

Le stenosi intracraniche: oltre la velocità

XXI CORSO NAZIONALE DI

**ULTRASONOLOGIA
VASCOLARE
DIAGNOSI E TERAPIA**

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BERTINORO

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UOC Neurologia IRCCS Scienze
Neurologiche

Ospedale Maggiore Bologna

Perchè cercarle?

8-10% stroke ischemici in USA
30-50% nella popolazione asiatica

asintomatica: basso rischio di stroke (5.9% a 2 aa)

sintomatica: a maggior rischio di recidiva di stroke

Uno studio anatomico-patologico in soggetti deceduti per ictus ha evidenziato una frequenza di stenosi intracraniche del 9%.

Dati preliminari di uno **studio di popolazione** depongono per una frequenza di circa il **9% di stenosi intracraniche sintomatiche.**

Il tasso annuale di stroke in pazienti con stenosi intracraniche varia da 8% to 24% (Mazighi M, Stroke 2004).

Prevalenza di stenosi intracraniche sintomatiche in pazienti ricoverati per stroke

5-10% : caucasici

11-15%: ispanici

6-17% : afro-americani

33-51%:asiatici

La prevalenza stimata **delle stenosi intracraniche sintomatiche varia dal 20% al 53% a**

RISCHIO DI RICORRENZA

Lo studio WASID ha segnalato che il grado di stenosi del lume influenza il rischio di recidiva di ictus

Ad esempio i pazienti con stenosi dal 70% al 99% avevano un tasso di stroke annuale fino al 22.5%, mentre quelli portatori di stenosi dal 50% al 69% avevano un tasso dell'8.2%, con una crescita lineare al crescere della stenosi

Oltre alla riduzione del diametro del lume , anche la lunghezza della stenosi sembra rilevante

Il rischio di ischemia di stroke a un anno dopo angioplastica
dell'8% per lesioni <di 5 mm
del 12% per lesioni da 5-10 mm

RISCHIO DI RICORRENZA

Varia dal 15-38% entro 2 anni nel territorio tributario dell'arteria con stenosi


In generale il rischio di ricorrenza dipende :

dal grado di stenosi ed è doppio in soggetti con stenosi > 70% rispetto a quelle del 50-69%

Il rischio di ricorrenza di TIA e Stroke in pazienti con stenosi severa di MCA è

Prospective study of symptomatic atherothrombotic intracranial stenoses : the GESICA study ;M Mazighi,R Tanasescu , X Ducrocq Chimowitz et Al 2005 ; Kasner et AL 2006 ; ThiJs et AL 2000)

Evaluating Intracranial Atherosclerosis Rather Than Intracranial Stenosis

Xinyi Leng, Ka Sing Wong, and David S. Liebeskind 

Originally published 7 Jan 2014 | <https://doi.org/10.1161/STROKEAHA.113.002491> | Stroke. 2014;45:645–651

- stenosi 70-99% predittore indipendente rischio recidiva >20%
- stenosi 50-69% predittore indipendente rischio recidiva 10%

-morfologia di placca

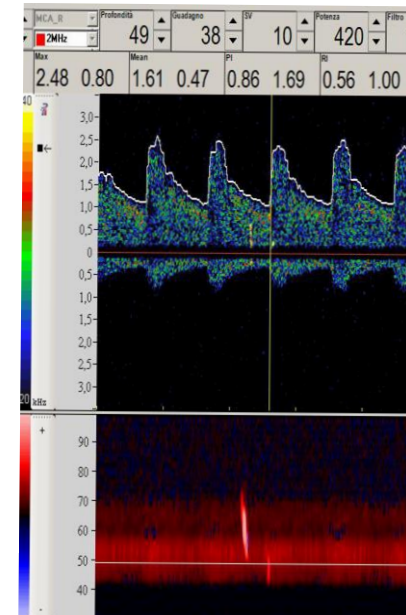
Lunghezza: > 5 mm o < 5 mm

Superficie: regolare-irregolare

-calcificazioni murali (volume delle calcificazioni valutate con TAC

Microembolic Signal Predicts Recurrent Cerebral Ischemic Events in Acute Stroke Patients With Middle Cerebral Artery Stenosis prossimali)

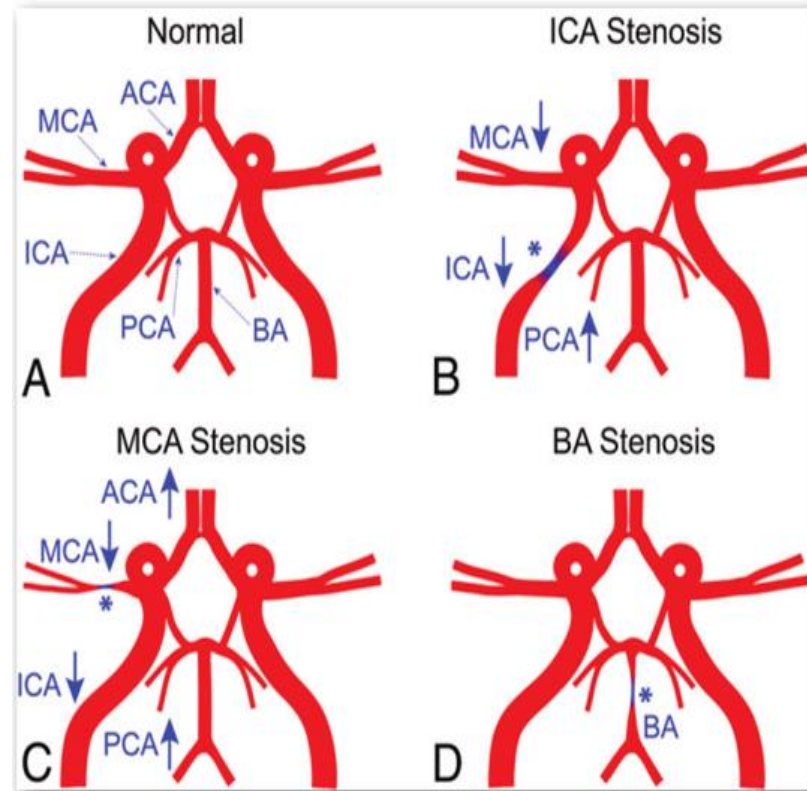
Shan Gao, Ka Sing Wong, Tjark Hansberg, Wynnie W. M. Lam, Dirk W. Droste, and E. Bernd Ringelstein



Dove sono

ICA INTRACRANICA (49%)
MCA (20%)
PCA (11%)
VERT.V4 e BASILARE(11%)
ACA (9%)

