



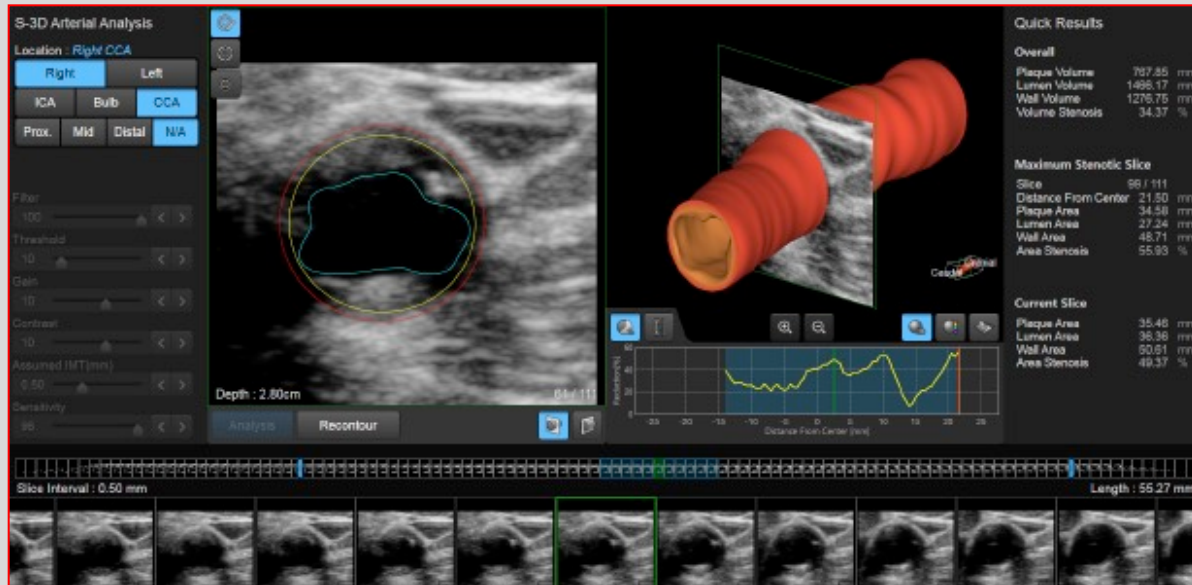
Roma, 7-10 novembre 2019



ITALIAN CHAPTER



Studio della placca aterosclerotica e dei flussi emodinamicamente significativi





Roma, 7-10 novembre 2019

Conflitti di interesse



Ai sensi dell'art. 4.5 su “Docenti e moderatori dell'evento”, pag. 8 del Manuale Nazionale di Accreditamento per l'erogazione di eventi ECM del 06/12/2018, dichiaro che negli ultimi 2 anni **non** ho avuto rapporti diretti di finanziamento con soggetti portatori di interessi commerciali in campo sanitario.



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- **75% of men and 62% of women aged 65 yrs have a carotid artery narrowing**
- **10-15% of ischemic stroke and TIA in the territory of a severely stenosed ICA**
Li, Stroke 1994; Neurology 1994
- **Stroke: hemodynamic effects due to area reduction, complicate structure and surface creating emboli or occlusion**
Stroke 2012



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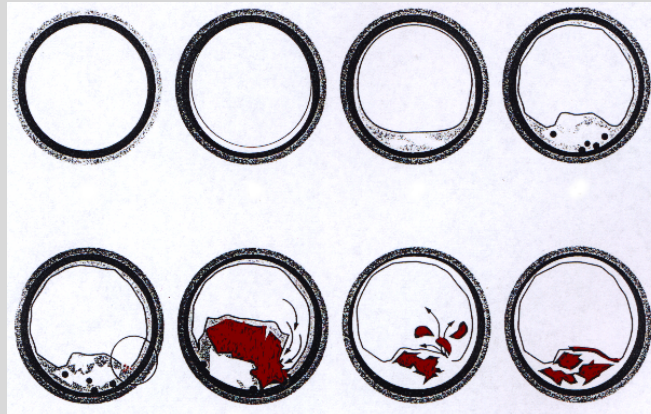
Ultrasonography of carotid stenosis



Degree of stenosis: decision between an invasive or non-invasive treatment of extracranial ICA stenoses

Rapid increase in the degree of stenosis: important indicator of an increased risk of stroke in asymptomatic stenosis

Saba, Cardiovascular Intervent Radiol 2014, Clinical Neurosciences and Mental Health 2014





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Internal carotid artery stenosis: rate of progression

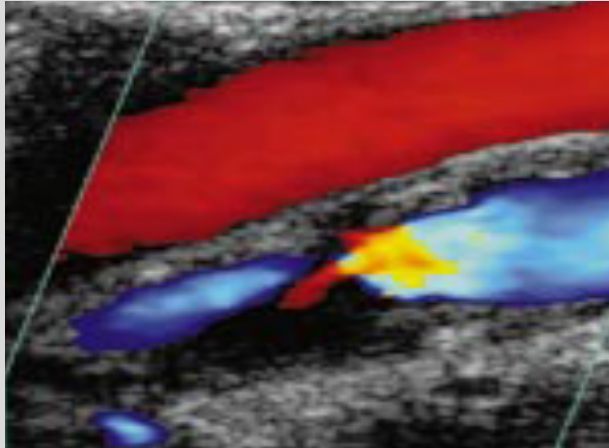


3%	incidenza di progressione/anno
15%	progressione media della stenosi
16%	nei p. con stenosi 25-50%
24%	nei p. con stenosi 50-70%

Liapis et al. Eur J Vasc Endovasc Surg 2000;19:111-117



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Le stenosi della carotide extra-cranica causano circa il 15-30% degli ictus ischemici

L'incidenza annuale di ictus cresce con l'aumentare della stenosi carotidea

(NASCET 1991)

% stenosi	incidenza ictus/anno
< 30	0.4%
70-79	10%
80-89	14%
> 89	17%



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La placca carotidea “asintomatica” è predittiva di eventi vascolari ?



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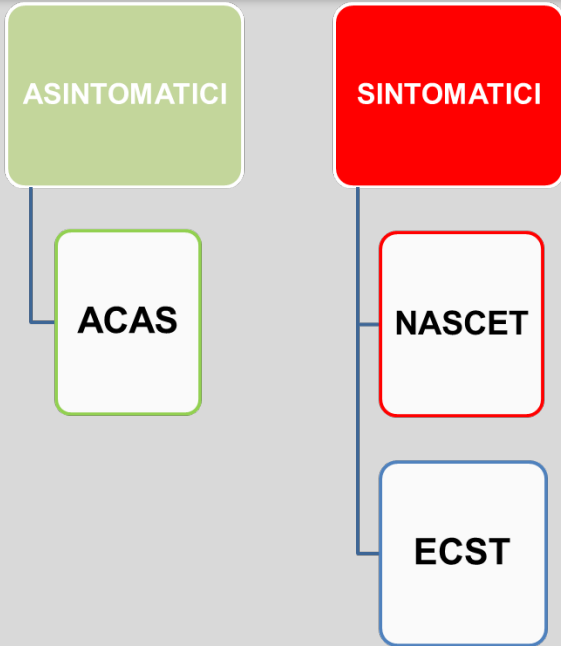
Frequenza annuale degli eventi				
Stenosi %	TIA	Ictus	Eventi cardiaci	Morte Vascolare
25-50%	1	1.3	2.7	1.8
50-75%	3	1.3	6.6	3.3
> 75%	7.2	3.3	8.3	6.5

- Norris (Stroke 1991) mediante studio EcoDoppler in una coorte di 696 paz.
- “European Carotid Surgery Trialists Cooperative Group” Lancet 1995.



...L'ORIGINE DEL DIBATTITO CLASSIFICATIVO...

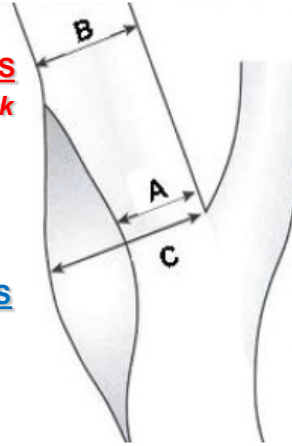
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**NASCET ED ECST DEFINISCONO LA
 QUANTIFICAZIONE % DELLA STENOSI
 DELL'ICA IN MANIERA OGGETTIVAMENTE
 DIFFERENTE**

DISTAL STENOSIS
Haemodynamic risk

LOCAL STENOSIS
Occlusion risk



NASCET	ECST
30	65
40	70
50	75
60	80
70	85
80	91
90	97

Figure 1. Different methods for grading carotid stenosis. Differentiation between the European Carotid Surgery Trial (ECST) and the North American Symptomatic Carotid Endarterectomy Trial (NASCET).

ECST: Percentage of local diameter reduction: the degree of stenosis (A) is determined in relation to the original lumen (C) of the ICA (A vs. C).

NASCET: Percentage of distal diameter reduction: the degree of stenosis (A) is determined in relation to the distal lumen (B) of the ICA (A vs. B).

