus (wake-up stroke)
- Leucopathie vasculaire
  - ↗ risque hémorragique après TIV
- Hyperintense vessel sign (HVS)
  - Flux lent / réseau collatéral
  - Marqueur de stenose ou occlusion

Hyperintense Vessel Sign (HVS)



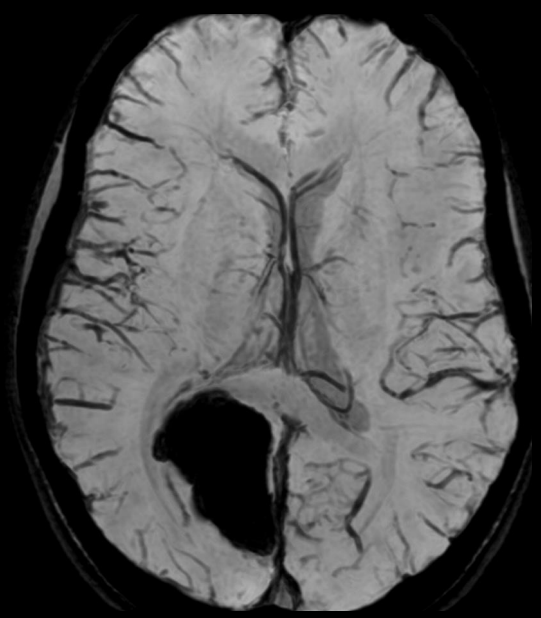
FLAIR et wake-up stroke

- Diffusion-FLAIR mismatch = lésions ischémiques détectées en diffusion et non visibles en FLAIR
- Peut être ultilisé comme un marqueur tissulaire pour estimer le début de l'AVC ischémique (mismatch = début < 4.5 H)
- « Wake-up » stroke study : évolution favorable à 3 mois : 53,3% dans le groupe TIV versus 41,8% dans le groupe placebo (p=0.02)

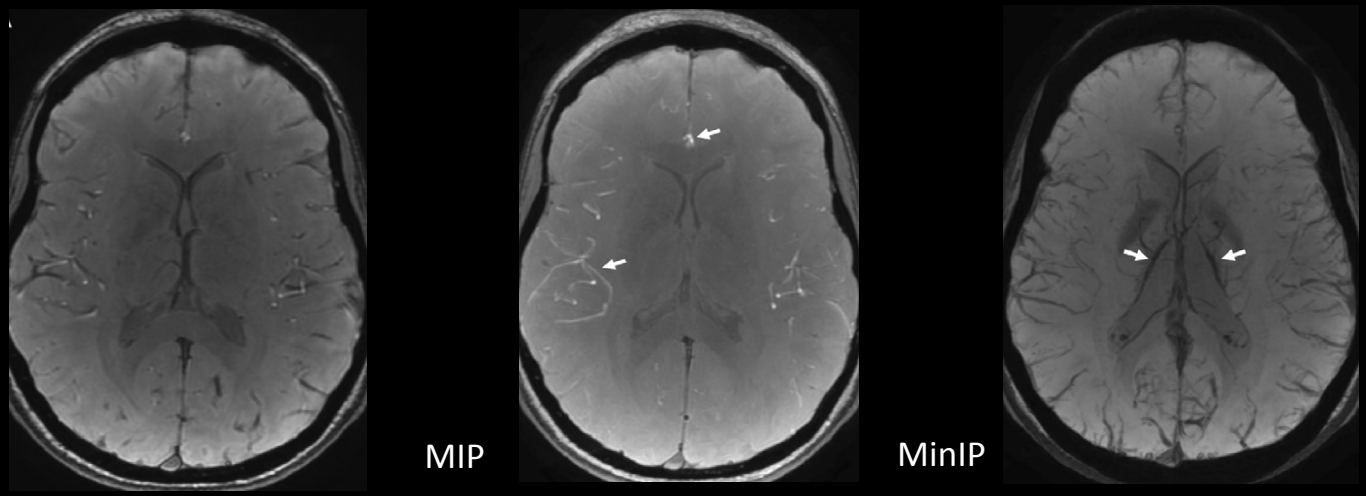


Thomalla G and wake-up investigators. MRI-Guided Thrombolysis for Stroke with Unknown Time of Onset. N Engl J Med 2018; 379:611-622

T2* ou SWI



- SWI > T2*
  - Hémorragie
  - Thrombus
  - Microbleeds
- SWAN, SWI, SWIp
  - TE court : effet TOF (artères)
  - TE long : effet de susceptibilité (veines)



Hodel J et al. Comparison of 3D multi-echo gradient-echo and 2D T2* MR sequences for the detection of arterial thrombus in patients with acute stroke. Eur Radiol 2014;24:762-9

T2* ou SWI

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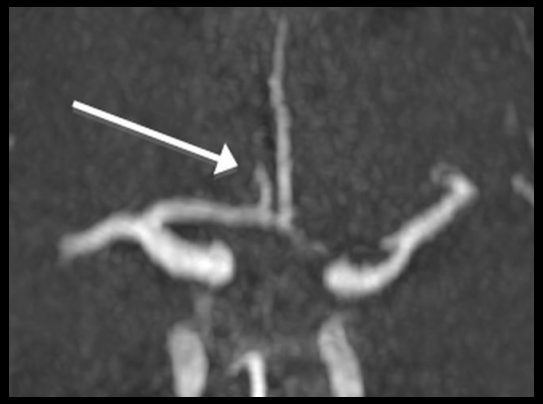

TOF MIP

SWAN MIP

Occlusion

Alternative au TOF et T2*

Vanaerde O, Verclytte S et al. Comparison between enhanced susceptibility-weighted angiography and time of flight sequences in the detection of arterial occlusion in acute ischemic stroke.J Neuroradiol. 2017;44:210-216

T2* ou SWI

- SWI > T2*
  - Hémorragie
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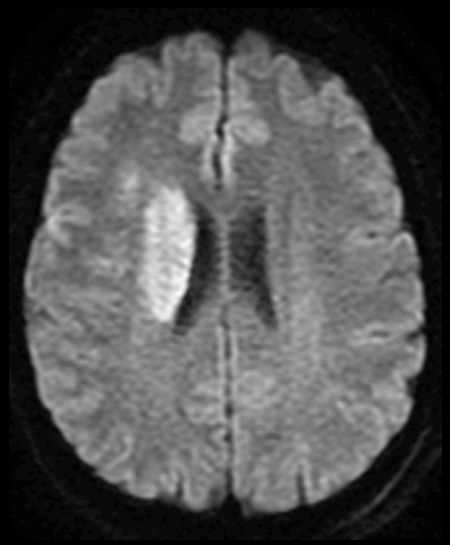
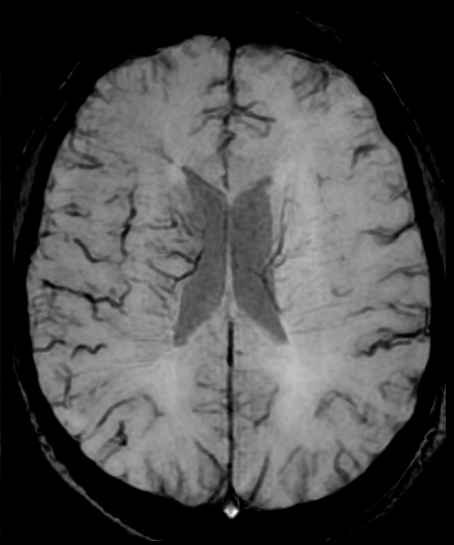


DWI



SWAN MinIP

Brush sign

- Veines corticales et médullaires dilatées au niveau de la pénombre (effet BOLD de DeoxyHb)
- Augmentation de la fraction d'extraction en oxygène.

Park MG et al. Multiple hypointense vessels on susceptibility-weighted imaging in acute ischemic stroke: surrogate marker of oxygen extraction fraction in penumbra ?. Cerebrovasc Dis. 2014;38:254-61.

T2* ou SWI

- SWI > T2*
  - Hémorragie
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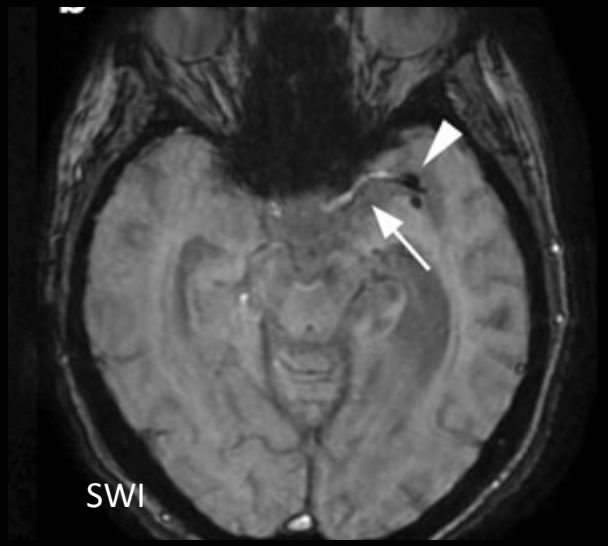

