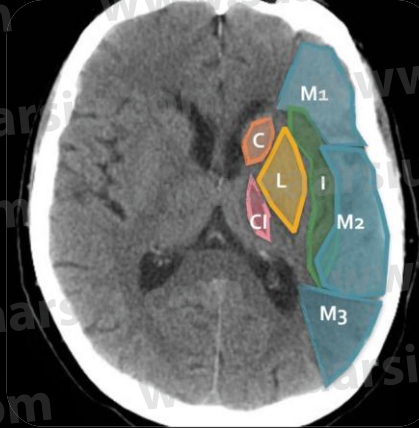




Imagerie dans l'AVC ischémique

Velly Lionel

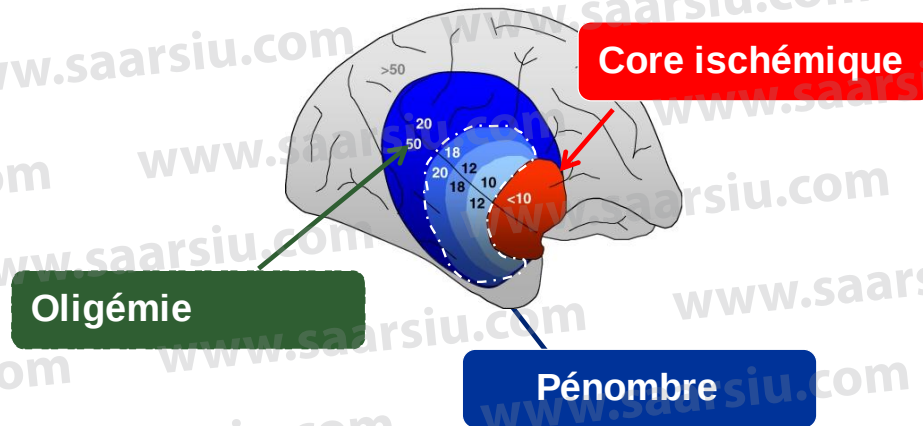
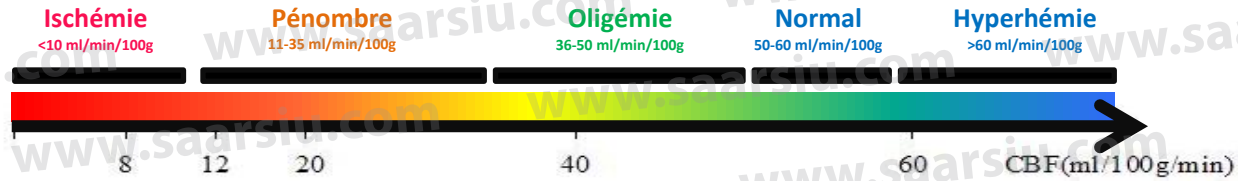
PU-PH



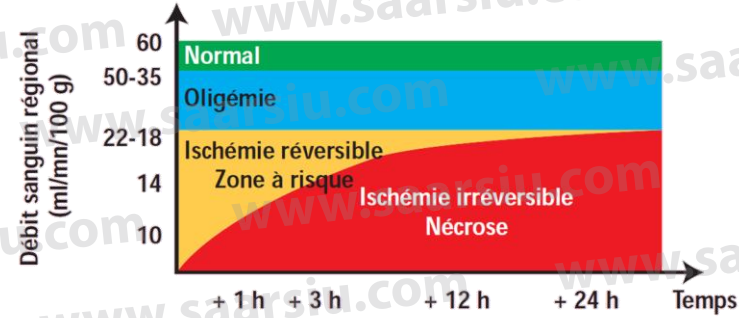
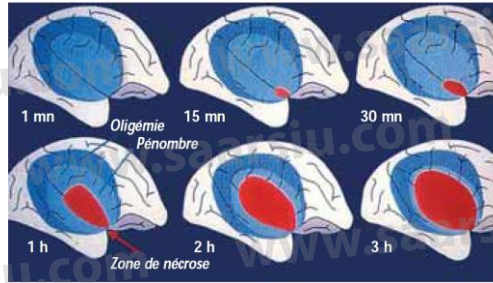
Service d'Anesthésie-Réanimation
CHU Timone Marseille

Seuils Ischémiques

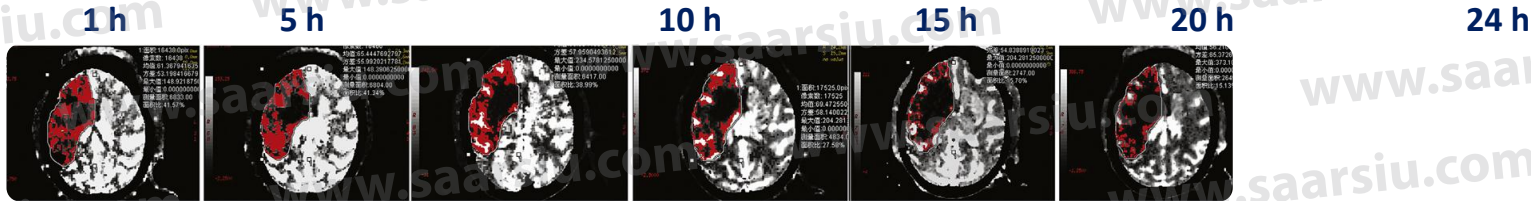
Modèle le plus simple : l'AVC Ischémique



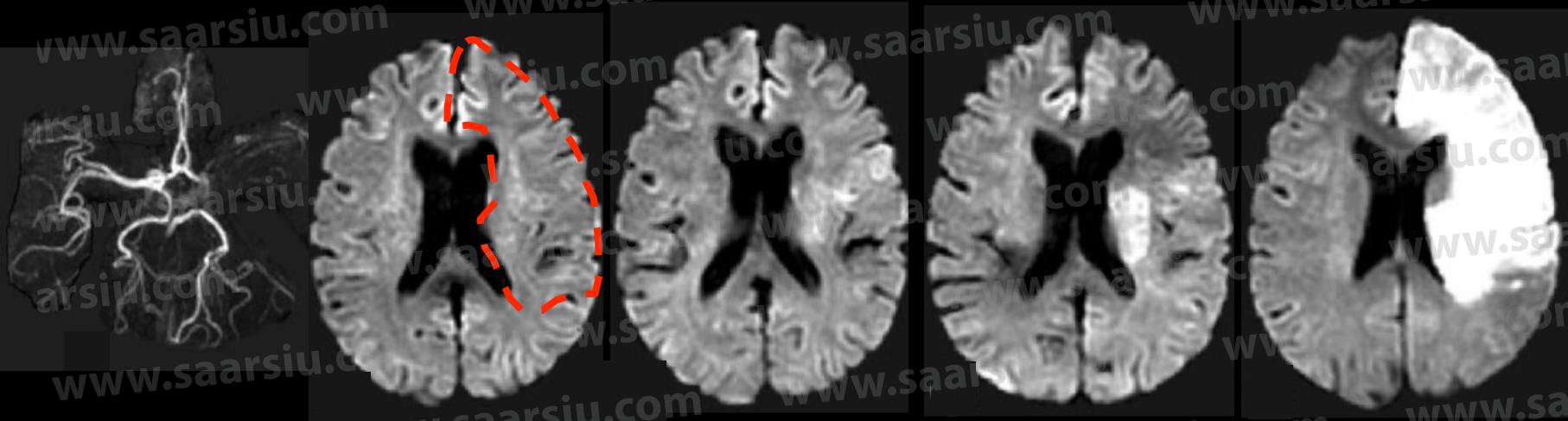
Pénombre ischemique



Baron, Cerebrovasc Dis 1999;9:193-201



Sun et al., Acad Radiol. 2010;17:1535-1542



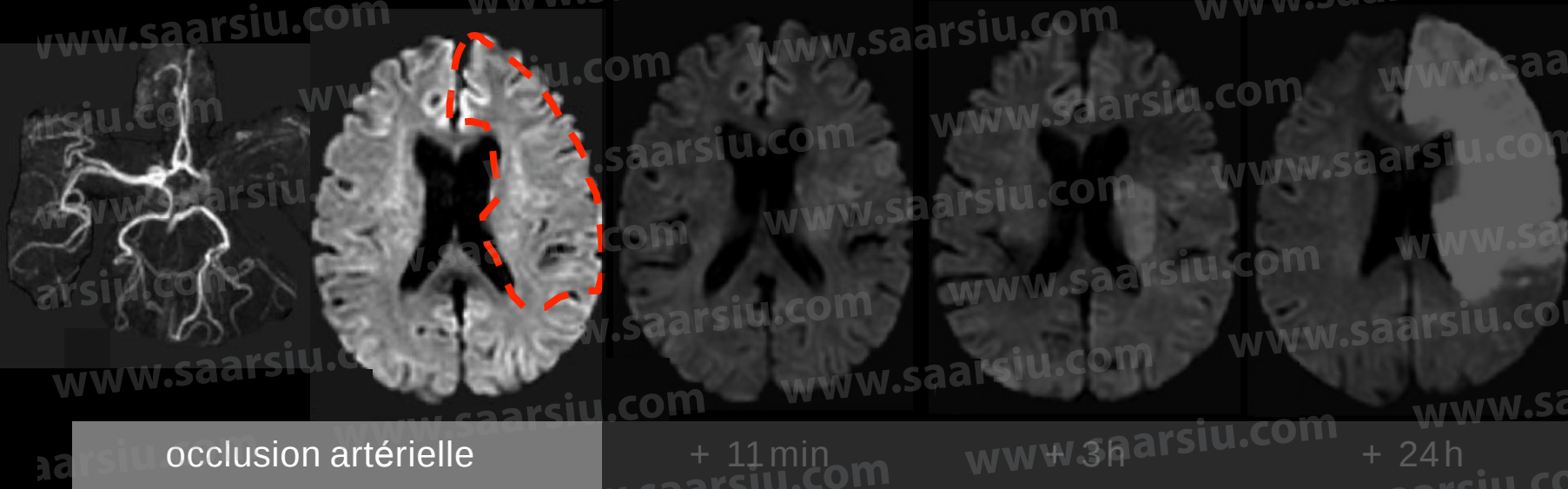
occlusion artérielle

+ 11 min

+ 3 h

+ 24 h

- 2×10^6 neurones / minute



occlusion artérielle

+ 11 min

+ 3h

+ 24h

= cible thérapeutique

IMAGERIE "MINIMALE" ?

..PROTOCOLES EN 2019

Scanner

Le minimum

- ▶ TDM cérébrale sans PDC
- ▶ Angioscanner cérébral et cervical

IRM

Le minimum

- ▶ Diffusion T2*
- ▶ FLAIR
- ▶ 3D TOF (cérébrale +
- ▶ +/- ARM Gd cervicale)

Oct. 1, 1971

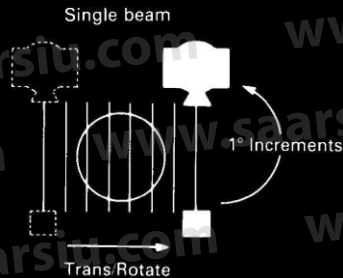


Sir Godfrey Hounsfield (1919-2004)
EMI Research Division
Nobel Prize - 1979



Sir Godfrey Hounsfield (1919-2004)
EMI Research Division
Nobel Prize - 1979

1^o génération



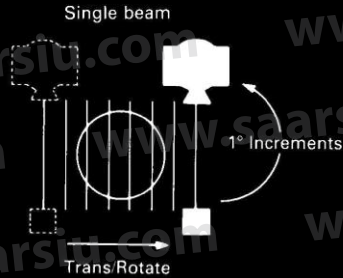
1972-73



Evolutions techniques

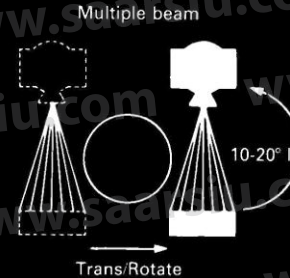
générations CT scanners

1^o génération



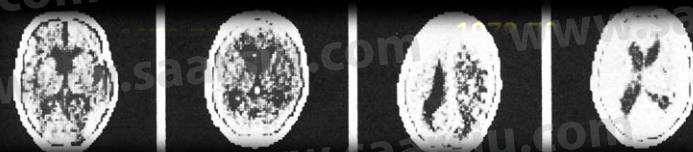
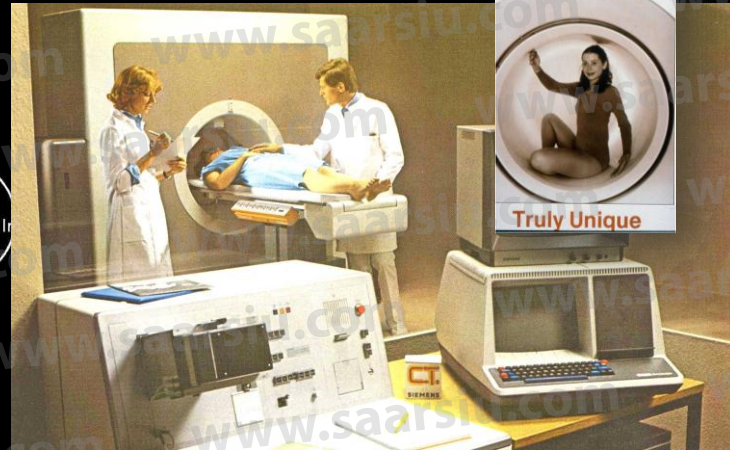
1972-73