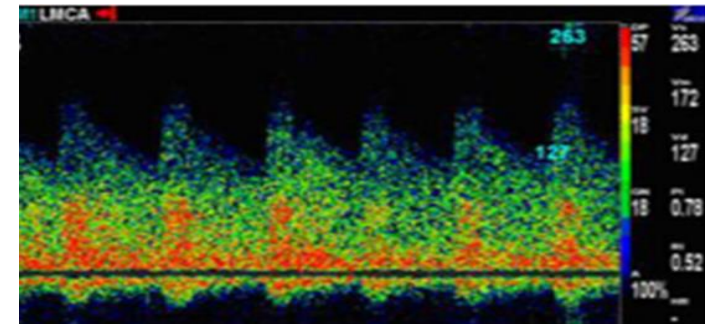
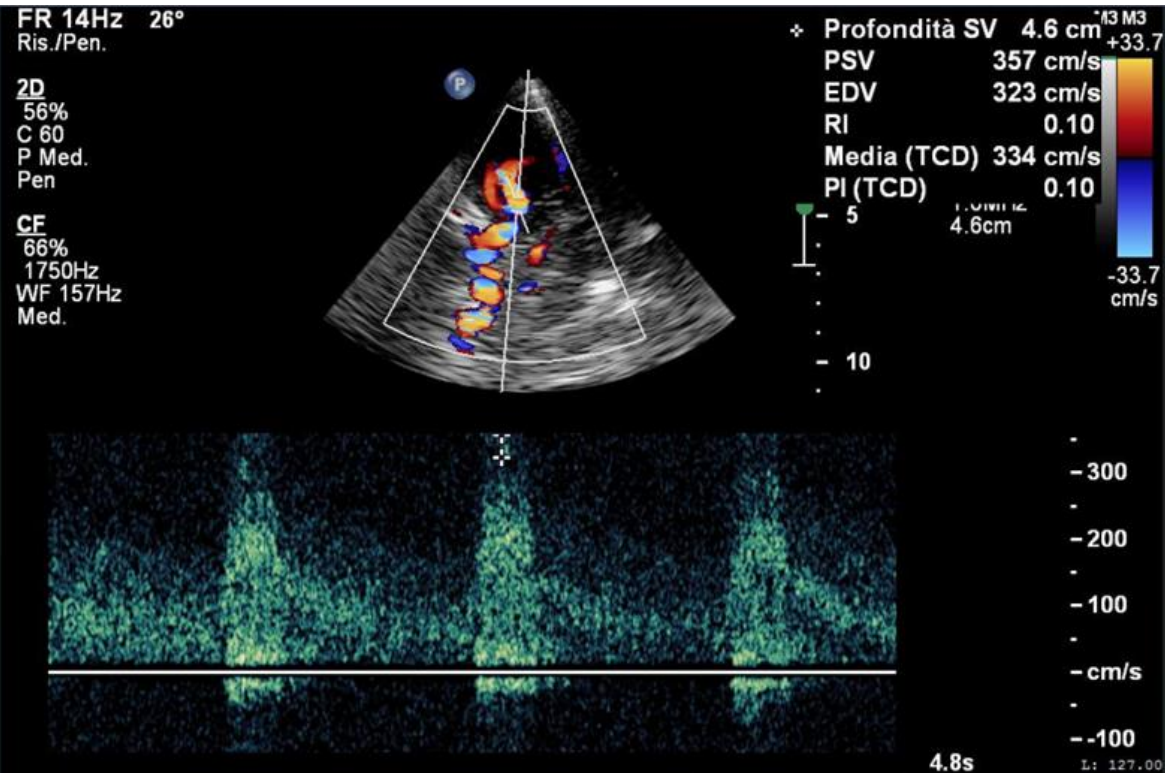
Atkins P.T.Stroke



van den Wijngaard IR. Brain Behav 2016

Valutazione Neurosonologica

La valutazione delle stenosi intracraniche è strettamente basata su criteri emodinamici e il parametro principale è la velocità massima del punto di stenosi



Comparison of cerebral angiography and transcranial Doppler sonography in acute stroke.

E M Zanette, C Fieschi, L Bozzao, C Roberti, D Toni, C Argentino and G L Lenzi

Originally published 1 Jul 1989 | <https://doi.org/10.1161/01.STR.20.7.899> | Stroke. 1989;20:899-903

Abstract

We compared digital intra-arterial angiography and transcranial Doppler sonography in acute cerebral ischemia as part of a wider study on a continuous series of 48 patients with acute focal cerebral ischemia in the carotid territory, observed within 4 hours of the onset of symptoms. The most significant Doppler findings of the middle cerebral artery included no detection of the artery when occlusion of the carotid siphon or the middle cerebral artery at its origin was shown by angiography and reduced flow velocities and asymmetry (symptomatic less than asymptomatic) when the occlusion was located in the terminal tract of the middle cerebral artery mainstem or in numerous terminal branches. Higher flow velocities in the anterior cerebral artery or posterior cerebral artery, mostly in the symptomatic hemisphere, often accompanied middle cerebral artery pathology, probably indicating collateral compensatory pathways.

Zanette et al Indice di ASIMMETRIA (IA) = $(mv1-mv2)/[(mv1+mv2)/2] \times 100\%$, ove mv1 e mv2 sono le velocità medie rispettivamente nel lato sintomatico e controlaterale , il valore soglia di asimmetria era +/- 21% e un valore IA di -200% era indicativo di occlusione sul lato sintomatico studiato

A reduction of the MCA flow velocity in relation to the controlateral side TCD is still proposed as a useful

MFV : $PSV+(EDV \times 2) / 3$

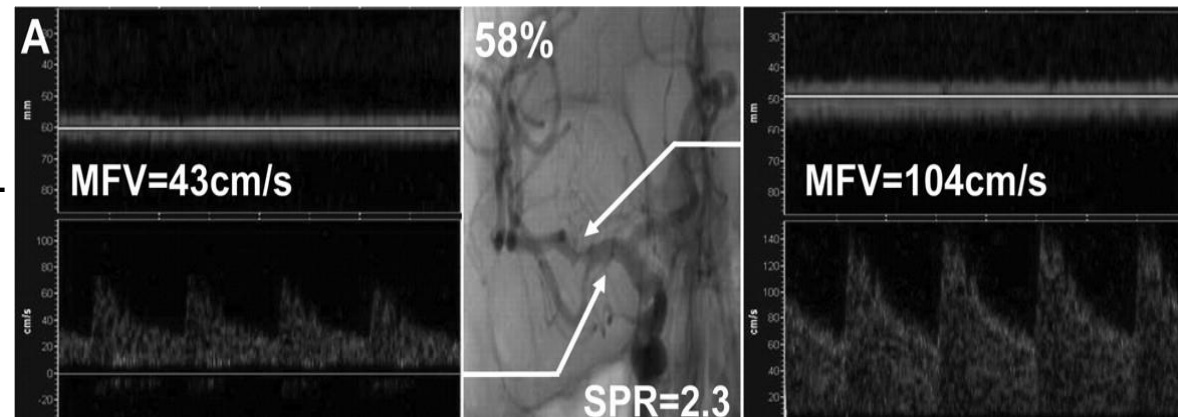
Stenotic-to-Prestenotic ratio (SPR) aumenta l'accuratezza della diagnosi velocitometrica delle stenosi $\geq 50\%$ e $\geq 70\%$

SPR è calcolato dividendo la la più alta velocità media del punto stenotico per la velocità media prestenotica .

Per stenosi all'origine del vaso, veniva usata come velocità prestenotica la velocità controlaterale a pari profondità (segmento omologo controlaterale).

