

# EVALUATION du DEGRÉ de STÉNOSE CAROTIDE

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# Déclaration de CI

- Propriété intellectuelle logiciel M'Ath
- Revenus liés à la R et D logiciels de quantification de l'athérosclérose

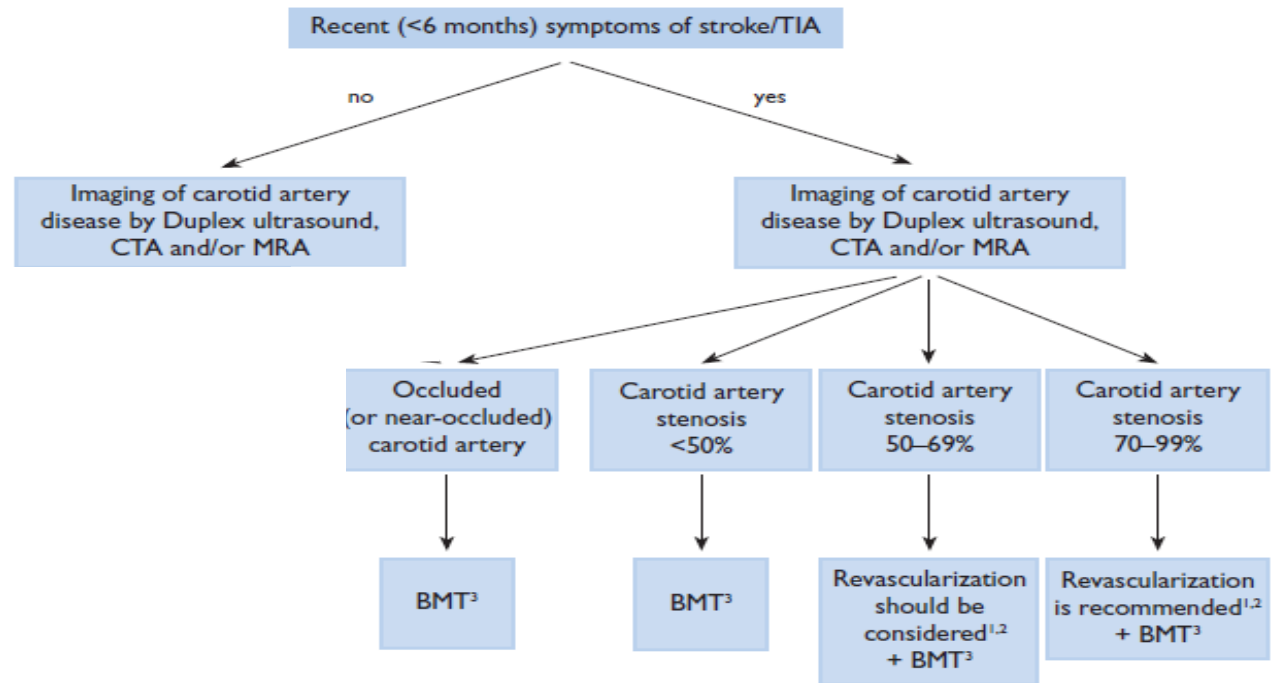
# Algorithm for the management of extracranial CAD

In patients with symptomatic 70-99% stenosis of the internal carotid artery, CEA is recommended for the prevention of recurrent stroke.

I	A
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In patients with symptomatic 50-69% stenosis of the internal carotid artery, CEA should be considered for recurrent stroke prevention, depending on patient-specific factors.

IIa	A
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<sup>1</sup>: The management of symptomatic carotid artery disease should be decided as soon as possible (<14 days after onset of symptoms)

<sup>2</sup>: After multidisciplinary discussion including neurologists

<sup>3</sup>: BMT = best medical therapy

# Explorations ultrasonores cervicales

- Doppler continu
  - Evaluation des perturbations hémodynamiques des axes carotides extra-crâniens
- Doppler transcrânien
  - Evaluation des perturbations hémodynamiques des axes vaisseaux intra-crâniens
- Echotomographie
  - Information morphologique sur la paroi et ses lésions

# Evaluation du Degré de sténose.



Bifurcation normale



Plaque bulbe carotide



Sténose ACI régulière



Sténose ACI anfractueuse

## Évaluation multi-paramétrique:

### *Hémodynamique*

- *Vitesses systoliques et diastoliques.*
- *Rapports des vitesses.*
- *Index de résistances.*
- *RHIC*




### *Morphologique*

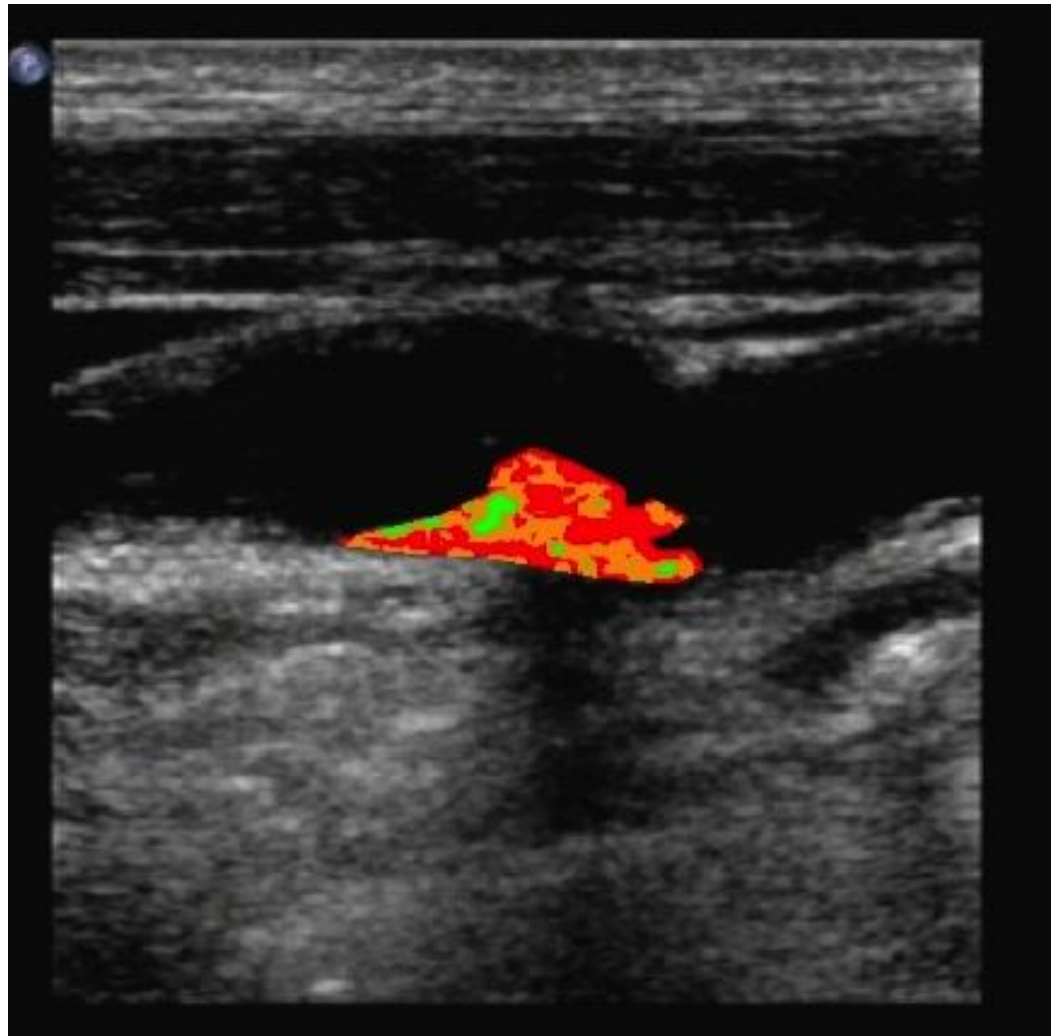
- *Planimétrie en diamètre.*
- *Planimétrie en surface.*
- *Structure et morphologie.*