2^o génération



1974-76

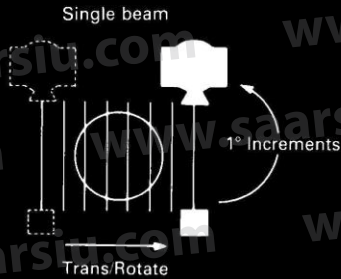
Siemens



Evolutions techniques

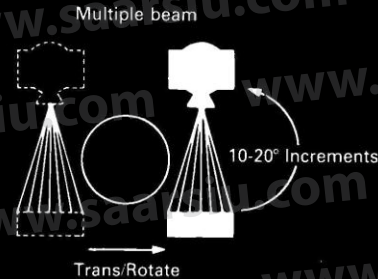
générations CT scanners

1^o génération



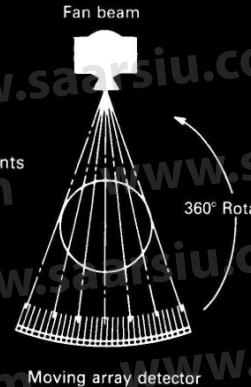
1972-73

2^o génération



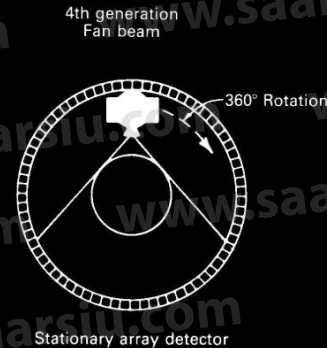
1974-76

3^o génération



1976-78

4^o génération

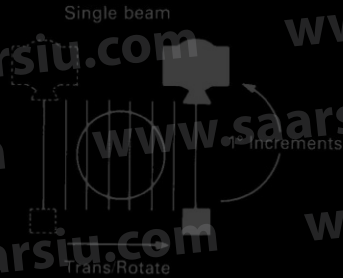


1978-79

Evolutions techniques

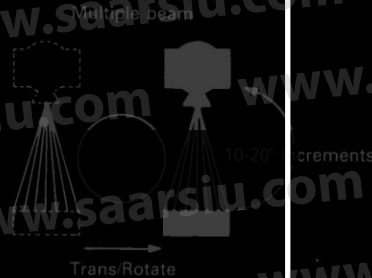
générations CT scanners

1^o génération



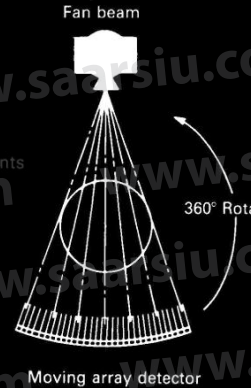
1972-73

2^o génération



1974-76

3^o génération



1976-78

4^o génération



1978-79

Evolutions techniques

généralions CT scanners

Oct. 1, 1971



Matrix 80x80



1980 - 1995



Matrix 512x512



Evolutions techniques

générations CT scanners

Oct. 1, 1971



Matrix 80x80

1980 - 1995



Matrix 512x512



Evolutions techniques

Oct. 1, 1971



1996 - 2007



Evolutions techniques

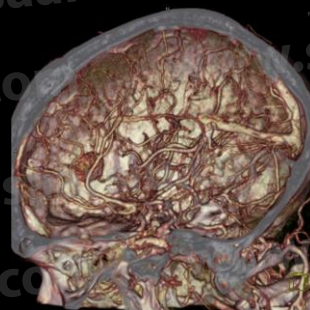
Oct. 1, 1971



2007

16-64 détecteurs

3D Volume rendering



Evolutions techniques

Oct. 1, 1971

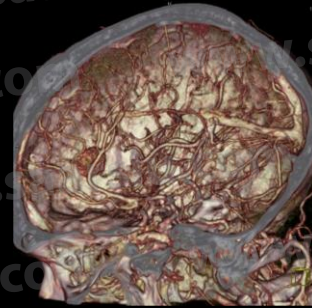


2007

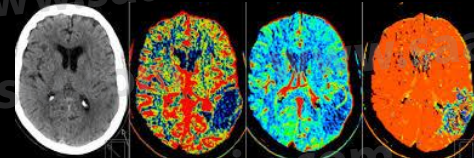
16-64 détecteurs



3D Volume rendering



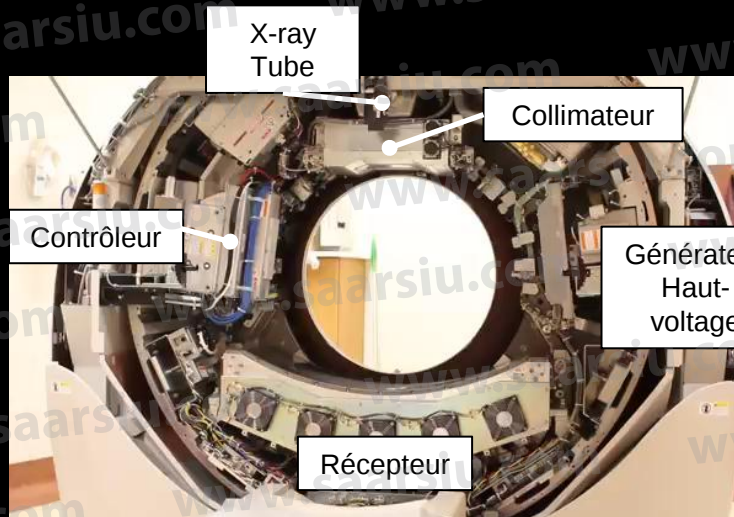
4D Perfusion sur 4 cm



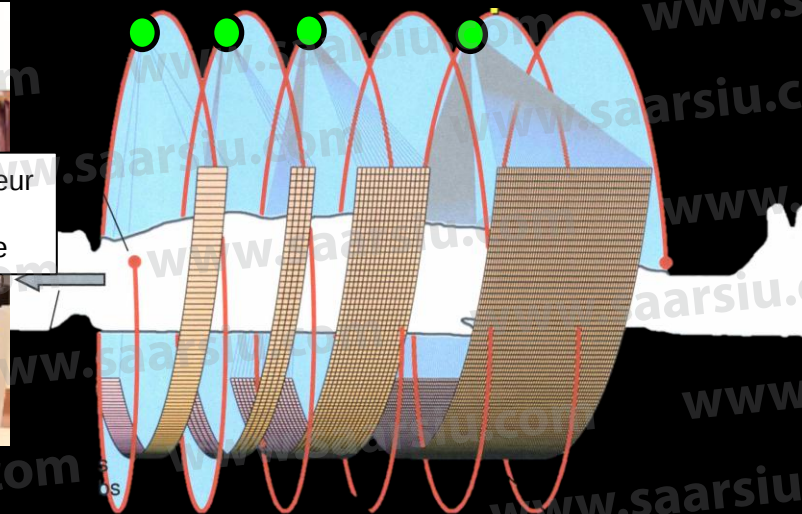
Nouveautés techniques

Loi de Moore

Nb de passages (spiral) / tour:



Générateur + détecteur = 800 kilos



Nouveautés techniques

16 barrettes



Détecteurs de 4 cm !!

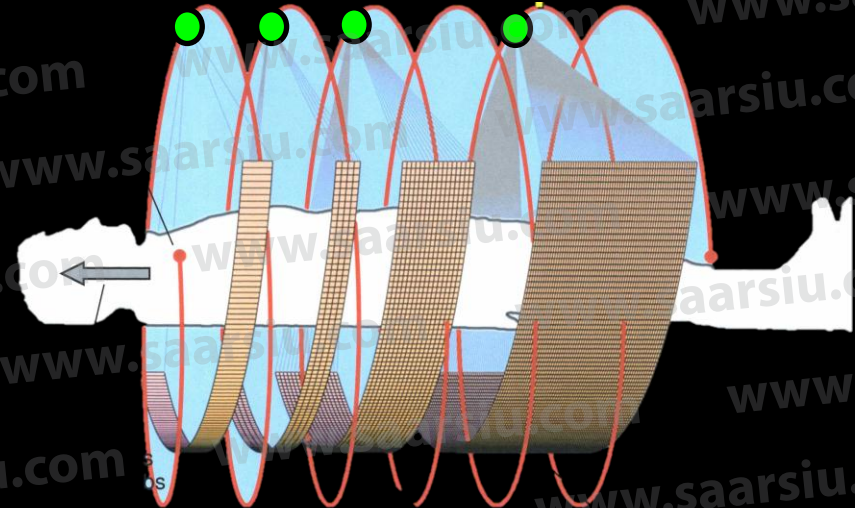
256-320 barrettes



Détecteurs de 30 cm

Loi de Moore

Nb de barrette(s):



1996

1998

2002

2004

2013

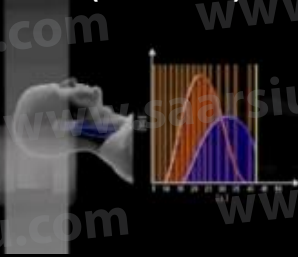
4 x 1mm 16 x 0,75mm 2x32x 0,6mm

1 x 5mm

320x 0,5mm

Nouveautés techniques

Multidetectors CTA Perfusion (MCTAP)



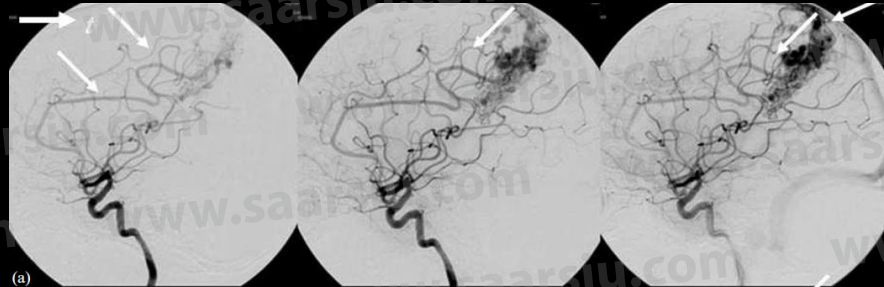
256-320 barettes



Détecteurs de 30 cm !

2014

Artériographie conventionnelle



(a)

4D

CTA Multidetector Dual energy



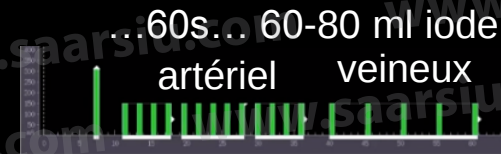
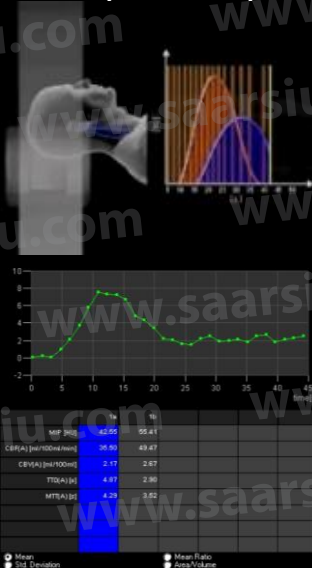
(b)

256-320 détecteurs

NEWS

Nouveautés techniques

Multidetectors CTA Perfusion (MCTAP)



2014

Artériographie conventionnelle



4D

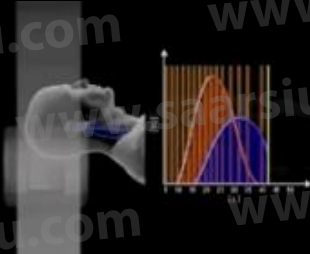
CTA Multidetector Dual energy



256-320 détecteurs

Nouveautés techniques

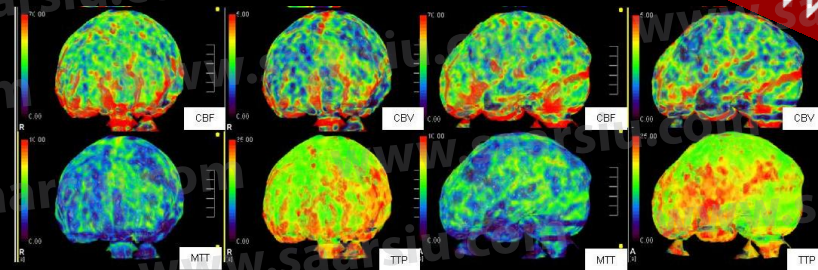
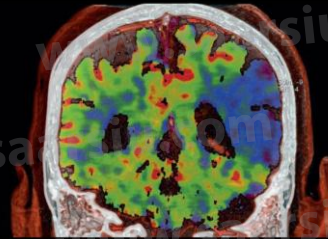
MCTAP



60s... 60-80 ml iode
artériel veineux

2014

Scanner de perfusion « Cerveau entier »



hémiplégie D,
aphasie



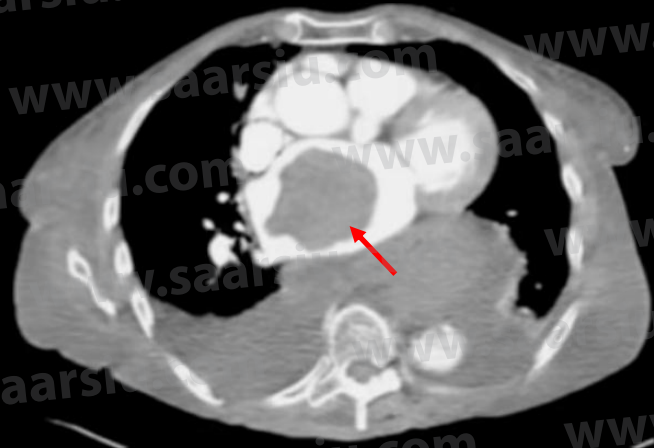
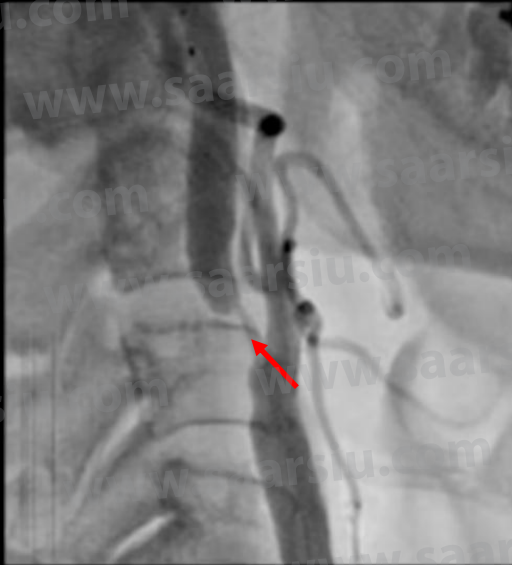
Scanner sans injection de
pdc 1h10 du début des
symptômes

hémiplégie D,
aphasie



Salle d'angiographie
Thrombectomie

Hyperdense artery

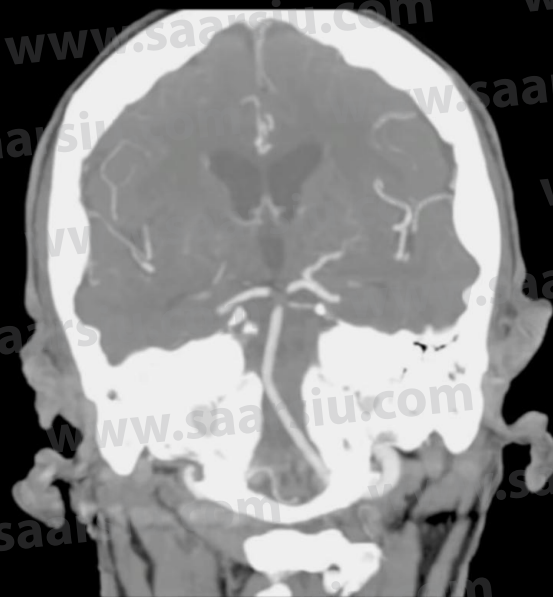


Hyperdense artery



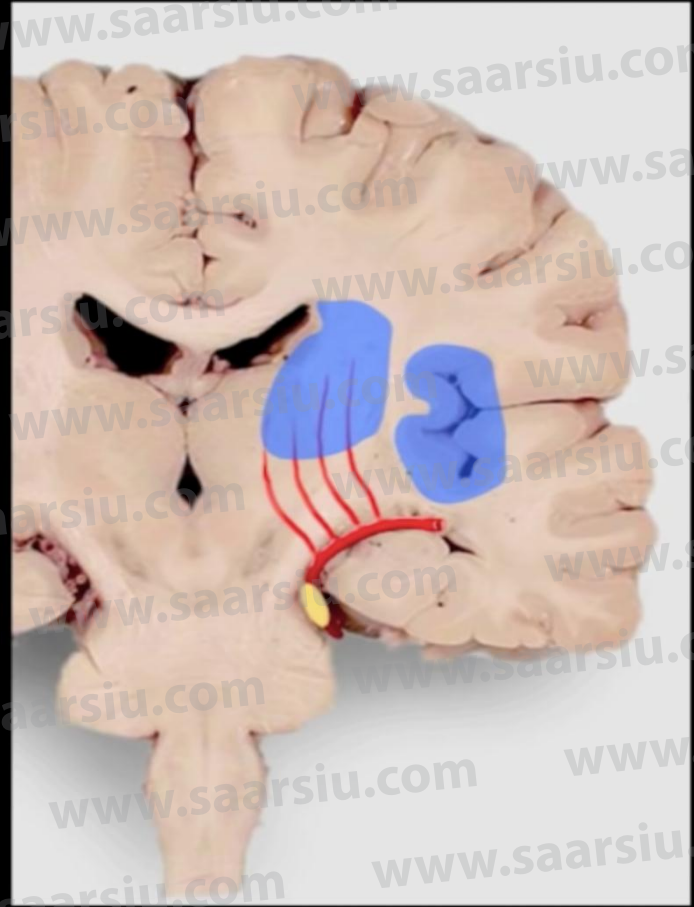
Hyperdense artery





- lentiform nucleus, caudate nucleus and insular ribbon

• as early as 1 hour after occlusion











Score ASPECTS

Divise le territoire de l'artère cérébrale moyenne (ACM) en 10 régions, superficielles ou corticales (n=7), profondes ou sous corticales (n=3)
Deux plans de coupes axiaux.

