ECHOCOLORDOPPLER LESSONS

INTRACRANIAL STENOSIS

Franco Accorsi
Intracranial stenosis

INTRODUCTION

In the hemodynamic intracranial stenosis the main echocolor Doppler findings are: local flow acceleration, disturbed flow with spectral broadening in the region of the stenosis and reduced maximum and mean flow velocities distal to the stenosis. Transcranial color Doppler (TCCD) is useful for ruling out intracranial stenosis but less reliable for ruling in this pathology, therefore, TCCD should ideally be used as the initial screening tool. Intracranial atherosclerotic stenosis is a dynamic lesion: such dynamicty is the result of various processes, including superimposed thrombus formation, intraplaque hemorrhage and increase in atherosclerotic growth. These dynamic processes imply a need for surveillance with a non-invasive technique: the possibility of studying and monitoring the intracranial vessels using TCCD in real time is important for diagnosis, prognosis and therapy. In this lesson the echocolor-Doppler findings of the intracranial stenosis will be presented.
INTRACRANIAL STENOSIS

A. DEFINITION AND EPIDEMIOLOGY
B. NATURAL HISTORY
C. US DIAGNOSIS
D. US MONITORING OF INTRACRANIAL STENOSIS
1. focal intracranial disease is defined as:
   - ≥50% diameter reduction

2. diffuse (one artery) intracranial disease is defined as:
   - multiple segments of stenosis in one artery
   - or a long (≥ 1 cm) stenosis in one major artery
IC STENOSIS AND STROKE

- Atherosclerotic stenosis of the major intracranial arteries (intracranial ICA, MCA, VA, BA) is probably the most common cause of stroke worldwide §
- Intracranial atherosclerosis causes 30% to 50% of strokes in Asia *
- Intracranial atherosclerosis causes 8% to 10% of strokes in North America °

§ Gorelick PB. Large artery intracranial occlusive disease: a large worldwide burden but a relatively neglected frontier. Stroke 2008;
° Sacco RL. The Northern Manhattan Stroke Study. Stroke 1995
INTRACRANIAL STENOSIS
DEFINITION AND EPIDEMIOLOGY

PREVALENCE OF ASYMPTOMATIC MCA STENOSIS

- the prevalence of asymptomatic MCA stenosis escalated quadratically with increasing number of associated factors:
  - from 7.2% for one
  - to 29.6% for four (elderly, hypertension, diabetes, and hyperlipidemia) associated factors

Wong KS, Neurology 2007

- admission (acute stroke) hyperglycaemia was significantly associated with focal stenosis as visualized on a MRA

Taqui AM, J Pak Med Assoc 2009
INTRACRANIAL STENOSIS

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INTRACRANIAL STENOSIS
NATURAL HISTORY

SYMPTOMATIC VS ASYMPTOMATIC MCA STENOSIS

- 102 consecutive pts. with significant MCA stenosis or occlusion (46 pts sympt.; 56 asymptomatic). Mean follow-up of 31 months

- pts. with symptomatic MCA had an overall stroke risk of **12.5%** per year

- 2.8% in asymptomatic

**WASID TRIAL (warfarin vs aspirin)**

- inclusion criteria: TIA or nondisabling stroke (within 90 days before randomization and attributable to angiographically verified 50 to 99% stenosis of a major intracranial artery)

- a mean follow-up period of 1.8 years

- the primary end point (ischemic stroke, brain hemorrhage or death from vascular causes other than stroke) occurred in 22.1% of the pts in the aspirin group and 21.8% of those in the warfarin group

*Chimowitz MI et al. for WASID. N Engl J Med 2005*
INTRACRANIAL STENOSIS
NATURAL HISTORY

SYMPTOMATIC INTRACRANIAL STENOSIS

SAMMPRIS STUDY
(medical management alone vs medical management plus PTAS)

METHODS
- inclusion criteria: pts with a recent TIA or stroke attributed to stenosis of 70 to 99% of a major intracranial artery to aggressive medical management alone or aggressive medical management plus PTAS
- primary end point: stroke or death within 30 days after enrollment or after a revascularization procedure for the qualifying lesion during the follow-up period or stroke in the territory of the qualifying artery beyond 30 days