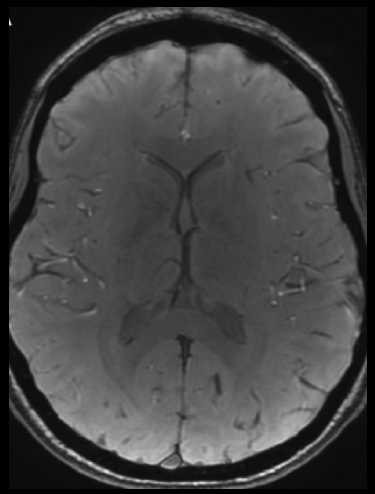

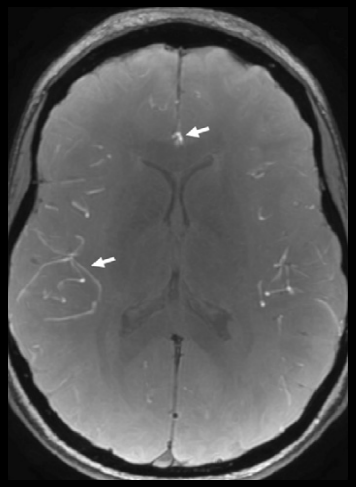

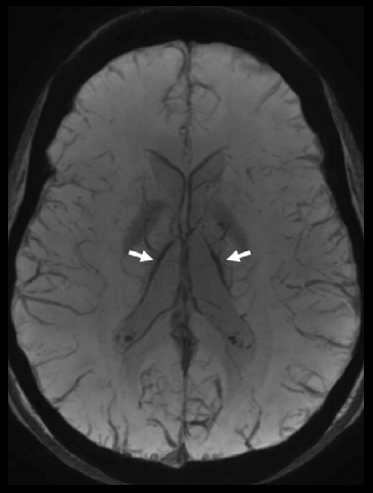

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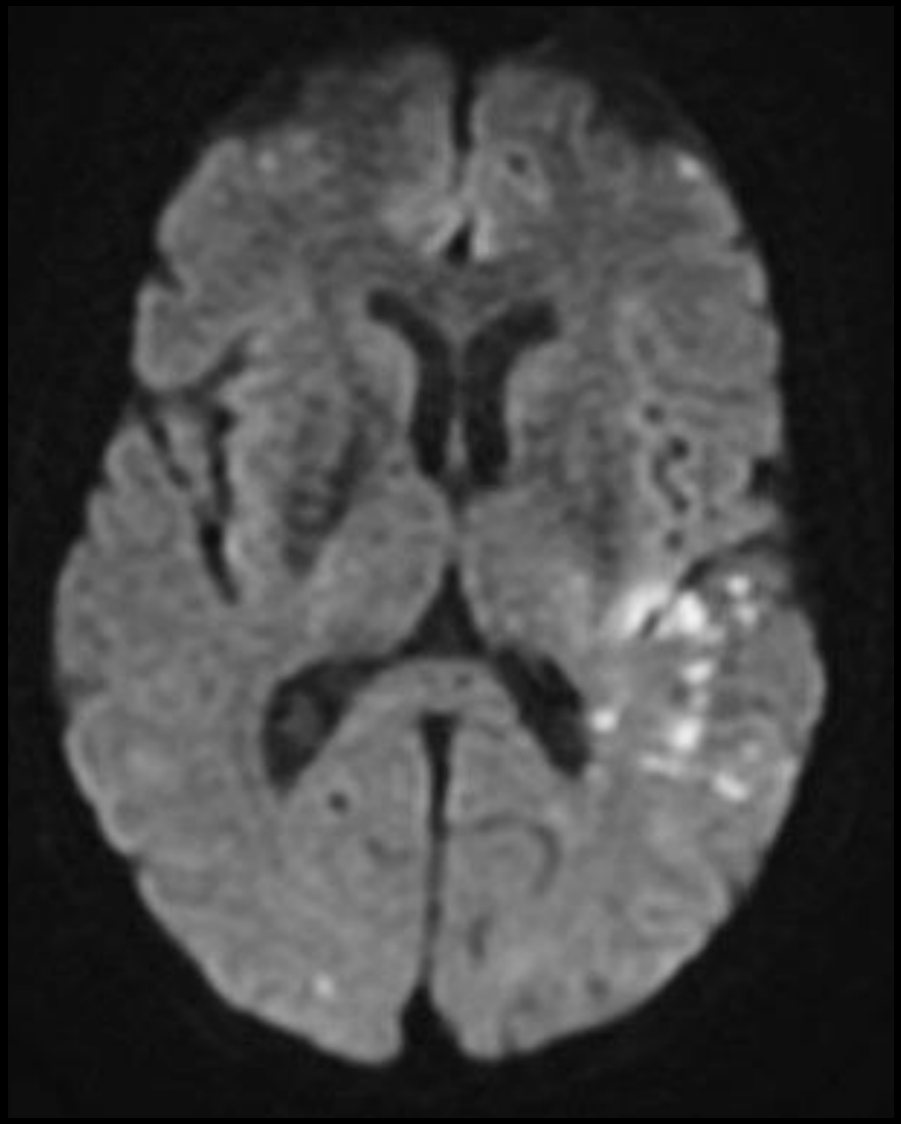
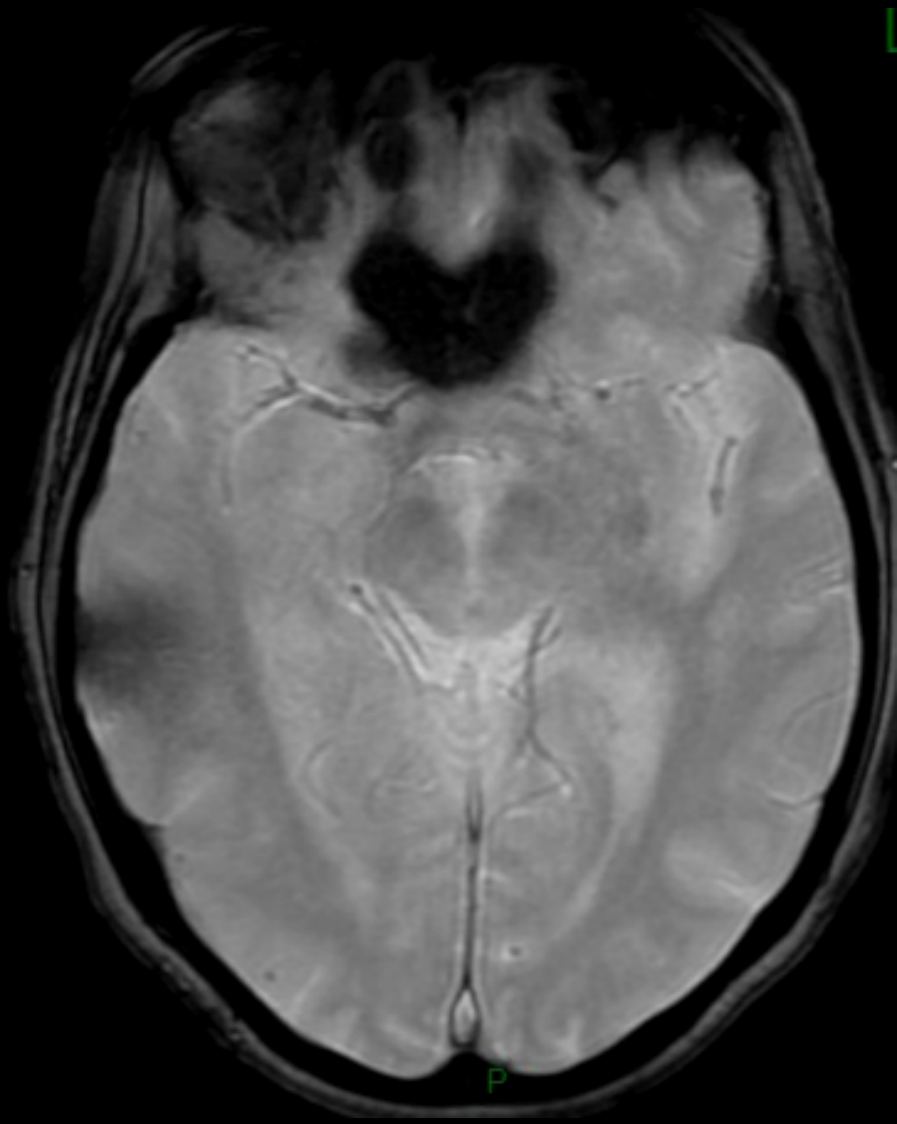
60 ans. Troubles du langage d'apparition soudaine il y a 4 H



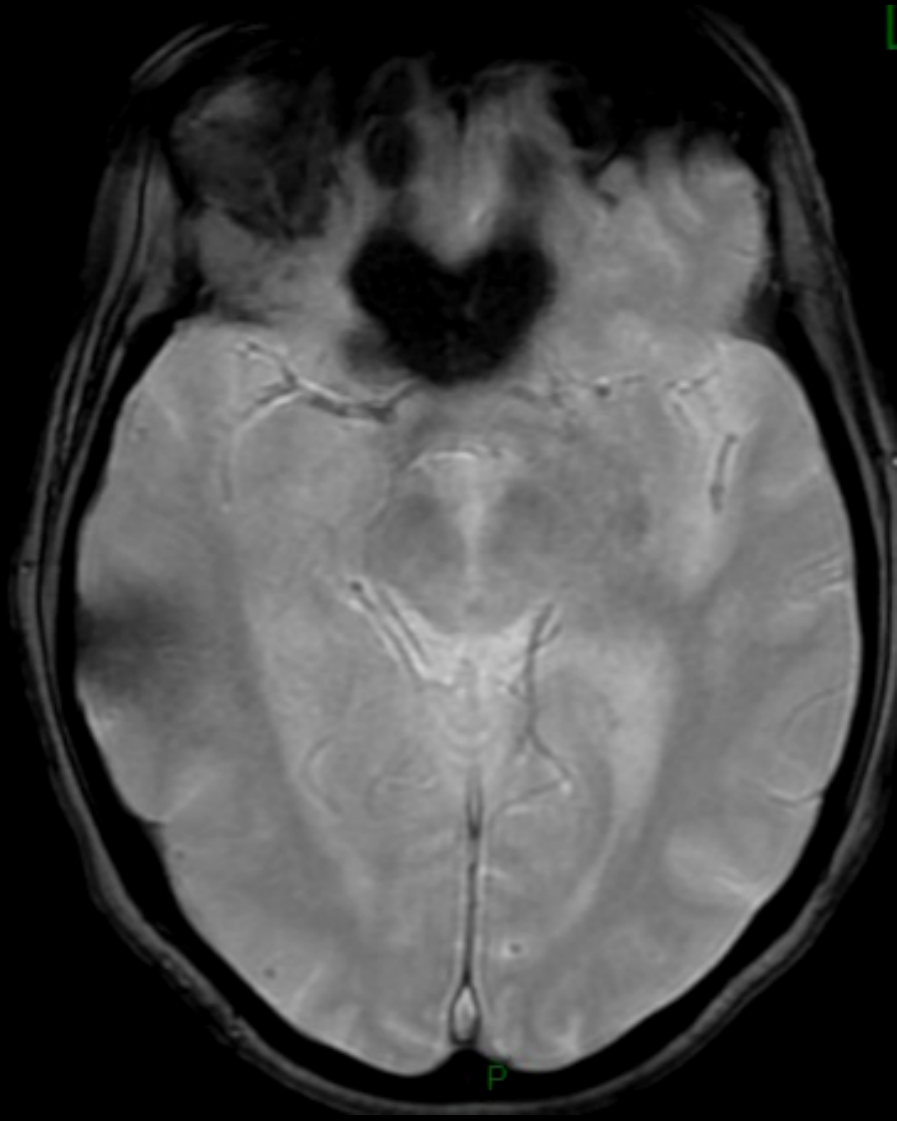
DWI



T2*

60 ans. Troubles du langage d'apparition soudaine il y a 4 H

SWI-MinIP

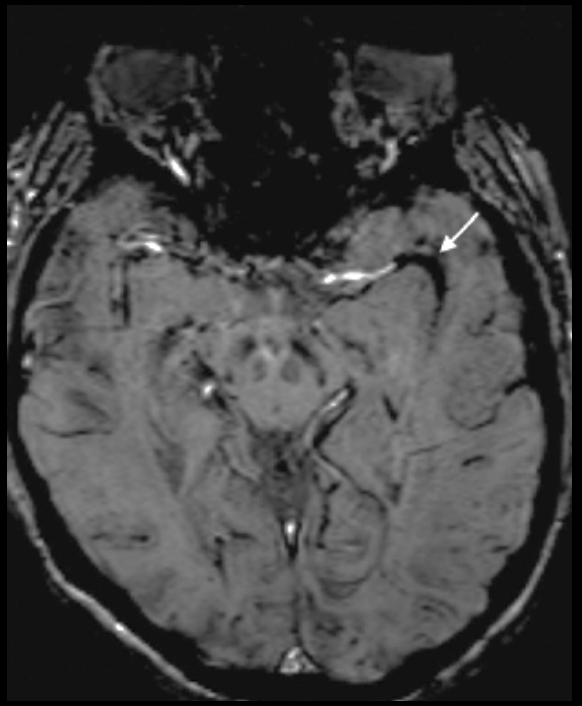


« blooming effect » en SWI

T2*

Blooming effect : SWI > T2*

- Susceptibility vessel sign (SVS)
  - SVS + = contenu riche en GR
    - Extraction en bloc (fragmentation)
  - SVS - = contenu riche en fibrine
    - Extraction difficile (adhérence)