- ☐ C- Noyau caudé
- ☐ I- Ruban insulaire
- ☐ IC- Capsule interne
- ☐ L- Noyau Lenticulaire
- ☐ M1- ACM antérieur
- ☐ M2- Territoire de l'ACM devant le ruban insulaire
- ☐ M3- ACM postérieure
- ☐ M4- Territoire ACM antéro-supérieur
- ☐ M5- Territoire ACM latéro-supérieur
- ☐ M6- Territoire ACM postéro-inférieur

Absence d'hypodensité = 1 point

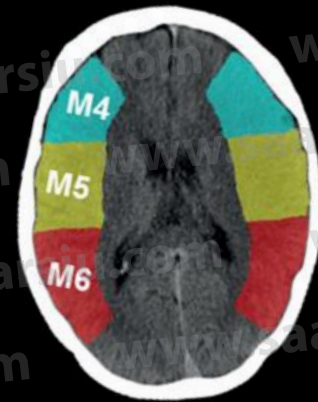
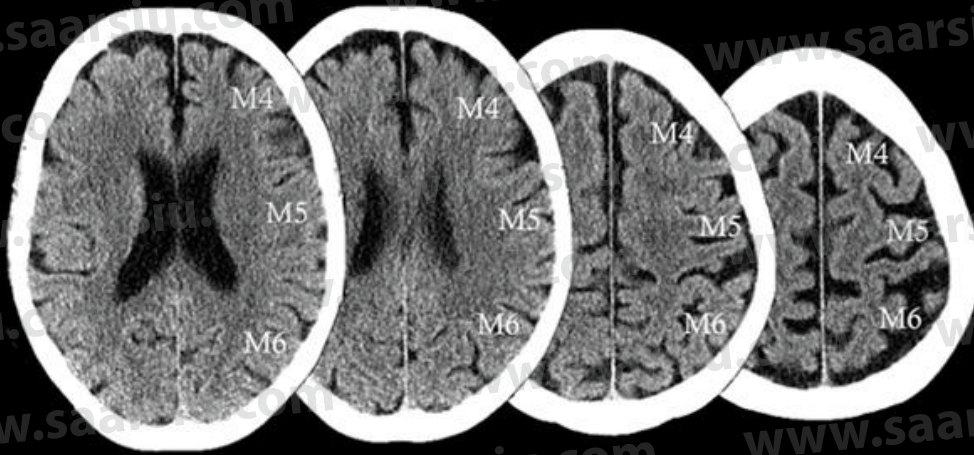
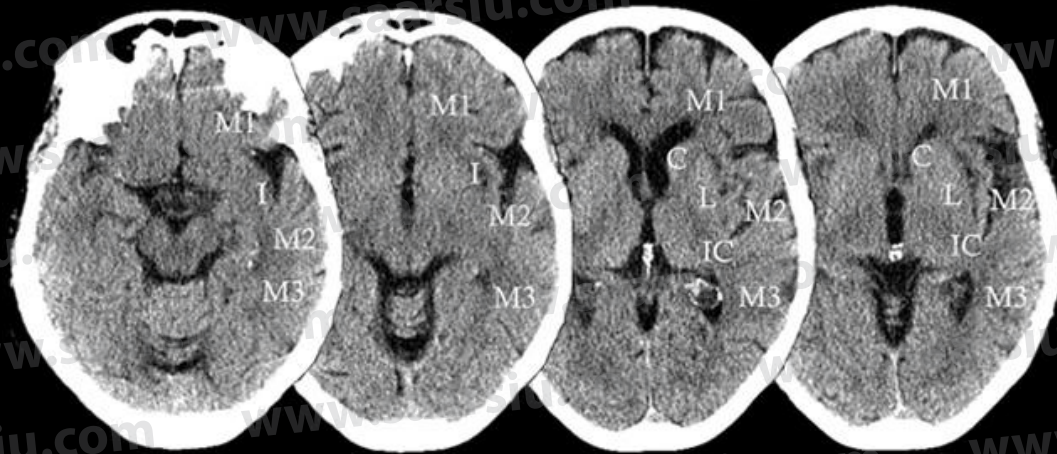
Score =10 = absence totale d'hypodensité

Score =0 = hypodensité de tout le territoire de l'ACM

Score ASPECTS = /10

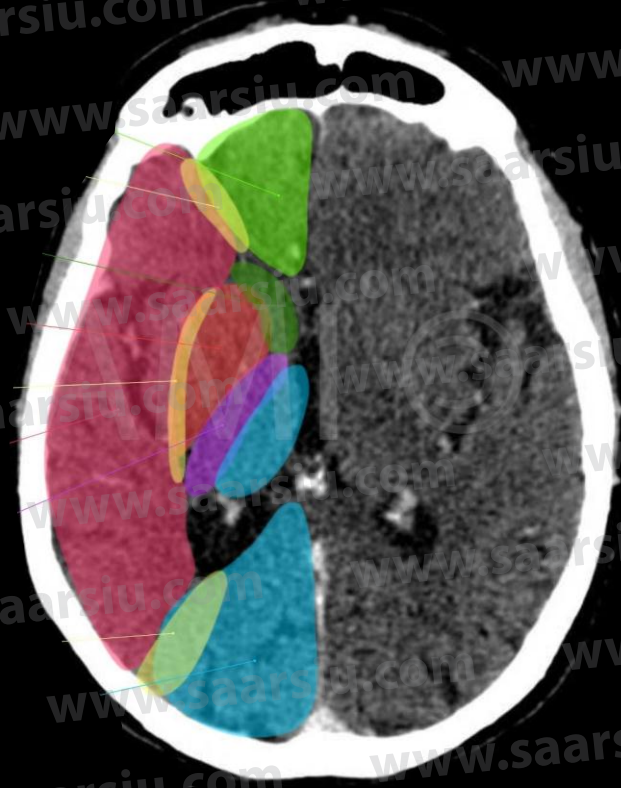
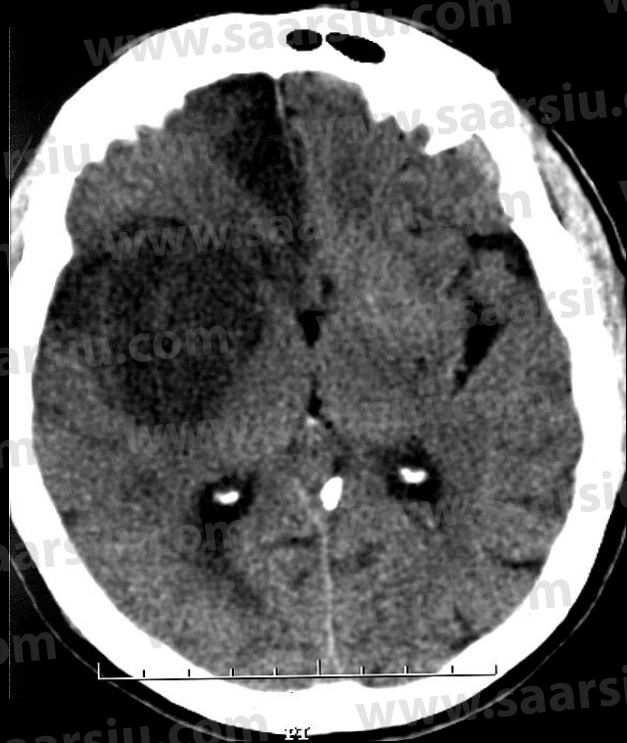
Un score ≤ 7 = pronostic péjoratif

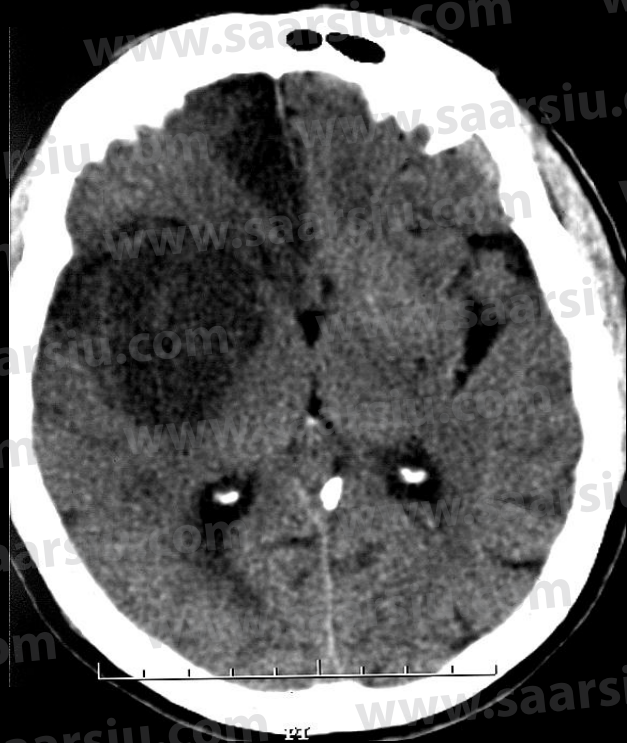
Handicap résiduel / Risque de transformation hémorragique



M1-6 + Caudate Lentiform Insula IntCapsule / 10







Collateral Flow in Pial Arterioles

Grade 4: complete and fast collateral (retrograde)

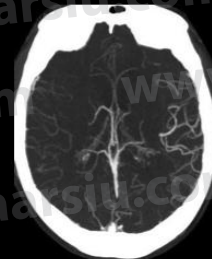
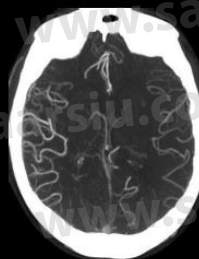
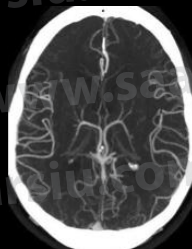
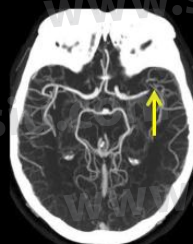
Grade 2: quick collateral with persistence of a defect

Grade 1: poor collateral

Occlusion site

Phase 1

Phase 2



Evolutions techniques

Un autre joujou ... l'IRM

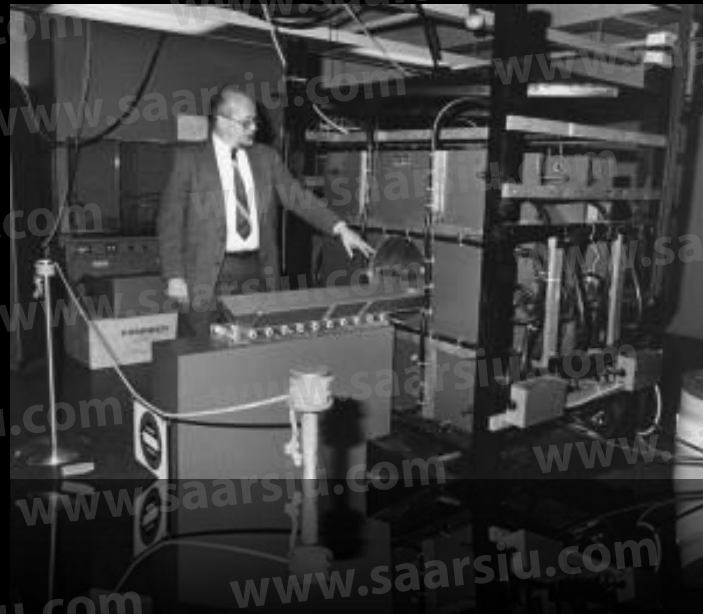
APR. 13, 1978



Sir Peter Mansfield (1933)

University of Nottingham

Nobel Prize - 2003



IMAGERIE "MINIMALE" ?

..PROTOCOLES EN 2019

Scanner

Le minimum

- ▶ TDM cérébrale sans PDC
- ▶ Angioscanner cérébral et cervical

IRM

Le minimum

- ▶ Diffusion T2*
- ▶ FLAIR
- ▶ 3D TOF (cérébrale +
- ▶ +/- ARM Gd cervicale)

MRI

Avant 6 heures

Le minimum

DTI 6dir

FLAIR

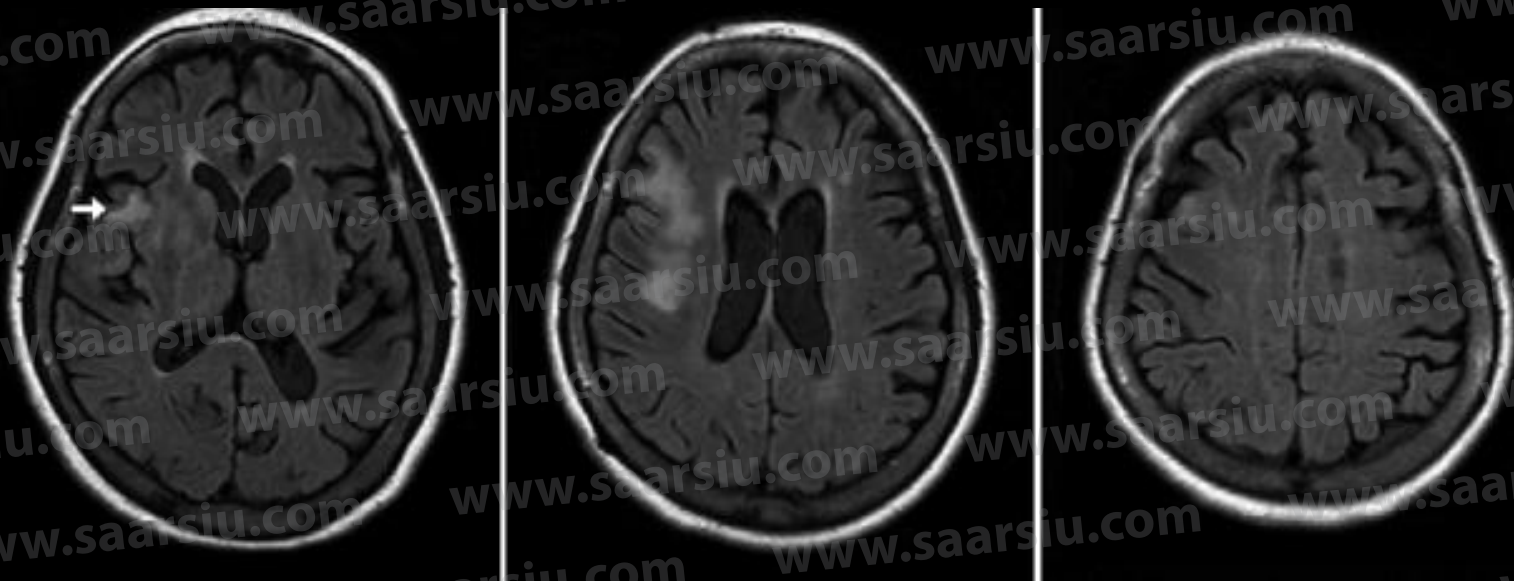
3D TOF
(cérébrale
+/- ARM Gd
cervicale)