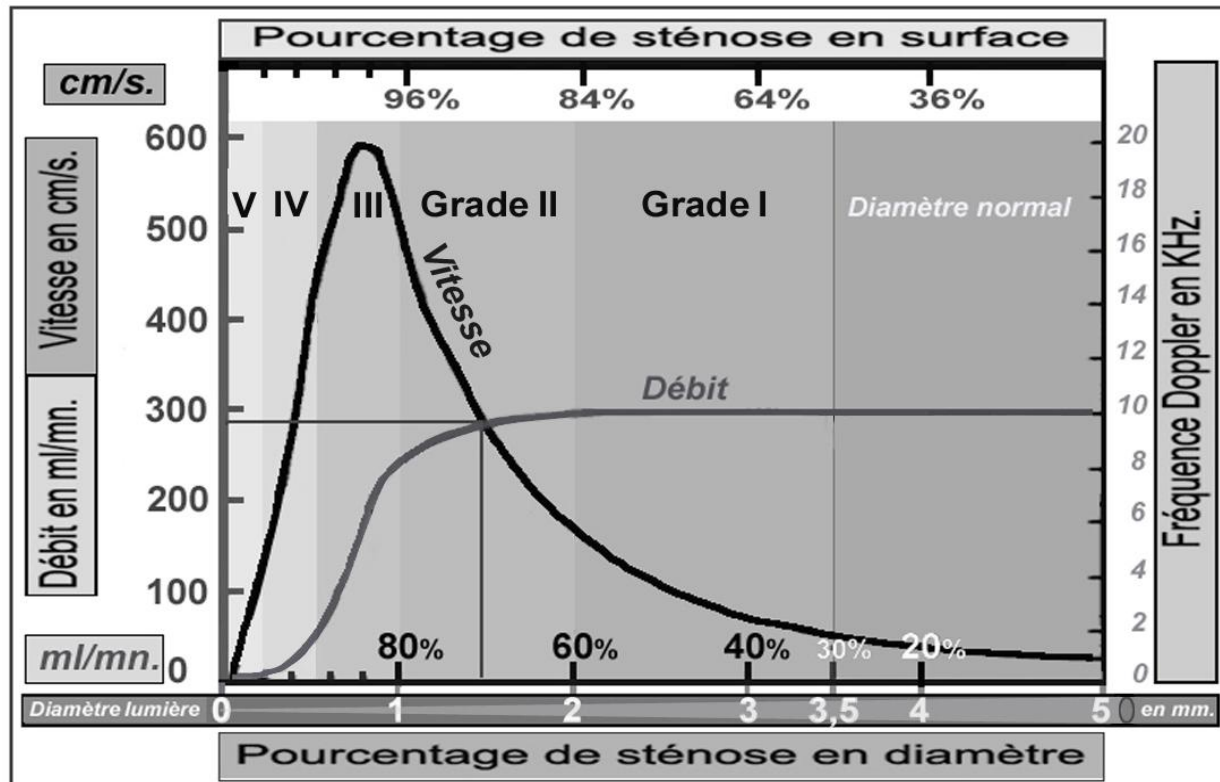
Occlusion ACI  
Thrombose

**Pertinence : Convergence des paramètres**

-  High Density  
( Calcium)
-  Mean density  
( Fibrotic)
-  Low Density  
(Thrombus or Haemorrhage)



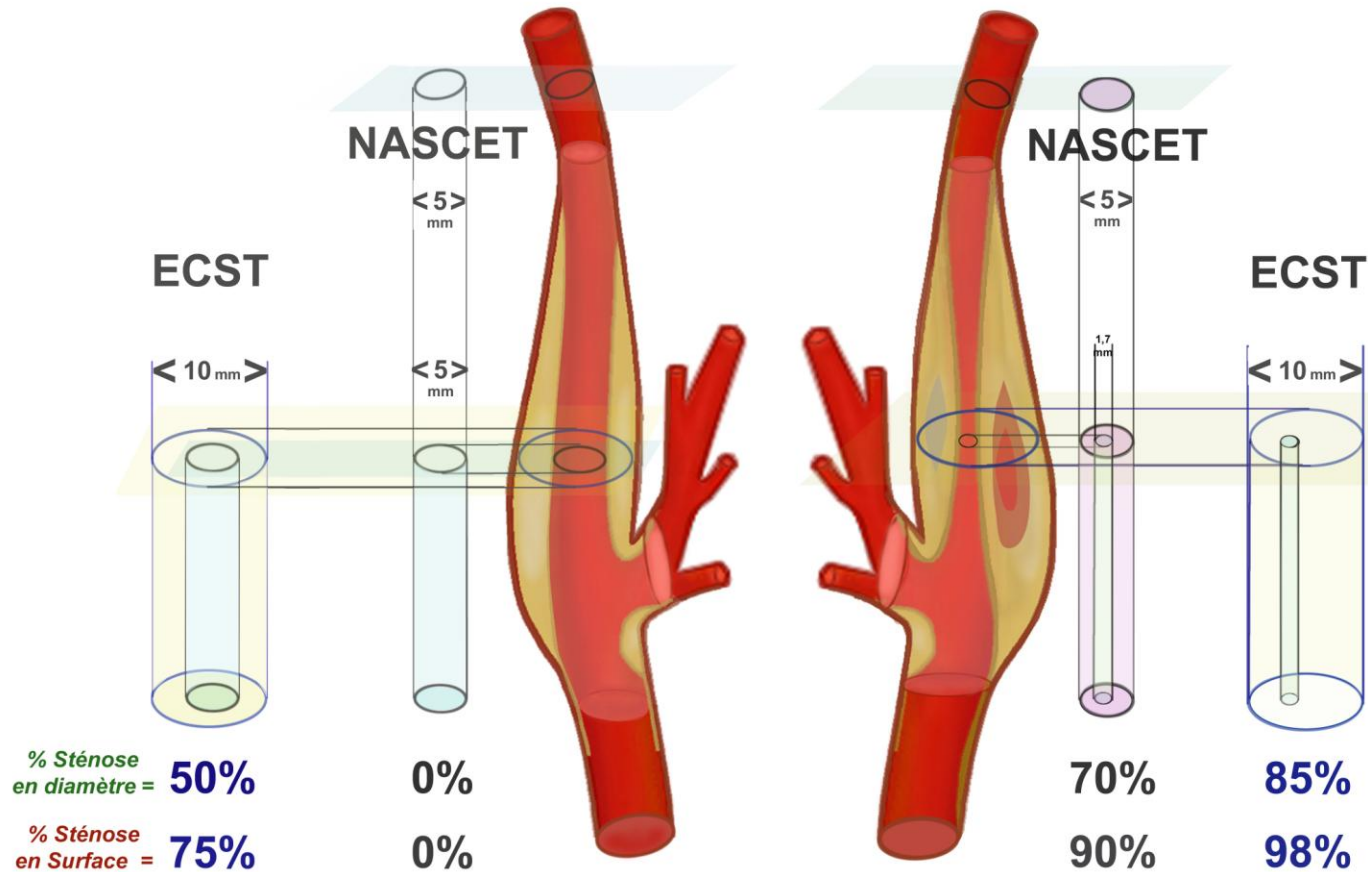
# Degré de sténose : variables hémodynamiques.