Nel lavoro veniva presa in considerazione anche la velocità bassa

Zhao, Stroke 2011;42:3429-3434



Artery	Stenosis >50% (MFV, SPR)	Stenosis >70% (MFV, SPR)	Diffuse disease or near occlusion (MFV, SPR)
MCA	>100 cm/s, >2	>120 cm/s, >3	<30 cm/s, <1
ACA	>80 cm/s, >2	n.a., >3	<30 cm/s, <1
PCA	>80 cm/s, >2	n.a., >3	<30 cm/s, <1
BA	>90 cm/s, >2	>110 cm/s, >3	<20 cm/s, <1
VA	>90 cm/s, >2	>110 cm/s, >3	<20 cm/s, <1

Optimal combined criteria for $\geq 70\%$ stenosis were: middle cerebral artery >120 cm/s, or stenotic/pro

Zhao, Stroke 2011;42:3429-3434

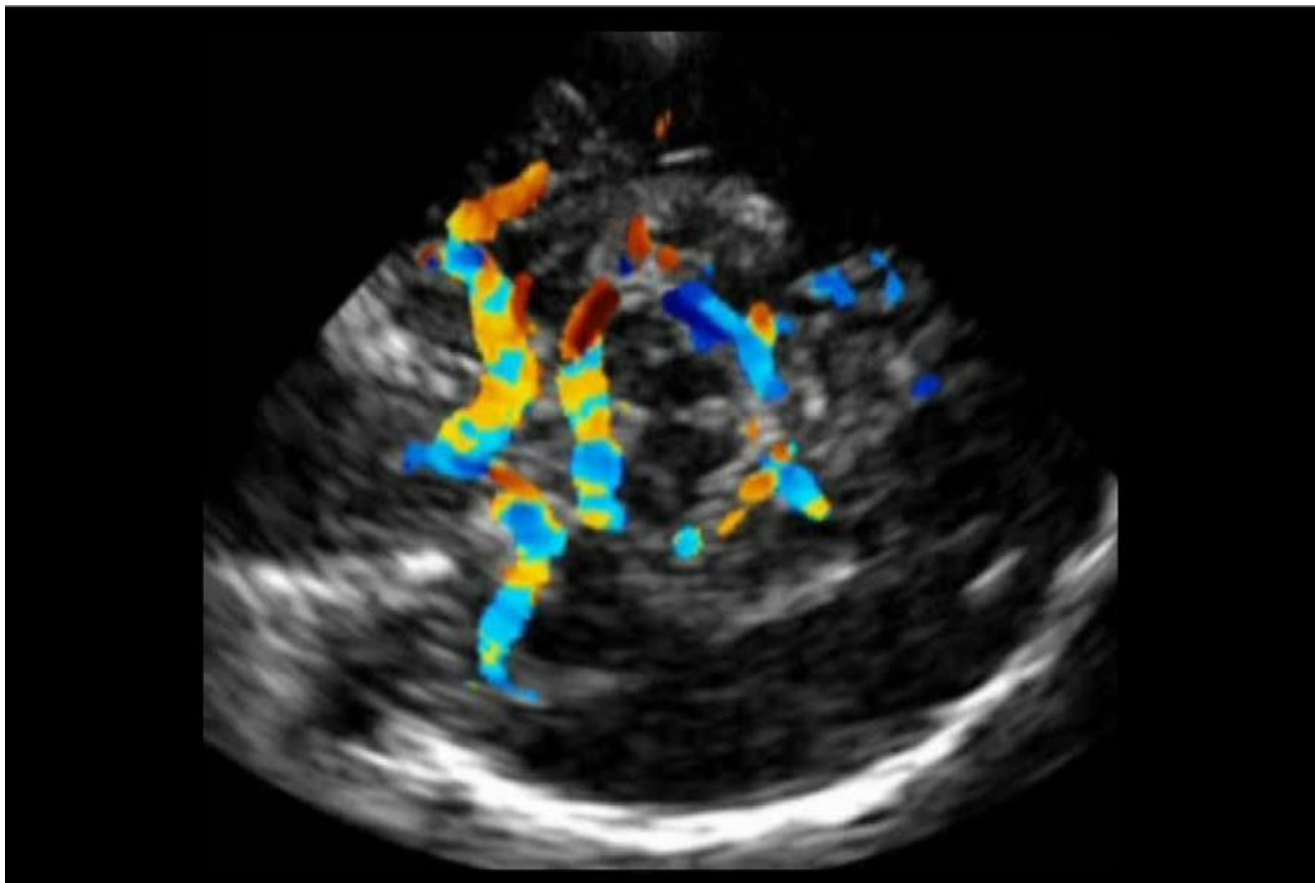


TABLE 2. Ultrasonic Detection of <50% Intracranial Stenoses (n=38) With Angiography as Standard of Reference

		Ultrasound				Angiography	
	PSV Cutoff, cm/s	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %	No.	Mean±SD Degree (Range)
ACA*	≥120	100	99	73	100	5	38±12 (20–47)
MCA	≥155	94	100	95	100	18	36±8 (22–48)
PCA	≥100	100	100	100	100	5	29±12 (13–41)
BA	≥100	100	100	100	100	4	33±4 (29–37)
VA	≥90	100	100	100	100	5	32±6 (25–39)