20 cc solution @ 1.5 ml/sec



IRM

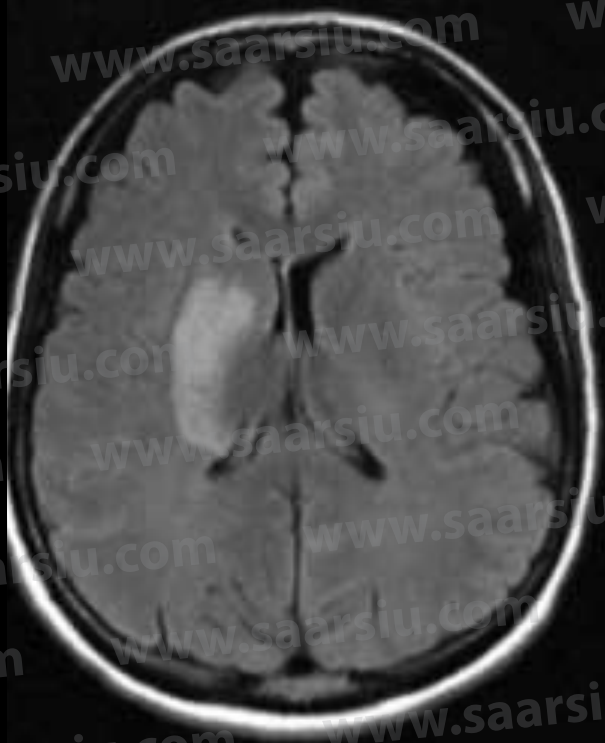
T2 Weigthed image : FLAIR

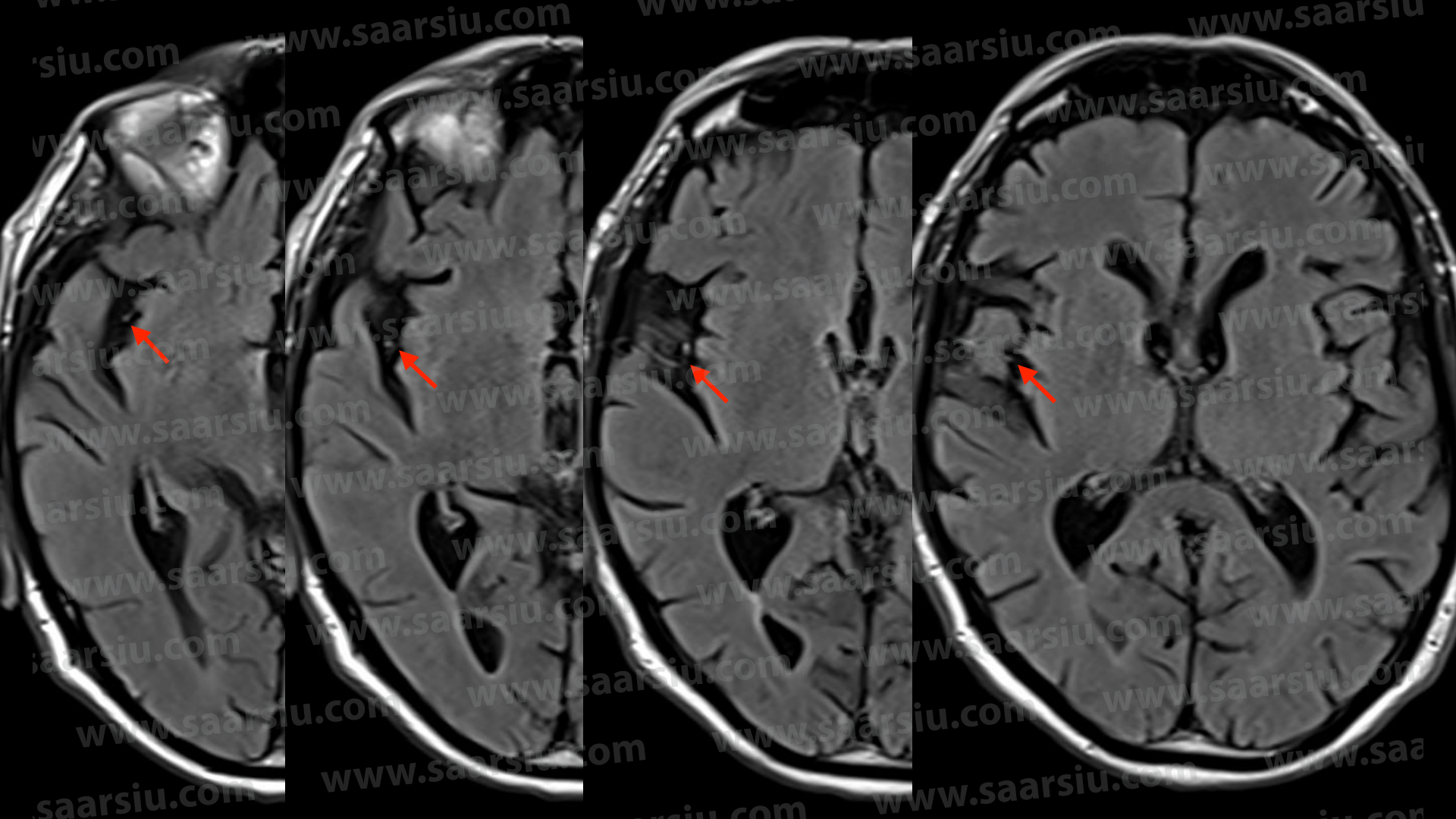


IRM

T2 Weigthed image : FLAIR

AVC « constitué » en
hypersignal FLAIR >6H





IRM

T2 Weigthed image : T2*



T2 *

IRM

T2 Weigthed image : T2*

Hématome
composante hémorragique récente.

Thrombus intra-artériel

Séquelles d'hématome, microbleeds.



T2*

IRM

ARM: Séquence TOF (time of flight)



IRM

ARM: Séquence TOF (time of flight)



Volume T1 sans injection

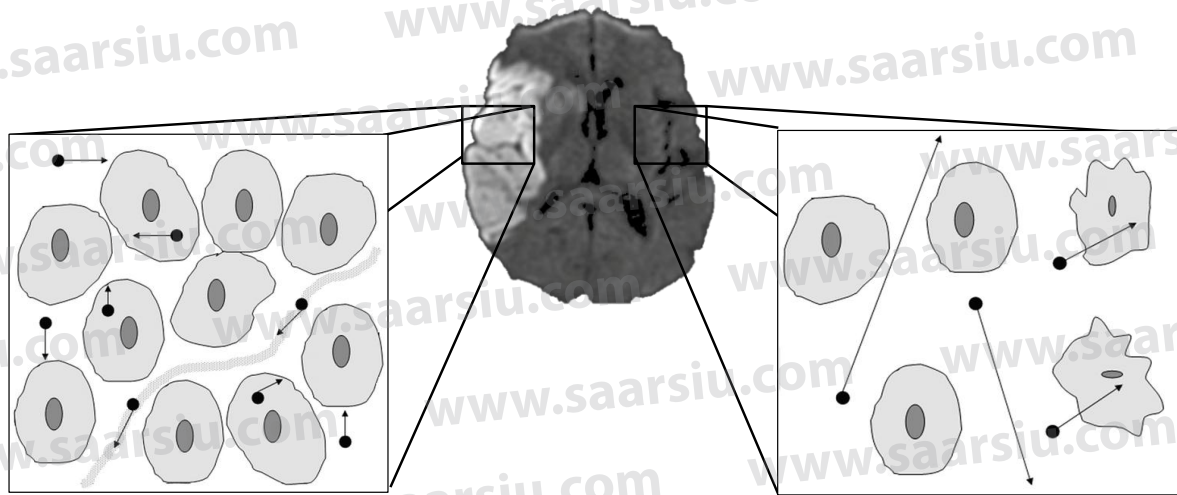
ARM des artères cervicales (vaisseaux du cou)

- Volume T1 avec injection de Gadolinium
- Artères cervicales et intracrâniennes
 - Bonne corrélation avec l'angiographie conventionnelle
 - Sténose, occlusion, dissection



MRI

Diffusion MRI



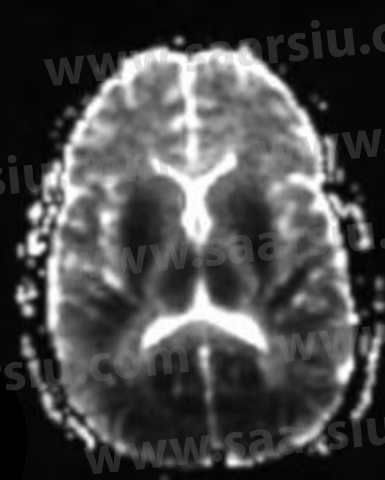
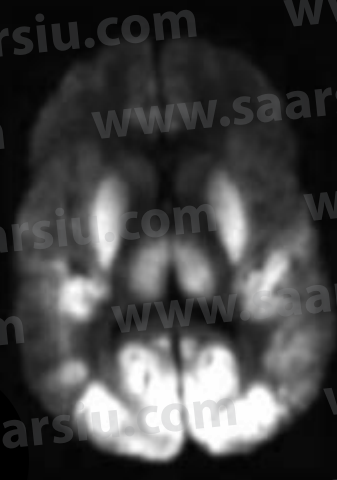
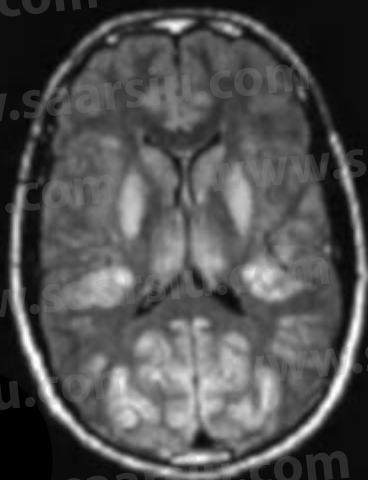
IRM

Diffusion

FLAIR

DWI

ADC



IRM



Diffusion Weighted Imaging
(DWI)



Apparent Diffusion Coefficient
(ADC)