Doppler continu: Relation degré de sténose / vitesse / débit.

Spencer MD. JVS.1979.

# Degré de sténose : Définitions.

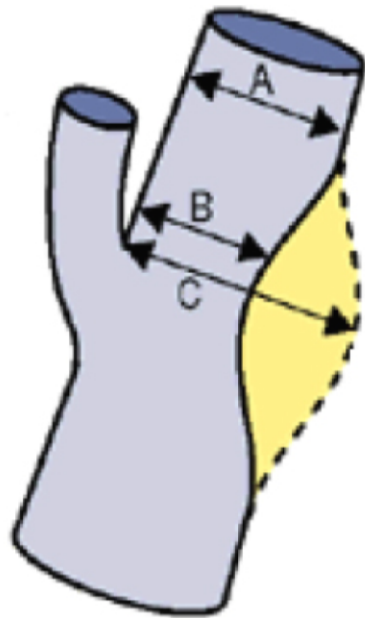


**Critères de quantification: Références & Méthodes.**



# Degré de sténose. *Parler le même langage.*

HAS 2008

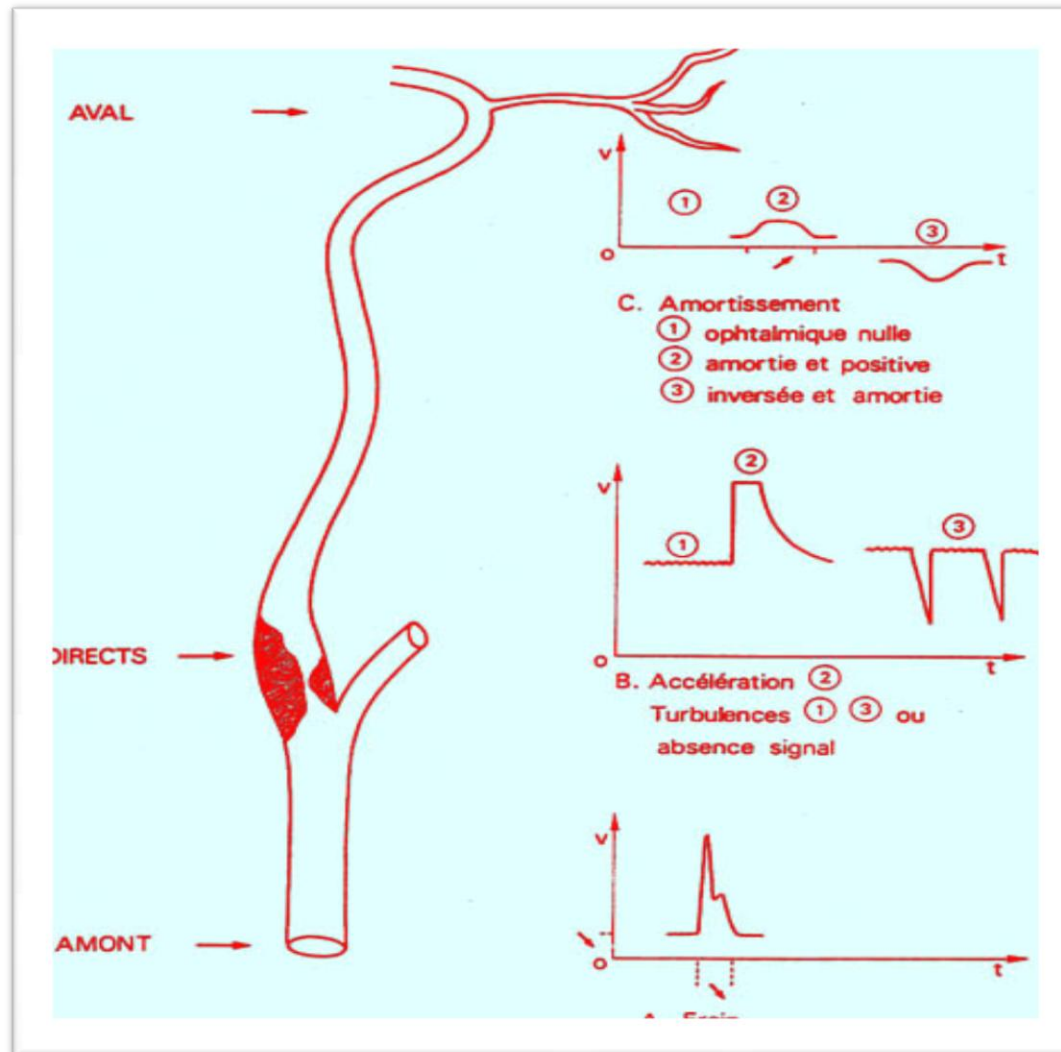


NASCET = $(1-B/A) \times 100 \%$	ECST = $(1-B/C) \times 100 \%$
30	65
40	70
50	75
60	80
70	85
80	91
90	97

Équivalences entre NASCET et ECST pour le degré de sténose de la carotide interne

**Comparaison des % de sténose en diamètre**

# Sémeiologie analytique et topographique

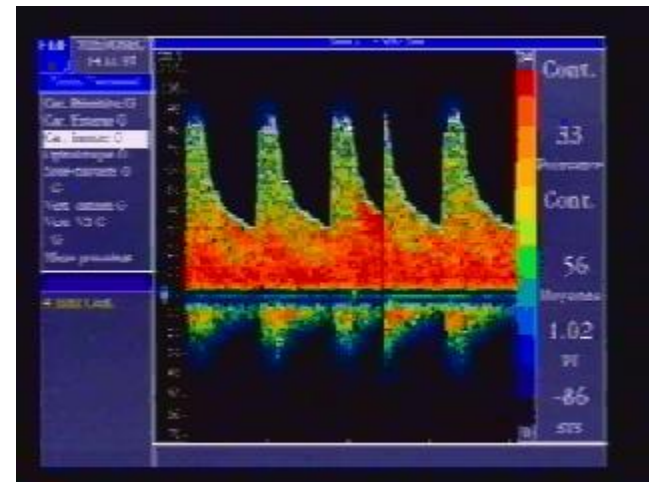
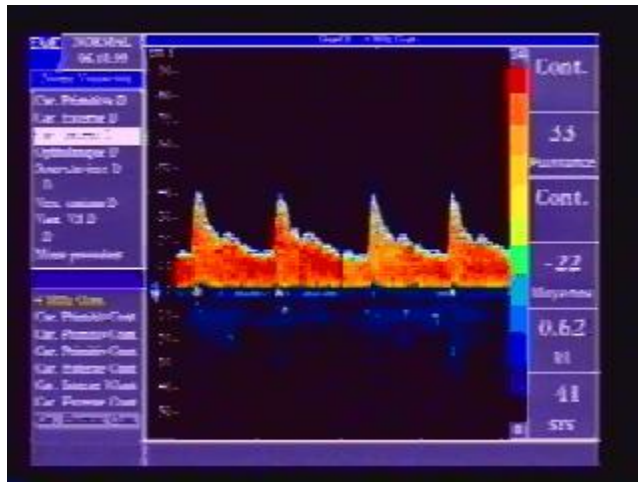