RESULTS
- the mean duration of follow-up: 11.9 months
- probability of the occurrence of a primary end-point event: 1-year rates of the primary end point of 20.0% in the PTAS group and 12.2% in the medical-management group

PROSPECTIVE STUDY OF SYMPTOMATICATHEROTHRombotic INTRACRANIAL STENOSES

- in GESICA study recurrent cerebral ischemic events occurred in a median time of 2 months following the first qualifying event
- the short time for recurrence argues for an aggressive frontline therapeutic strategy

Mazinghi M. The GESICA Study; Neurology 2006
INTRACRANIAL STENOSIS
NATURAL HISTORY

IS AND HIGH RISK OF STROKE

MORPHOLOGICAL FEATURES OF THE MCAS IN CONSECUTIVE POSTMORTEM ADULTS

1. the degree of luminal stenosis
2. the percentage of the plaques containing more than 40% lipid area
3. the prevalence of intraplaque hemorrhage, neovascularature and thrombus

were higher in those plaques associated with infarct

Chen XY. Cerebrovasc Dis 2007
PREDICTORS OF ISCHEMIC STROKE IN THE TERRITORY OF A SYMPTOMATIC INTRACRANIAL STENOSIS

Among patients with symptomatic i.c. stenosis, the risk of subsequent stroke in the territory of the stenotic artery is:

- greatest with stenosis $\geq 70\%$
- after recent symptoms
- and in women

*Kasner SE and WASID Investigators. Circulation 2006*
INTRACRANIAL STENOSIS
NATURAL HISTORY

IS AND HIGH RISK OF STROKE

MICROEMBOLIC SIGNALS IN ACUTE STROKE PATIENTS WITH MCA STENOSIS

- in acute stroke patients with MCA stenosis, MES predicts further cerebral ischemia.
- this procedure should be considered as part of routine investigation and might identify a group of patients who are most likely to benefit from antithrombotic treatment.

_Gao S. et al. Stroke 2004_

- there were no microembolic signals in the asymptomatic, control, and normal groups
- among 20 patients in the symptomatic group, microembolic signals were detected in 3 patients (15%)

_Wong KS et al. J Neuroimaging 2001_
INTRACRANIAL STENOSIS
NATURAL HISTORY

LOCATION, TYPE, AND SEVERITY OF STROKE
IN PATIENTS WITH IS IN WASID TRIAL
(warfarin vs aspirin in 569 pts /TIA or
nondisabling stroke in 50-99% ic stenosis)

- 106 pts (18.6%) had an ischemic stroke during a mean follow-up of 1.8 years
- stroke occurred in the territory of the symptomatic artery in 77 (73%) of 106 pts
- among the 77 strokes in the territory, 70 (91%) were nonlacunar and 34 (44%) were disabling

intracranial stenosis
natural history

moderate IS may be causal in MCA infarction?

- a case-control autopsy study (123 pts with unilateral MCA territory infarction) evaluating the frequency of ats plaque and moderate (<70%) or severe (≥70%) stenosis in the ipsilateral and contralateral MCA

Conclusions:

- moderate MCA ats stenosis may be responsible for parent territorial stroke
- these neuropathological data suggest that not only is severe MCA stenosis causal but that moderate intracr. stenosis < 30% may also be causal in ipsilateral MCA infarction

Pierre Amarenco. Cerebrovasc Dis 2010
INTRACRANIAL STENOSIS

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SCREENING FOR INTRACRANIAL ARTERIAL STENOSIS

- in patients with ischemic symptoms, including those with lacunar syndromes, screening for intracranial arterial stenosis by vascular imaging is strongly recommended

INTRACRANIAL STENOSIS DIAGNOSIS

NONINVASIVE AND INVASIVE METHODS FOR QUANTIFYING THE SEVERITY OF IC ATS STENOSIS

1. **digital subtraction angiography** (gold standard): invasive, there are radiation and allergy and stroke risks, and the test is expensive and not widely available