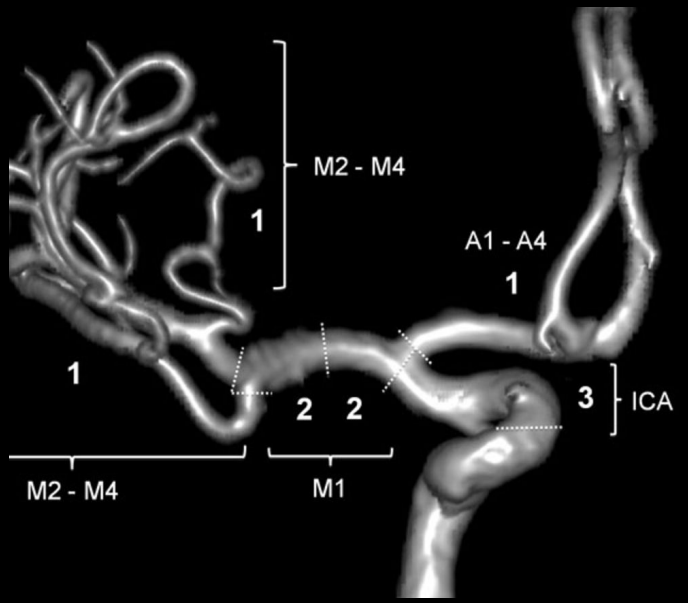


Bourcier R et al. MRI quantitative T2 mapping to predict dominant composition on in vitro thrombus. AJNR Am J Neuroradiol 2019;40:59-64*

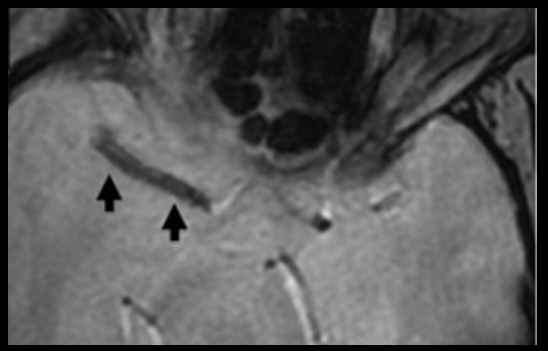
Payabvash S et al. Susceptible vessel sign: identification of arterial occlusion and clinical implications in acute ischaemic stroke. Clin Radiol. 2017 Feb;72(2):116-122

Blooming effect : SWI > T2*

- Susceptibility vessel sign (SVS)
  - SVS + = contenu riche en GR
    - Extraction en bloc (fragmentation)
  - SVS - = contenu riche en fibrine
    - Extraction difficile (adhérence)
- Clot Burden Score (CBS)
  - Longueur du thrombus (de 0 à 10)
  - > 6 = meilleur prognostic après TIV

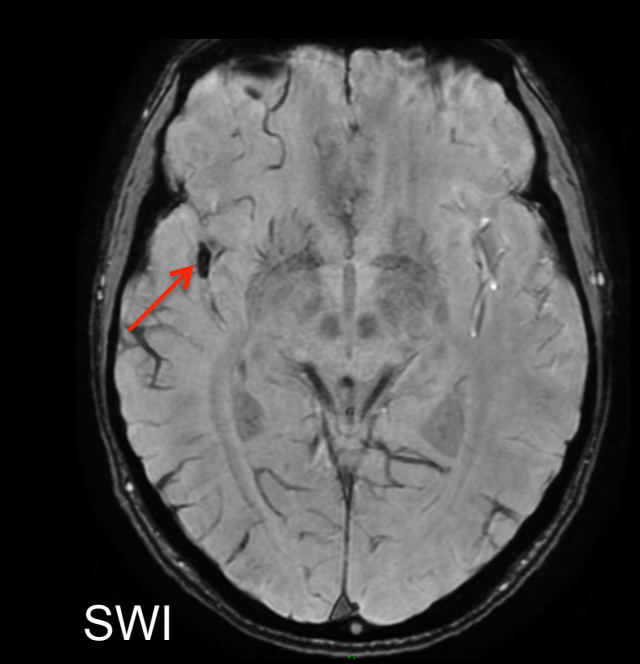


0 = complete occlusion
10 = no occlusion

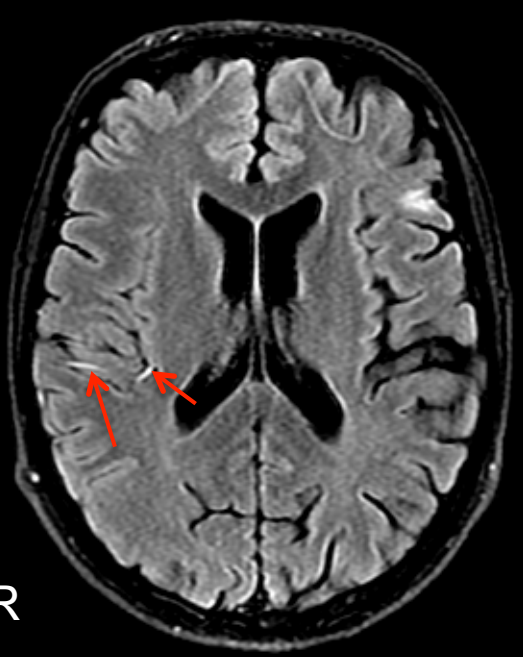


Legrand L et al. Clot burden score predicts recanalization and clinical outcome in acute stroke. Stroke 2013;44,1878-84.

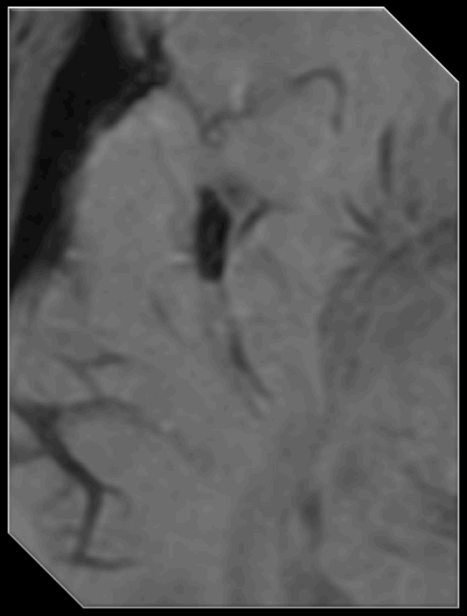
50 ans. Déficit hémicorporel gauche brutal survenu il y a 3 heures



SWI



FLAIR



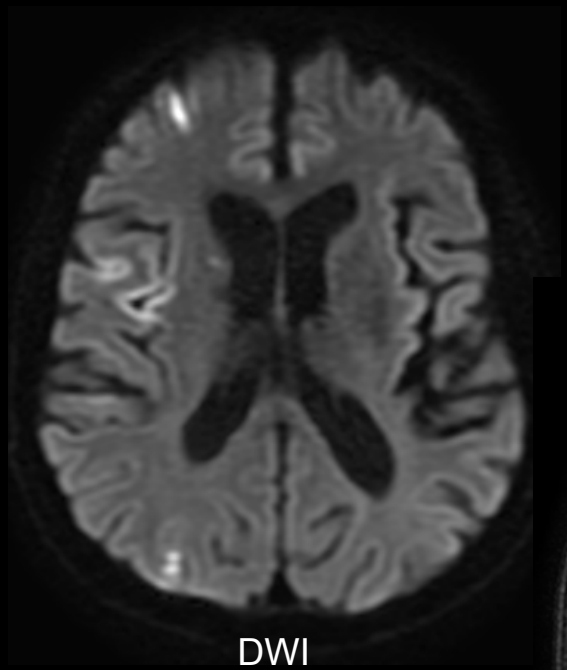
Time of flight (TOF)

Détection une occlusion proximale (LVO)

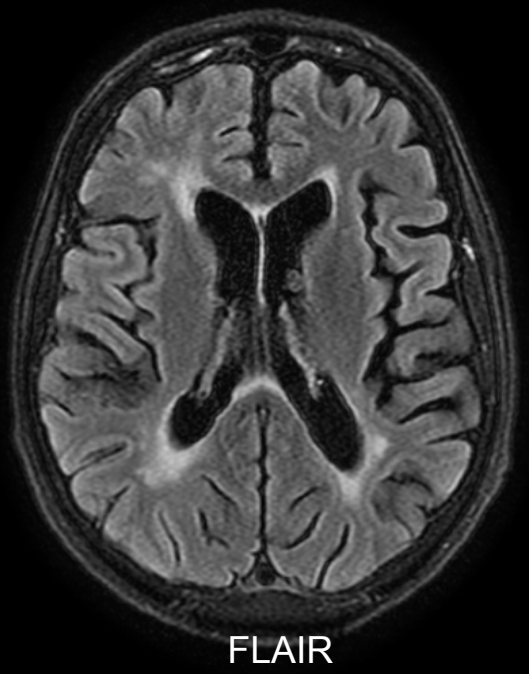
- Temps d'acquisition réduit
- Qualité d'image sous-optimale
- Artéfacts de flux

TOF (TA :90 sec)