# Sténose Carotide interne

## Signes directs

Seuil de détection: sténose > 60% ( 30% NASCET)

- Accélération localisée de la vitesse circulatoire: augmentation de la V max systolique+++  
Vitesse proportionnelle au degré de sténose
- Appréciation de manière comparative



# Sténose Carotide interne

## Signe d ' aval: amortissement

Sténose entre 70 et 90%

- Diminution de la vitesse circulatoire et baisse de pression de perfusion
- Variations de l ' ophtalmique ( amplitude et sens)
  - amortie
  - nulle
  - inversée (sténose >85%)

# Sténose Carotide interne

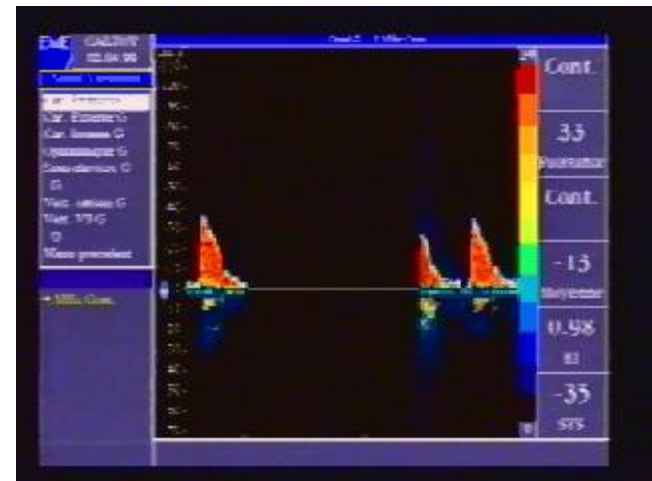
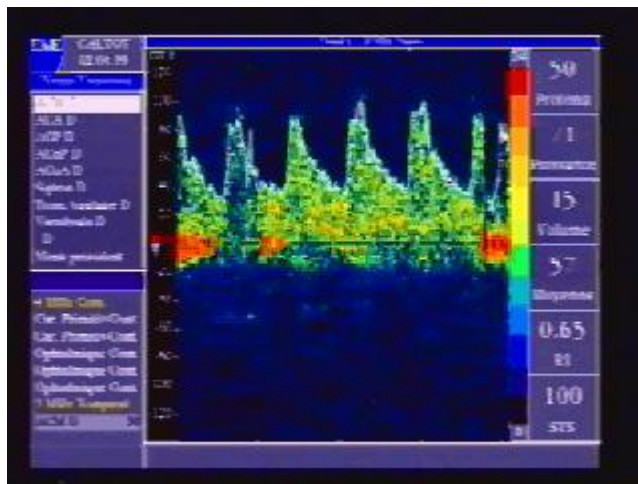
## Signe d'amont: signe de frein

Sténose > 90%

- Augmentation de l'index de résistance RI

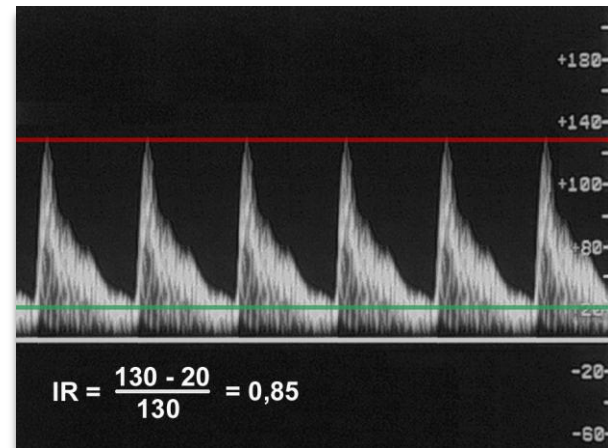
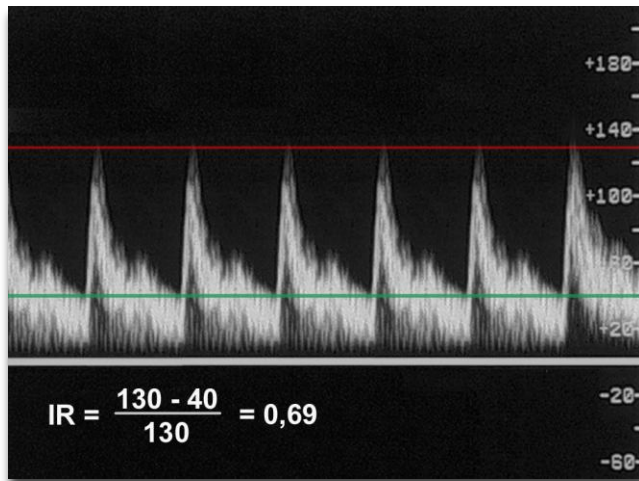
$RI = VS - VD / VS = 0,55 \text{ à } 0,75$  (normal)

$RI > 0,8$  et normal de l'autre côté: frein  
hémodynamique sur la carotide interne



# Intérêt de l'IR

- $IR = (V_{max} - V_{min}) / V_{max}$
- IR = f ( perfusion aval)
- IR >>>> => SS ou occlusion



## Diagnostic différentiel

### Accélération isolée origine Carotide interne

- Sténose serrée ou occlusion controlatérale (augmentation compensatoire)
- Boucle
- Petites artères (femme jeune)
- Hyperthyroïdie, hyperthermie
- Ménopause
- Fistule carotido-caverneuse
- Dysplasie fibro-musculaire

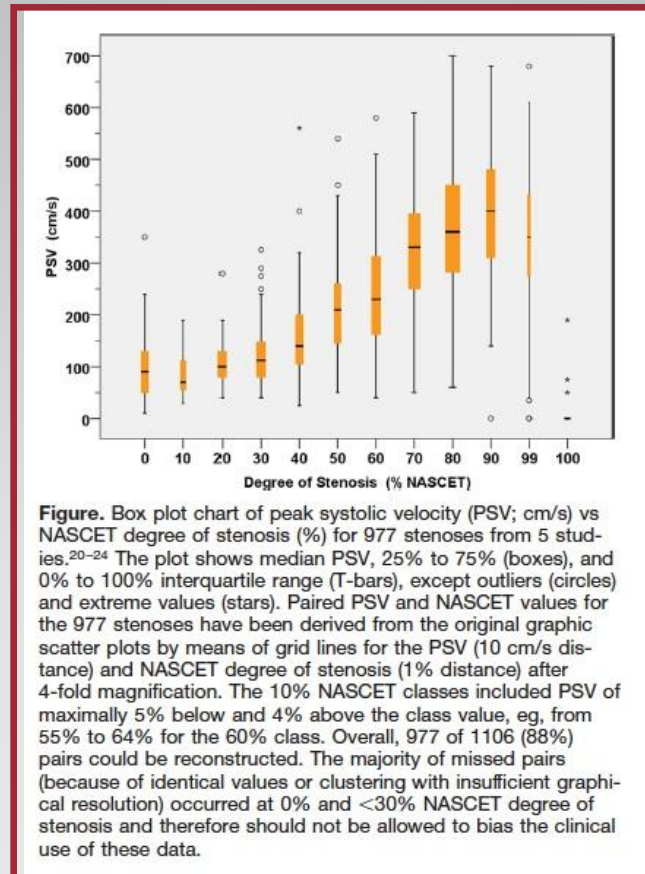
# Consensus

## **Grading Carotid Stenosis Using Ultrasonic Methods**

Gerhard-Michael von Reutern, MD, PhD; Michael-Wolfgang Goertler, MD, PhD; Natan M. Bornstein, MD; Massimo Del Sette, MD; David H. Evans, PhD, DSc; Andreas Hetzel, MD, PhD; Manfred Kaps, MD, PhD; Fabienne Perren, MD, PhD; Alexander Razumovky, PhD; Michael von Reutern, MD, PhD; Toshiyuki Shiogai, MD, PhD; Ekaterina Titianova, MD, PhD, DSc; Pavel Traubner, MD, PhD; Narayanaswamy Venketasubramanian, MD; Lawrence K.S. Wong, MD; Masahiro Yasaka, MD, PhD; on behalf of the Neurosonology Research Group of the World Federation of Neurology