2. **TCCD**: the least expensive or invasive, but it is operator dependent, and in some pts access to vessels may not be available because of transtemporal window thickening

3. **MRA**: may more accurately identify stenosis, but it may overestimate the severity of stenosis, and the test is not available everywhere

4. **CTA**: identifies disease reasonably well, is less expensive and more available than MRA, but there are dye and radiation risks

*Qureshi AI. J Neuroimaging. 2009 Oct; Consensus Conference on Intracranial Atherosclerotic Disease*
DETECTION OF INTRACRANIAL ATHEROSCLEROSIS

availability of CTA, MRA and TCD in the evaluation of intracranial arterial disease in multiple European hospitals

- availability was higher for CTA, followed by MRA and TCD

Ringelstein EB et al. Detection of intracranial atherosclerosis: which imaging techniques are available in European hospitals? Stroke 2009
INTRACRANIAL STENOSIS DIAGNOSIS

TRANSCRANIAL COLOR DOPPLER

Transcranial color Doppler is an ultrasound non-invasive technique that can:

a. show the intracranial vessels
b. study the direction and the velocity of the flow
1. upstream: high-resistance waveforms

2. over the stenotic segment: high-frequency signal during syst/diastole

3. downstream: monophasic waveforms in the absence of reversed component
**INTRACRANIAL STENOSIS**  
**US DIAGNOSIS**

**IS diagnosis**
- local flow acceleration
- disturbed flow with spectral broadening in the region of the stenosis due to the increase in low frequency and retrograde flow components
- reduced maximum and mean flow velocities distal to the stenosis

*Lindegaard K.F.: J Neurol Neurosurg Psychiat 1986*
1. focal intracranial disease ($\geq 50\%$ diameter reduction)

2. diffuse disease:
   - multiple segments of one artery
   - long (>1 cm) stenosis in one major artery
INTRACRANIAL STENOSIS

US DIAGNOSIS

US diagnosis:
high-frequency signal during syst/diastole

↑ Stenosis ------->  ↑ PSV
CRITERIA GENERALLY USED FOR US DIAGNOSIS OF INTRACRANIAL ARTERIAL STENOSIS:

A. criteria WASID/SONIA (TCD-MFV)

- MCA: \[\geq 100 \text{ cm/sec (>50\%)}\]
- TICA/ACA: \[\geq 90 \text{ cm/sec (>50\%)}\]
- VA/BA/PCA: \[\geq 80 \text{ cm/sec (>50\%)}\]
- stenotic to prestenotic MFV ratio > 2

or

B. criteria BAUMGARTNER et al. (TCCD-PSV)

intracranial stenosis \(<50\% / \geq 50\%\)

- MCA: \[\geq 155 / 220 \text{ cm/s}\]
- ACA: \[\geq 120 / 155 \text{ cm/s}\]
- PCA: \[\geq 100 / 145 \text{ cm/s}\]
- BA: \[\geq 100 / 140 \text{ cm/s}\]
- VA: \[\geq 90 / 120 \text{ cm/s}\]
intracranial stenosis
us diagnosis

TCCD in IS Diagnosis (1999)

US detection of IS > 50% with angiography as standard of reference
in case of peak systolic velocities cutoff:

- MCA \( \geq 220 \text{ cm/s} \)
- ACA \( \geq 155 \text{ cm/s} \)
- PCA \( \geq 145 \text{ cm/s} \)
- BA \( \geq 140 \text{ cm/s} \)
- VA \( \geq 120 \text{ cm/s} \)

sensitivity, specificity, positive & negative predictive values: 91-100%

Baumgartner R.W.: Stroke 1999
**INTRACRANIAL STENOSIS US DIAGNOSIS**

**MCA and PCA stenosis US diagnosis**

- **US detection of IS with Angiography as Standard of Reference**
  - Peak systolic velocities:
    - MCA: \( \geq 155 / 220 \text{ cm/s} \)
    - ACA: \( \geq 120 / 155 \text{ cm/s} \)
    - PCA: \( \geq 100 / 145 \text{ cm/s} \)
    - BA: \( \geq 100 / 140 \text{ cm/s} \)
    - VA: \( \geq 90 / 120 \text{ cm/s} \)