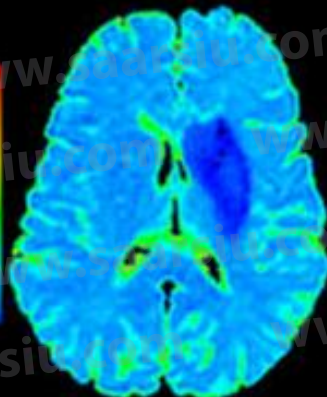
IRM

T2 Weigthed image : FLAIR

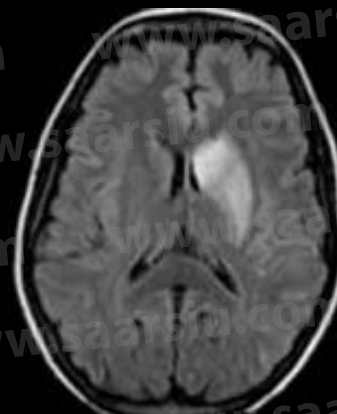
Cas 1



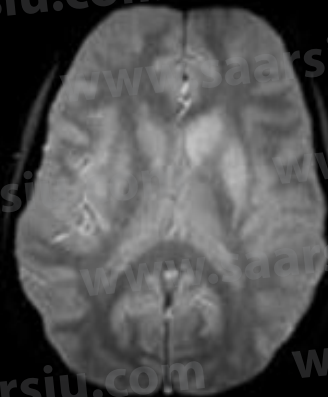
Diffusion



ADC



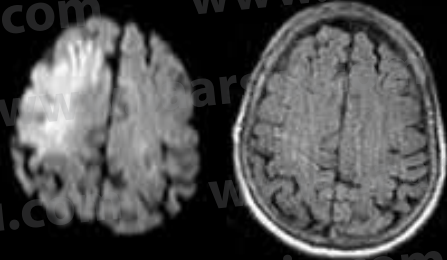
FLAIR



T2*

IRM

DWI-FLAIR mismatch



DWI

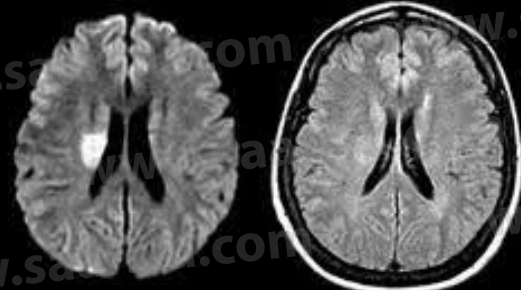
FLAIR



DWI

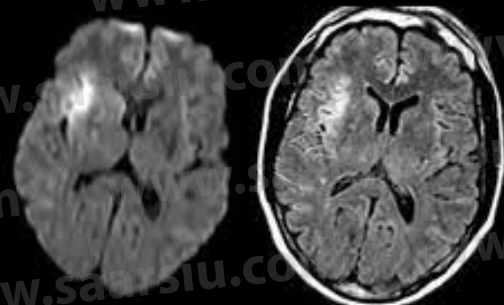
FLAIR

No DWI-FLAIR mismatch



DWI

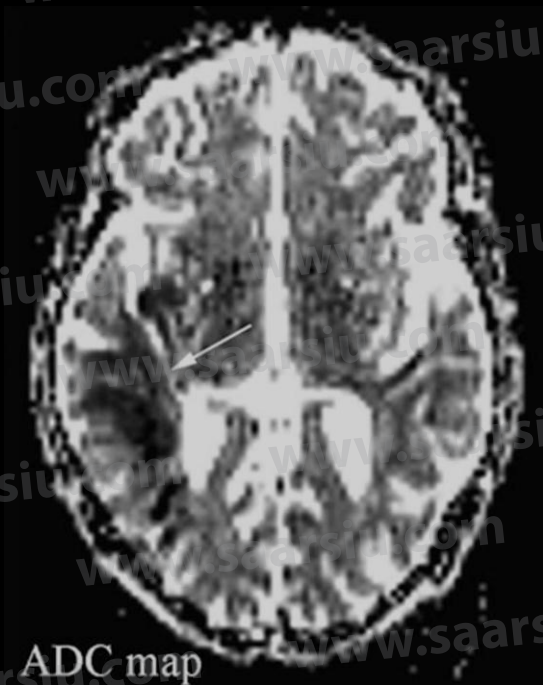
FLAIR



DWI

FLAIR

IRM

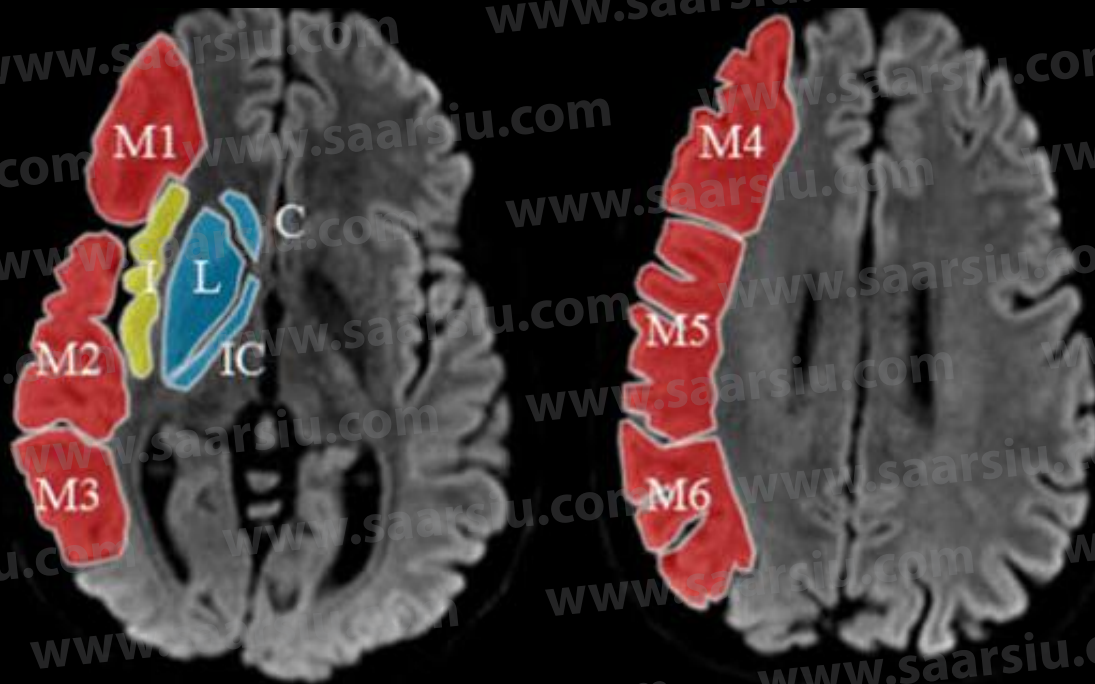


ADC map

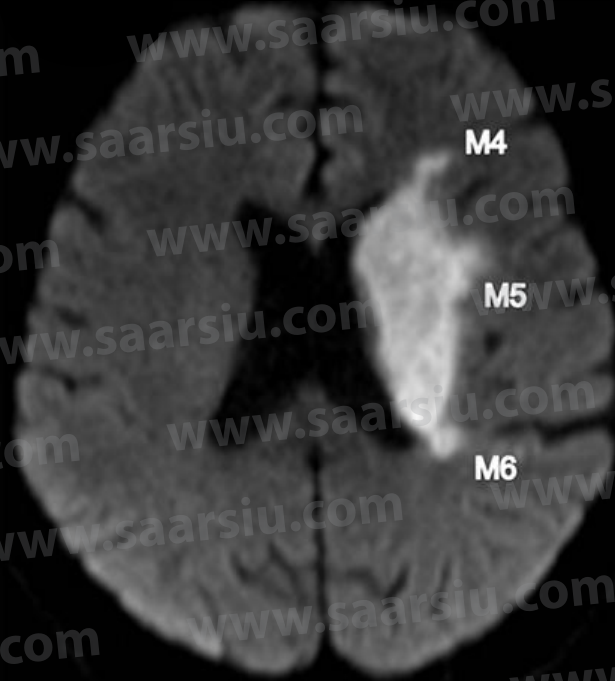
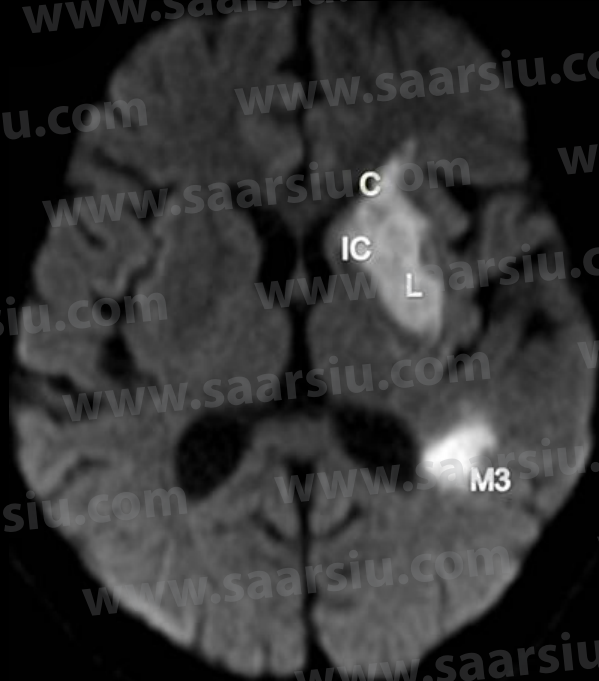


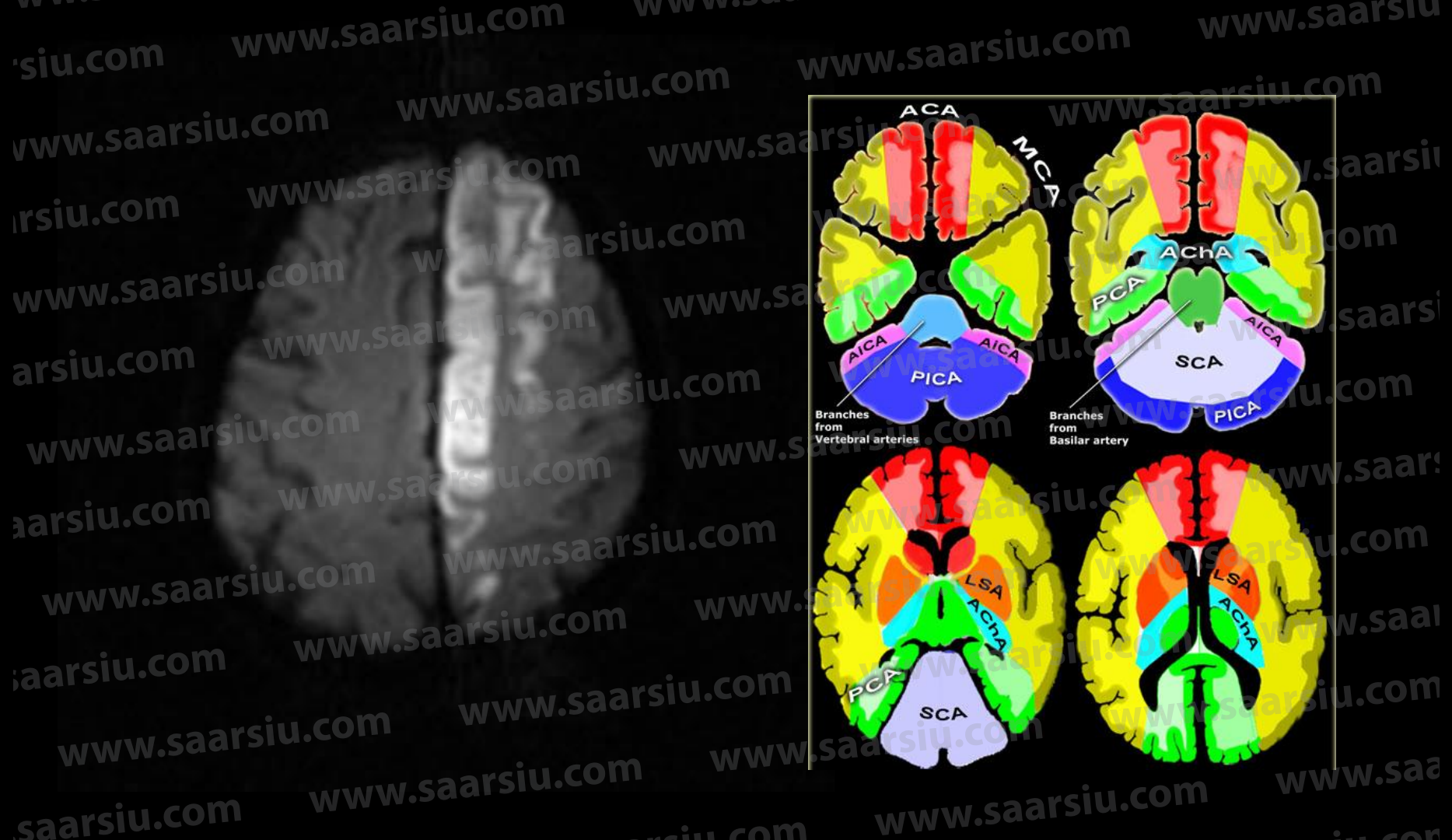
DTI trace

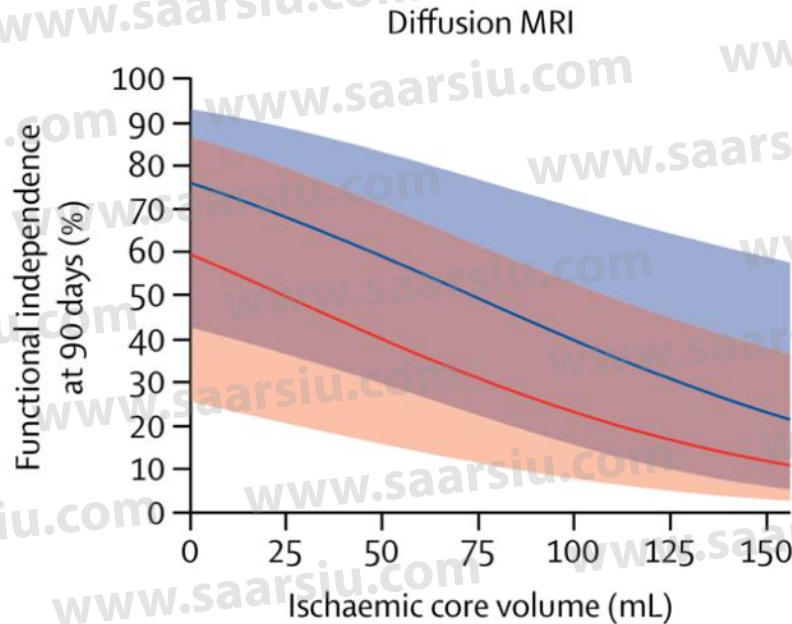
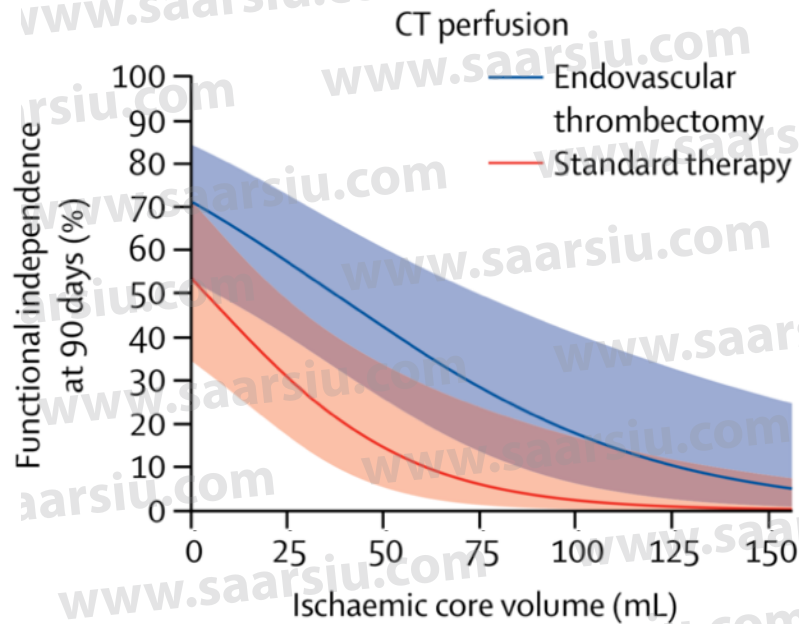
Score ASPECT



IRM







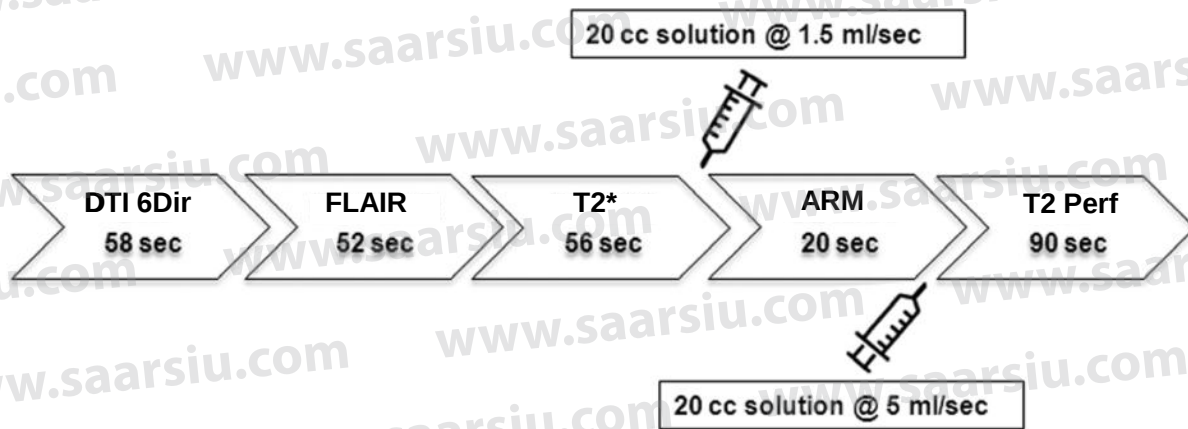
Médiane core scanner: 10 mL (3-28)

Médiane core DWI: 21 mL (10-52)

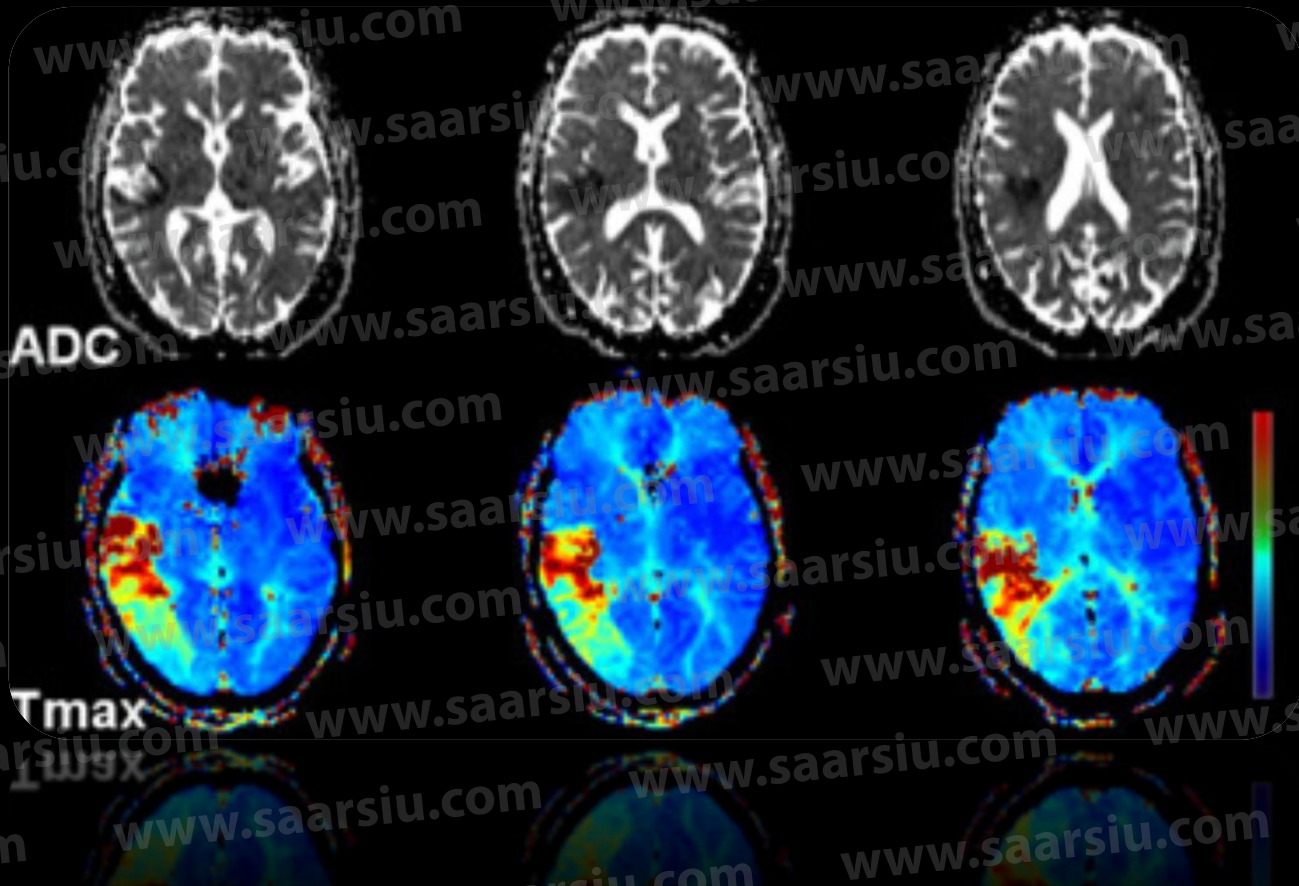
Campbell et al. Lancet Neurol. 2018;18:46-55.