# PSV variability : NASCET : PSV



# The best according to the level

**LOW DEGREE : 0-50%**

**B-Mode**

**MODERATE DEGREE: 50-70%**

**B-Mode+PSV**

**HIGH DEGREE: > 70%**

**B-Mode+PSV+CFlow**

## *Low-Degree Stenosis 0% to 40% (NASCET)*

This is the domain of B-mode imaging in the longitudinal and cross-sectional planes. Velocity measurement rules out a more severe stenosis sometimes suggested by an inappropriate sectional plane. It is recommended to measure, in addition to the reduction of diameter in percent, the thickness and length of the plaque as well as the residual lumen.

## *Moderate Stenosis 50% to 60% (NASCET)*

This is a class of stenosis in which local increase of velocity, color flow, and B-mode imaging can be combined for grading. PSV is, in general, <230 cm/s. Collateral flow is not present.

## *Hemodynamically Relevant Stenosis $\geq 70\%$ (NASCET)*

This is the domain of combined hemodynamic criteria, such as increased PSV or end-diastolic velocity or the "carotid ratio" (ratio of internal to common carotid PSV), but there is a considerable overlap with moderate stenoses. Collateral flow is demonstrated by examining the ophthalmic artery branches (Doppler ophthalmic test), the anterior cerebral artery, proving cross-flow or the P1 segment of the posterior cerebral artery, indicating collateral flow through the posterior communicating artery. In case of established collateral flow, hemodynamic relevance of the stenosis is proven and it can be classified as high-degree ( $\geq 70\%$  NASCET irrespective of the intrastenotic PSV).<sup>29</sup> Poststenotic flow velocity in the segment distal to the disturbed flow field is another criterion. In case of a clear reduction of signal pulsatility and poststenotic velocity (eg, <30 cm/s PSV), the diameter reduction is  $\approx 90\%$  and the residual lumen is <1 mm irrespective of the PSV in the stenosis. The degree of reduction of poststenotic flow velocity (as a result of reduced flow volume) helps to differentiate between 70% (severe) and 80% to 90% (very severe) stenosis, a differentiation not

# Grading Carotid Stenosis ( 2012)

**Table. Combined Criteria for Grading Internal Carotid Stenosis**

Degree of Stenosis as Defined by NASCET (%)	Grading of Internal Carotid Stenosis						
	10-40	50	60	70	80	90	Occlusion
<b>Main criteria</b>							
1. B-mode image, diameter	Applicable	Possibly applicable					Imaging of occluded artery
2. Color Doppler image	Plaque delineation	Flow	Flow	Flow	Flow	Flow	Absence of flow
3. PSV threshold (cm/s)		125		230		NA	NA
4a. PSV average (cm/s)	≤160	210	240	330	370	Variable	NA
4b. PSV poststenotic (cm/s)				≥50	<50	<30	NA
5. Collateral flow (periorbital arteries or circle of Willis)				Possible	Present	Present	Present
<b>Additional criteria</b>							
6. Prestenotic flow (diastole) (CCA)				Possibly reduced	Reduced	Reduced	Reduced
7. Poststenotic flow disturbances (severity and length)		Moderate	Pronounced	Pronounced	Pronounced	Variable	NA
8. End-diastolic flow velocity in the stenosis (cm/s)			<100	>100		Variable	NA
9. Carotid ratio ICA/CCA	<2	≥2	≥2	>4	>4	Variable	NA

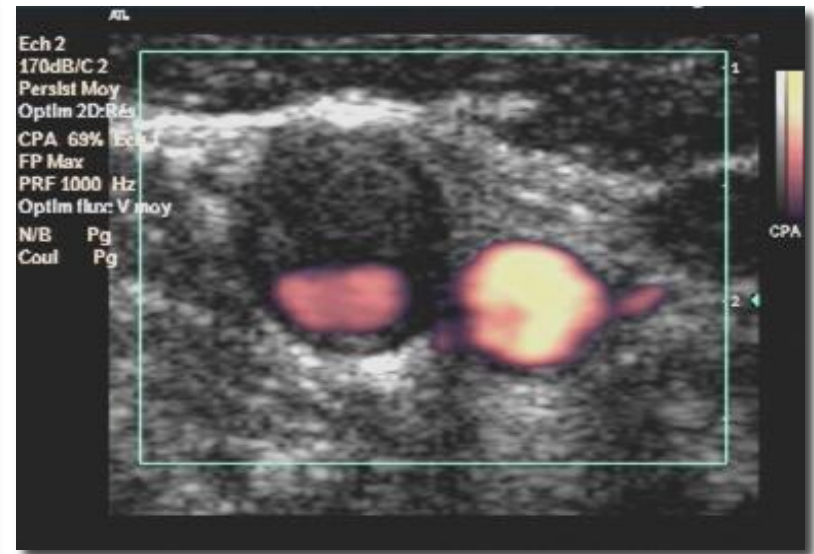
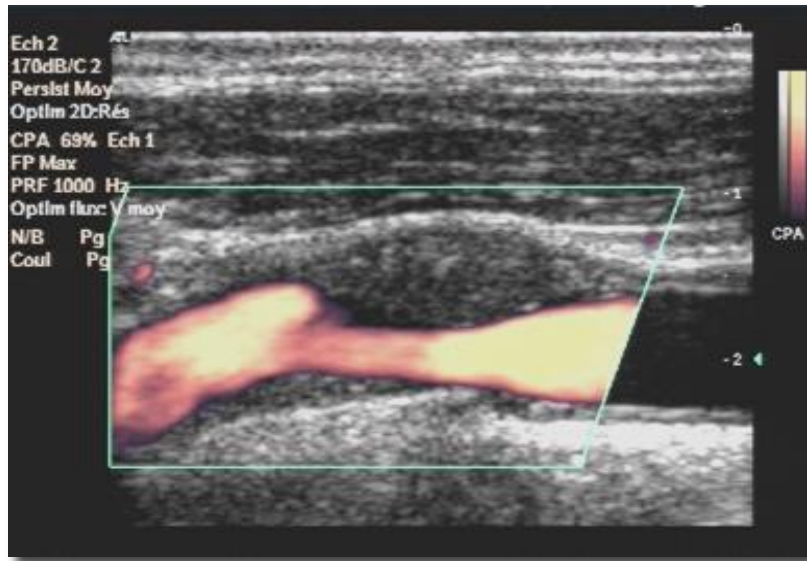
These criteria do not apply for external carotid stenosis. Note the hierarchical order of main and additional criteria and the change of reliability of each criterion for different degrees of stenosis. Examples how to use this Table are given in the text under "Main and Additional Criteria" and "Advantages of a Multiparametric Approach." For definition of classes of stenosis, see Figure legend.

Criterion 1: Visualization of the ICA by B-mode imaging is needed to prove no flow.