*Baumgartner R.W. Stroke 1999*

**Measurement Values**
- **PCA: PSV = 2.63 m/s.**
- **MCA: PSV = 2.26 m/s.**
INTERRACRANIAL STENOSIS
US DIAGNOSIS

VA 4 STENOSIS

VA 4 STENOSIS (cut off stenosis > 50%: PSV > 120 cm./sec.)
a. VA4 rt.: aliasing and significantly elevated velocity (= 218 cm/s.) indicative of a significant stenosis
b. VA 4 lt.: significantly elevated velocity (=223 cm/s.) indicative of a significant stenoses

Baumgartner R.W. Stroke 1999
1. focal intracranial disease (≥ 50% diameter reduction)

2. diffuse disease:
   - multiple segments of one artery
   - long (>1 cm) stenosis in one major artery
INTRACRANIAL STENOSIS

**US DIAGNOSIS**

**US diagnosis:**
in diffuse severe ic stenosis systolic velocity can be low
FOCAL SEVERE (≥ 50%) STENOSIS ACM
VS is 140 cm/sec or higher or VM is 90 cm/sec. or higher (sensitivity = 83.3%, specificity = 91.2%)

DIFFUSE SEVERE (≥ 50%) STENOSIS ACM
VS is lower than 40 cm/sec or 140 cm/sec or higher (sensitivity = 81.8%, specificity = 92.1%)

except for high flow velocity, the addition of a low cutoff of normal flow velocity in our criteria not only increases the study sensitivity but also enables the identification of around half of diffuse severe MCA stenosis

*Sung-Chun Tang, J Ultrasound Med 2005*
VA4 DIFFUSE SEVERE STENOSIS

- low velocity in VA4 diffuse severe stenosis

(in diffuse severe intracranial stenosis systolic velocity can be low)
INTRACRANIAL STENOSIS
US DIAGNOSIS

DIFFUSE SEVERE STENOSIS ACM

- low velocity in MCA diffuse severe stenosis

*(in diffuse severe intracranial stenosis systolic velocity can be low)*
INTRACRANIAL STENOSIS

US DIAGNOSIS

1. OLD GENERATION TOOLS:
   a. only velocity study!

2. LATEST GENERATION TOOLS:
   a. velocity and
   b. morphological study!
INTRACRANIAL STENOSIS

OLD GENERATION TOOLS:
ONLY VELOCITY STUDY!

MCA STENOSIS

TCCD IN IS DIAGNOSIS

- disturbed flow with spectral broadening in the region of the stenosis
INTRACRANIAL STENOSIS

US DIAGNOSIS

OLD GENERATION TOOLS:
ONLY VELOCITY STUDY!

MCA STENOSIS

TCCD IN IS DIAGNOSIS

a) high velocity (= 4.04 m/s.) flow in the region of the MCA stenosis

b) reduced flow velocity (= 0.70 m/s.) and disturbed flow distal to the stenosis
INTRACRANIAL STENOSIS
US DIAGNOSIS

OLD GENERATIONTOOLS: ONLY VELOCITY STUDY!

MCA STENOSIS

TCCD IN IS DIAGNOSIS

a) aliasing and (b) high velocity (= 3.40 m/s.) and disturbed flow with spectral broadening in the region of the MCA stenosis

b) the flow velocity is = 1.46 m/s. distal to the stenosis
INTRACRANIAL STENOSIS
US DIAGNOSIS

PCA STENOSIS

OLD GENERATION TOOLS:
ONLY VELOCITY STUDY!

TCCD IN IS DIAGNOSIS

a) aliasing and (b) high velocity (= 2.02 m/s.) and disturbed flow with spectral broadening in the region of the PCA stenosis
c) reduced maximum (= 0.21 m/s.) and mean flow velocities distal to the stenosis
INTRACRANIAL STENOSIS
US DIAGNOSIS

LATEST GENERATION TOOLS:
1. VELOCITY AND
2. MORPHOLOGICAL STUDY!