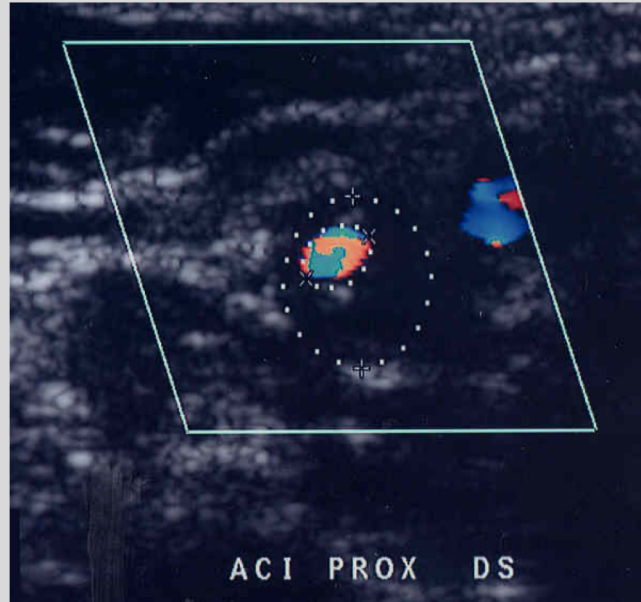
NASCET NEJM 1991
 ECST LANCET 1999
 ACAS JAMA 1995



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Valutazione eco-color del grado di stenosi in sezione assiale



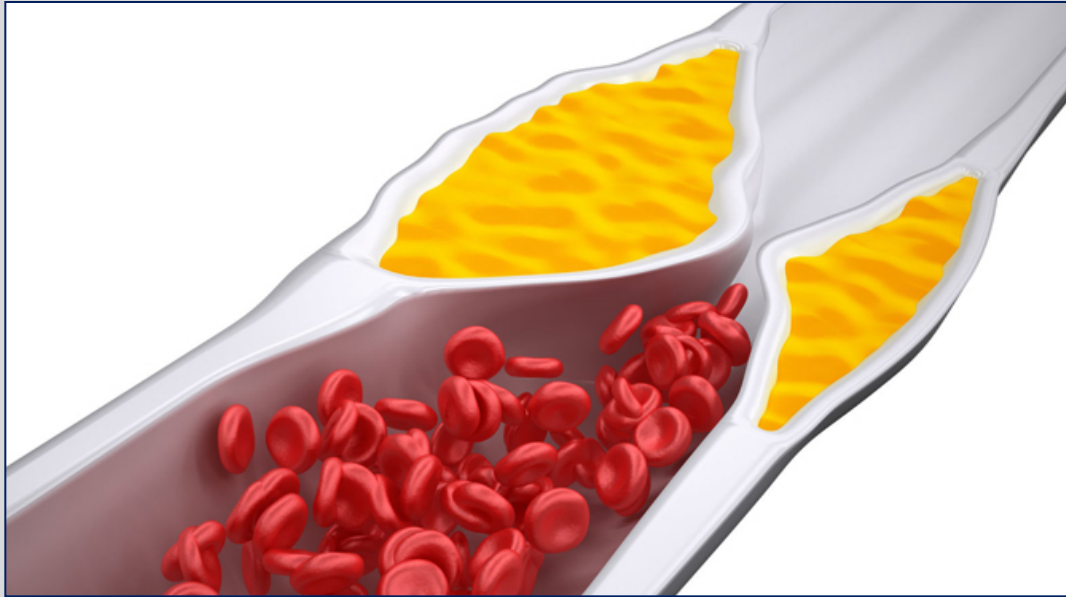


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L'entità della stenosi può essere l'unico elemento predittivo di rischio di stroke?



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Grant EG 2000, Grant EG 2003.



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Less emphasis on the severity of stenosis and more emphasis on morphology and functional characteristics of the “instable plaque”

Raccomandazione 5.3.b

Forte a favore

Lo studio ecocolordoppler dei tronchi sovra-aortici è raccomandato nella valutazione della stenosi carotidea ai fini della scelta terapeutica in senso chirurgico, quale indagine conclusiva e quindi sostitutiva dell'angiografia, dopo averne verificato l'accuratezza, eventualmente completata con i dati di altre tecniche non invasive di neuroimmagine (angio-RM; angio-TC).

Sintesi 5.3.i

I mezzi di contrasto ecografici possono meglio caratterizzare la placca carotidea a rischio embolico.

Sintesi 5.3.j

Nei pazienti con stenosi carotidea il monitoraggio transcranico dei microemboli (monitoraggio in corrispondenza dell'arteria cerebrale media per la durata di un'ora) contribuisce alla stratificazione del rischio di macro-embolia.



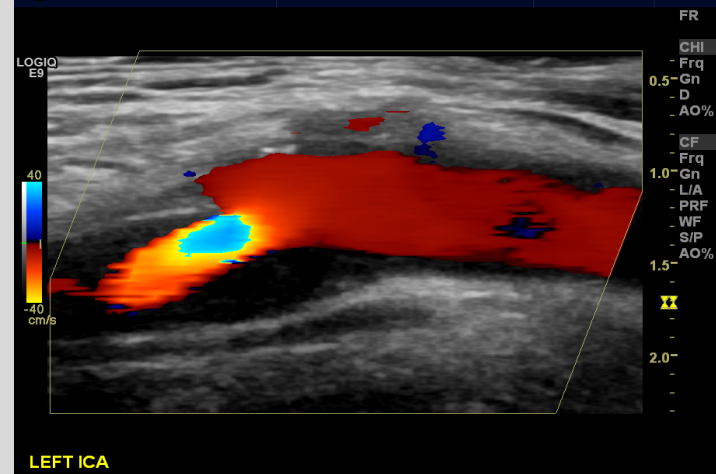
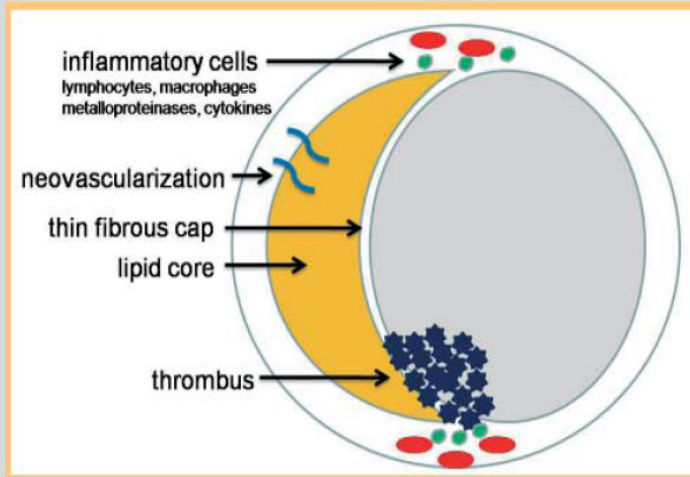


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Definitions of Vulnerable Plaque



It is a plaque, often with low-grade of stenosis, thrombosis-prone with a high probability of undergoing rapid progression or erosion or rupture.

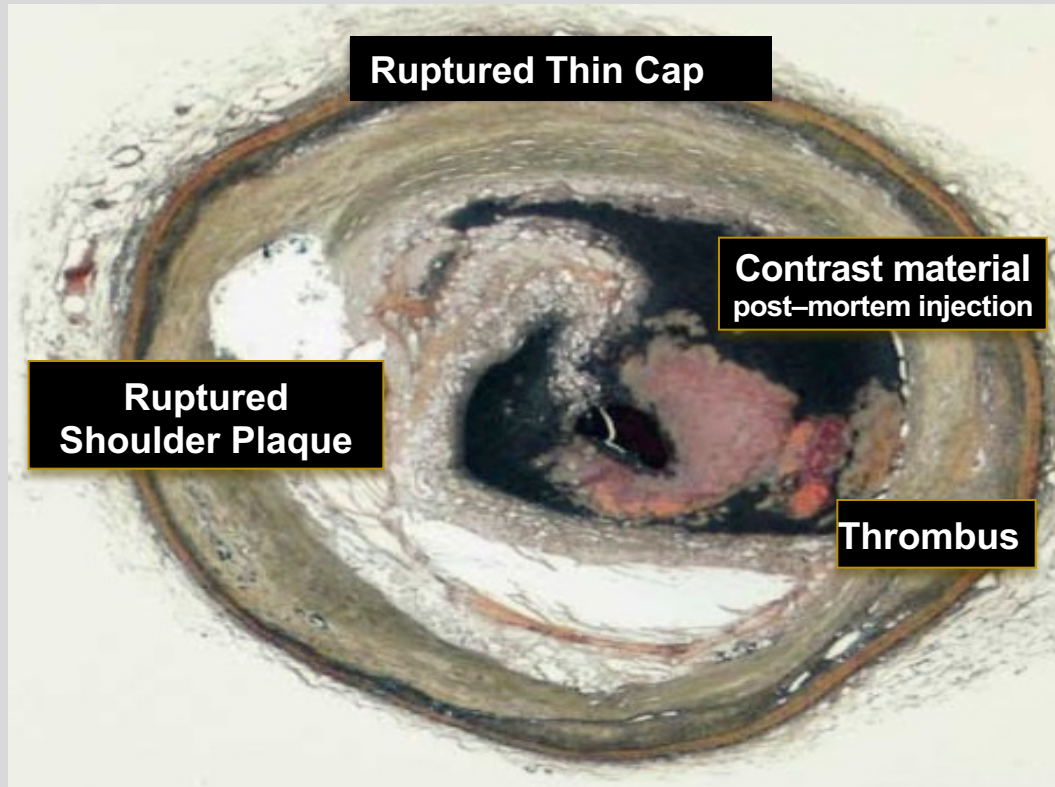




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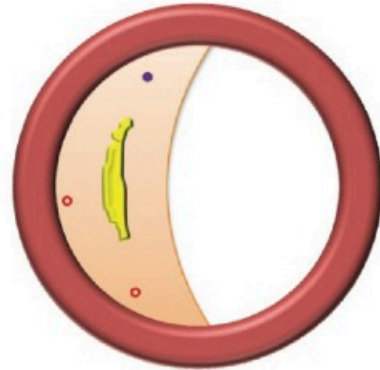