MRI

Après 6 heures



MRI



Collaterality and penumbra

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

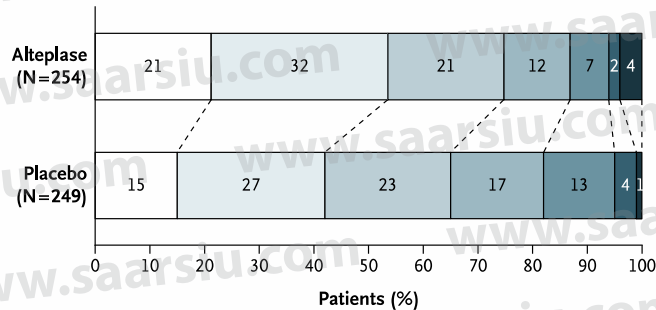
AUGUST 16, 2018

VOL. 379 NO. 7

MRI-Guided Thrombolysis for Stroke with Unknown Time of Onset

Score on the Modified Rankin Scale at 90 Days

0 1 2 3 4 5 6



The NEW ENGLAND JOURNAL of MEDICINE

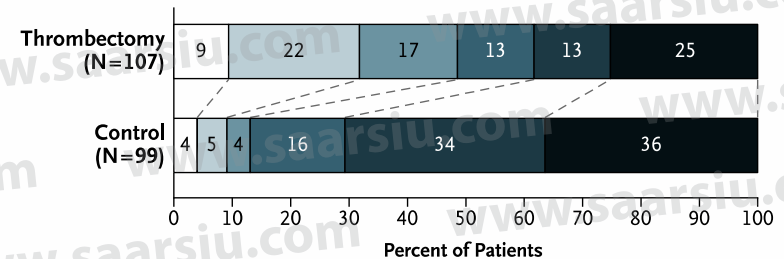
ESTABLISHED IN 1812

JANUARY 4, 2018

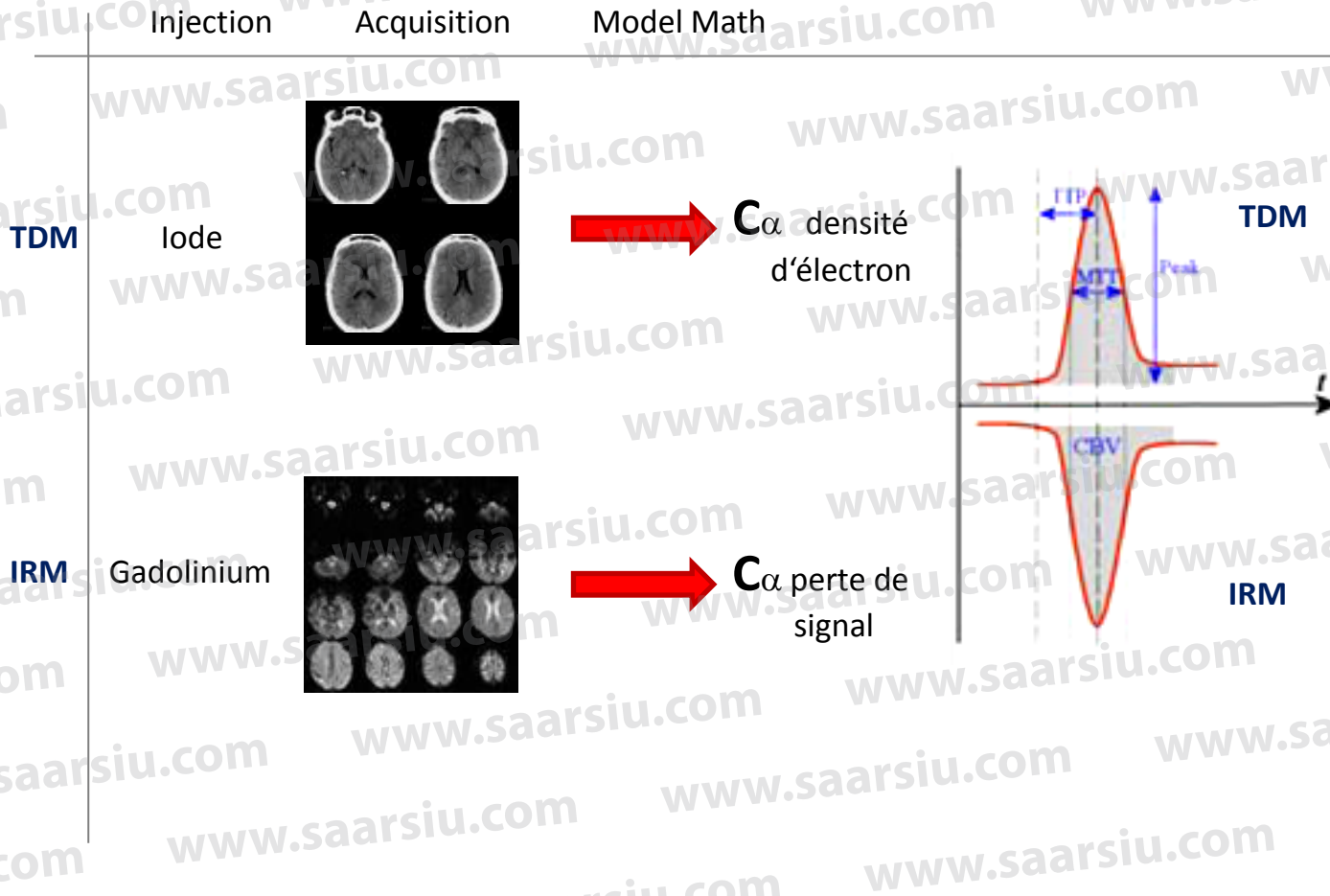
VOL. 378 NO. 1

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

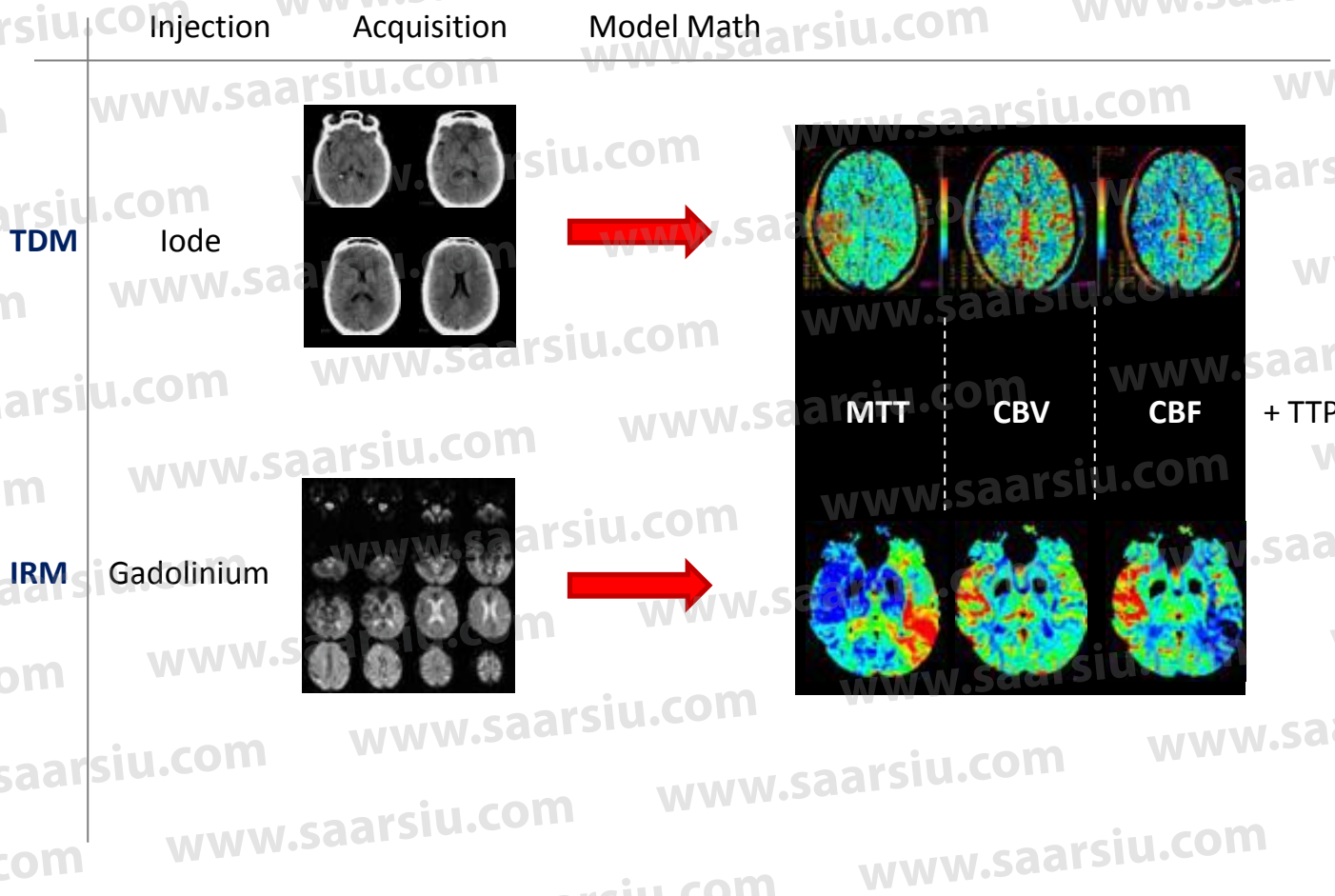
A Intention-to-Treat Population



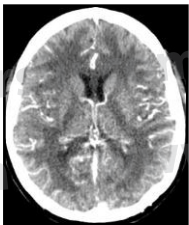
Méthodes IRM et TDM de perfusion



Méthodes IRM et TDM de perfusion



Méthodes IRM et TDM de perfusion



Mean Transit Time (MTT)

Temps moyen de traversé des capillaires

Unité: seconde

Cerebral Blood Volume (CBV)

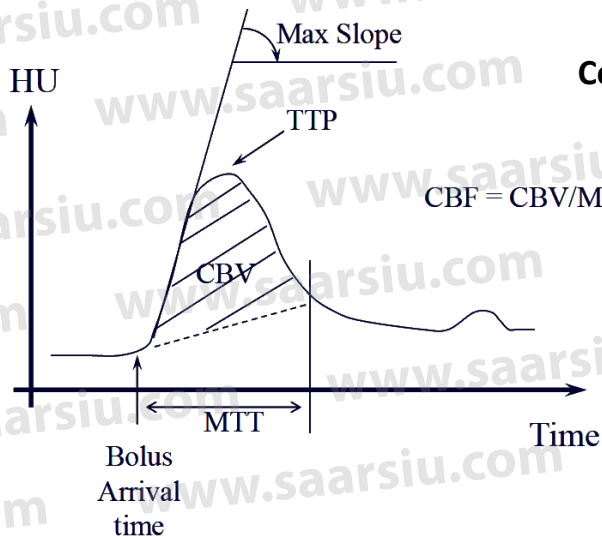
Mesure de l'autorégulation

Unité: ml/100g de tissu

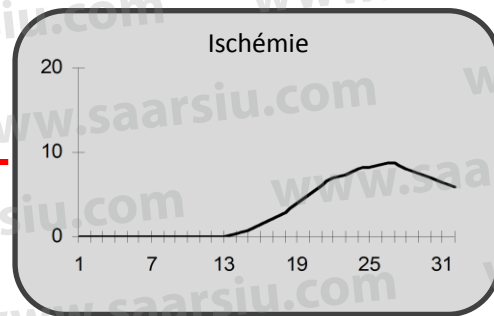
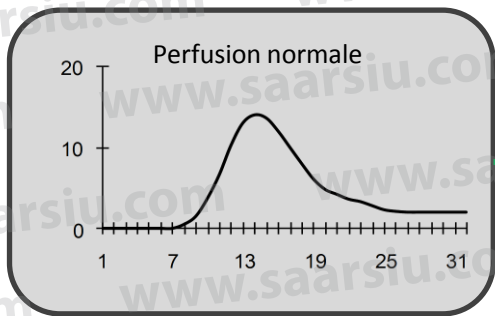
Cerebral Blood Flow (CBF)

$CBF = CBV / MTT$

Unité: ml/100g de tissu/min



Méthodes IRM et TDM de perfusion



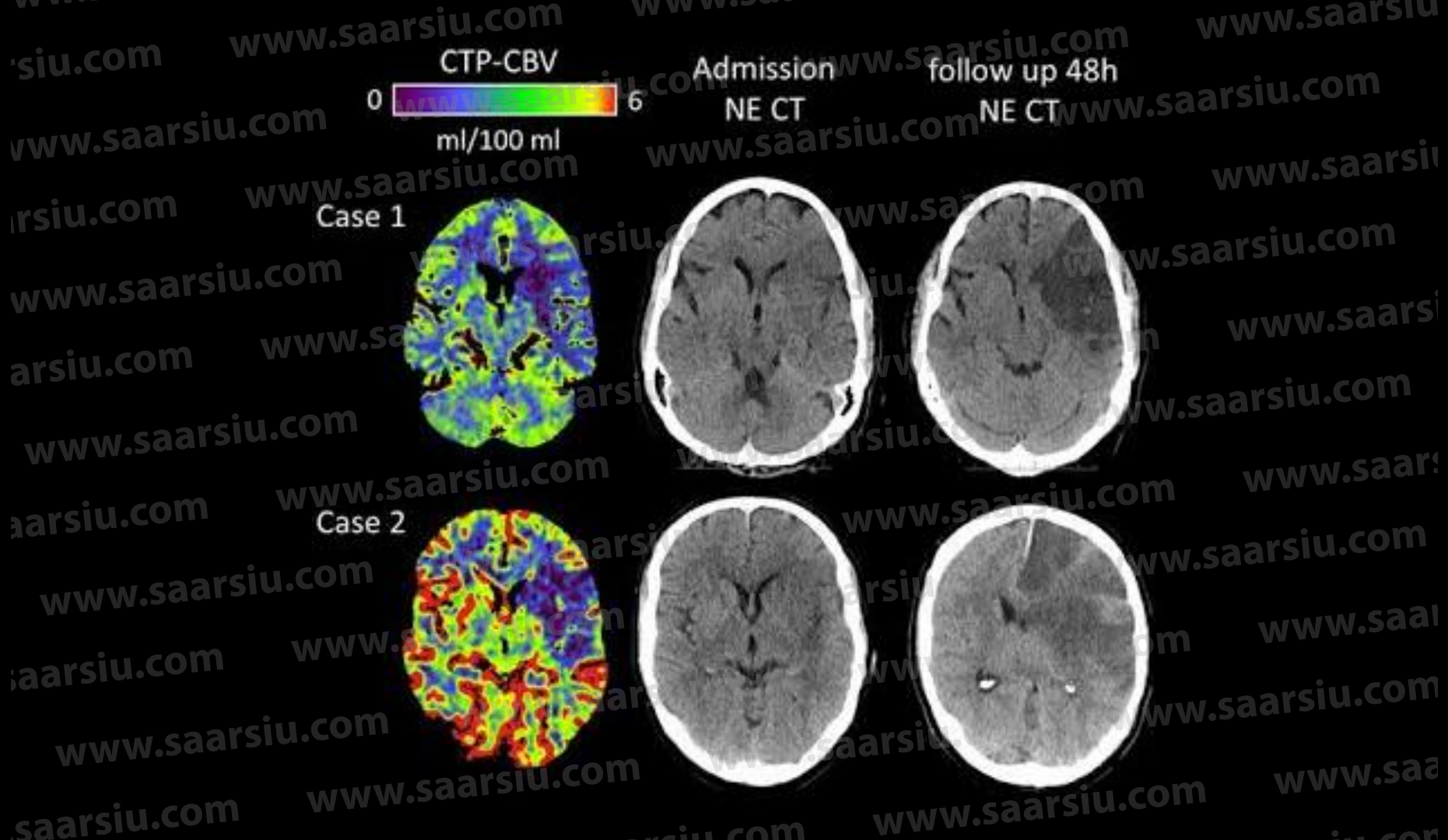
Ischémie

↑ MTT et ↑ TTP
↓ CBV
↓ CBF

$CBV = \text{Cœur ischémique (ADC)}$

$MTT = \text{Cœur} + \text{Ischémie réversible}$
(Pénombre)