TOF : artéfacts de flux



DWI



FLAIR

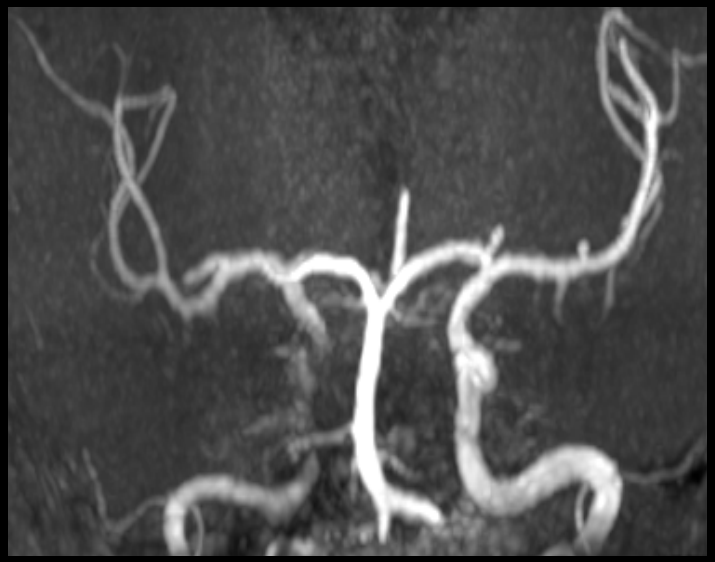
3D TOF

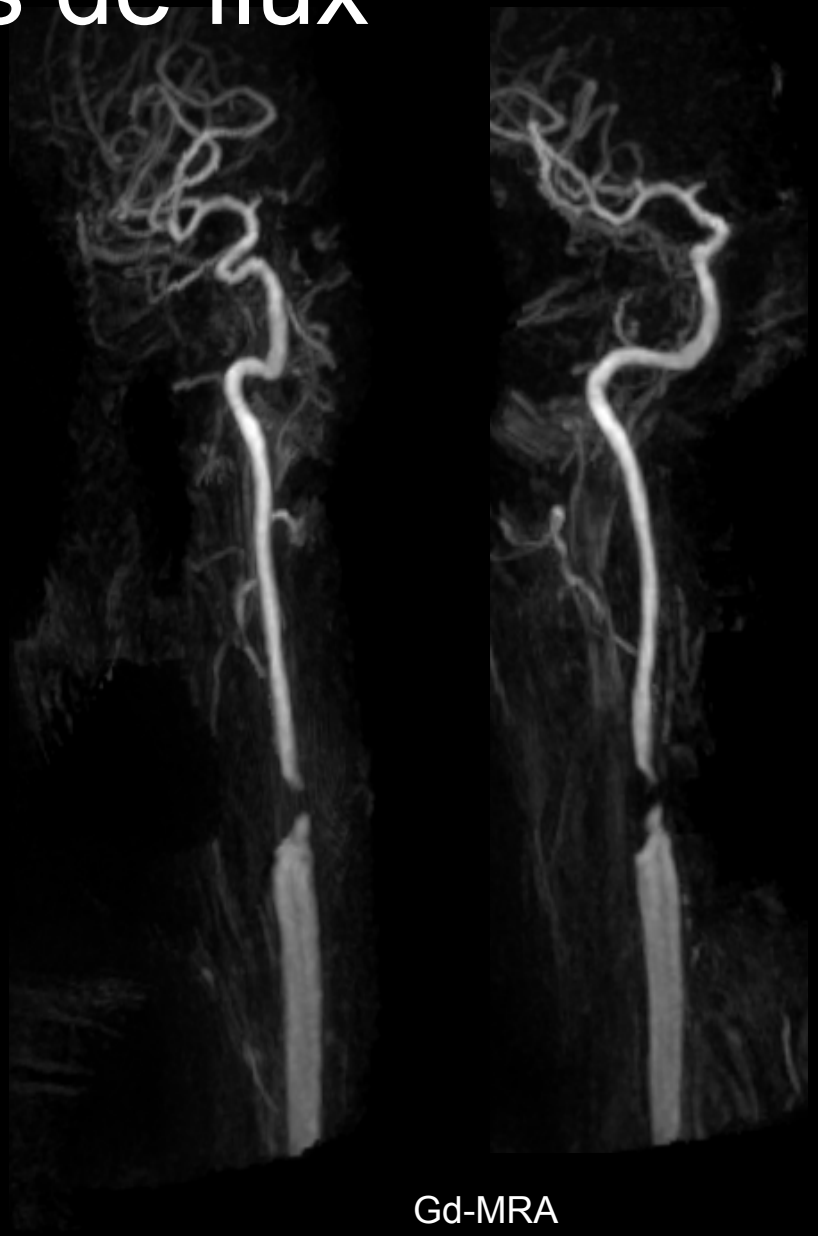
Hémiparesie gauche d'apparition brutale

IRM 4H après le début des symptômes

TOF : artéfacts de flux

3D TOF

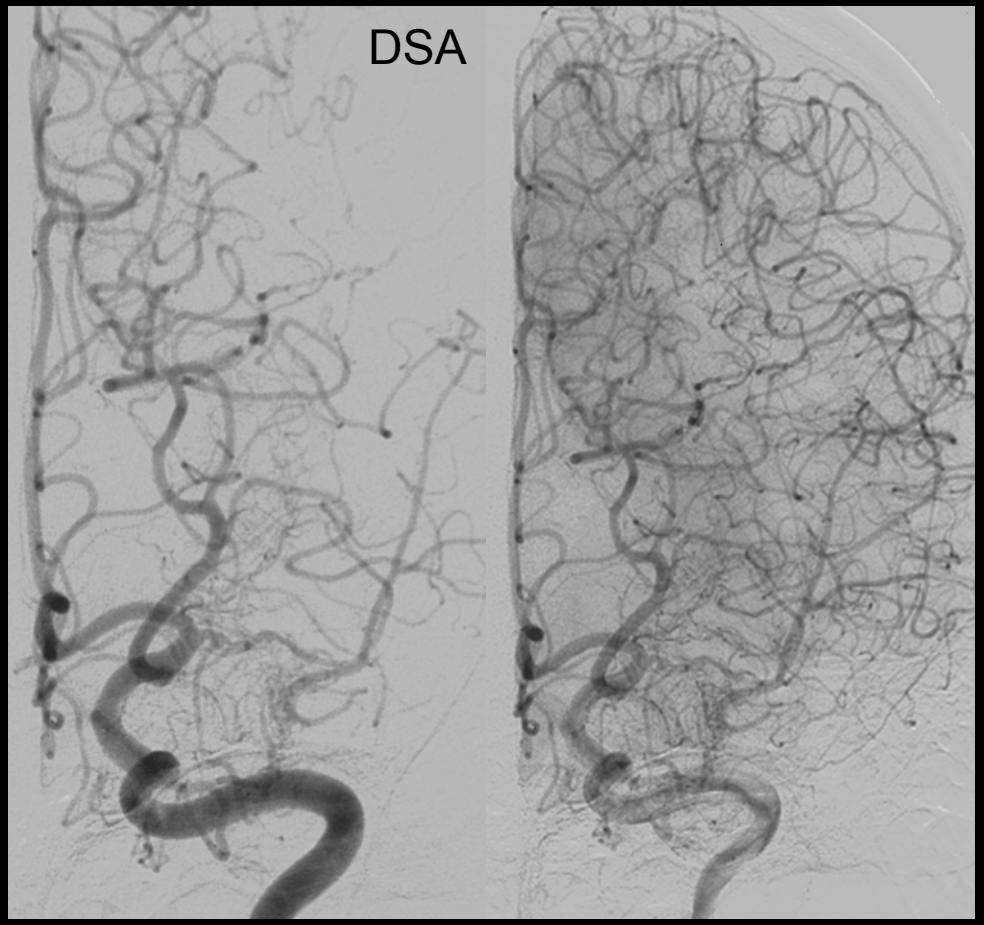


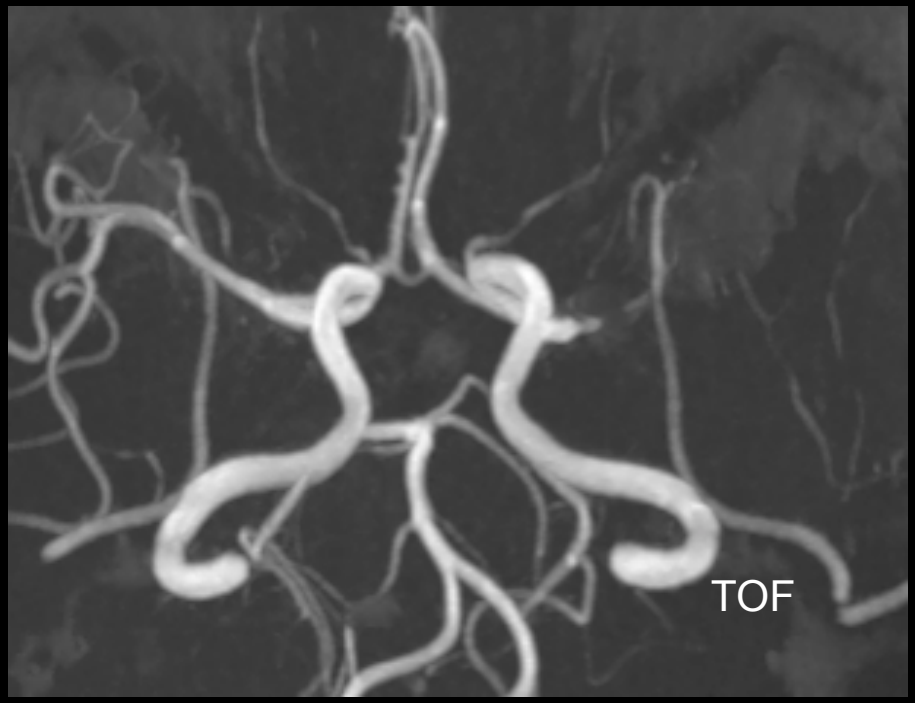


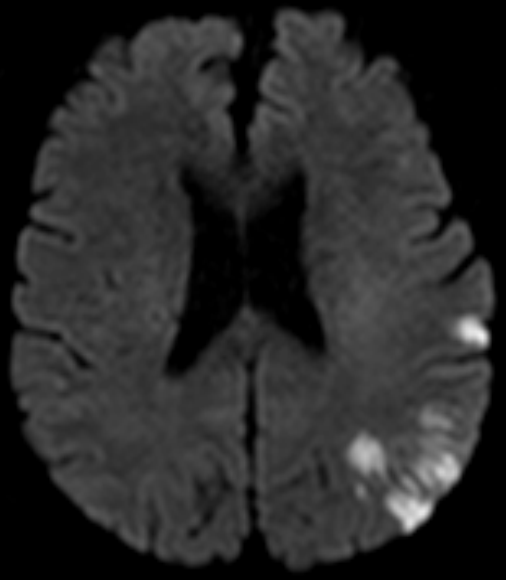
Gd-MRA

55 ans. Troubles phasiques et sensitifs hémicorporel droits. NIH = 6 à l'admission.

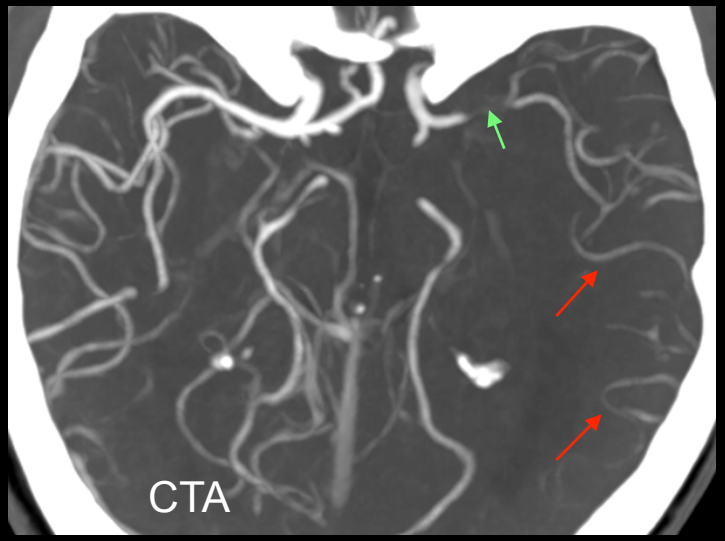
IRM H4 : Infarctus peu étendu, cortical, pariétal gauche (Vol 25 cc)







CTA > TOF pour évaluer le flux distal



Meilleure évolution clinique et volume de l'infarctus inférieur après recanalisation chez les patients présentant des collatérales développées en angioscanner

Nambiar V et al. CTA Collateral Status and Response to Recanalization in Patients with Acute Ischemic Stroke. AJNR 2014;35:884-90

55 ans. Troubles phasiques et sensitifs hémicorporel droits. NIH = 6 à l'admission.