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Stable Plaque

Vulnerable Plaque



Small lipid core

Thick fibrous cap

Low macrophage content

Low microvessel density

No Intraplaque hemorrhage

No cap rupture, no superimposed thrombus



Large lipid core

Thin fibrous cup

High macrophage content

High microvessel density

Intraplaque hemorrhage

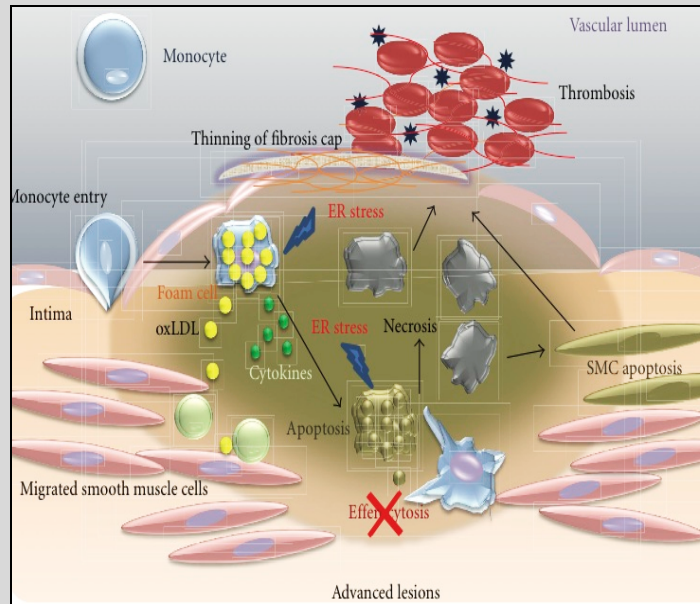
Cap rupture and thrombus



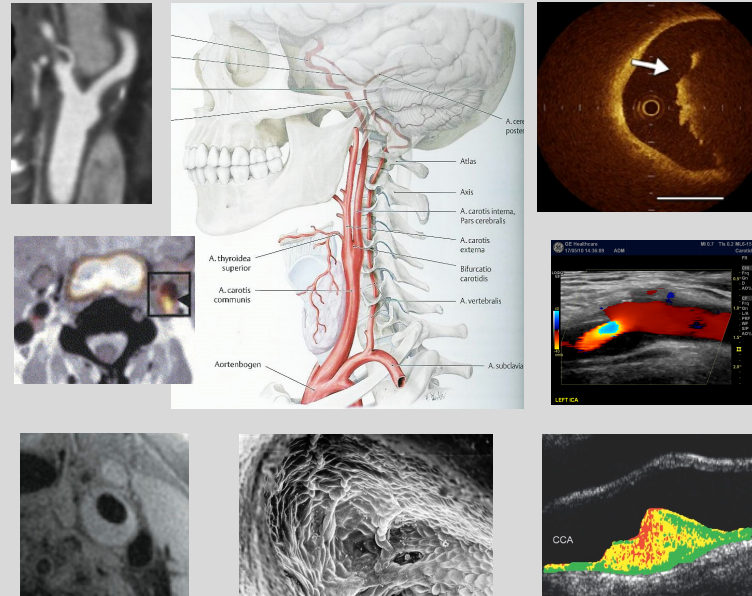
Markers of Vulnerability

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Biological Markers



Imaging





Beyond the stenosis: evaluating carotid plaque

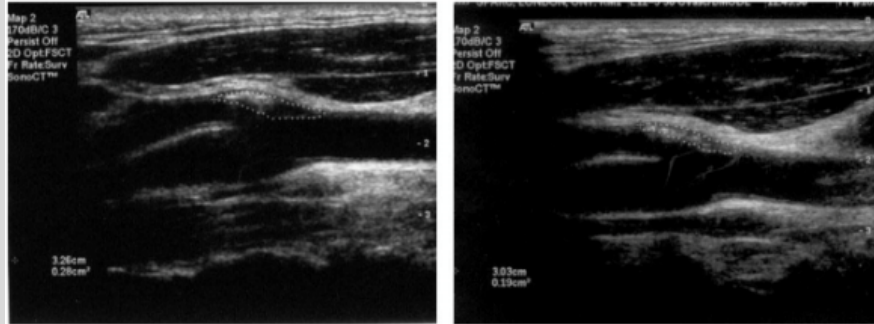


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Total plaque area: strongly predicts risk of stroke, IMA and death

Powerful measurement
of medical therapy response



Plaques progress along the artery wall, in the axis of flow 2.4 times faster than they thicken

Spence, Stroke 2010; Graebe Ultrasound Med Biol 2014

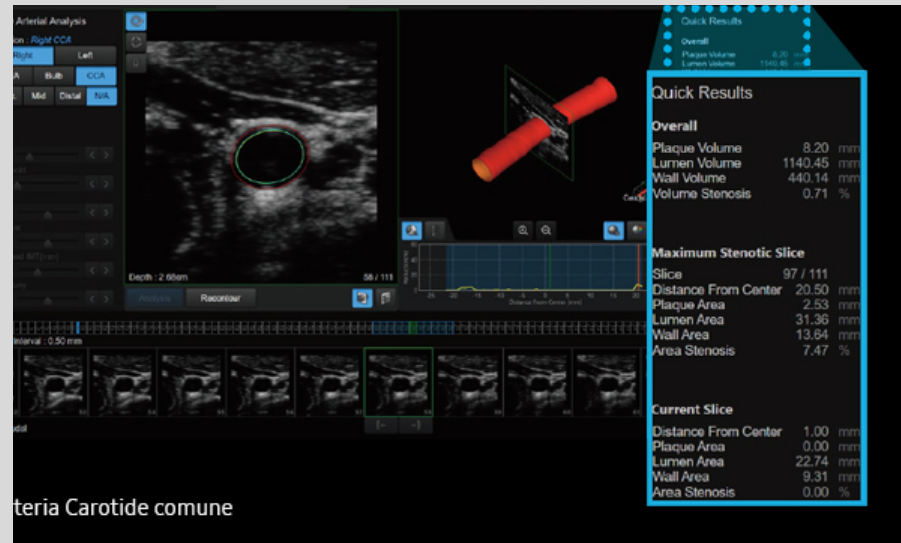


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Plaque volume: is a critical determinant of **vulnerability**, better describing atherosclerosis disease severity than stenosis degree



3D US quantification methods of the carotid plaque volume: systematic inter-observer differences

4D US evaluation for plaque surface movement: further studies are needed

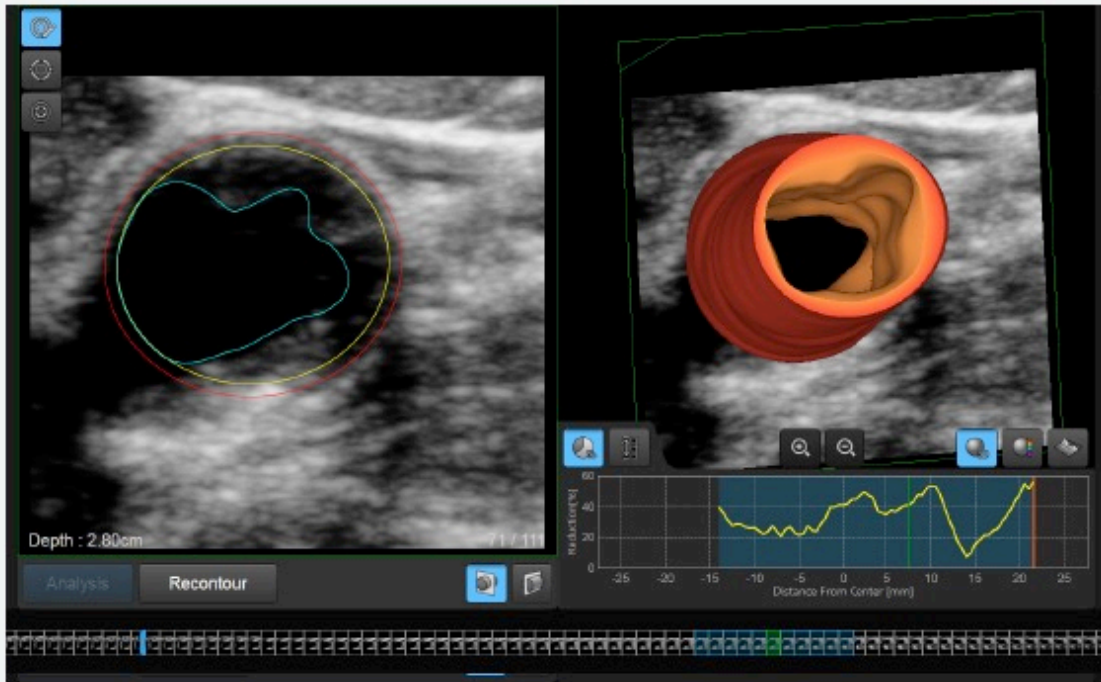
Pelz, Plos One 2017



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Quick Results

Overall

Plaque Volume	755.80	mm ³
Lumen Volume	888.52	mm ³
Wall Volume	398.63	mm ³
Volume Reduction	45.96	%

Maximum Stenotic Slice

Slice	26 / 111	
Distance from center	-15.00	mm
Plaque Area	43.97	mm ²
Lumen Area	7.04	mm ²
Wall Area	13.45	mm ²
Area Reduction	86.20	%

Current Slice

Plaque Area	46.66	mm ²
Lumen Area	24.09	mm ²
Wall Area	15.74	mm ²
Area Reduction	65.95	%



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Limitation of
2D ultrasonography