ACM: PSV = 3.41 m/s

MCA HIGH-GRADE STENOSIS
INTRACRANIAL STENOSIS

US DIAGNOSIS

MCA SEVERE STENOSIS

LATEST GENERATION TOOLS:
1. VELOCITY AND
2. MORPHOLOGICAL STUDY!

ACM- PSV:
3.05 m/s → 1.17 m/s

COLOR
INTRACRANIAL STENOSIS

US DIAGNOSIS

MCA SEVERE STENOSIS

LATEST GENERATION TOOLS:
1. VELOCITY AND
2. MORPHOLOGICAL STUDY!

ACM- PSV:
3.05 m./s → 1.17 m./s
INTRACRANIAL STENOSIS
US DIAGNOSIS

LATEST GENERATION TOOLS:
1. VELOCITY AND
2. MORPHOLOGICAL STUDY!

MCA: NOT
HEMODYNAMIC STENOSIS
TCCD: MORPHOLOGICAL STUDY

ACM:
PSV = 0.67 m./s
(normal velocity)
INTRACRANIAL STENOSIS
US DIAGNOSIS

LATEST GENERATION TOOLS:
1. VELOCITY AND
2. MORPHOLOGICAL STUDY!

MCA LOW-GRADE STENOSIS
INTRACRANIAL STENOSIS

US DIAGNOSIS

SIPHON STENOSIS

STUDY THROUGH THE TEMPORAL WINDOW WITH CORONAL SCAN:

a) aliasing

b) local flow acceleration (PSV = 212 cm/s.) with disturbed flow due to the increase in low frequency and retrograde flow components
INTRACRANIAL STENOSIS

US DIAGNOSIS

IN-STENT RESTENOSIS

- the role of TCCD (and non-invasive tests such as MRA and CTA) in detecting in-stent restenosis is not established
- DSA remains the most accurate modality for determining instent restenosis

INTRACRANIAL STENOSIS US DIAGNOSIS: PITFALLS!
US INTRACRANIAL STENOSIS

PITFALLS

INTRACRANIAL STENOSIS: DIAGNOSIS
IT IS ALWAYS REQUIRED:

- an evaluation of extracranial vessels
- an evaluation of the bilateral intracranial circulation

INTERFERING FACTORS ON VELOCITY

A) FACTORS THAT REDUCE THE VELOCITY

- advanced age
- reduction in cardiac output
- distal obstruction of the vessel explored
- increased intracranial pressure

B) FACTORS THAT INCREASE THE VELOCITY

in all vessels, or multiple intracranial vessels

- systemic diseases: anemia, hyperthyroidism
- subarachnoid hemorrhage (vasospasm)
- use of contrast agents for U.S.

In one or a few intracranial vessels

- local causes: in compensatory arteries, in MAV
US INTRACRANIAL STENOSIS

PITFALLS

STENOSIS

_falsely normal findings_

1. angle correction inappropriate
2. increased vascular resistance
   - hypoplastic artery
   - distal arterial obstruction
   - acute ischemic stroke
3. reduction in systolic output

STENOSIS

_falsely abnormal findings_

1. angle correction inappropriate
2. contrast-enhanced TCCD (PSV 20-26%↑)
3. increased CBF (collaterals, MAV, FAV, SAH, anemia, hyperthyreosis)
US INTRACRANIAL STENOSIS

PITFALLS

ACA rt: PSV = 1.65 m/sec.

falsely high velocity!

ICA OCCLUSION (falsely abnormal findings):
GOOD COLLATERAL SUPPLY VIA ANT. COMMUNICATING ARTERY
GOOD COLLATERAL SUPPLY VIA POST. COMMUNICATING ARTERY

BILATERAL ICA OCCLUSION (falsely abnormal findings):

US INTRACRANIAL STENOSIS PITFALLS

AB: pSV = 1.70 m/sec.
Falsely high velocity!