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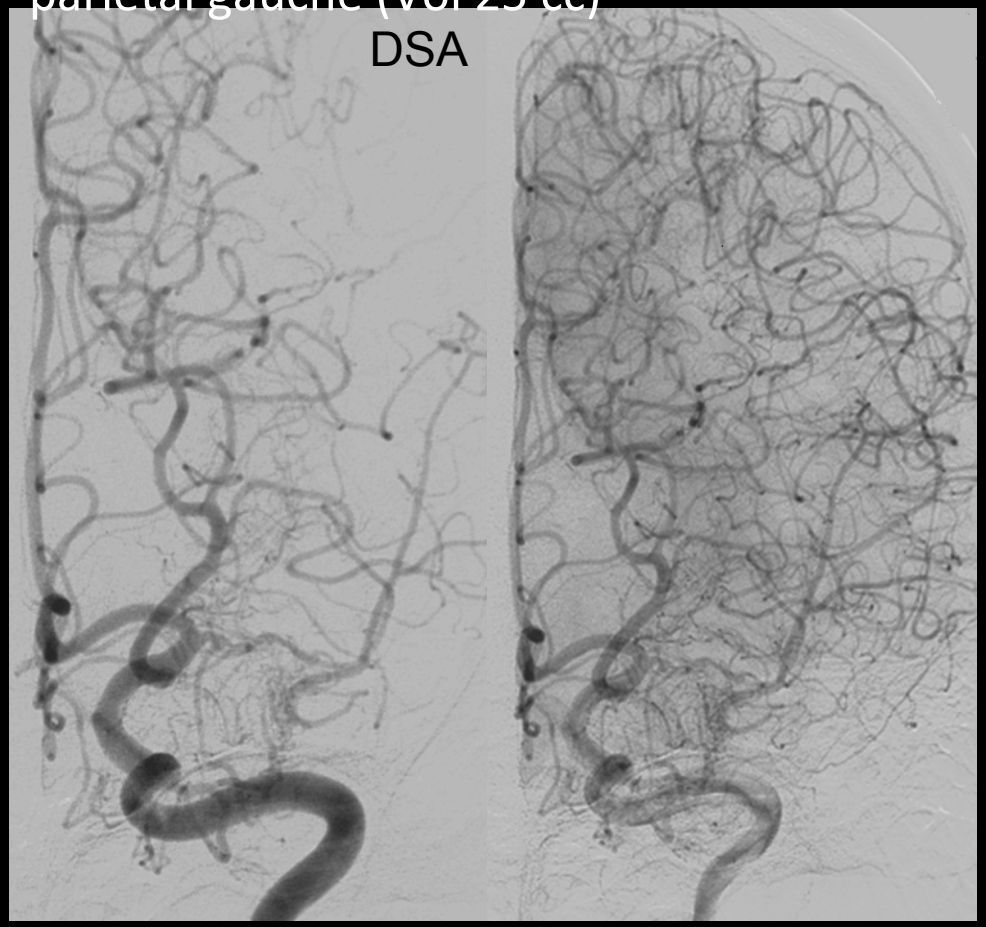
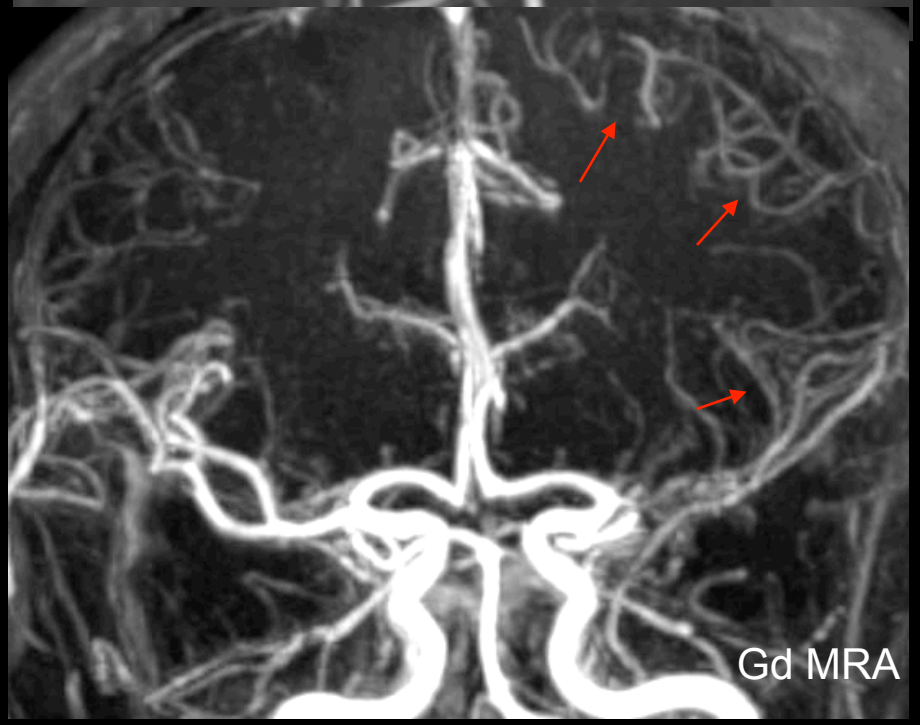
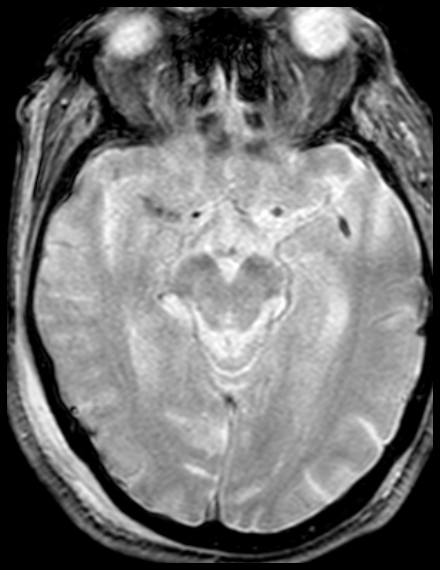


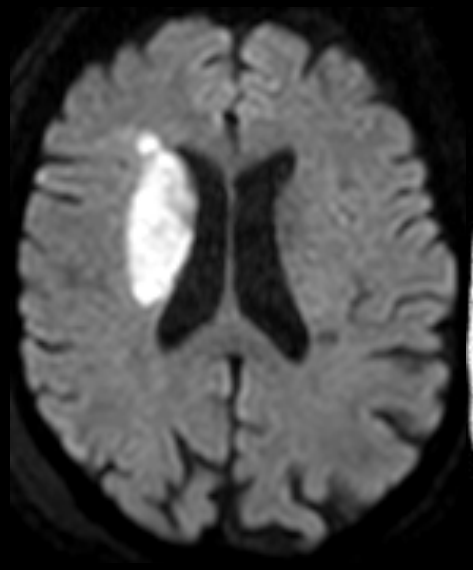


66 ans. Wake-up stroke. Hémiparésie gauche et somnolence.

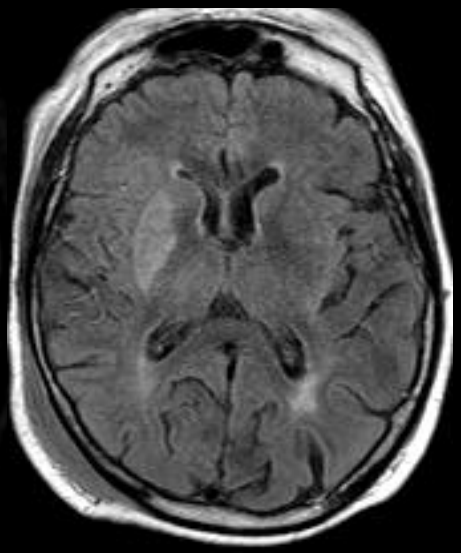
AC/FA. NIHSS =10



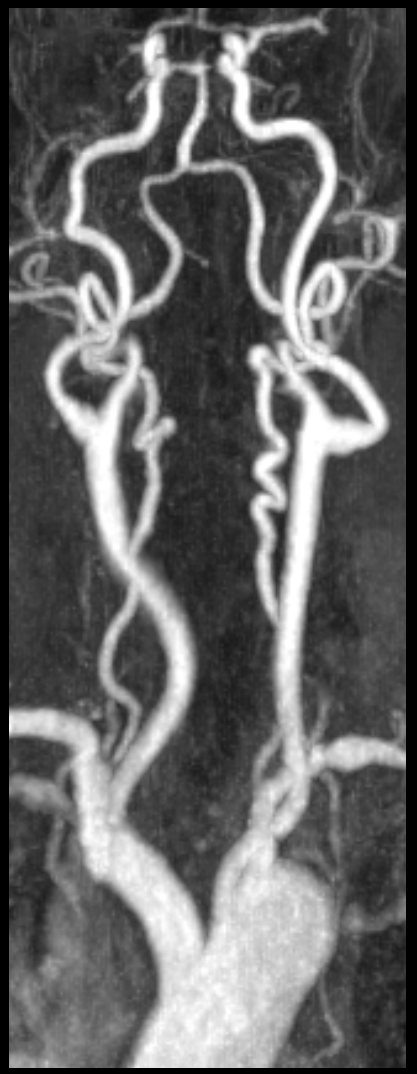
T2*



DWI

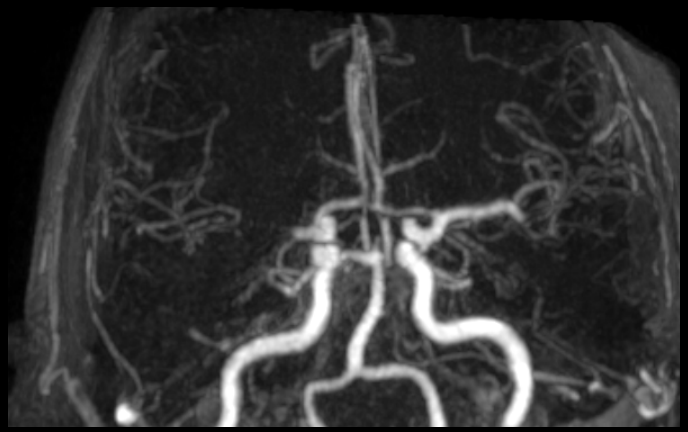


FLAIR



Gd-MRA

TOF



Gd-MRA

Après 6 H = concept « tissue-clock »