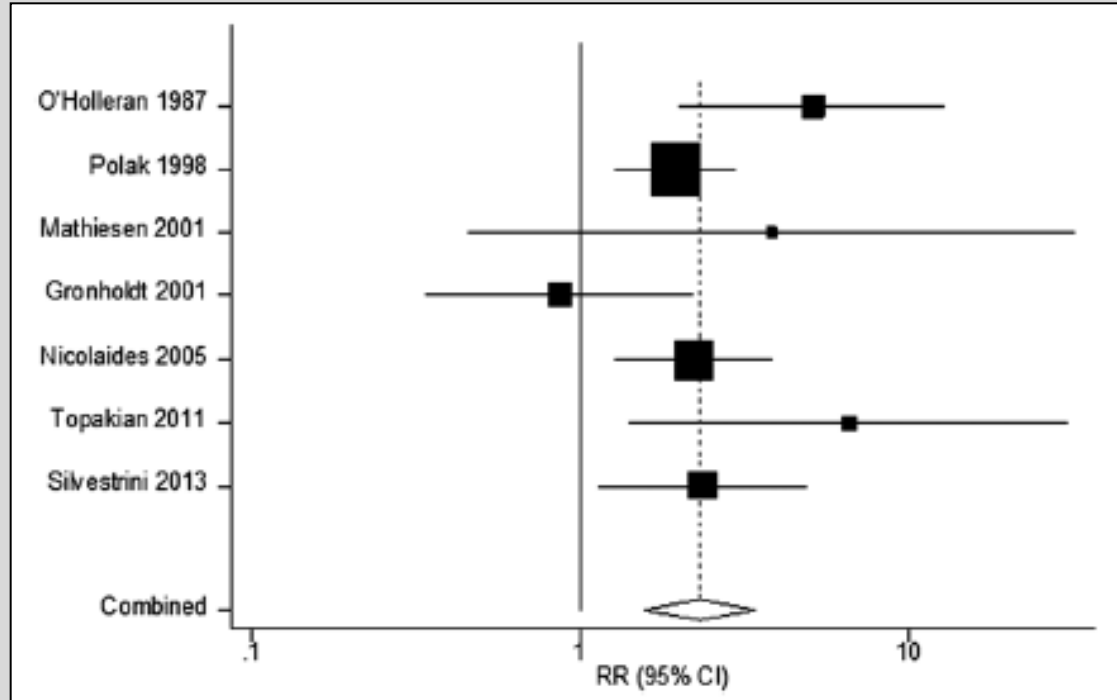
However, the existing 2D ultrasonography



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Systematic review and meta-analysis, 7 studies, 7500 pts:

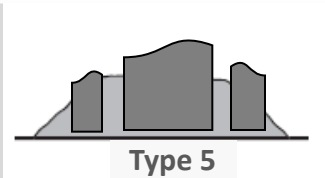
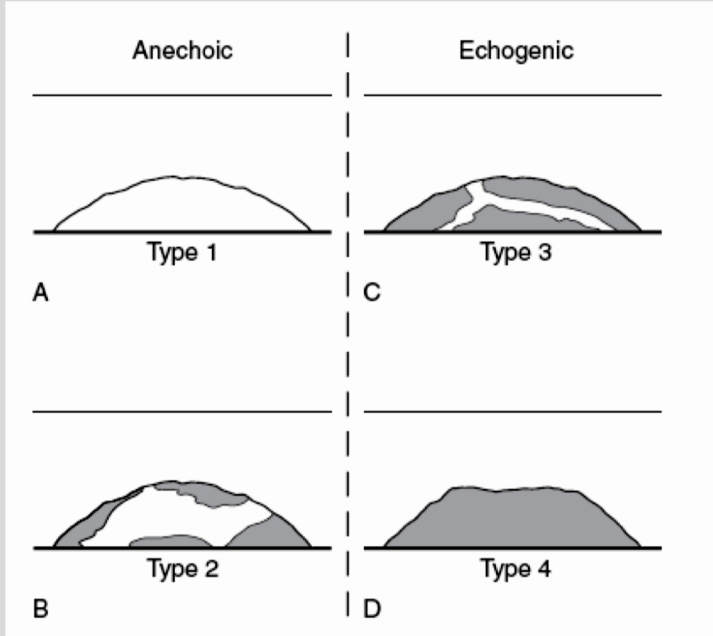
relationship between echolucent asymptomatic plaques and **risk of future ipsilateral stroke** across all stenosis severity: (0% to 99%; relative risk 2.31; 95%CI 1.58-3.39; $P < 0.001$)





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CLASSIFICAZIONE DI GRAY-WEALE



TIPO 1 Uniformemente ipo-aneecogena: meno del 15% dell'area è occupato da aree iperecogene.

TIPO 2 Prevalentemente ipo-aneecogena: aree iperecogene dal 15 al 50%.

TIPO 3: Prevalentemente ecogena: le aree iperecogene dal 50-85%.

TIPO 4: Uniformemente ecogena: aree iperecogene più dell'85%.

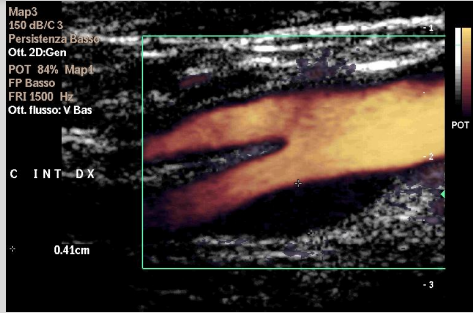
TIPO 5: Superficie calcifica > 15%, con "cono d'ombra" che impedisce di visualizzare la placca.



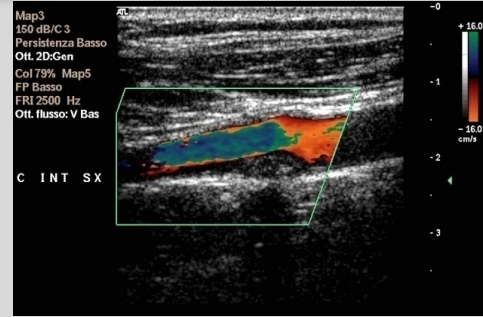
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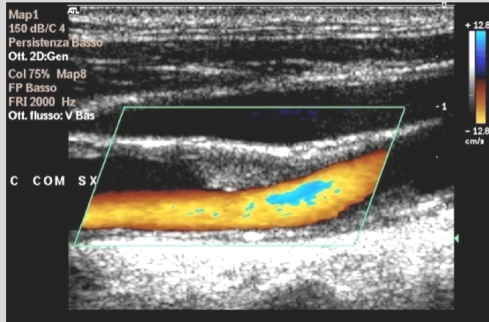
TIPO 1



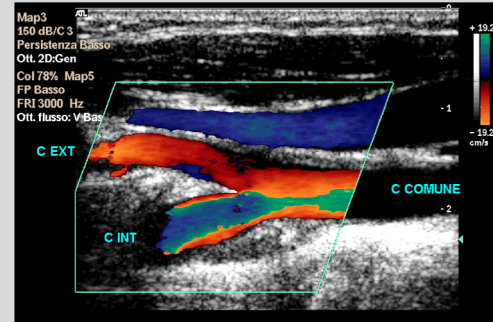
TIPO 2



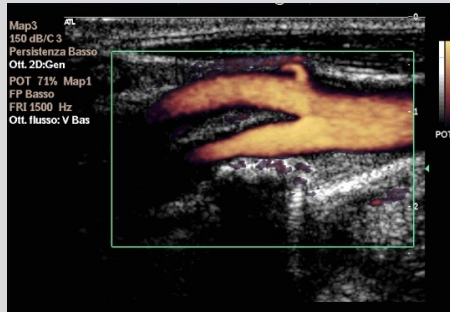
TIPO 3



TIPO 4



TIPO 5





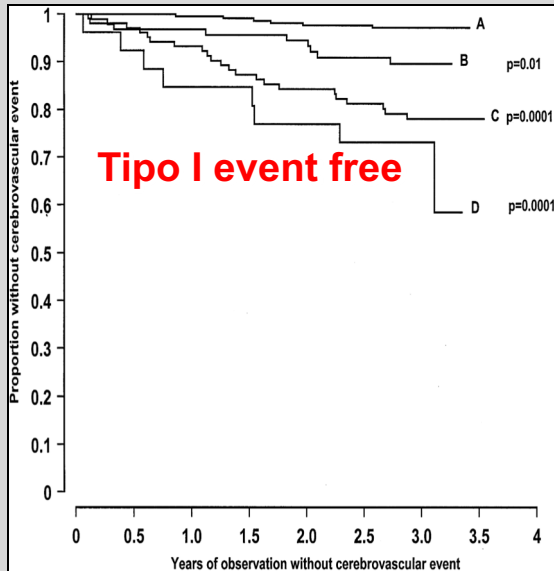
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Echolucent plaques are associated with high risk of ischemic cerebrovascular events in carotid stenosis



The Tromsø Study (in [sami Romsa](#))

EB Mathiesen, Circulation 2001



Gray Weale	Eventi CV a 3 anni
Tipo I: echolucent	29.6%
Tipo II: predominantly echolucent	21.4%
Tipo III: predominantly echogenic	9.7%
Tipo IV: echogenic	9.5%





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Modified Gray-Weale scale:

- 1: anechogenic
- 2: predominantly anechogenic with <25% echogenic areas
- 3: predominantly hyperechogenic with <25% echolucency
- 4: uniformly dense echogenic
- 5: calcified plaque

Br J Surg 1997

Gray scale Median (GSM):

to improve detection of plaque components, expressed in gray-tone range 0-256 (black-white)

Eur J Vasc Endovasc Surg
2012

Ultrasound-determined **carotid plaque echolucency** provides predictive information and **reflects the plaque composition**