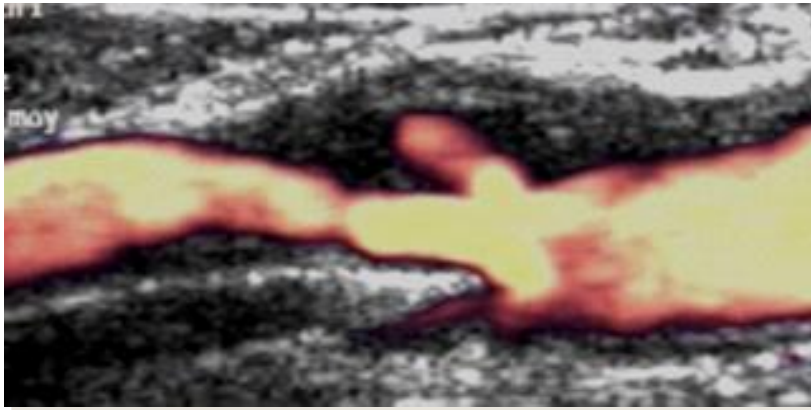
Criterion 4a: Values taken from Figure.

Criterion 4b: Poststenotic indicates measured distal to turbulences. In case of a short neck or a bifurcation in high position, respectively, these criteria are difficult to assess with a conventional duplex technique. Then, a lateral scan head position behind the jaw angle or a scan head with a lower frequency, as for abdominal examinations, may give access to the more distal lying segments of the ICA. Another possibility is the examination of the distal ICA with 2-MHz pulsed Doppler sonography.

# Degré de Sténose.



# PLAQUE.



## Echostructure :

- *Hypoéchogène.*
- *Echogène.*
- *Hyperéchogène.*

## Hétérogénéité :

- *Homogène.*
- *Hétérogène.*

## Surface:

- *Régulière.*
- *Irrégulière.*

Geroulakos. *Eur J Vasc Surg.* 1996.

*Classification opérateur dépendante.  
Reproductibilité intra et inter observateur médiocre.*

## Degré de sténose : Critères convergents.

**Conférence de Consensus de l'ACR: Critères morphologiques & écho-doppler de quantification des sténoses de l'ACI.**

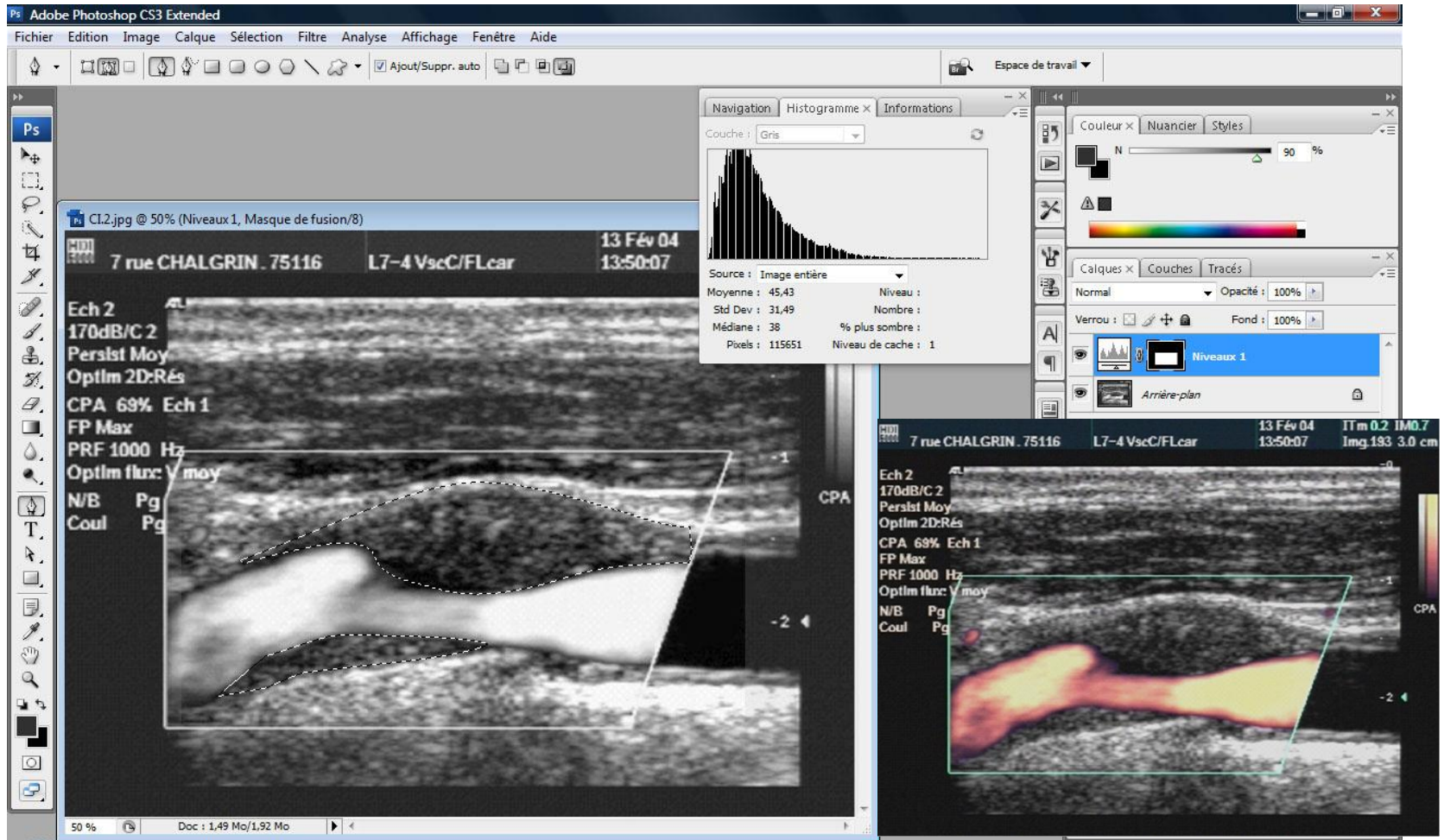
Degré sténose (%)*	Critères dominants		Critères additionnels	
	PSV (cm.s-1)	Plaque (%)*	ACI/ACC PSV	VTD ACI (cm.s-1)
Sténose = 0	< 125	Non	< 2	< 40
< 50	< 125	< 50	< 2	< 40
50 - 69	125 - 230	≥ 50	2 - 4	40 - 100
≥ 70	≥ 230	≥ 50	≥ 4	≥ 100
Préocclusion	Haut, Bas, Indélectable	Visible	Variable	Variable
Occlusion totale	Indélectable	Visible Lumière indélectable		

**\* Critères écho-Doppler validés pour un % de sténose en diamètre NASCET.**

Grant EG et al. *Radiology* 2004. Braun RM. *Ultrasound* 2008.