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 4, 2018 VOL. 378 NO. 1

Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct

The NEW ENGLAND JOURNAL of MEDICINE

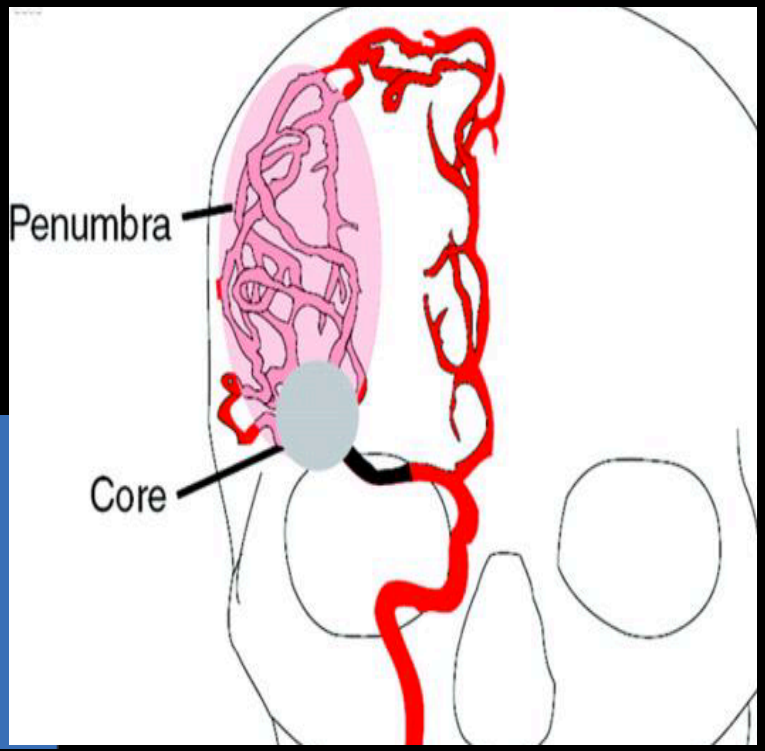
ORIGINAL ARTICLE

Thrombectomy for Stroke at 6 to 16 Hours with Selection by Perfusion Imaging

Thrombectomie (TB) : recommandations 2018

AVC entre 6 et 24 heures et occlusion artérielle proximale (LVO) de la circulation antérieure :

- Scanner de perfusion
- IRM de Perfusion

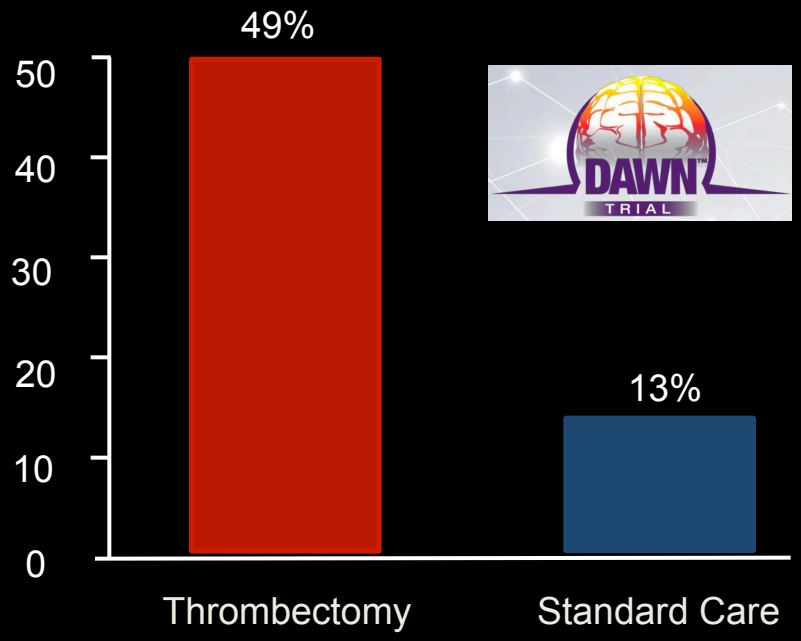


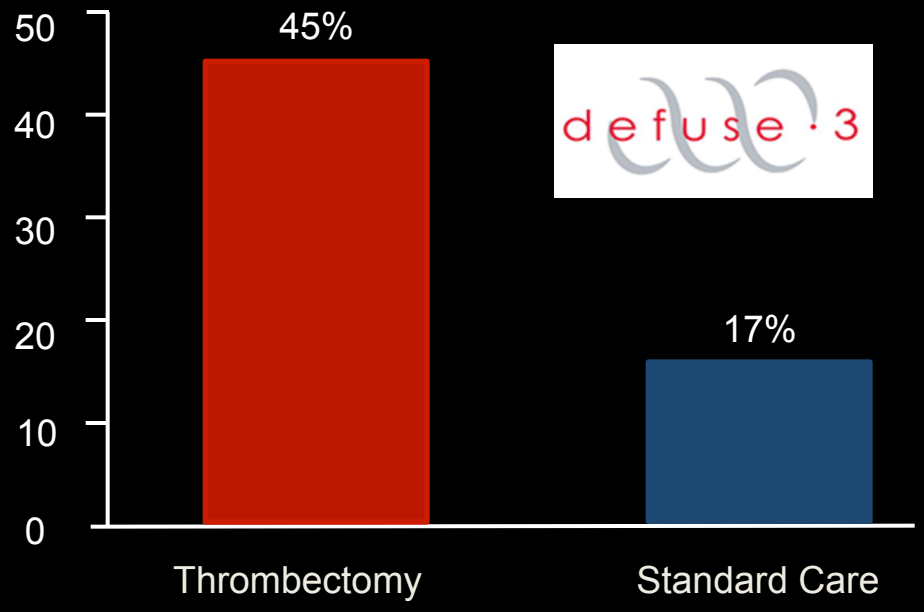
12. In selected patients with AIS within 6 to 24 hours of last known normal who have LVO in the anterior circulation, obtaining CTP, DW-MRI, or MRI perfusion is recommended to aid in patient selection for mechanical thrombectomy, but only when imaging and other eligibility criteria from RCTs showing benefit are being strictly applied in selecting patients for mechanical thrombectomy.	I	A

- Mismatch radio-clinique (DAWN)
  - *-> 6-24h*
  - *-> NIHSS / DWI (35%)*
  - *-> ou NIHSS / CT perf (65%)*
- Mismatch radiologique (DEFUSE 3)
  - *-> 6-16h*
  - *-> DWI / Perf T2* (25%)*
  - *-> ou CT perf (75%)*

Heure de début indéterminée
90% dans DAWN, 60% dans DEFUSE
« last known normal »

mRS 0-2 à 3 mois



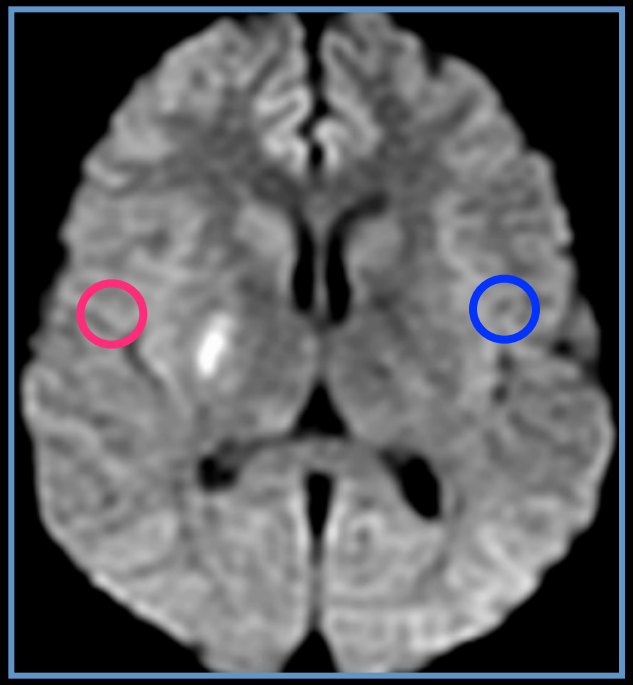


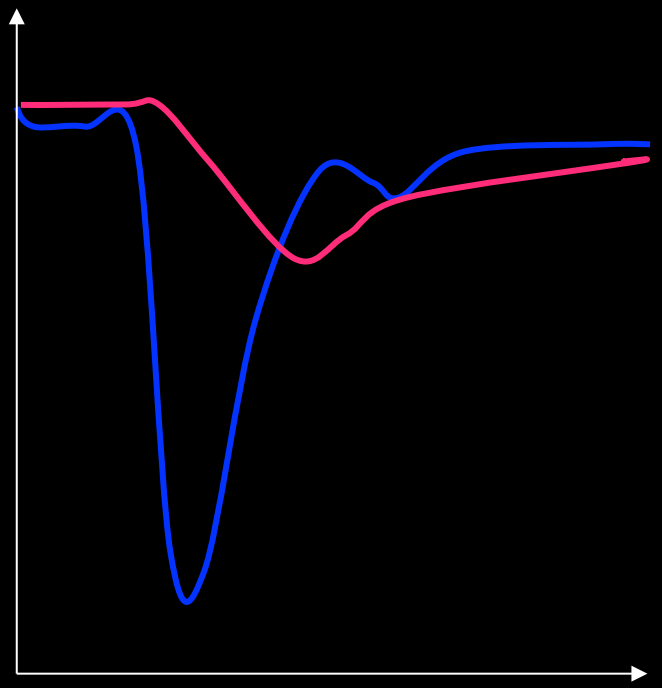
Group	Age	NIHSS	Infarct
A	≥ 80	≥ 10	≤ 20 mL
B	< 80	≥ 10	≤ 30 mL
C	< 80	≥ 20	≤ 50 mL

- Age 18 - 90
- NIHSS ≥ 6
- Infarctus core : < 70 mL
- Pénombre : Tmax > 6 sec
- Mismatch ratio ≥ 1.8
- Mismatch volume ≥ 15 mL

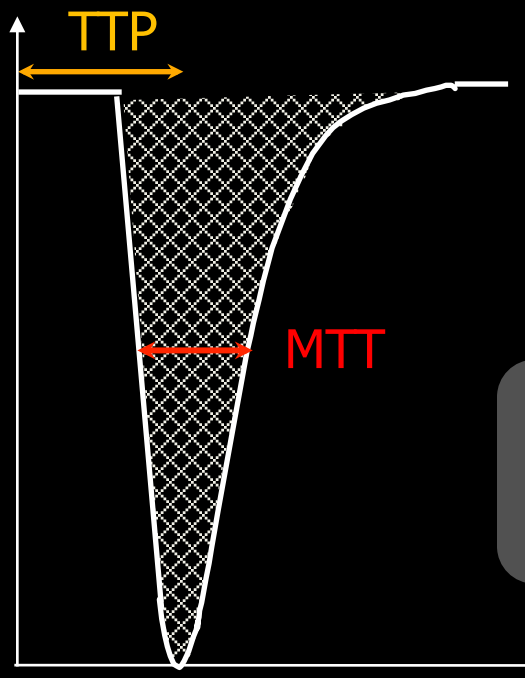
MR perfusion

- Effet de susceptibilité d'un bolus de Gd en EPI T2*
- Acquisitions répétées de l'ensemble du cerveau (12 coupes de 5 mm)
- Injection Gd : 5ml/sec (18G), dose unique (0.1 mmol/Kg), 20 ml NaCl
- Signal = f(t)



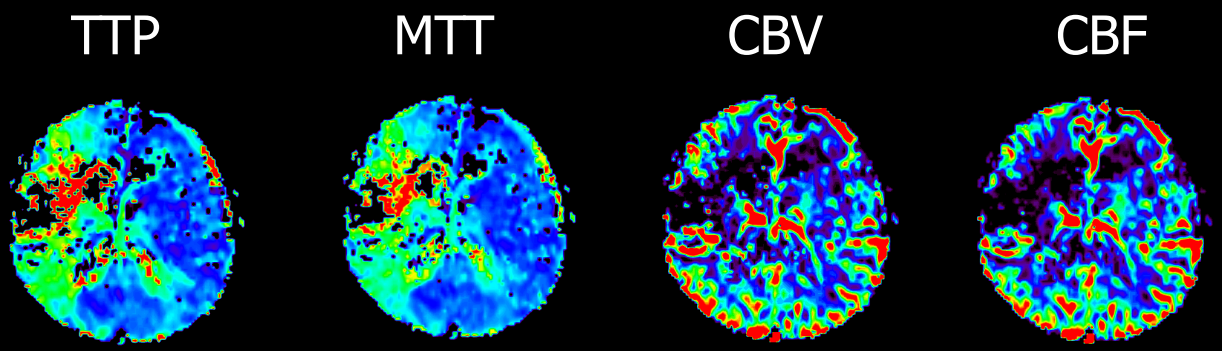


IRM de perfusion/Signal = f(t)