Gupta, Stroke 2014



ANALISI DENSITOMETRICA DELLA PLACCA



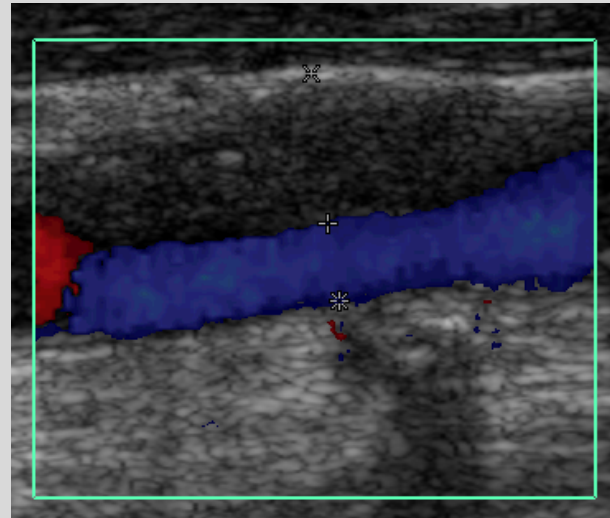
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- Immagine B-mode normalizzata secondo due riferimenti: sangue e avventizia
- **Median Gray Scale Value (MGSV)** dei pixel della placca in unità arbitrarie in scala da 0 (nero) a 255 (bianco)
- Valore soglia ottimale: **32**, discrimina le placche **ipoecogene** da quelle **iperecogene**

INCIDENZA DI INFARTO CEREBRALE RISPETTO AL VALORE DI MGSV

190 pz	MGSV < 32 versus MGSV > 32	
Sintomatici	6.3	2.13
Asintomatici	8.3	3.8
>70%	6.2	2.13
50-69%	9.0	2.86

Nicolaides 1996





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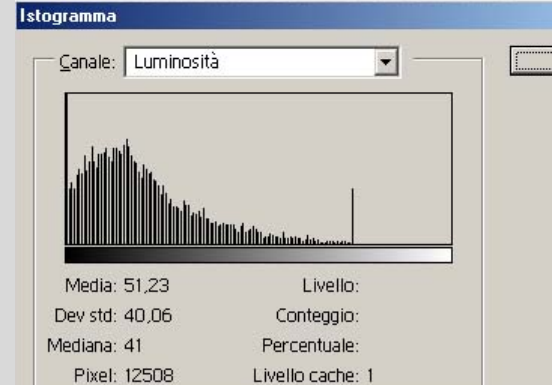
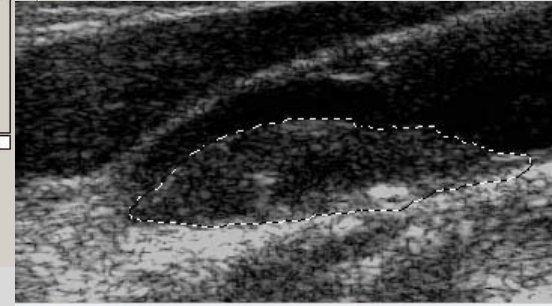
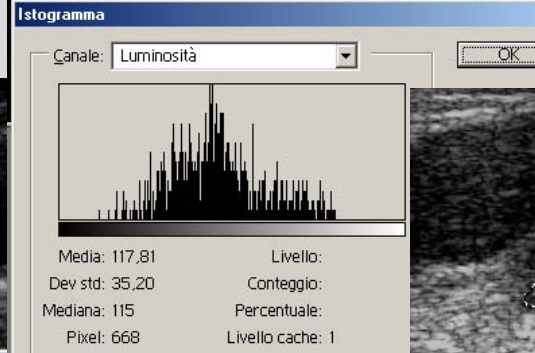
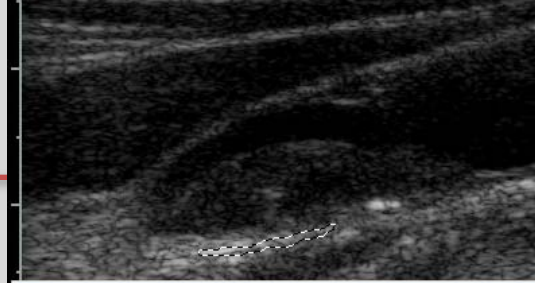


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Persiste la variabilità inter/intra-osservatore

GrayScaleMedian

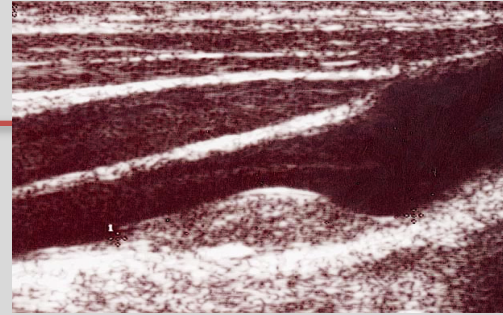




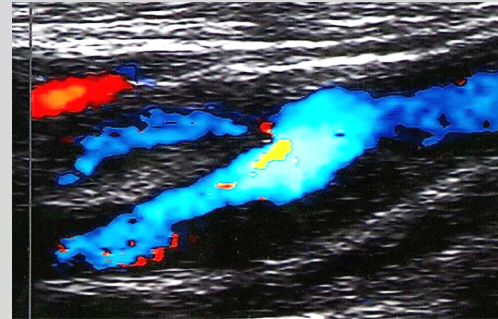
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SUPERFICIE

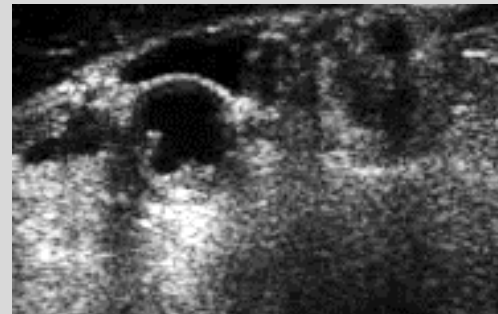
REGOLARE



IRREGOLARE (DA 0.4 A 2 MM)

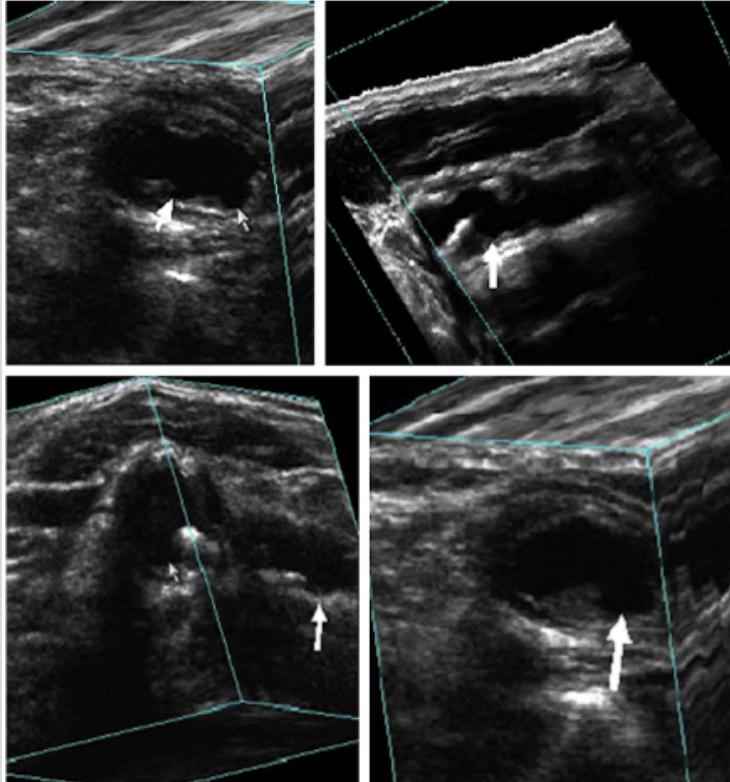


ESCAVATA (> 2 MM)





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The attempt to classify carotid plaque ulceration by 2D DUS was poor.

3D DUS: pts with 3 or more ulcers or a total ulcer volume of 5 mm^3 or more, have a higher 3-5 years risk of stroke or death ...

Standardization is needed

Madani Neurology 2011;
Kuk, Stroke J Cereb Circ 2014



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CEUS



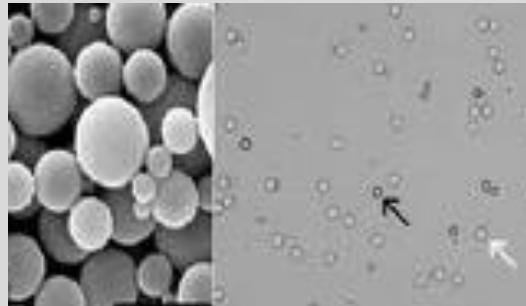


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flussi per immagini significativi



- Sensibilità maggiore rispetto al color-Doppler
- Sensibilità maggiore flussi a bassa velocità
- Riduce gli artefatti del color-Doppler
- **Valutazione dell'angiogenesi della placca**