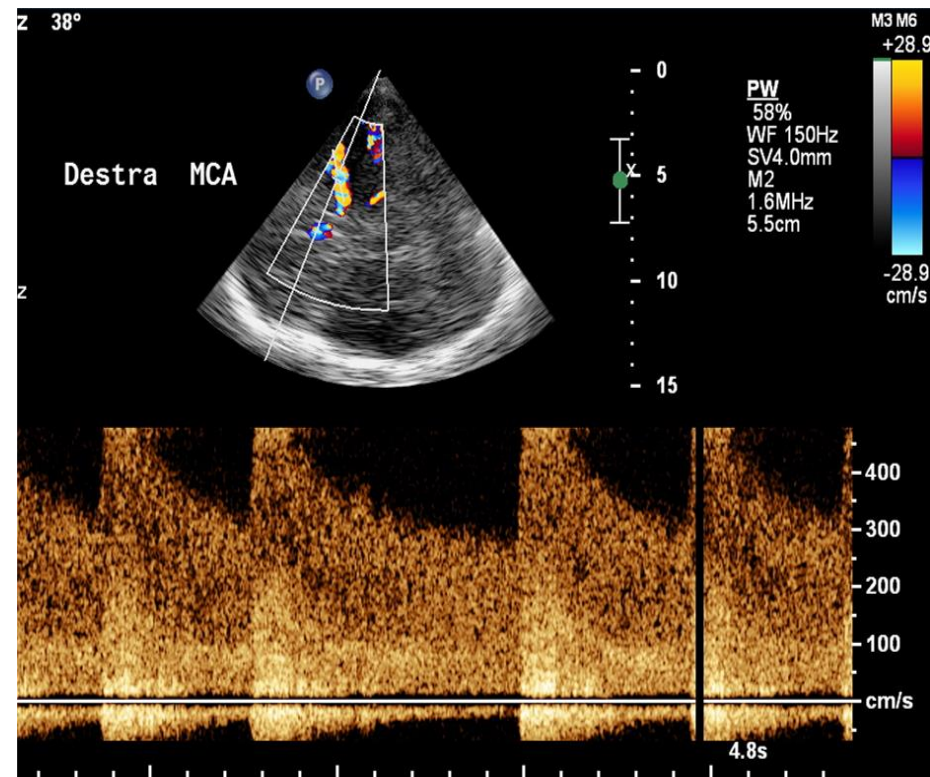
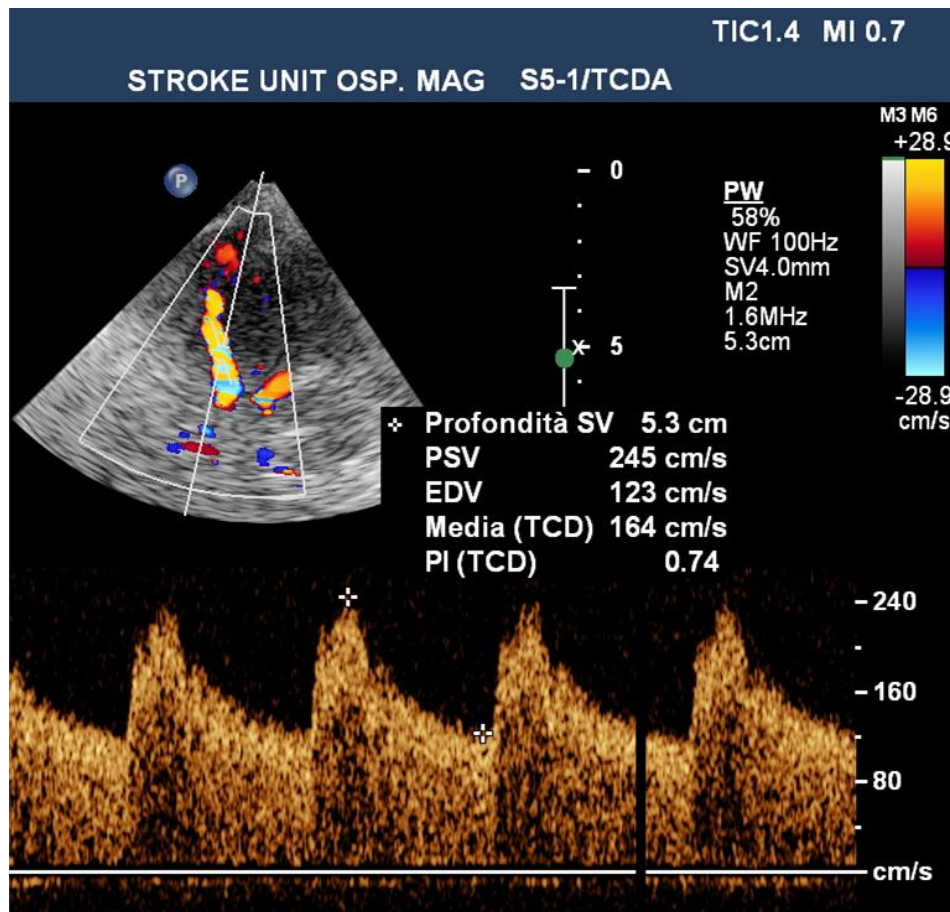
*One stenosed anterior cerebral artery was missed because of an inadequate temporal bone window.

Baumgartner Stroke 1999

TABLE 1. Ultrasonic Detection of $\geq 50\%$ Intracranial Stenoses (n=31) With Angiography as Standard of Reference

	Ultrasound					Angiography	
	PSV Cutoff, cm/s	Sensitivity, %	Specificity, %	Positive Predictive Value, %	Negative Predictive Value, %	No.	Mean \pm SD Degree (Range)
ACA	≥ 155	100	100	100	100	4	60 \pm 8 (52–71)
MCA	≥ 220	100	100	100	100	11	67 \pm 11 (50–80)
PCA	≥ 145	100	100	100	91	10	63 \pm 7 (50–72)
BA	≥ 140	100	100	100	100	3	67 \pm 14 (53–85)
VA	≥ 120	100	100	100	100	3	69 \pm 14 (55–84)

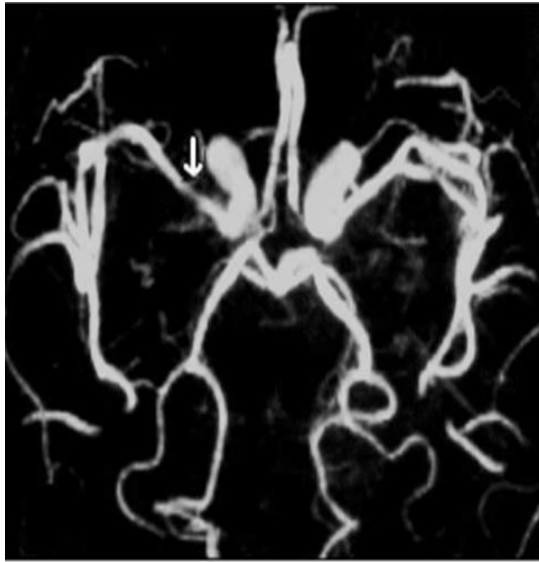
Baumgartner Stroke 1999



Transcranial Color-Coded Sonography for the Detection of Middle Cerebral Artery Stenosis

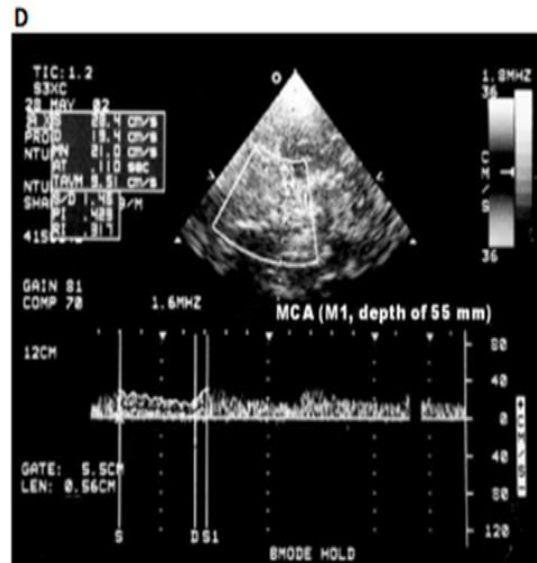
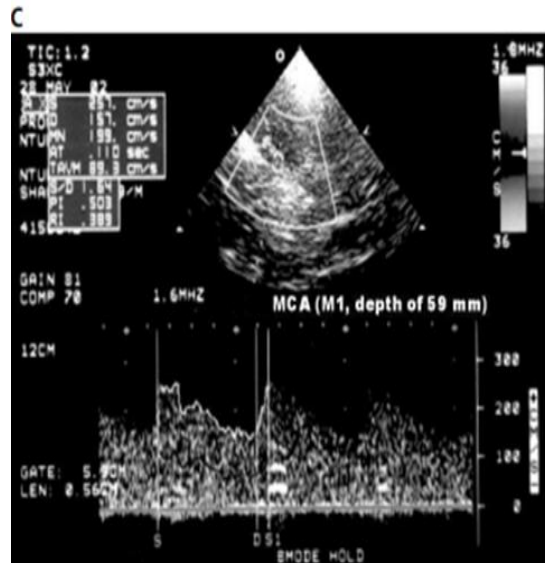
*Sung-Chun Tang, MD, Jiann-Shing Jeng, MD,
Ping-Keung Yip, MD, Chien-Jung Lu, MD,
Bao-Show Hwang, BS, Wen-Hwan Lin, RN,
Hon-Man Liu, MD*

- La stenosi classificata come segue:
- grado 0 da normale a lieve (<50%)
- grado 1, stenosi focale grave (≥50% e lunghezza stenotica all'interno del segmento di prebiforcazione M1)
- grado 2, stenosi diffusa grave (≥50% e lunghezza stenotica superiore al segmento di prebiforcazione M1)
- grado 1 può essere raggiunta se V_s è pari o superiore a 140 cm/s o V_m è pari o superiore a 90 cm/s (sensibilità:83%; specificità:91%).
- grado 2 si ottiene se V_s è inferiore a 50 cm/s o V_s è pari o superiore a 140 cm/s (sensibilità:81,8%; specificità: 92,1%).