PITFALL!
rt. VA AND BILATERAL ICA OCCLUSION:
GOOD COLLATERAL SUPPLY VIA LT VA AND BA (Lt VA and BA falsely abnormal findings: high vel. flow in Lt VA2 (=1.48 m/sec) and in BA (= 1.73 m/sec.)
US INTRACRANIAL STENOSIS
PITFALLS

PITFALL!

ARTERIOVENOUS MALFORMATION
(falsely abnormal findings)

ACP:
PSV = 1.87 m./s
PDV = 1.27 m./sec.
IR = 0.47
falsely high velocities!
US INTRACRANIAL STENOSIS PITFALLS

PITFALL!

DISTAL ARTERIAL OBSTRUCTION
(falsely normal findings)

ACM:
PSV = 0.36 m/s
falsely low velocity!
US INTRACRANIAL STENOSIS PITFALLS

PITFALL!

ACM: PSV = 0.99 m/sec no aliasing and falsely normal velocity!

SIPHON: aliasing and high velocity flow (stenosis)

TANDEM STENOSIS (falsely normal findings on the distal stenosis)
US INTRACRANIAL STENOSIS PITFALLS

PROBLEMS IN THE STUDY OF THE SIPHON (FOR THE TORTUOSITY)

TCD IN DETECTING SIPHON INTERNAL CAROTID ARTERY (SICA) STENOSIS VS DSA (145 PATIENTS)

- PSV = 120 cm/s. had the largest area under the ROC curve
- so the criteria for SICA stenoses were defined as:
  - PSV = 120 cm/s.
  - plus additional parameters (abnormal spectrum, circumscribed velocity changes, or side-to-side difference)
- accuracy parameters for TCD were: sensitivity = 96.7%, specificity = 93.9%, PPV = 65.9%, NPV = 99.6%.

CONCLUSIONS

- the criteria have limited but acceptable sensitivity and specificity in detecting SICA stenoses
- abnormal TCD findings of siphon require further clarification

INTRACRANIAL STENOSIS

US DIAGNOSIS

PITFALL!

SIPHON
TRANSTEMPORAL EXAMINATION
coronal plane
1. over the stenotic segment: local flow acceleration
2. downstream: reduced max. and mean flow velocities
INTRACRANIAL STENOSIS

US DIAGNOSIS

SIPHON STENOSIS

A) SIPHON:
- aliasing +
- PSV = 3.21 m/s
- STENOSIS

B) SIPHON:
- PSV = 1.83 m/s
- STENOSIS?
- TORTUOSITY?
US INTRACRANIAL STENOSIS

US ACCURACY

US IN IS DIAGNOSIS

ACCURACY
US INTRACRANIAL STENOSIS

US ACCURACY

TCCD IN IS DIAGNOSIS (1999)

US detection of IS with Angiography as Standard of Reference Intracranial Stenosis <50% / ≥50

Peak systolic velocities cutoff:

- MCA: ≥155 / 220 cm/s
- ACA: ≥120 / 155 cm/s
- PCA: ≥100 / 145 cm/s
- BA: ≥100 / 140 cm/s
- VA: ≥90 / 120 cm/s

Sensitivity, specificity, positive & negative predictive values:

Stenosis ≥50%: 91-100%; stenosis <50%: 73-100%

Baumgartner R.W.: Stroke 1999
US INTRACRANIAL STENOSIS

US ACCURACY

TCD IN FOCAL I.S. > 50% AND SEVERE (OR LONG) I.S.
angiography as standard of reference
in pts with symptoms of cerebral ischemia

1. TCD mean flow velocities were classified as:

- MFV normal (30 to 99 cm/s)
- MFV high (> 99 cm/sec)
- MFV low (< 30 cm/sec)
- pulsatility index ≥1.2 was considered high

focal ≥ 50% intracranial stenosis

- a focal ≥ 50% intracranial stenosis was diagnosed if TCD showed high MFV with variable PI values

very severe, a long or multiple stenoses in a single IC artery

- a combination of low MFV and high PI is likely to predict very severe stenosis, a long (≥ 1 cm) intracranial segment stenosis, or multiple stenoses in a single artery