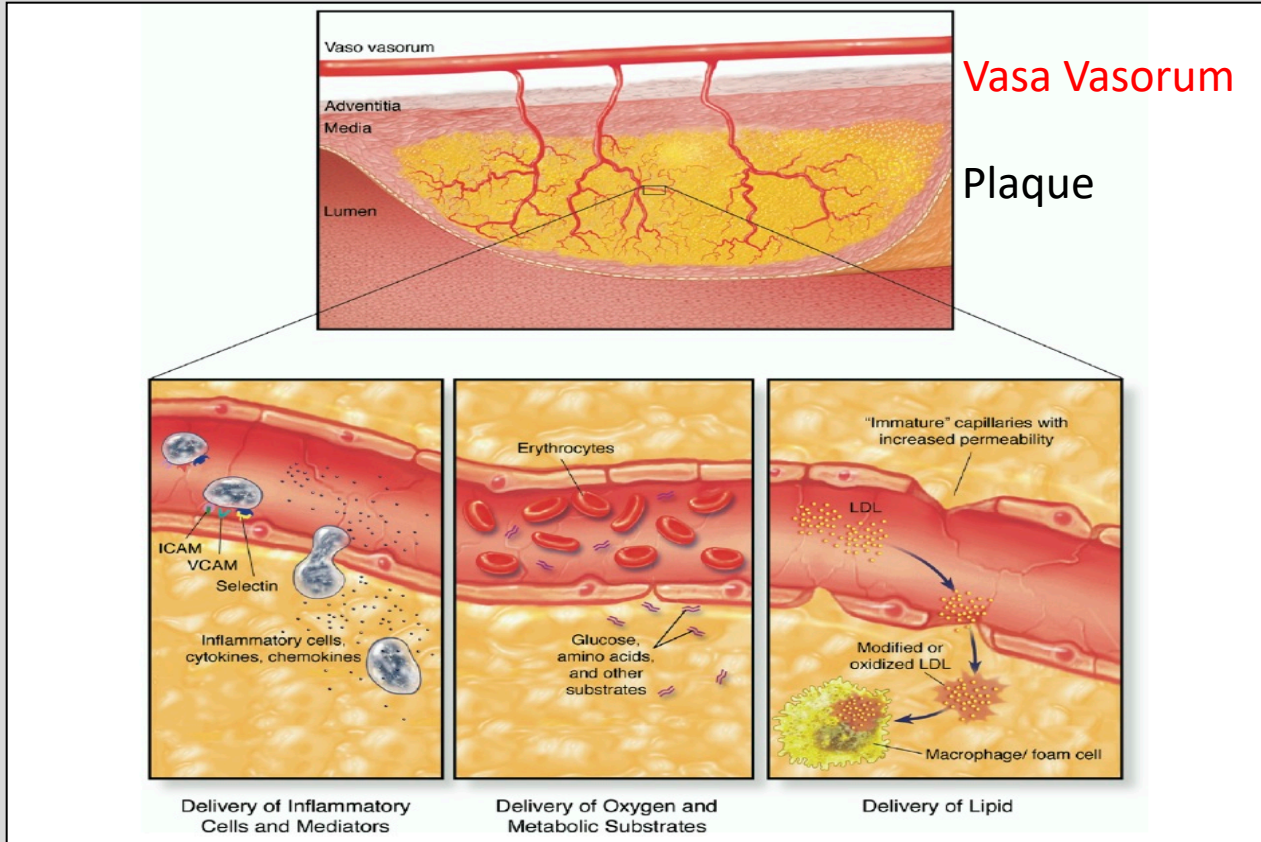


Contribution of Neovascularization to Plaque Growth



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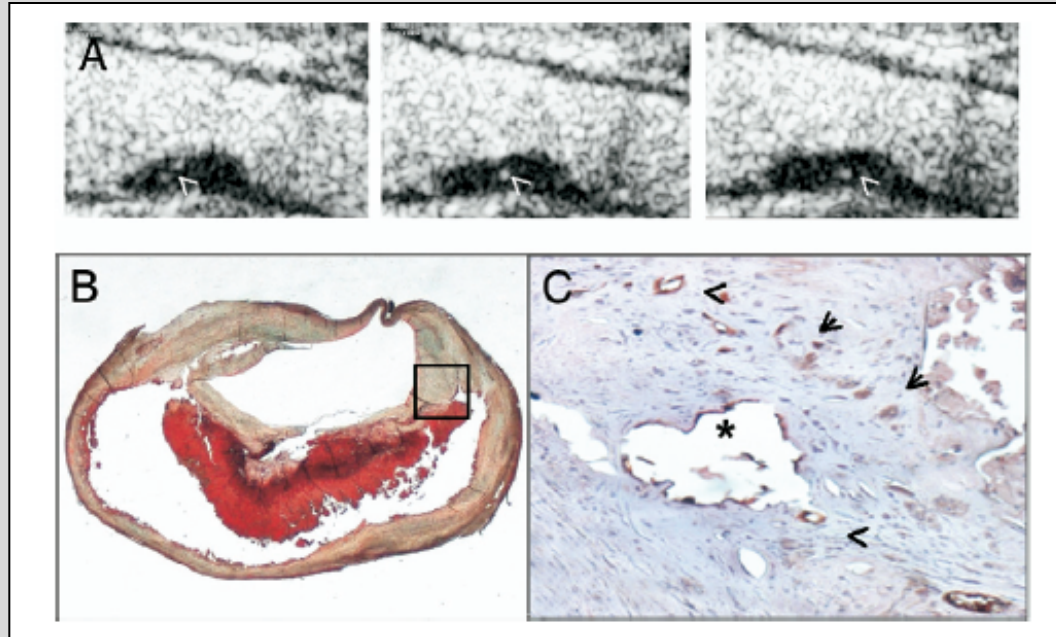
ITALIAN CHAPTER



Plaque rupture: strongly associated with neovascularization degree.

CEUS: correlation with neovessels histological density and echolucent plaques.

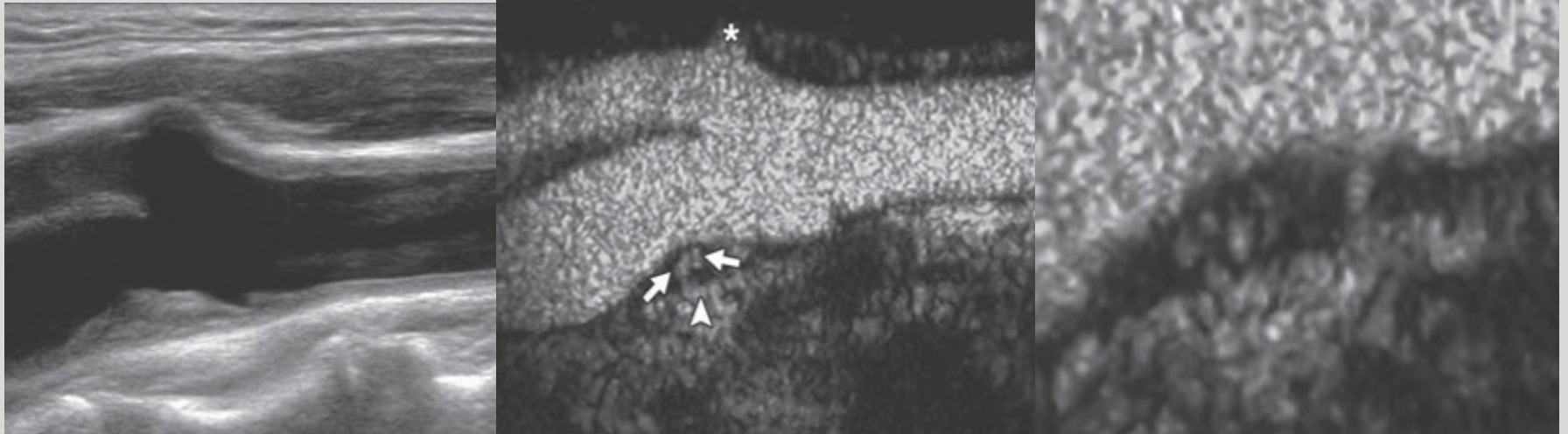
Not with stenosis degree





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CEUS



Partovi S, AJR 198:W13-W19, 2012



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Pattern di distribuzione (classificazione quantitativa in tre categorie)



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- **grado 0** quando nessuna microbolla è visibile all'interno della placca
- **grado 1** quando le microbolle sono confinate nella zona della spalla della placca o raggiungono il layer avventiziale
- **grado 2** quando le microbolle raggiungono e superano il core lipidico della placca



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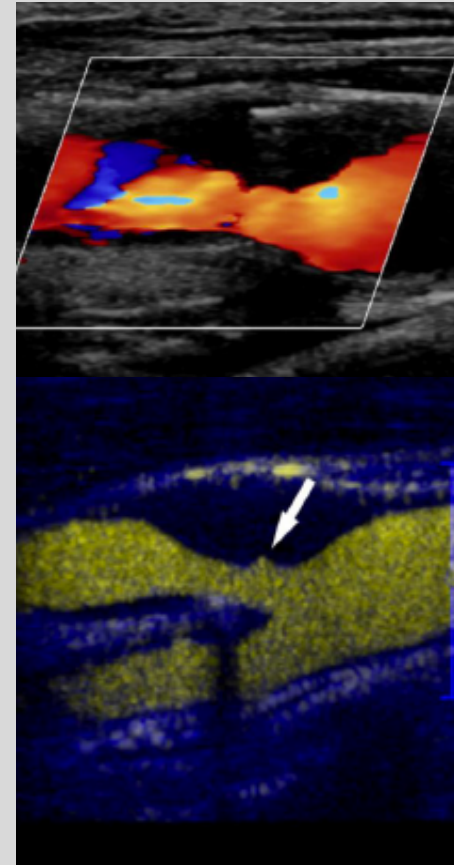
ITALIAN CHAPTER



Contrast enhanced ultrasound can contribute to characterization of vulnerable plaque

luminal irregularities, anechogenic plaques, dissections, **ulceration, neovascularization**

Zhou, BMC Med Imag 2013 Saba, Cardiovasc Intervent Radiol 2014; J vasc Surg 2013; Stroke 2014