Transcranial Color-Coded Sonography for the Detection of Middle Cerebral Artery Stenosis

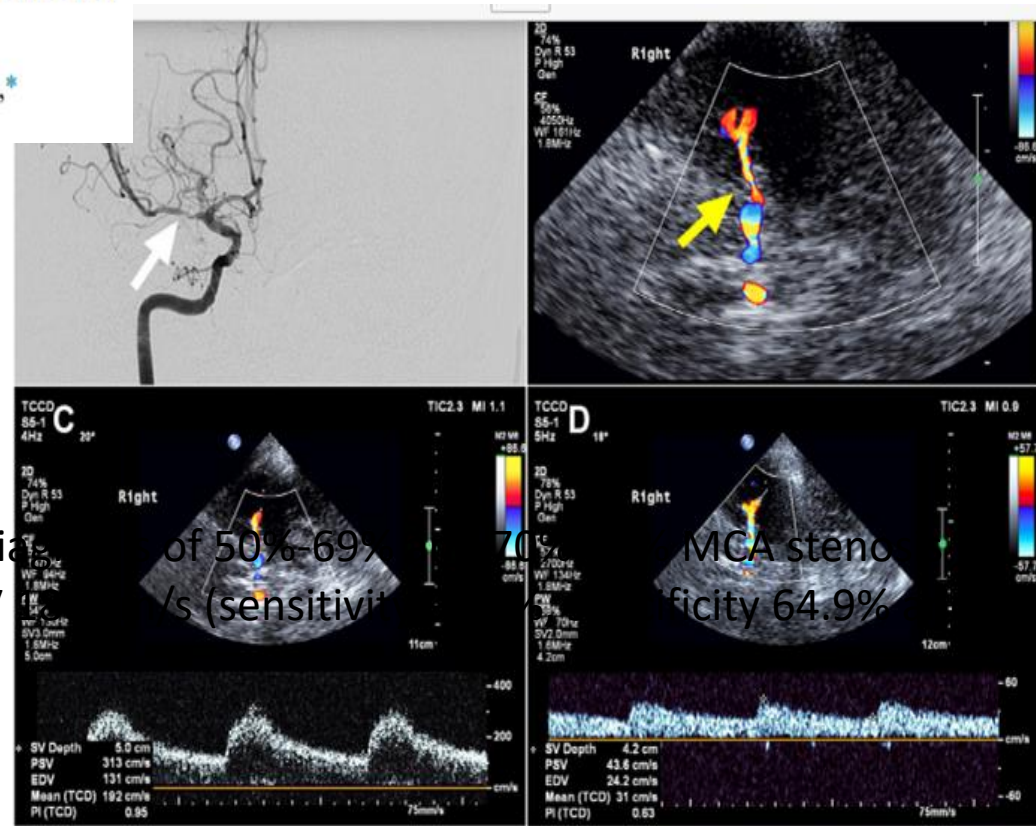
Sung-Chun Tang, MD, Jann-Shing Jeng, MD,
Ping-Keung Yip, MD, Chien-Jung Lu, MD,
Bao-Show Hwang, BS, Wen-Hwan Lin, RN,
Hon-Man Liu, MD



- sebbene le velocità possono aumentare nelle stenosi severe
- possiamo anche riscontrare quadri opposti , con spettri smorzati , basse velocità quando ci troviamo di fronte a lunghi segmenti stenotici o a stenosi diffuse

TRANSCRANIAL COLOR-CODED SONOGRAPHY CRITERIA FOR MODERATE AND SEVERE MIDDLE CEREBRAL ARTERY STENOSIS

RAN LIU,^{*2} JINGZHI LI,^{*1,2} YANG HUA,^{*3} JIE YANG,^{*1} YUE ZHAO,^{*} XIAOJIE TIAN,^{*} YAN MA,[†] and WENBO ZHAO[§]



SDR Parameters SDR, may increase accuracy in diagnosis of 50%-69% MCA stenosis. SDR Criteria for 50%-69% MCA stenosis were : PSV 192 cm/s (sensitivity 70.0%, specificity 64.9%)

Fig. 3. Digital subtraction angiography and transcranial color-coded sonography images of a 56-y-old man with 70%–99% middle cerebral artery (MCA) stenosis. (A) Digital subtraction angiography reveals the 70%–99% stenosis at a local site of the MCA (yellow arrow). (B) Transcranial color-coded sonography reveals a severely narrowing luminal diameter and disturbed blood flow at the stenotic lesion (white arrow). (C) Spectral Doppler waveform reveals high-velocity flow at a stenotic lesion with a peak systolic velocity of 313 cm/s and an end-diastolic velocity of 131 cm/s. (D) Spectral Doppler waveform reveals low-velocity flow at the distal section of the MCA with a peak systolic velocity of 43.6 cm/s and end-diastolic velocity of 24.2 cm/s.

CLASSIFICATION OF INTRACRANIAL STENOSES: DISCREPANCIES BETWEEN TRANSCRANIAL DUPLEX SONOGRAPHY AND COMPUTED TOMOGRAPHY ANGIOGRAPHY

LEON ALEXANDER DANYEL,^{*} SARA HADZIBEGOVIC,^{*} JOSE MANUEL VALDUEZA,[†] ANNA TIETZE,[‡]
SIMON FUCHS,[†] STEPHAN J. SCHREIBER,[§] and FLORIAN CONNOLLY^{*}

^{*}Department of Neurology, University Hospital Charité, Berlin, Germany; [†]Neurological Center, Segeberger Kliniken, Bad Segeberg, Germany; [‡]Department of Neuroradiology, University Hospital Charité, Berlin, Germany; and [§]Department of Neurology, Asklepios Fachklinikum, Brandenburg, Germany

Vessel	Mild stenosis <50%	Moderate stenosis 50%–69%	Severe stenosis ≥70%
M1-MCA	PSV ≥155 cm/s	PSV ≥220 cm/s	PSV ≥220 cm/s or variable PSV Distal M1/M2 post-stenotic FP Raised V_{mean} ipsilateral A1 and/or P2-PCA
M2-MCA	PSV ≥100 cm/s	PSV ≥140 cm/s	PSV ≥140 cm/s or variable PSV Distal M2 post-stenotic FP
A1-ACA	PSV ≥120 cm/s	PSV ≥155 cm/s	PSV ≥155 cm/s or variable PSV A2 post-stenotic FP Raised V_{mean} ipsilateral M1 or P2-PCA and/or contralateral A1
P1-P2-PCA	PSV ≥100 cm/s	PSV ≥145 cm/s	PSV ≥145 cm/s or variable PSV Distal PCA post-stenotic FP Raised V_{mean} ipsilateral M1 and/or A1
BA	PSV ≥100 cm/s	PSV ≥140 cm/s	PSV ≥140 cm/s or variable PSV Distal BA/PCA post-stenotic FP
V4–VA	PSV ≥90 cm/s	PSV ≥120 cm/s	PSV ≥120 cm/s or variable PSV Distal VA/BA post-stenotic FP