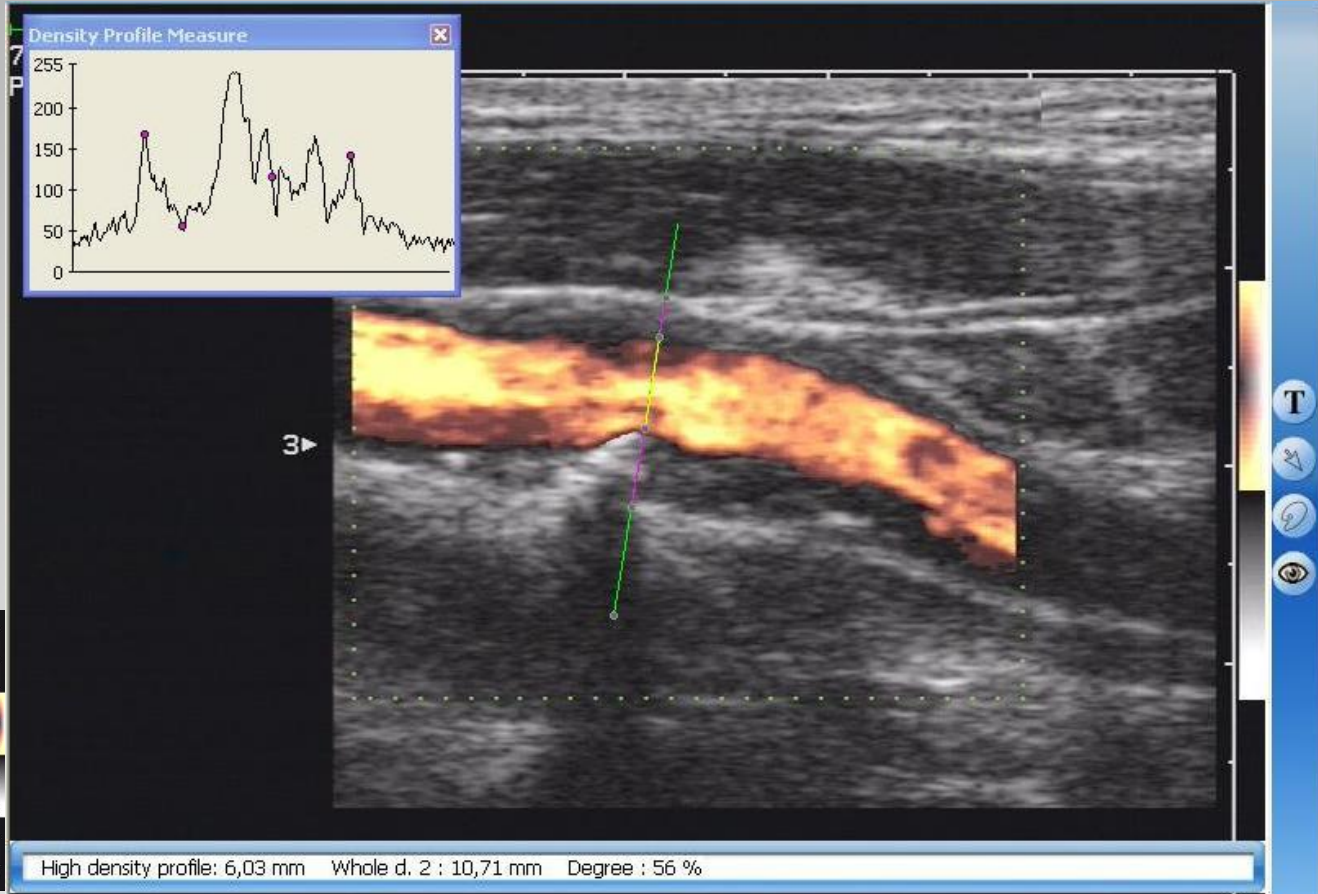
**Les seuils de vitesses Doppler ont été déterminés par rapport au % de sténose en diamètre à l'artériographie.**

# Normalisation



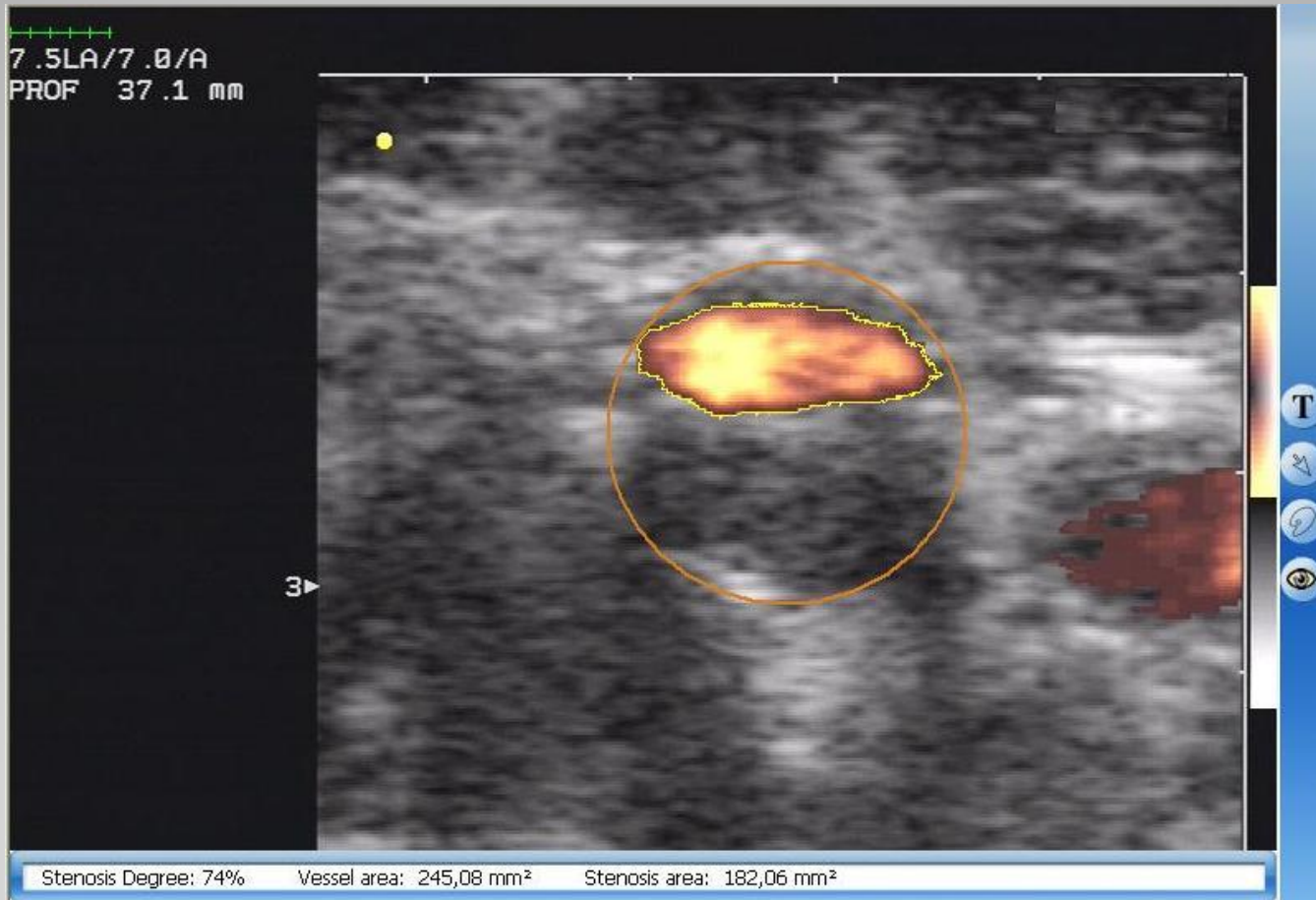
AN. Nicolaïdes **JVS 1998.** - .M.Sabetai **JVS 2000.-.** C. Denzel. **Stroke 2003.**  
AN. Nicolaidis. ACSRS. **Eur J Vasc Endovasc Surg 2005.-.** AN.