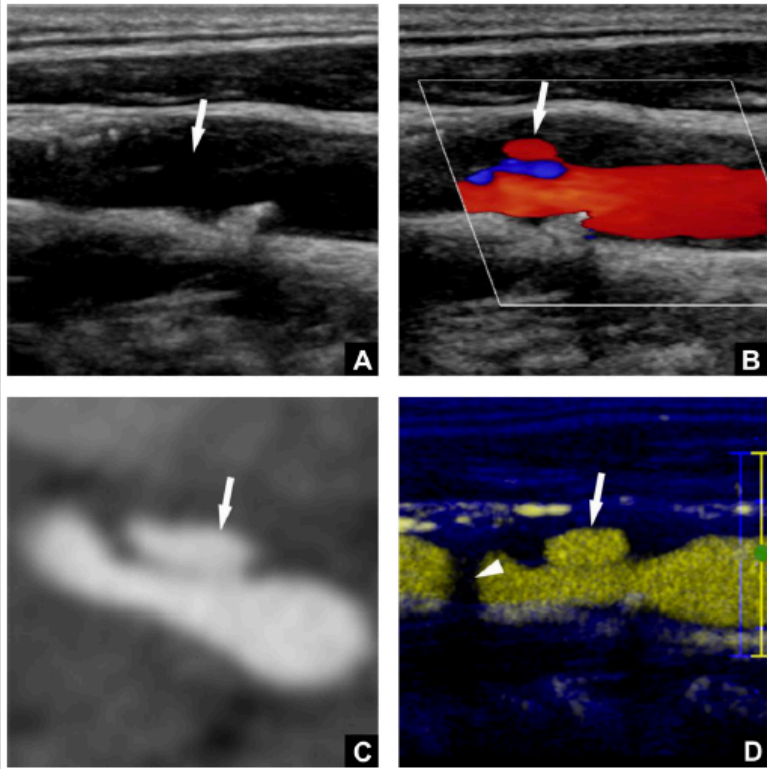


Plaques ulceration diagnostic accuracy: CEUS vs CDUS



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Comparison of color Doppler ultrasound (CDUS) and contrast-enhanced ultrasound (CEUS) for detection of carotid plaque ulceration

Variable	Method	
	CDUS	CEUS
Sensitivity (%)	29	88
Specificity (%)	73	59
Accuracy (%)	54	72
PPV (%)	46	63
NPV (%)	57	87

NPV = negative predictive value; PPV = positive predictive value.



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Systematic review of 24 studies and 1356 pts:

CEUS information: statistically significant correlation with microvascularization, echogenicity, **ulceration, intraplaque hemorrhage and microembolization** (100% agreement among studies)

Suitable patient?

Different acquisition and analysis of CEUS images

Bidimensional vs tridimensional techniques ...

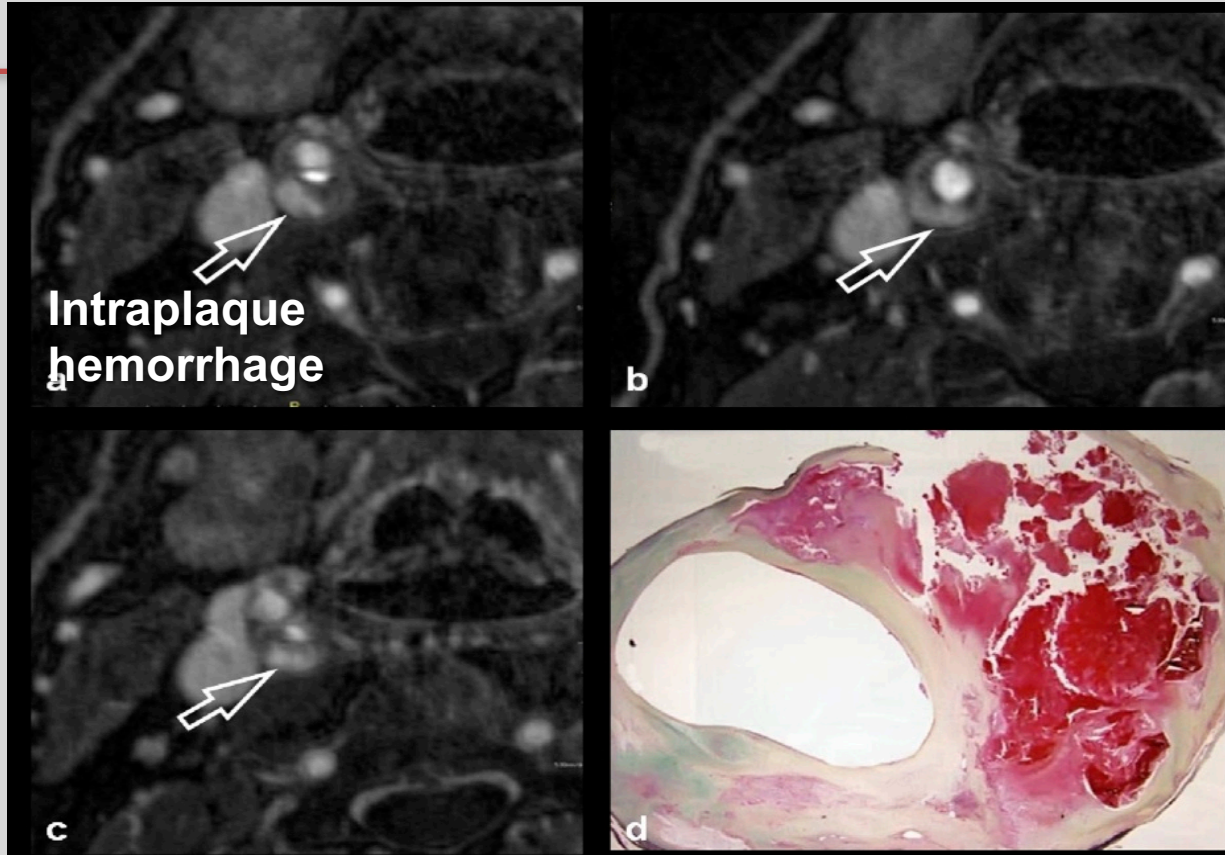
The role of CEUS in routine clinical practice remains **to be confirmed ...**



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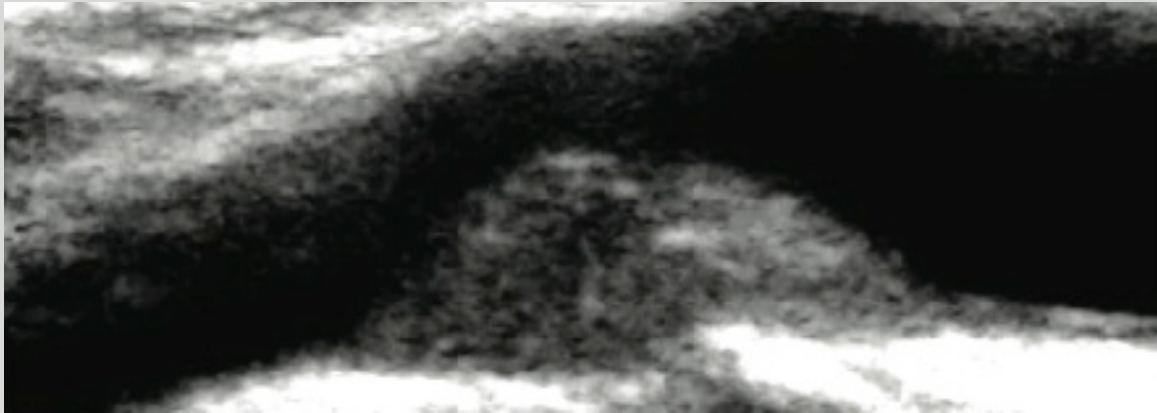
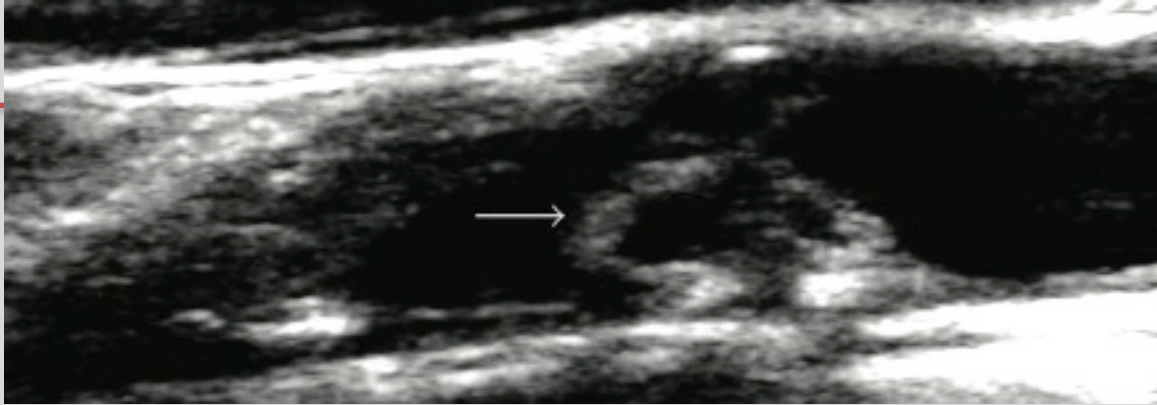


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Componente mobile della superficie della placca carotidea, che sale e scende in un modo non coerente col movimento pulsatile della parete arteriosa

(Segno della Medusa)

Sonographic appearance of a free-floating atheromatous plaque in a patient with acute stroke.