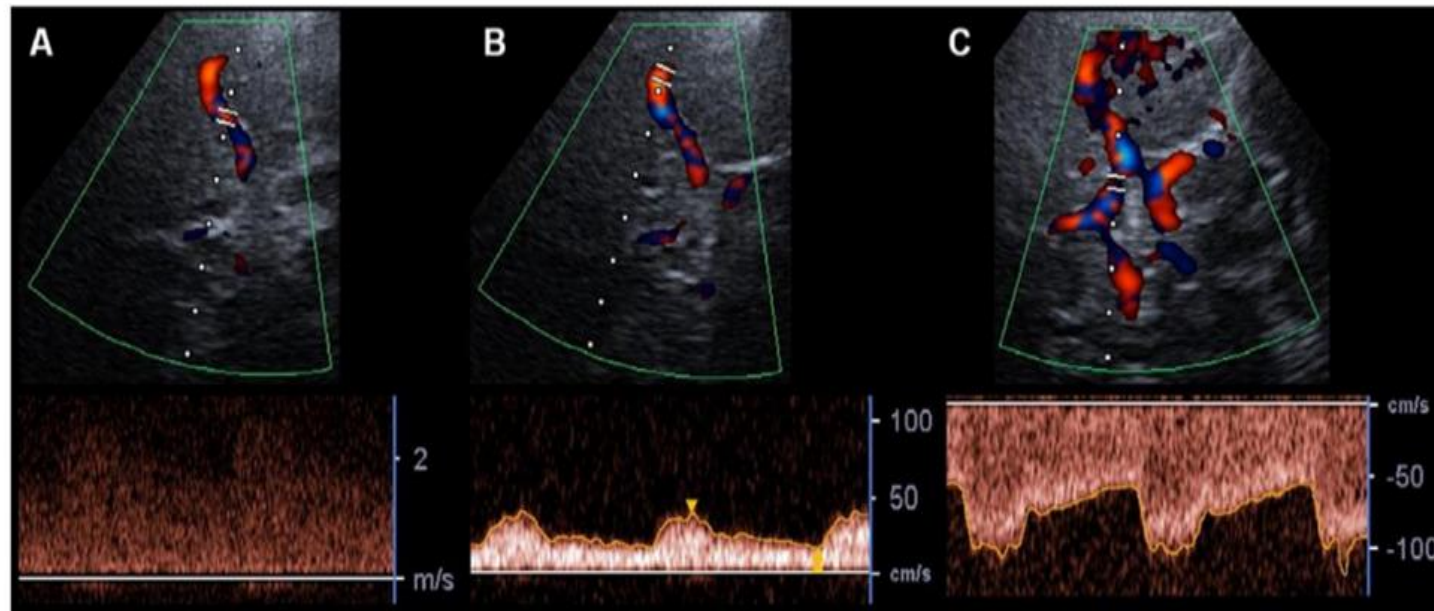


Fig. 11. Transcranial color-coded duplex sonography criteria for severe ISs. Right-sided insonation of M1-MCA segment in the axial midbrain plane reveals turbulent flow and increased peak systolic flow velocity ≥ 220 cm/s (a). Post-stenotic flow pattern is observed in the ipsilateral, distal MCA, suggesting severe-grade IS (b). Increase in ipsilateral peak systolic flow velocity in the A1-ACA segment (right A1-ACA: 115 cm/s; left (unaffected) A1-ACA: 60 cm/s, not shown) indicates collateral flow (c). ACA = anterior cerebral artery; IS = intracranial stenosis; MCA = middle cerebral artery.

• Il circolo intracranico e' un servosistema aperto che permette il compenso volumetrico in relazione alle necessita' per la ricerca costante di un equilibrio di portata

• Collaterali primari : AcoA, AcoP

• Collaterali secondari : oftalmica e circoli leptomeningei

• Microcircolo

•

STROKE UNIT OSP. MAG S5-1/TCDA

FR 18Hz 38°
P1

2D
62%
C 62
P Med.
Pen.

CF
63%
2700Hz
WF 148Hz
Alto

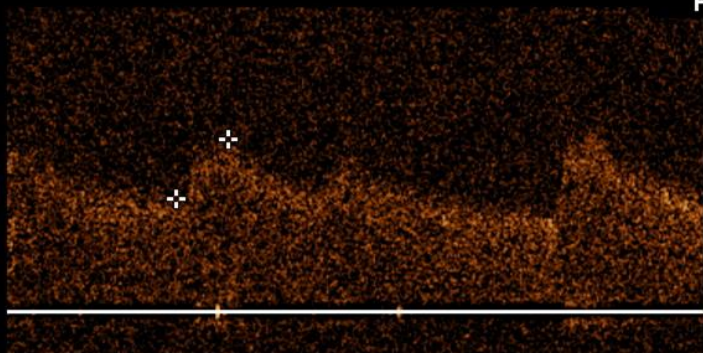
MCA Sinistra



PW
58%
WF 175Hz
SV4.0mm
M2
1.6MHz
5.8cm

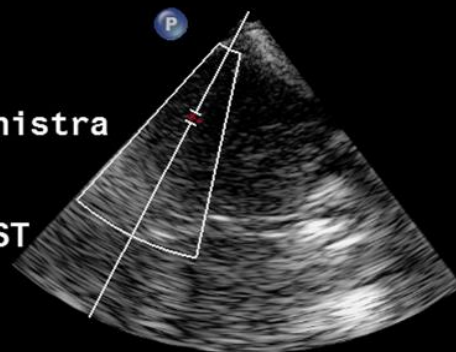


✦ Profondità SV 5.8 cm
PSV 522 cm/s
EDV 342 cm/s
Media (TCD) 402 cm/s
PI (TCD) 0.45

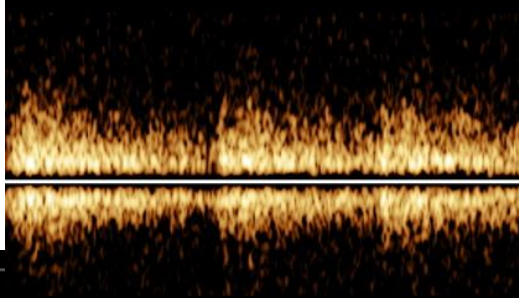


MCA Sinistra

POST



PW
58%
WF 100Hz
SV4.0mm
M2
1.6MHz
4.2cm



-60
-40
-20
-cm/s
-20
-40

PHILIPS

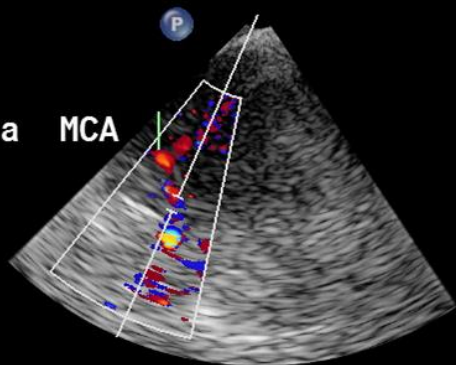
R 22Hz

2%
62
Med.
en.
E
5%
575Hz
F 141Hz
ed.