Noninvasive Detection of Diffuse IC Disease. VK. Sharma, AV Alexandrov Stroke 2007
US INTRACRANIAL STENOSIS
US ACCURACY

TCD DETECTION OF FOCAL AND DIFFUSE IC DISEASE:

- sensitivity 79.4% (95% CI: 65.8% to 93%)
- specificity 92.4% (95% CI: 87.7% to 97.2%)
- PPV 75.0%
- NPV 94.0%
- and overall accuracy 89.5%

- TCD is useful for ruling out IS (high NPV, 94%)
- but less reliable for ruling in disease (lower PPV, 75%)
- therefore, TCD should ideally be used as the initial screening tool for the detection of intracranial disease, and other neuroimaging modalities are necessary for the final confirmation of this diagnosis

Noninvasive Detection of Diffuse Intracranial Disease. VK. Sharma, AV Alexandrov Stroke 2007
TCD DETECTION OF FOCAL AND DIFFUSE IC DISEASE:

- TCD is useful for ruling out IS (high NPV, 94%)
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US DIAGNOSIS

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IC atherosclerotic stenoses are dynamic lesions demonstrating both progression and regression.
21 pts with 45 intracranial stenoses who underwent repeat angiography at an average interval of 26.7 months

- intracranial ICA stenosis: progression = 20%; regression = 14%
- ACA, MCA, PCA stenosis: progression = 61%; regression = 28%

intracranial atherosclerotic stenoses are dynamic lesions!

- progression (or regression) of an intracranial lesion may occur, with some heterogeneity depending upon the location
- such dynamicity is the result of various processes, including
  - superimposed thrombus formation
  - intraplaque hemorrhage
  - increase in atherosclerotic growth
- these processes imply a need for surveillance and medical intervention

Qureshi AI. J Neuroimaging 2009 Oct; Consensus Conference on Intracranial Atherosclerotic Disease
INTRACRANIAL STENOSIS

DYNAMIC LESIONS

MCA MODERATE STENOSIS
PSV = 2.20 m./s

TEN MONTHS LATER
MCA SEVERE STENOSIS: PSV = 3.41 m./s

INTRACRANIAL STENOSIS PROGRESSION

- a strong relationship between Intracranial Large Artery Atherosclerosis progression and further cerebral ischemic events during follow-up

Intracranial Large Artery Atherosclerosis Is Associated With a Proinflammatory State and Impaired Fibrinolysis. Juan F. Arenillas. Stroke 2008
INTRACRANIAL STENOSIS
DYNAMIC LESIONS

MCA in recent TIA
MCA: max. vel. = 2.33 m/s

MCA two months later
MCA: max. vel. = 1.23 m/s
INTRACRANIAL STENOSIS
DYNAMIC LESIONS

MCA in recent TIA
MCA: PSV=3,38 m/s

two months later
MCA: PSV= 2,25 m/s

four years later
MCA: PSV= 0,67 m/s
INTRACRANIAL STENOSIS
US DIAGNOSIS

CONCLUSIONS 1
US DIAGNOSIS

REASONS

- intracranial atherosclerosis causes 8% of all ischemic strokes

WHEN

- symptomatics patients
- patients with many risk-factors (?)

METHODS

- ecocolorDoppler-angiopower
- contrast agents

WHAT TO SEARCH FOR

- local flow acceleration
- disturbed flow with spectral broadening
CONCLUSIONS 2
US DIAGNOSIS

1. TCCD has high NPV and lower PPV
2. due to the high NPV, TCCD is important primarily by excluding the presence of IC stenosis
3. TCCD in different arteries and segments (eg, siphon) may provide different NPV and PPV values
4. TCCD is very useful in monitoring IC atherosclerotic stenoses (dynamic lesions)
5. the possibility of studying and monitoring the IC vessels using TCCD in real time is important for diagnosis, prognosis and therapy
short videos and playlists on ultrasound examinations of the intracranial arteries are available on my youtube channel: http://www.youtube.com/channel/UCij561sX0bQoEjXIWKuPnKg