# Degré de Sténose

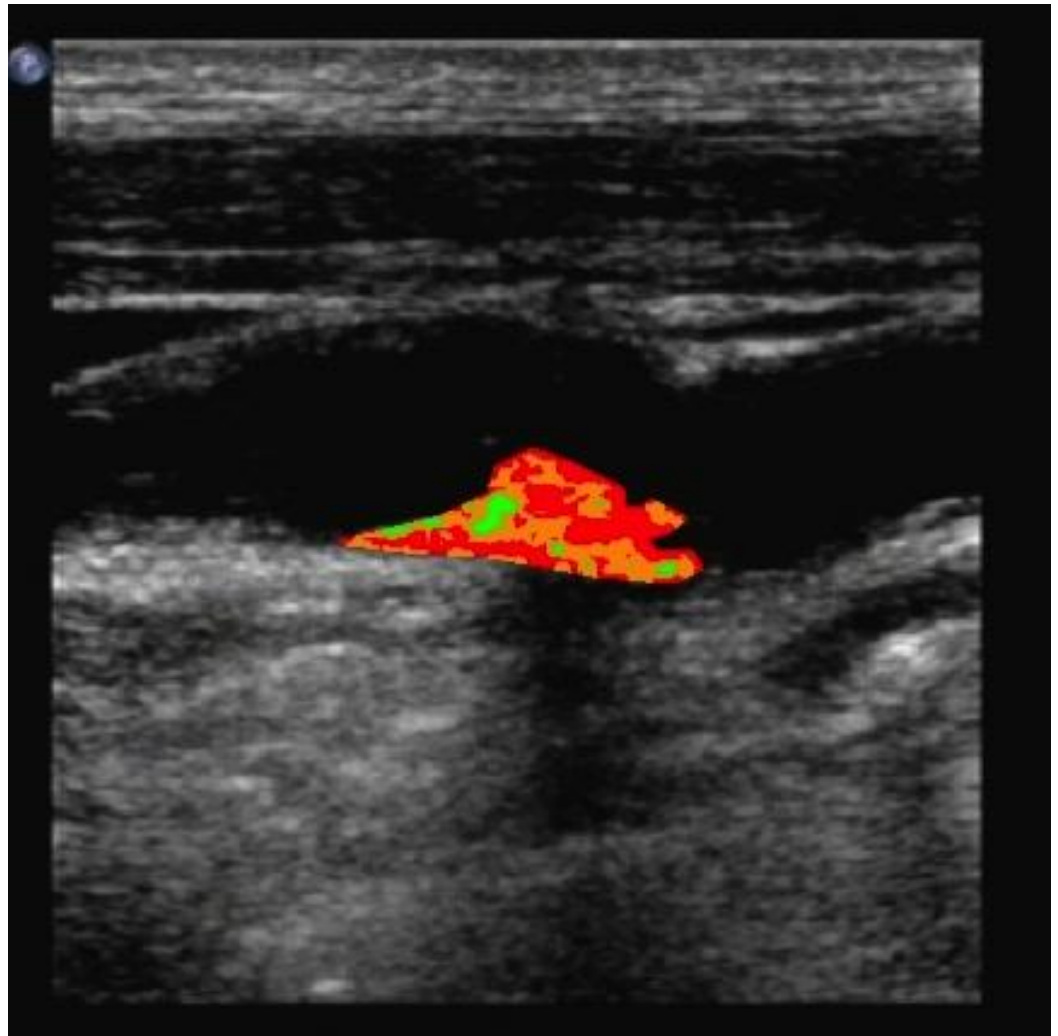




# Degré de Sténose



-  High Density  
( Calcium)
-  Mean density  
( Fibrotic)
-  Low Density  
(Thrombus or Haemorrhage)



# Normalisation & standardisation des images.

**Nicolaides A et al.** Effect of image normalization on carotid plaque classification and the risk of ipsilateral hemispheric ischemic events. *Vascular* 2005;13(4):211-21

## ACSRs:

- ❑ **34% évènements ischémiques (37/108) pour sténose < 60% NASCET**
- ❑ **% sténose : critère insuffisant pour évaluation du risque cérébral des sténoses asymptomatiques de l'ACI.**
- ❑ **GSM : Sténose 70 – 99 % du bulbe (50 – 99% équivalent NASCET) :**
  - **plaques types 1 à 3** (hypoéchogène/hétérogène) :
    - Taux cumulé d'AVC = **14% à 7 ans** (2% par an)
  - **plaque types 4 & 5 :**
    - Taux cumulé d'AVC = **0.9% à 7 ans** (0.14% par an).

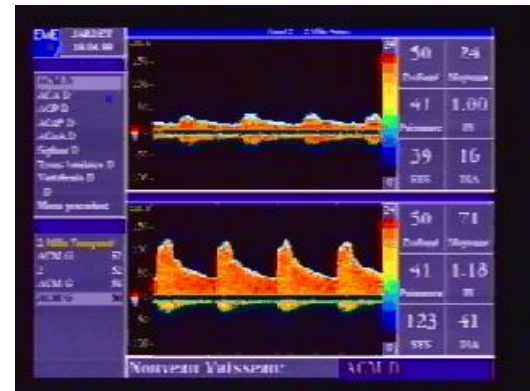
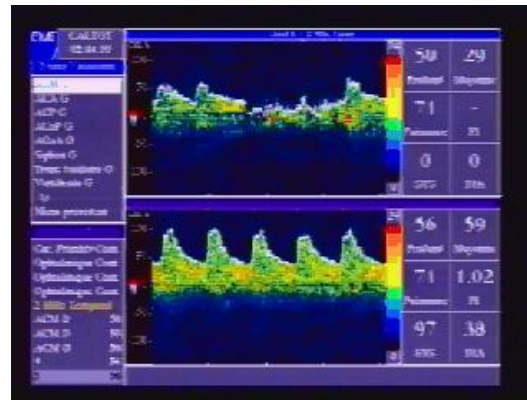
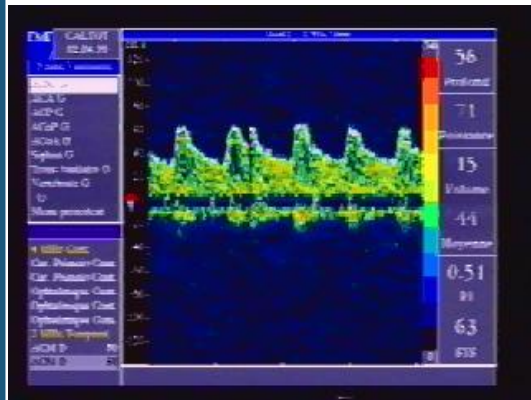
*Faible risque quelque soit le degré de sténose.*

**Etablir des critères combinés d'évaluation du risque :  
% sténose, NGM, DTC, Ratio vitesses des ACM, HITS, Débits?**

- ❑ **Diminution du GSM entre 6-9 mois (230/574 patients):**  
Prédictif d'évènements ischémiques cérébraux. Reiter. *Radiology*. 2008.

# Doppler transcrânien

⇒ Retentissement hémodynamique d'une sténose ou occlusion carotide interne extracrânienne ++



# Cas particuliers

- ✓ Dissections
- ✓ Sténoses intra crâniennes
- ✓ Sténose pseudo occlusive

# Conclusion

- ✓ Quantification morphologique ( paroi –plaques)
- ✓ Confrontation hémodynamique-morphologie
- ✓ Morphologie par EDC
- ✓ Etude des signes indirects (Oph- RHIC)