STROKE UNIT OSP. MAG S5-1/TCDA

TIC1.4

Sinistra MCA

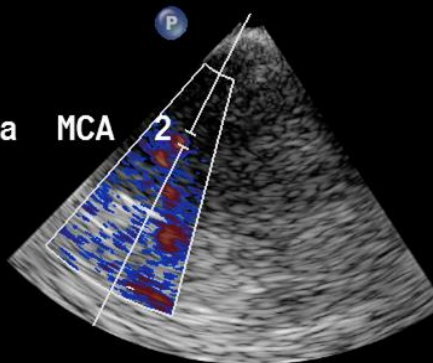


PW
86%
WF 100Hz
SV4.0mm
M2
1.6MHz
5.3cm

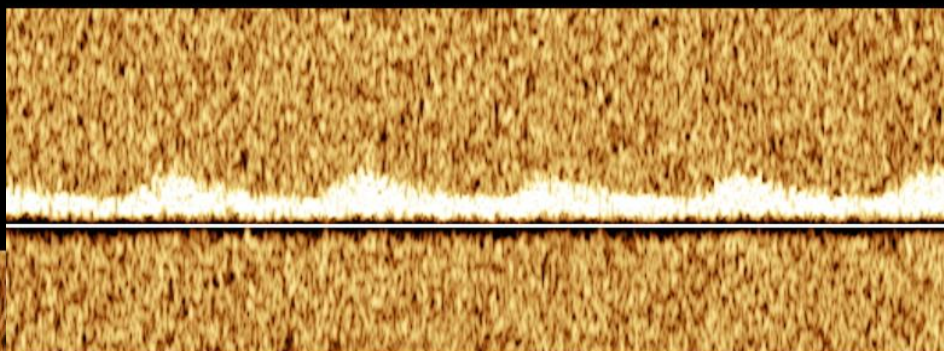
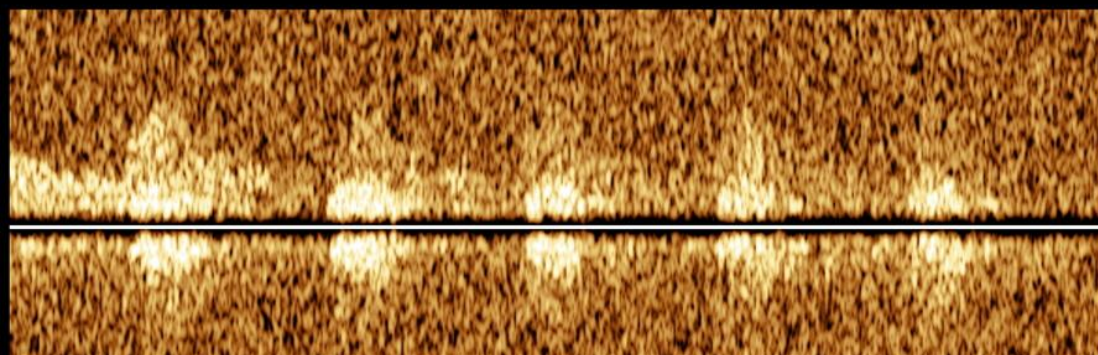
STROKE UNIT OSP. MAG S5-1/TCDA

TIC2.0

Sinistra MCA



PW
96%
WF 100Hz
SV4.0mm
M2
1.6MHz
3.7cm



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 Razumovsky, 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

Neurosonology research group of the
world federation of neurology,
multiparametric criteria

STROKE 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
Main criteria							
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
Additional criteria							
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.

Criterion 6: "Reduced" means side-to-side difference, mainly in diastolic velocity.

Modified from reference 11.

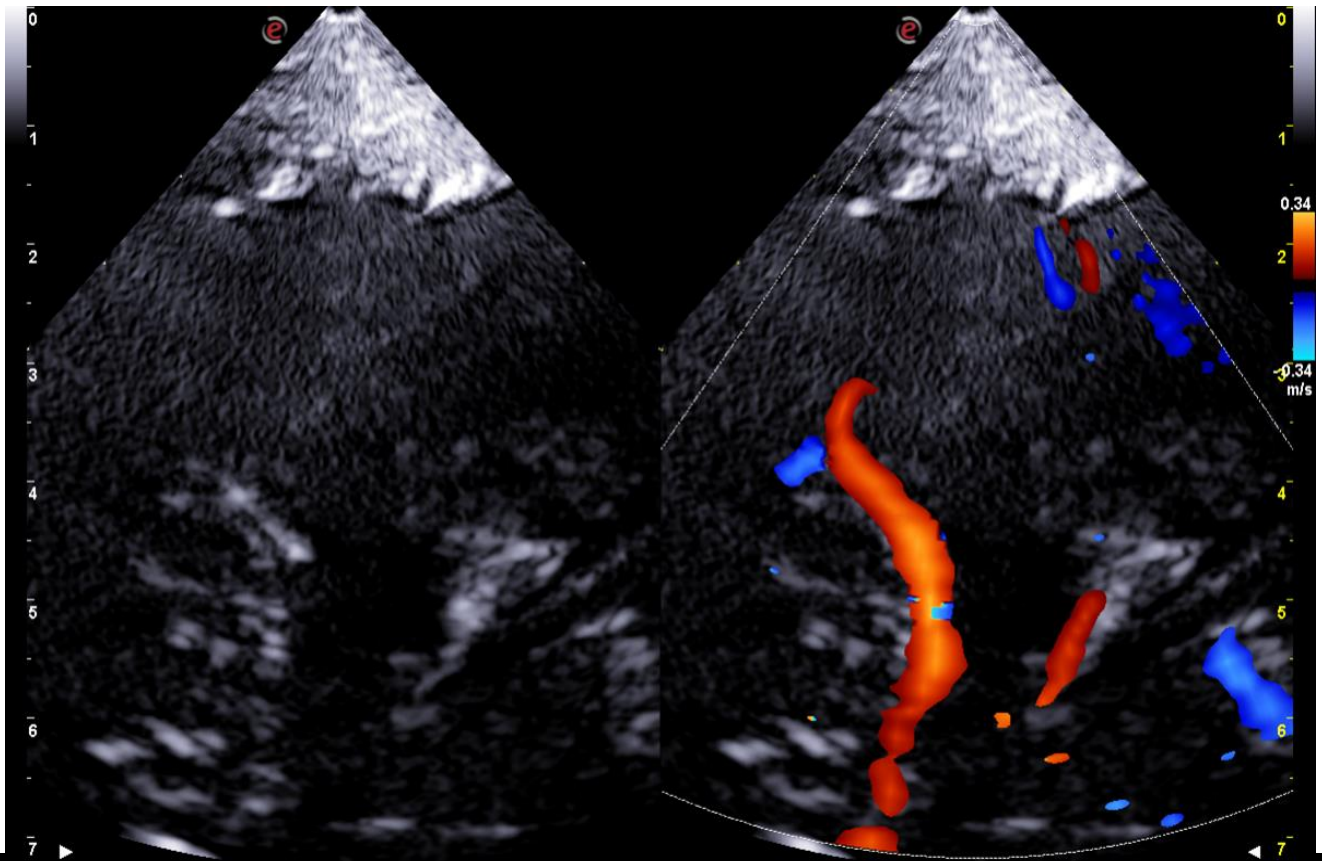
CCA indicates common carotid artery; ICA, internal carotid artery; NA, not applicable; PSV, peak systolic velocity.