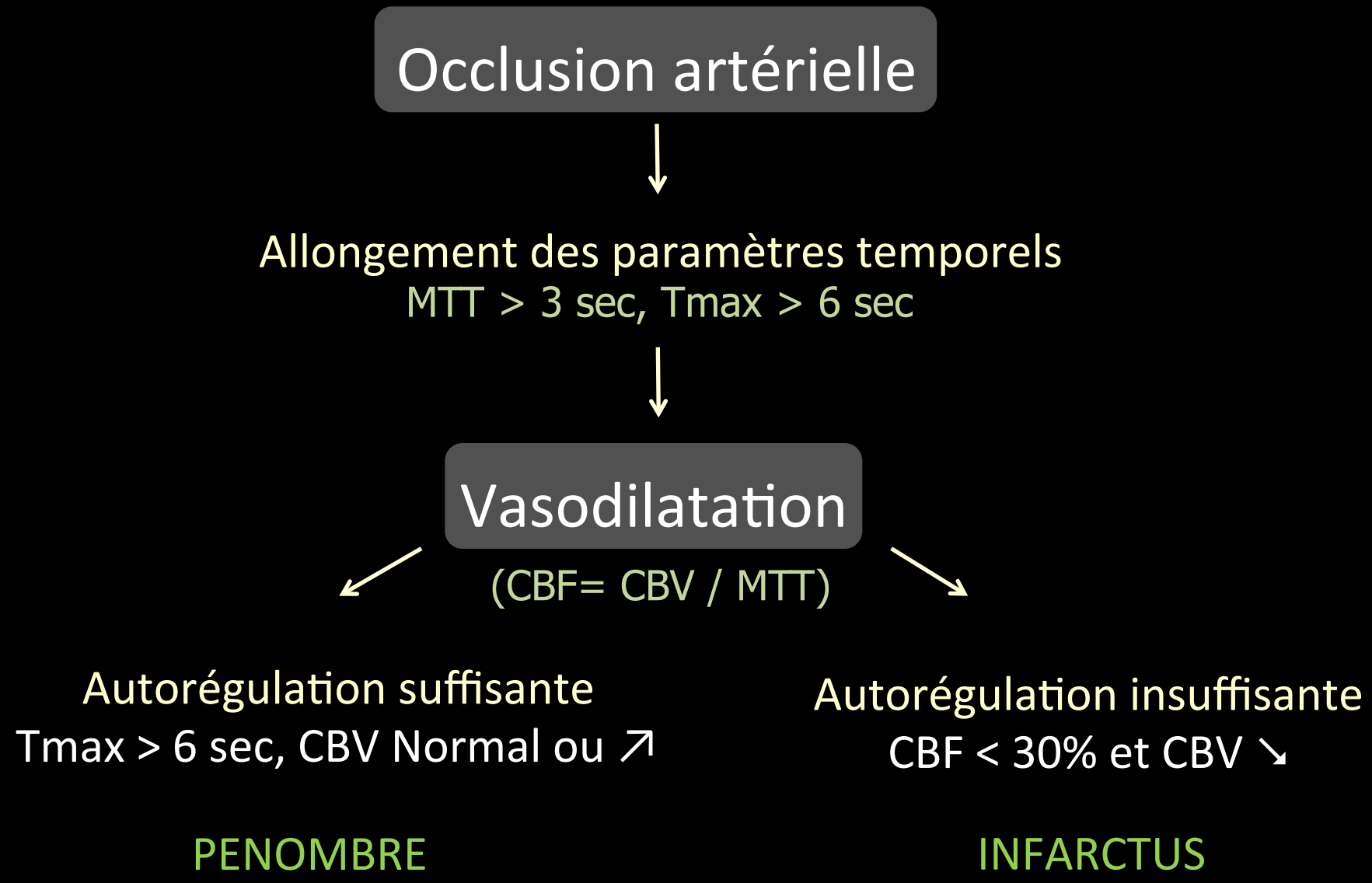


TTP	Time to peak
MTT	Mean transit time
CBV	Cerebral blood volume
CBF	Cerebral blood flow (= CBV / MTT)

Tmax = temps entre AIF et tissu cérébral
Permet de s'affranchir des variations inter-individuelles
Couramment utilisé et validé (Tmax > 6 sec = pénombre)



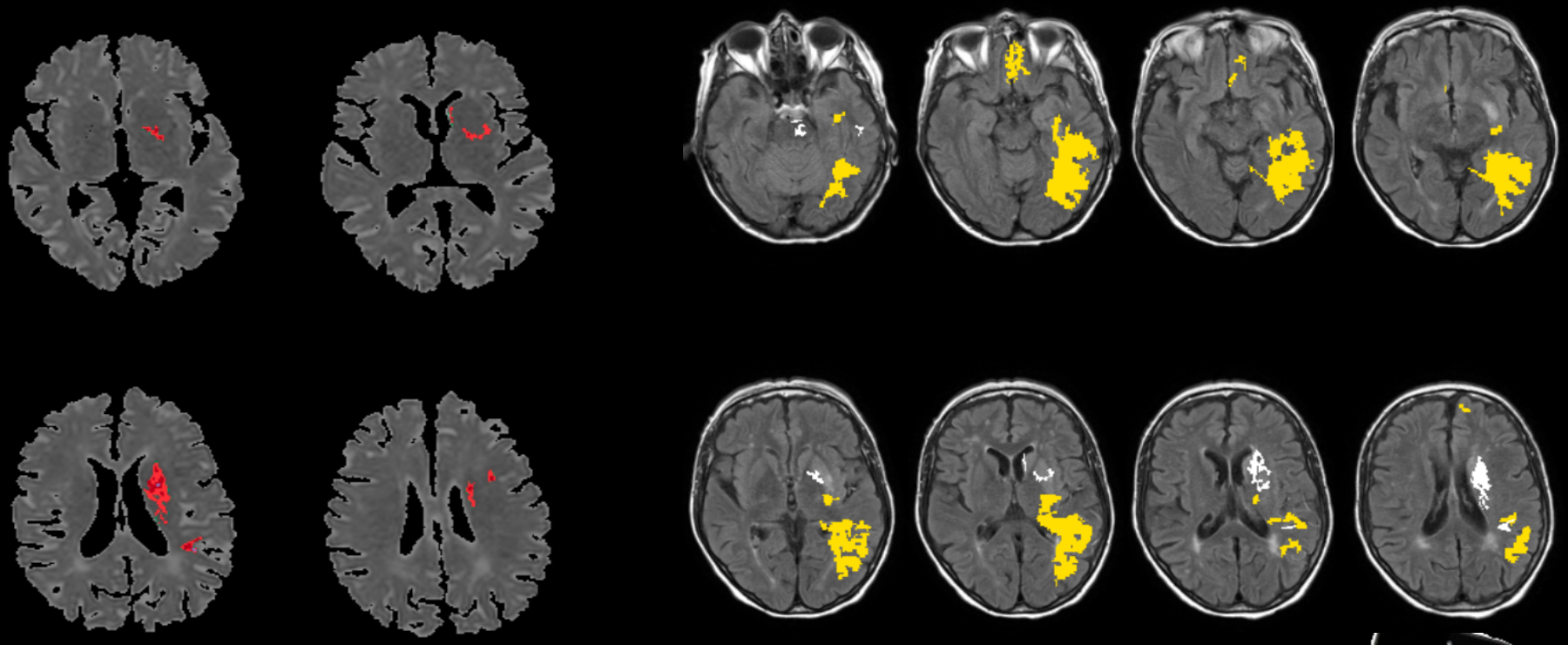
Ischémie cérébrale et autorégulation



DWI-PWI mismatch

Infarct core (Diffusion)

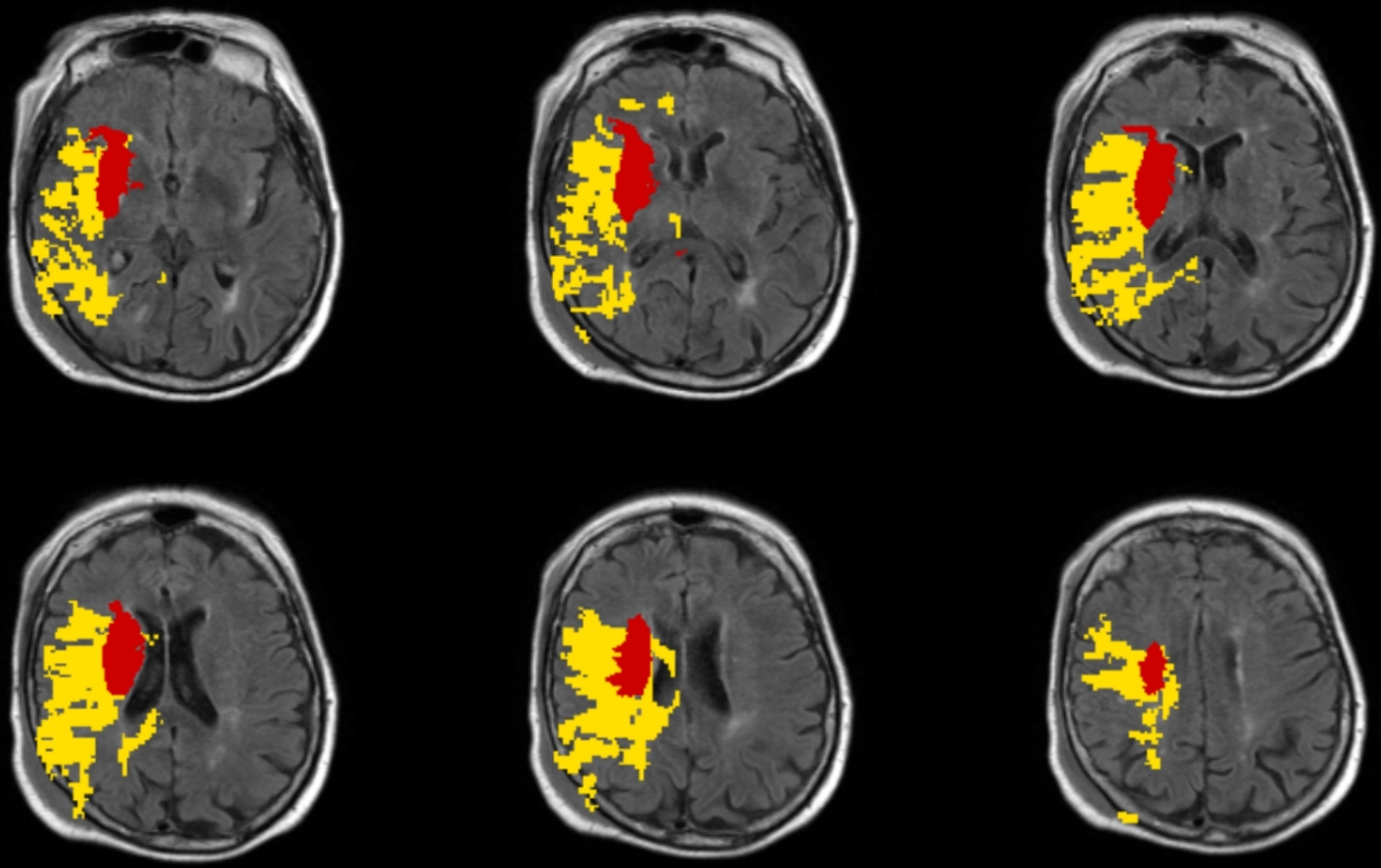
Penumbra (Tmax > 6 sec)