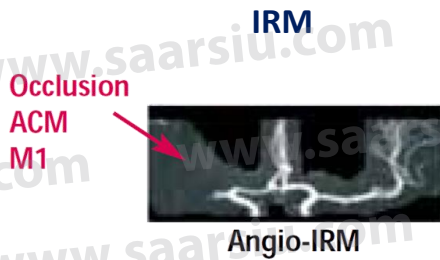
$\text{Mismatch} = \text{Pénombre} = MTT - CBV$



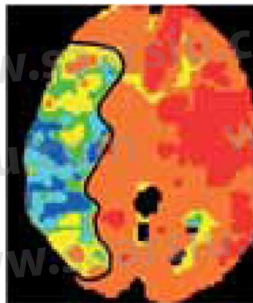
Méthodes IRM et TDM de perfusion

Ischémie	Cœur	AUC
MTT >145%	CBV <2 ml/100g	0.96
MTT >2	CBF <40%	0.85
Tmaw >6sec	CBF <30 %	0.87

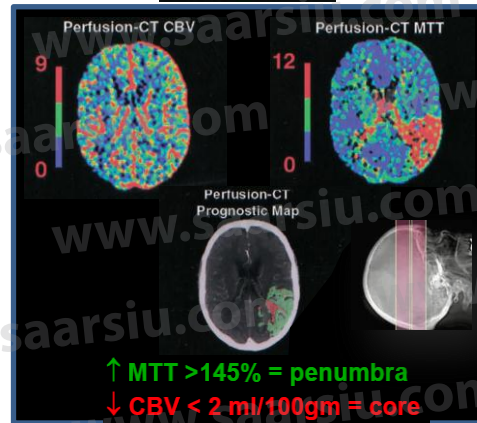
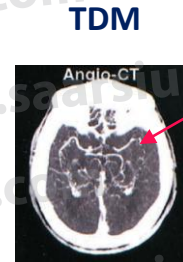
Pénombre ischémique



Diffusion
Souffrance tissulaire



Perfusion
Temps au pic



Critère de Mismatch

IRM

PWI
DWI

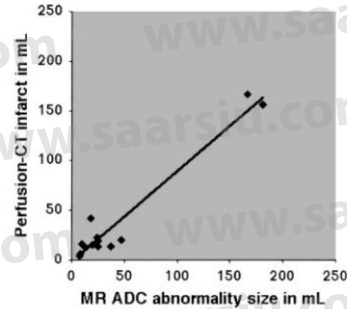
TDM

↑ MTT
↓ CBV

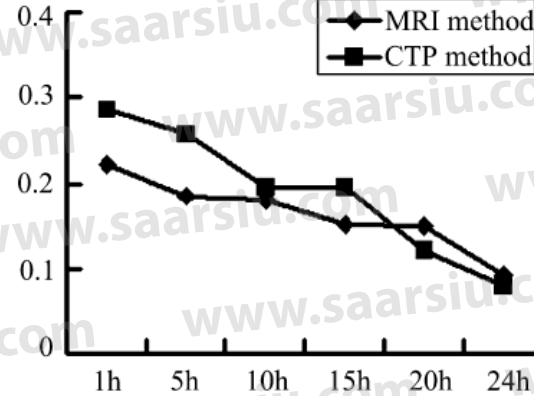
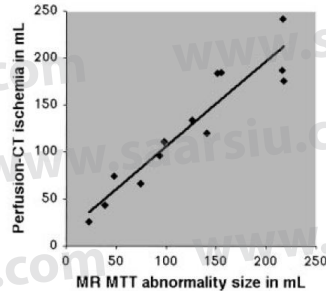
Pénombre ischémique

TDM vs IRM

Perfusion-CT infarct versus DWI abnormality



Perfusion-CT ischemia versus MR MTT abnormality



Sun et al., Acad Radiol. 2010;17:1535-1542

Wintermark et al., Stroke 2002;33:2025-31

Pénombre ischemique

Occlusion
ACM
M1



Angio-IRM

Thrombolyse i.v.

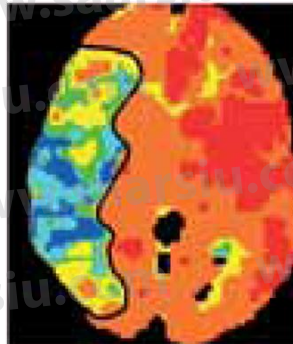


Angio-IRM



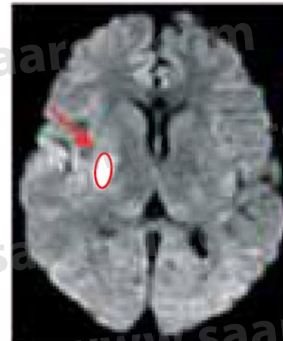
Diffusion

Souffrance tissulaire



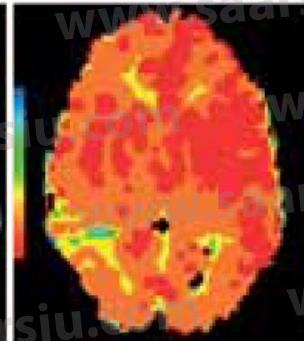
Perfusion

Temps au pic



Diffusion

Zone
à risque
ou pénombre ?

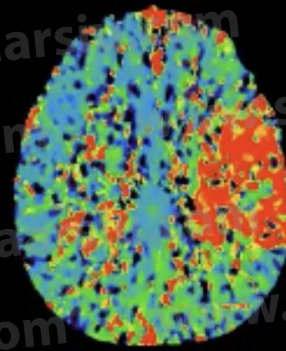
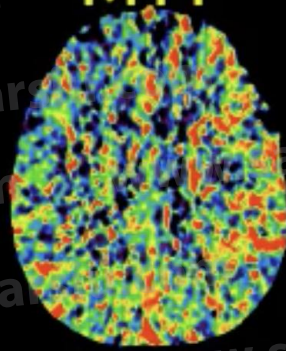
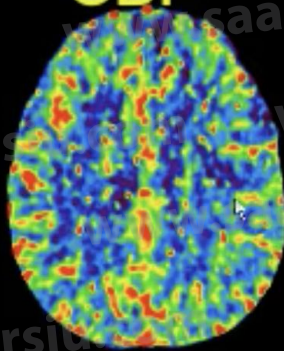
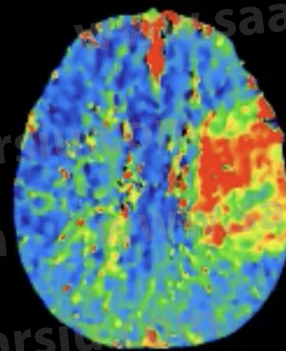
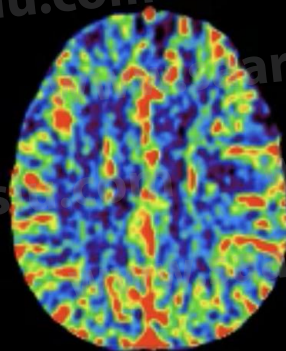


Perfusion

Anomalie
de perfusion
corrigée

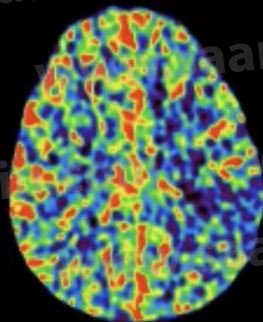
Désaccord
de perfusion-
diffusion



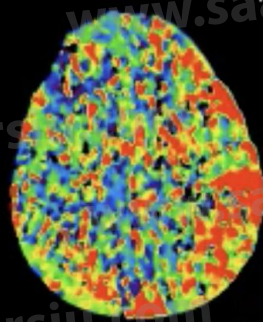




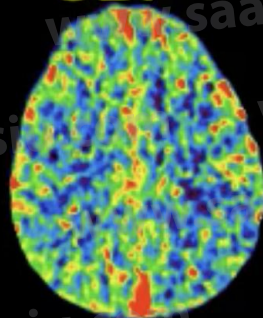
CBV



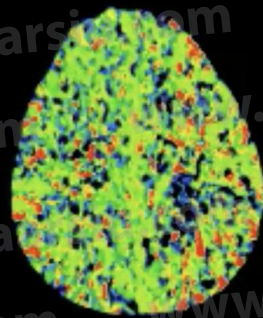
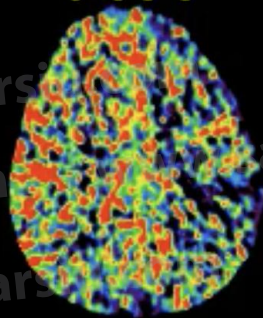
TTP



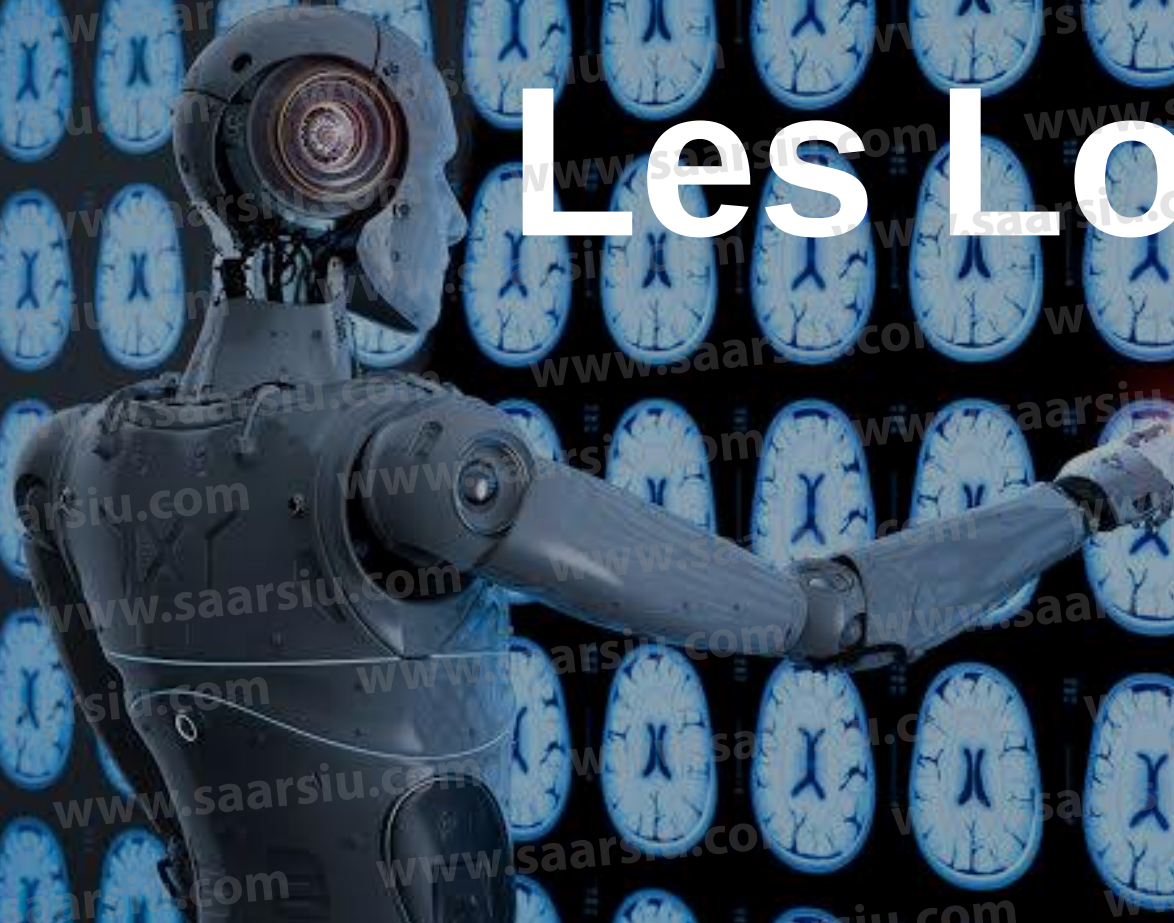
CBF



MTT



Les Logiciels



RAPID
iSchemaView

Brainomix[®]

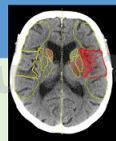
iz.ai



Non-contrast
CT viewer.

*Automated ASPECTS
identification.*

Non-dynamic PDF.



Non-contrast
CT viewer.

*Automated ASPECTS &
hypodense volume
measurement.*

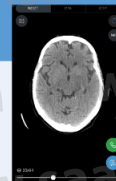
Dynamic image viewing.

Non-contrast CT

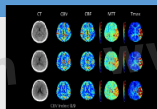
Non-contrast
CT viewer.

No automated ASPECTS,
rather, simplified CTA and CTP
direct LVO characterization
workflow.

Dynamic image viewing.

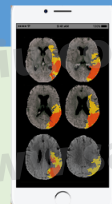


**CT Perfusion
Scan**



RAPID perfusion maps
automatically emailed
or pushed to mobile
device

Non-dynamic PDF and
Dynamic images.



Olea Sphere perfusion
maps automatically
emailed or pushed to
mobile device.

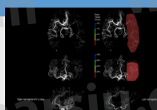
*Dynamic image
viewing.*

Viz perfusion maps
automatically pushed
directly to mobile
device.

*Dynamic image
viewing with full PACS
interface and motion
correction.*

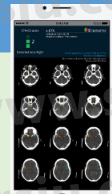


**CT Angiography
Scan**



RAPID
automatically
quantifies collateral
blood vessel
density.

*Indirect LVO
detection.*



e-CTA automatically
quantifies both
collateral blood flow
density and the LVO
directly.

*Direct LVO detection,
using AI.*

Automated direct
detection of LVO.

*Direct LVO
detection powered
by AI.*



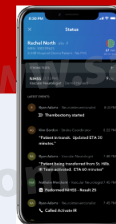
**Immediate AI-mediated
Activation of Emergency
Stroke Treatment Systems**

None, automatic
indication of "yes or
no" thrombectomy
candidacy if imaging
meets thrombectomy
criteria in prior trials.

None, user interprets
the imaging in
context of
thrombectomy
criteria.

Yes, AI independent
thrombectomy activation.

Secure, HIPAA-compliant
text messaging and
calling platform for the
coordination care.