Come passare dalla velocità alla morfologia con gli ultrasuoni:

TCCD-AHUSE TCCD Advanced Haemodynamic

Ultrasound Evaluation

Color Mode e
Doppler pulsato
hanno filtri che
eliminano il
rumore e gli



Le tecniche di AHUSE hanno caratteristiche specifiche con alta capacità di separare il segnale emodinamico da quello iperecogeno con possibilità di cogliere i segnali a bassa velocità e differenziarli dagli artefatti di movimento.

In pratica AHUSE è più sensibile

MicroV Technology to Improve Transcranial Color Coded Doppler Examinations

Giovanni Malferrari, Giuseppe Pulito, Attilia Maria Pizzini, Nicola Carraro, Giorgio Meneghetti, Enzo Sanzaro, Patrizio Prati, Antonio Siniscalchi, Daniela Monaco

Stroke Unit, Neurology Unit, Azienda Unità Sanitaria Locale – IRCCS, Reggio Emilia (RE), Italy (GM); Department of Anaesthesia and Resuscitation Service – Vito Fazzi Hospital, Lecce (LE), Italy (GP); Department of Medicine – Maggiore Hospital, Bologna (BO), Italy (AMP); Neurology Clinic, Department of Head and Neck – Integrated University Healthcare Company, Trieste (TS), Italy (NC); Department of Neurosciences, University of Padua School of Medicine, Padova, (PD) Italy (GM); Stroke Unit, Department of Medicine – Umberto I Hospital, Siracusa (SR), Italy (ES); Neurology Unit – CIDIMU, Torino (TO), Italy (PP); Department of Neurology, Annunziata Hospital, Cosenza (CS), Italy (AS); and Stroke Unit, Department of Medicine – Spirito Santo Hospital, Pescara (PE), Italy (DM).

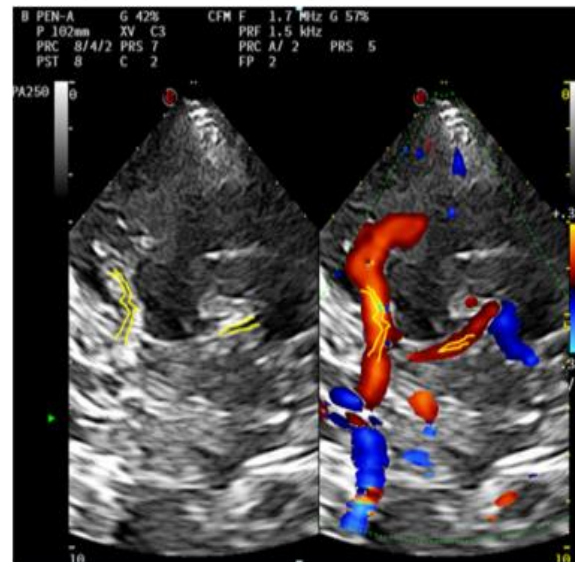


Fig 5. Transcranial Color Coded Doppler, left temporal window, axial access. Left: B-Mode imaging. Typical morphology of the proximal middle cerebral artery (M1) and proximal posterior cerebral artery (P1) can be clearly detected. Right: Color Coded Doppler study. B-mode images are overestimated versus to the real diameter of the vessel lumen.

AHUSE

E' utile nei casi in cui vi sia

- Sovra-saturazione del segnale Doppler che non ci fa esaminare bene la morfologia del vaso.

- Per esaminare basse velocità e vasi profondi e piccoli

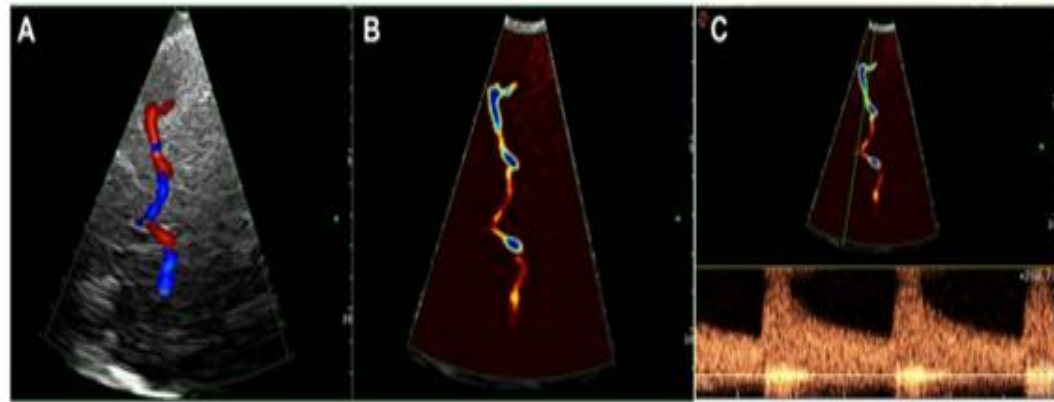
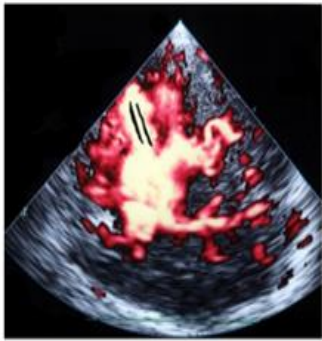


Fig 12. Stenosis of the middle cerebral artery and its first and second division (M1-M2) tracts. From left to right: (A) Transcranial Color Coded Doppler visualization of the M1-M2, showing an aliasing effect. (B) Reduction in vessel lumen with MicroV visualization in the same M1-M2 vessel. (C) Corresponding hemodynamic acceleration in Doppler Spectrum.

STUDIO SPEEDY

UOC Neurologia Ospedale Maggiore Bologna

UOC D.A.I. di Neuroscienze e Riabilitazione - U.O. Clinica Neurologica,
Azienda Ospedaliero-Universitaria 'S. Anna' di Fe

Dr. Giovanni Malferrari

Speedy si prefigge primariamente di ricercare e definire con tecniche di Advanced Power la sede, la lunghezza (<5 mm o ≥ 5 mm) la presenza di stenosi singola o multipla, la superficie regolare o irregolare del vaso arterioso intracranico

Ulteriori obiettivi (secondari) consisteranno nel confronto dei dati ottenuti con US



In conclusione

.La caratterizzazione morfologica della ateromasi intracranica può avere un valore prognostico sul rischio cerebrovascolare (più alto nelle stenosi più lunghe di 5 mm) così come il monitoraggio seriato (la rapidità della progressione incide sul rischio, specialmente al superamento del grado di

Grazie per l'attenzione