Volume evaluation (RAPID or OLEA softwares)

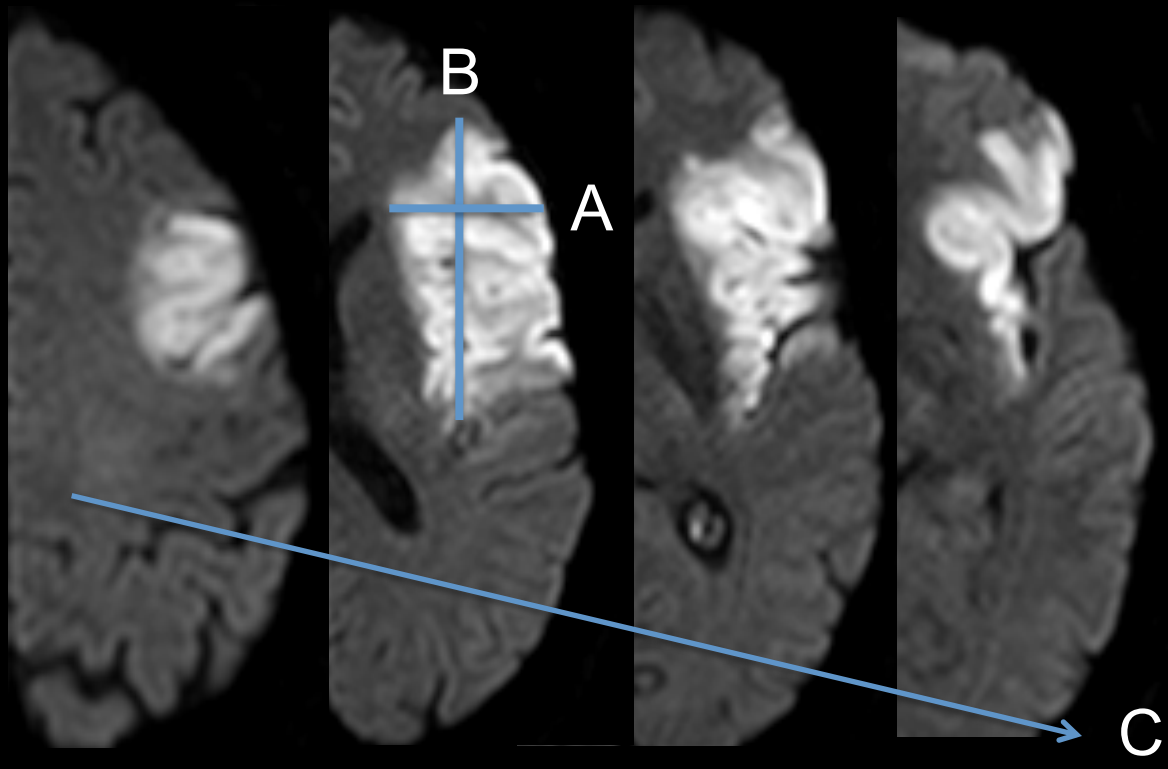
Category	Serie	Volume (ml)
Hypoperfused	TMAX	39,00
Lesion	b1000	6,64

Category	Serie	Volume (ml)	Mismatch ratio
Hypoperfused	TMAX	97,03	4,49
Lesion	b1000	21,59	



DWI-PWI mismatch

"ABC/2 method : highly reliable and accurate for quantifying the specific amount of MR imaging–determined mismatch"



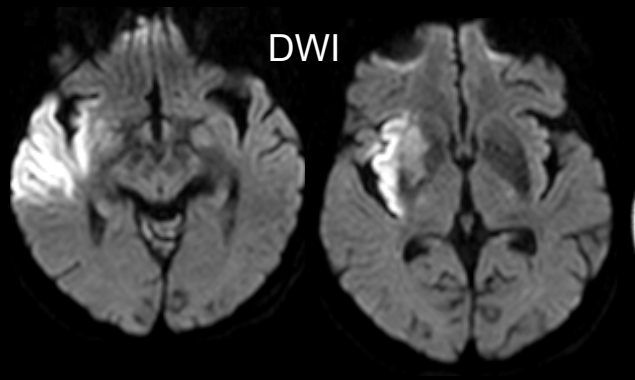
Sims JR et al. ABC/2 for rapid clinical estimate of infarct, perfusion and mismatch volumes. Neurology 2009;72:2104–10.

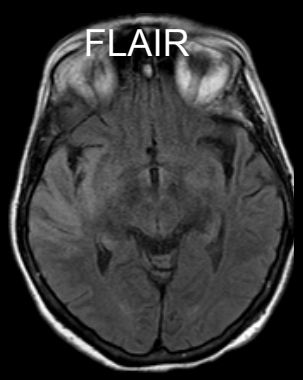
M Luby et al. Stroke Mismatch Volume with the Use of ABC/2 Is Equivalent to Planimetric Stroke Mismatch Volume AJNR Am J Neuroradiol 2013;34:1901-07

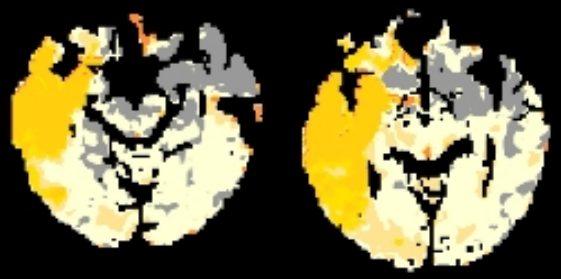
« Slow progressor »

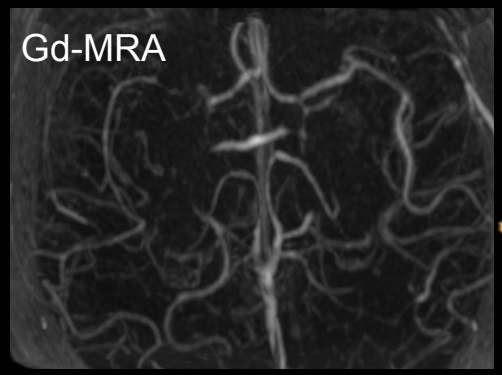
LVO et volume de l'infarctus < 70 ml après 6H

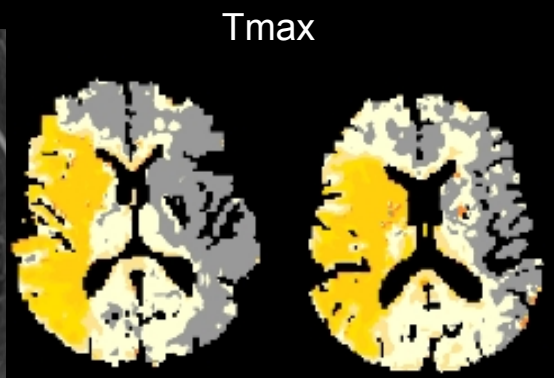
Large mismatch et collatérales développées



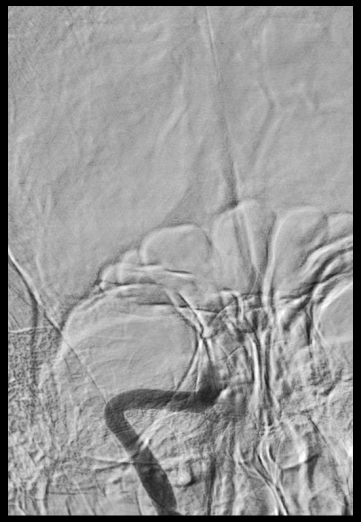


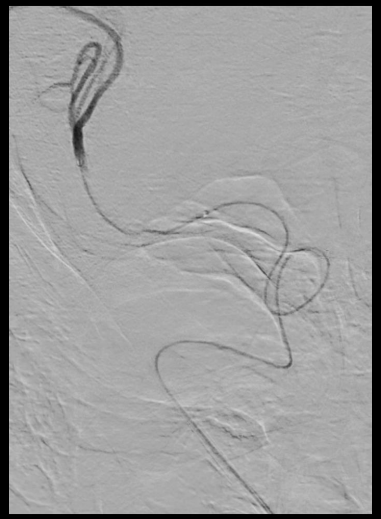




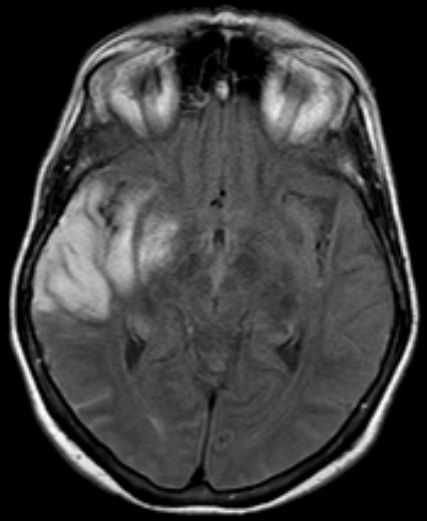


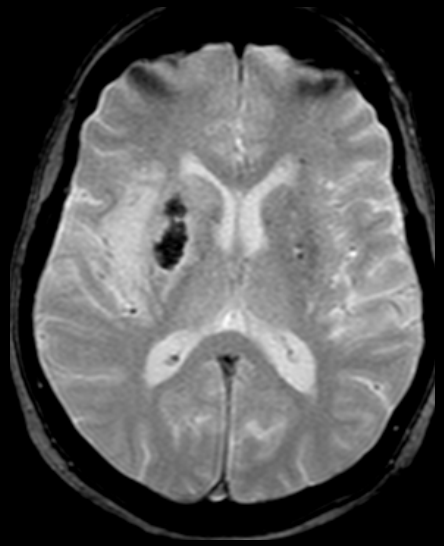
Femme de 78 ans admise pour hémiplégie gauche d'apparition brutale
Patiente vue « normale » la veille à 21H. NIHSS = 17. IRM à 10H





TIV + TB
(TICI 3)





IRM à 24H après TB (NIHSS = 6)
NIHSS = 2 à la sortie

Take-home messages

MRI et AVC ischémique aigu avec LVO

- Dans les 6 H
  - *« Time-clock »*
  - Volume de l'infarctus (DWI)
- Au-delà de 6 H ou Heure de début inconnu
  - *« Tissue-clock»*
  - Volume du mismatch (PWI)