[Scan List](#) [Upload Scans](#) [DICOM Log](#) [Admin](#) [Billing](#)

[Help](#) [admin@brainomix.com](#)

PATIENT DETAILS

Patient ID: EX004
Name: Example 4
DOB: -
Gender: Unknown

SCAN DETAILS

Study description: -
Series description: Example 5
Scanned: 2014-11-29 20:07:38
Processed: 2017-03-13 10:13:58 GMT
Workflow: Study
Slice thickness (as processed): 4.9 mm

ACUTE ISCHEMIC REGIONS

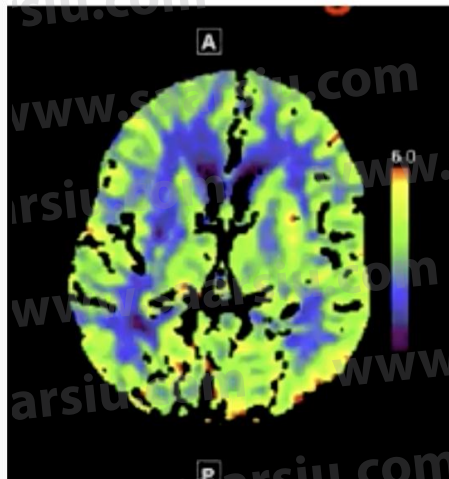
Left side: M1 · M2 · M3 · M4 · M5 · M6 ·
Lentiform · Insula

[CHANGE SIDE](#)

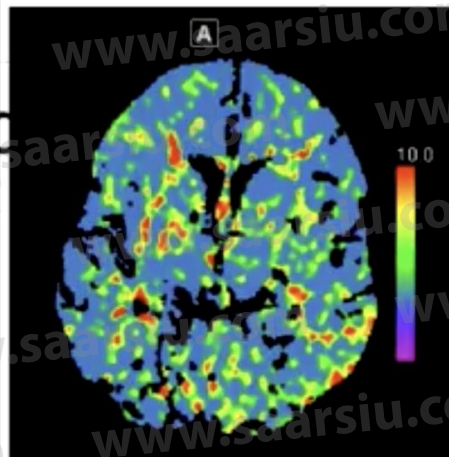
UNANNOTATED SCAN

RESULTS

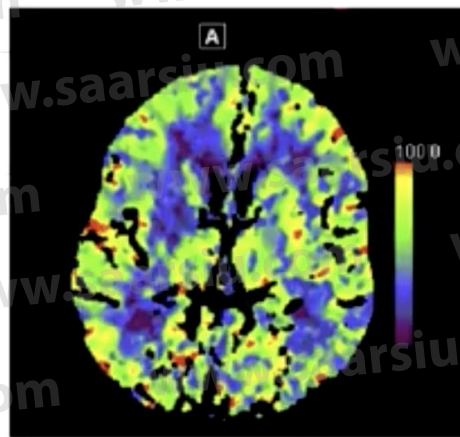




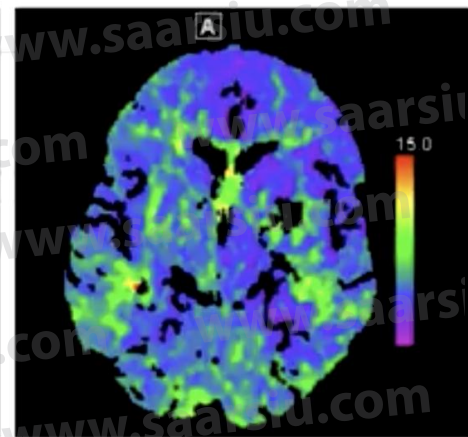
CBV



MTT



CBF



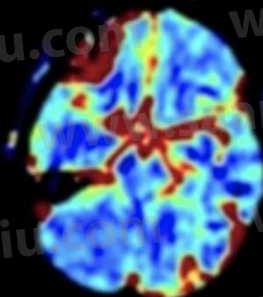
TTD



MRI DWI

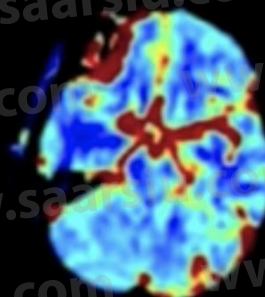
CBV

CBV [ml/100g]



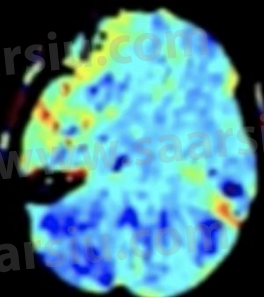
CBF

CBF [ml/100g/min]



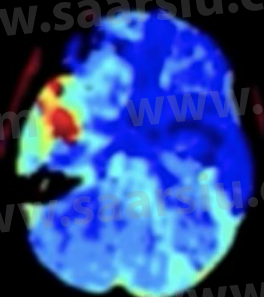
MTT

MTT [s]



Tmax

Tmax [s]



CBV [ml/100g]

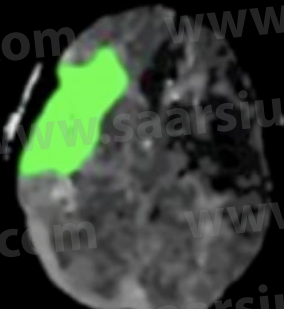
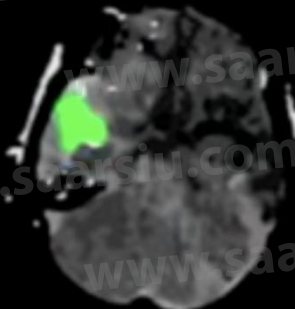
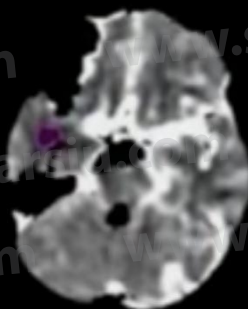
CBF [ml/100g/min]

MTT [s]

Tmax [s]

CBF-based Core

Tmax



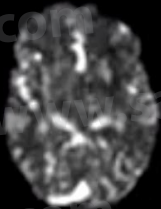
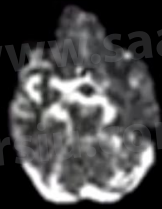
Infarct Core: 1 ml

Perfusion (Tmax > 6s) lesion: 27 ml

for research purposes only

www.saa

RAPID

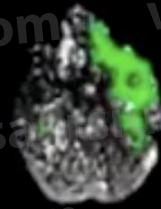


CBF < 30% volume: 0 ml



Mismatch volume: 45 ml

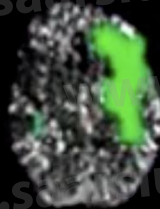
Mismatch ratio: infinite



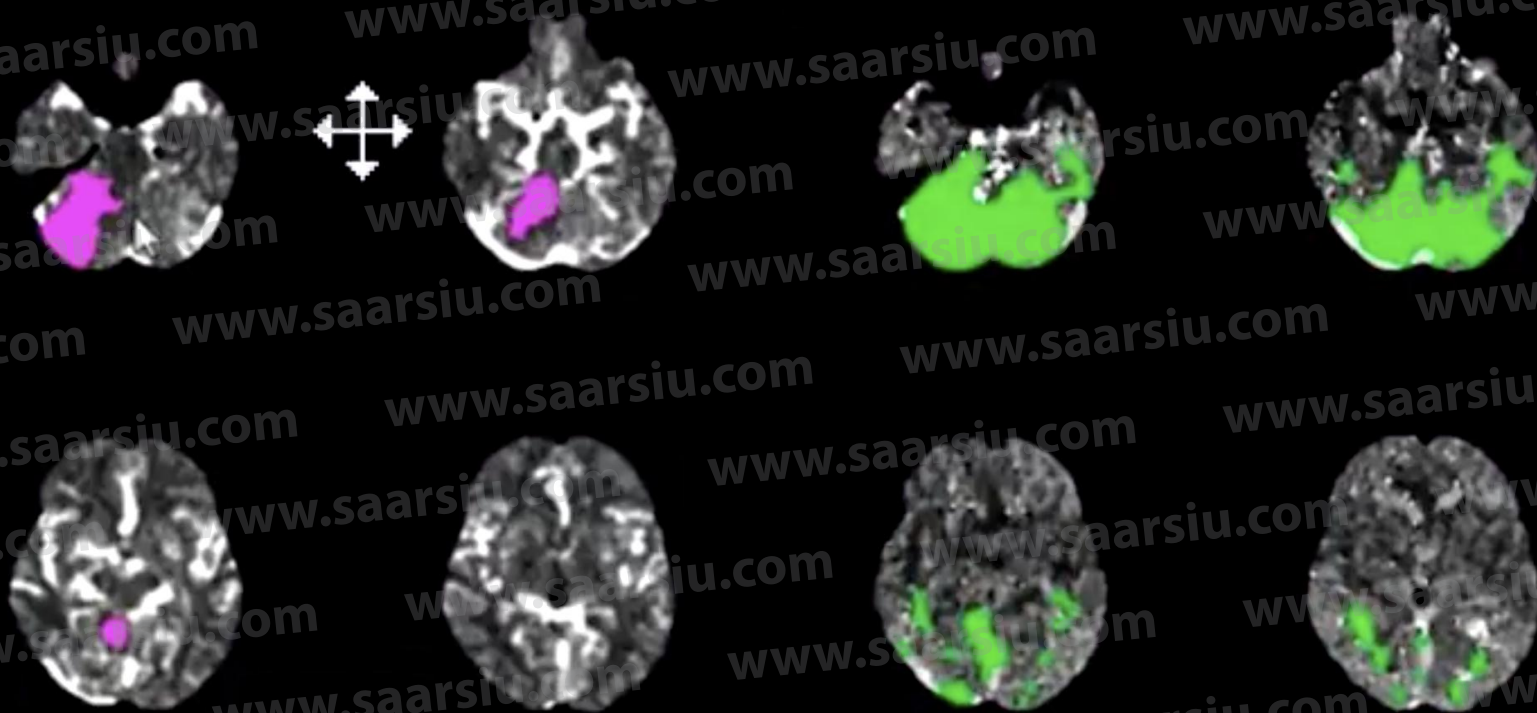
Tmax > 6.0s volume: 45 ml

$$45 - 0 = 45$$

$$45 / 0 = \text{infinity}$$

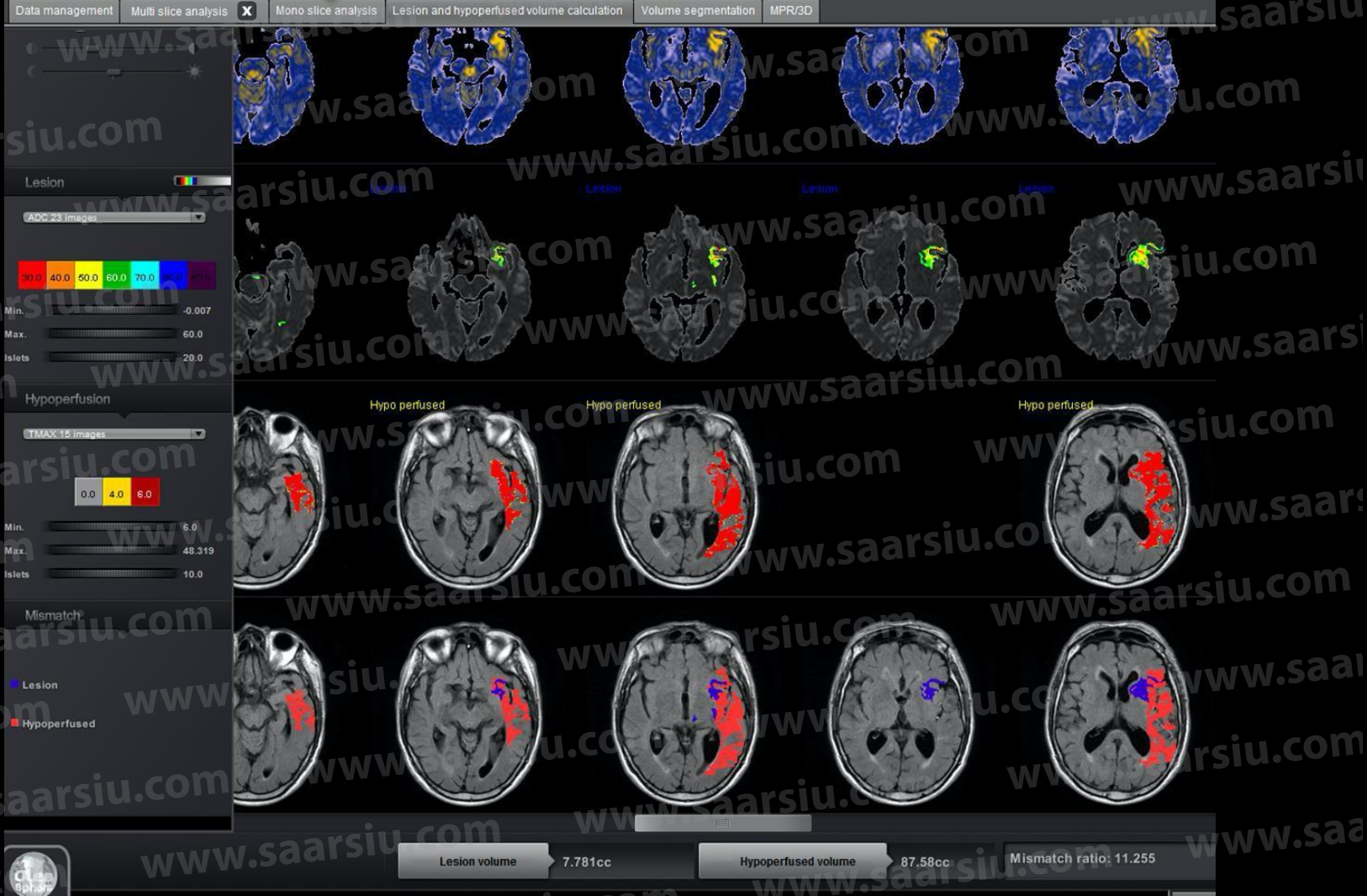


RAPID



CBF, CTD volume: 16 ml
Mismatch volume: 60 ml
Mismatch ratio: 4.8
Time to peak volume: 76 ml

OLEA



EN CONCLUSION

SCANNER MULTIMODAL

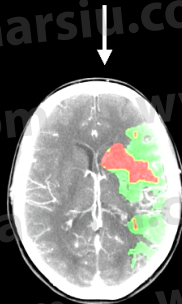
Infarctus vs
hématome

scanner



Pénombre
ischémique

core: CBF < 30%
pénombre: $T_{max} > 6s$



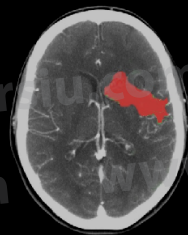
Niveau
d'occlusion

angioscanner



Risque
hémorragique

scanner de
perfusion



Campbell et al. Stroke. 2011;42:3435-40.
Lin et al. Stroke. 2014;45:1727-32.
Campbell et al. N Engl J Med. 2015;372:1009-18.

EN CONCLUSION

IRM MULTIMODALE

Infarctus vs
hématome

Pénombre
ischémique

Niveau
d'occlusion

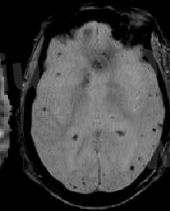
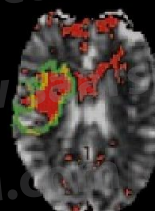
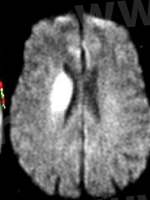
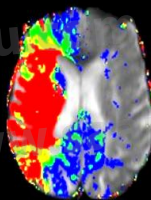
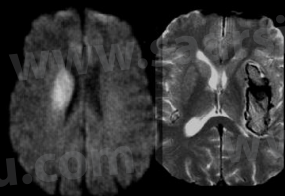
Risque
hémorragique

diffusion
T2*

core: DWI
pénombre: $T_{max} > 6s$

ARM

diffusion, T2*,
perfusion



ATTENTION



ATTENTION



ATTENTION