[Cho YP](#), [Kwon TW](#), [Kim GE](#)

J Clin Ultrasound Jun 2002; **30(5)** :317-21



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Original Paper

Cerebrovascular Diseases

Cerebrovasc Dis 2007;24:452–459
DOI: [10.1159/000108436](https://doi.org/10.1159/000108436)

Received: February 15, 2007
Accepted: May 24, 2007
Published online: September 19, 2007

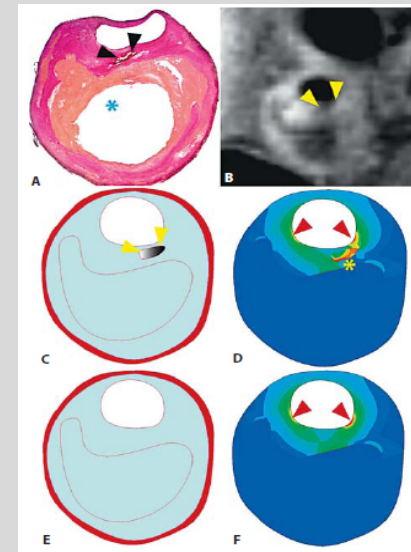
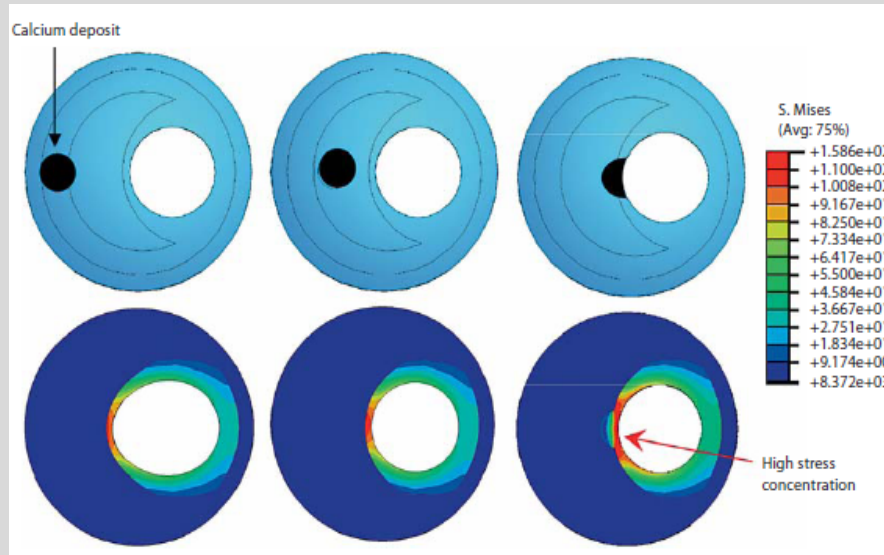


ITALIAN CHAPTER

Does Calcium Deposition Play a Role in the Stability of Atheroma? Location May Be the Key

Zhi-Yong Li^{a,b} Simon Howarth^a Tjun Tang^a Martin Graves^a Jean U-King-Im^a
Jonathan H. Gillard^a

^aUniversity Department of Radiology, Cambridge University Hospitals NHS Foundation Trust, and
^bDepartment of Engineering, University of Cambridge, Cambridge, UK



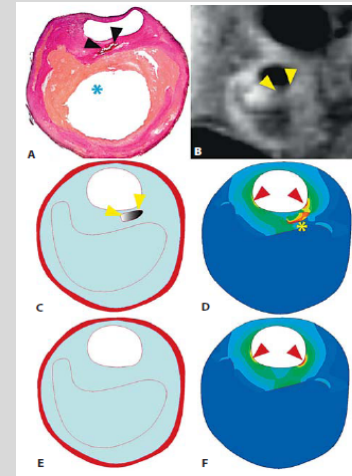
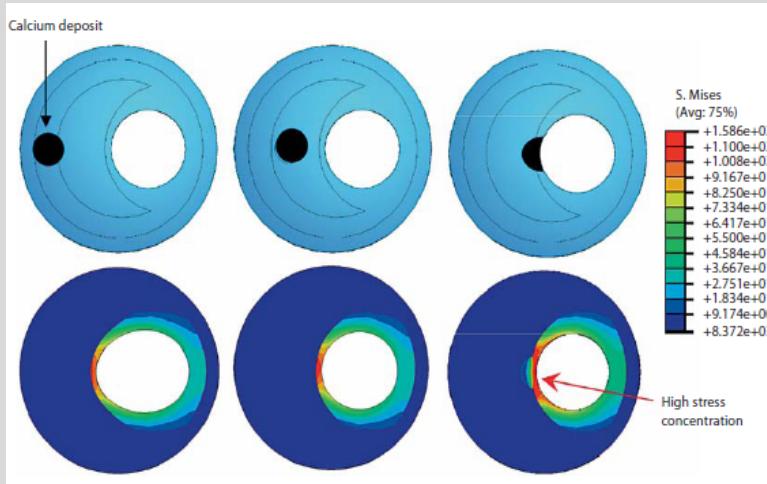


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Può il deposito di calcio giocare un ruolo nella stabilità dell'ateroma?



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le mappe di stress evidenziano valori più elevati in quelle placche dove il calcio è in prossimità del lume, rendendo queste placche più vulnerabili

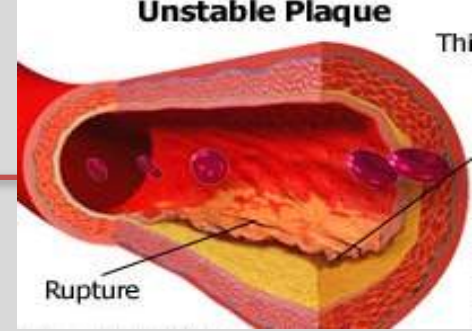
Does calcium deposition play a role in the stability of atheroma? Location may be the key
Zhi-Yong Li et al. Cerebrovascular Diseases 2007



Roma, 7-10 novembre 2019

La Placca Carotidea “vulnerabile”

Aspetti clinico-diagnostici



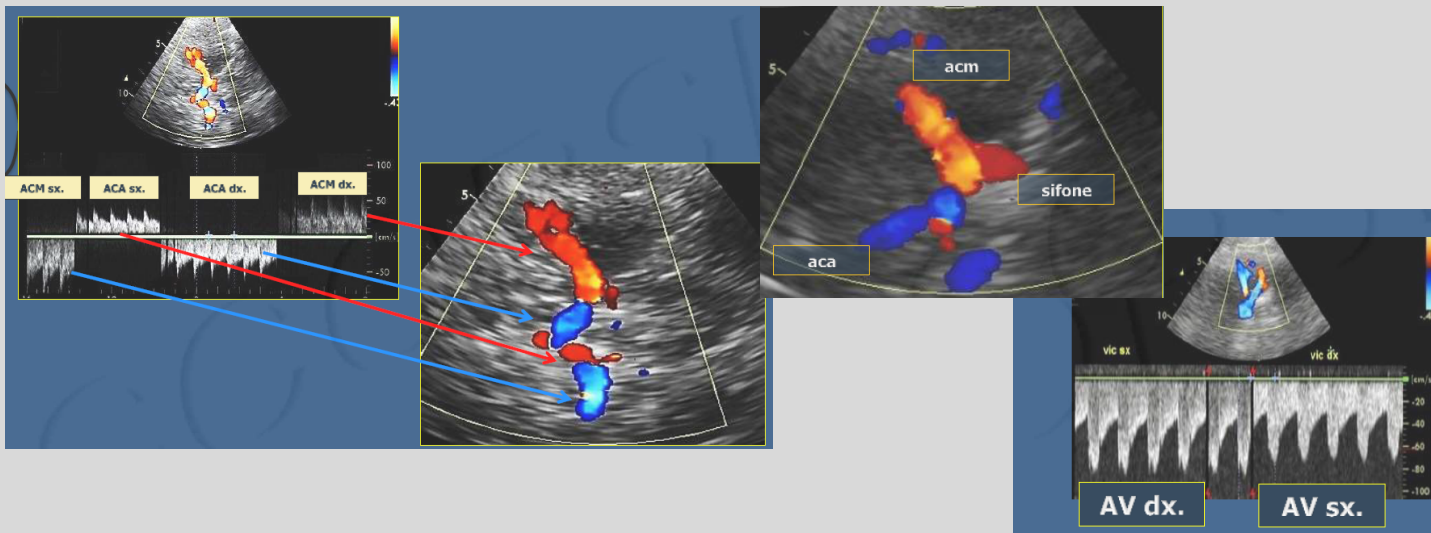
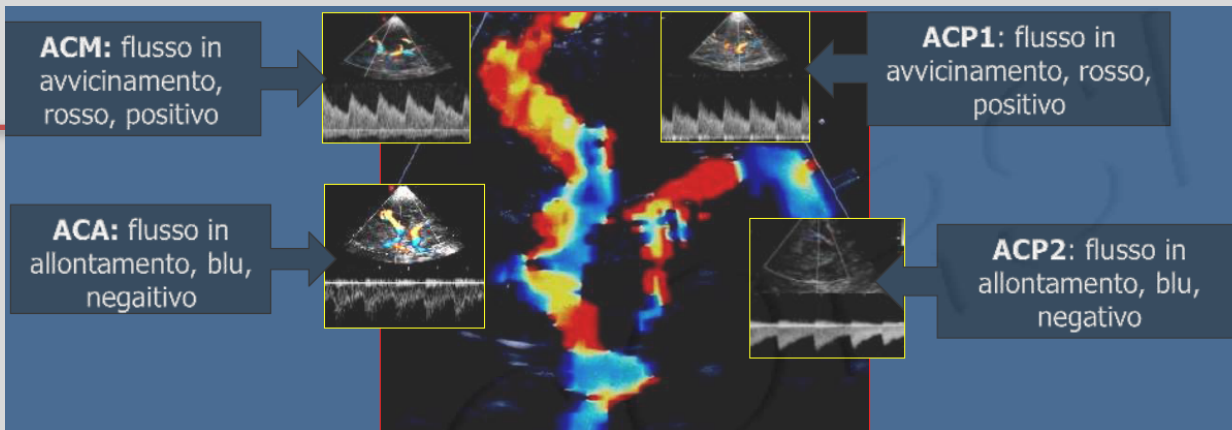
1. Gray-weale: placca «echolucent», tipo 1 e 2 (specificità 57-80%)
2. Ulcerazione ed emorragia intra-placca (buona specificità, bassa sensibilità)
3. CEUS
4. Placca Mobile (Jellyfish sign)
5. Circolo intra-cranico MES (microemboli) e TCCD



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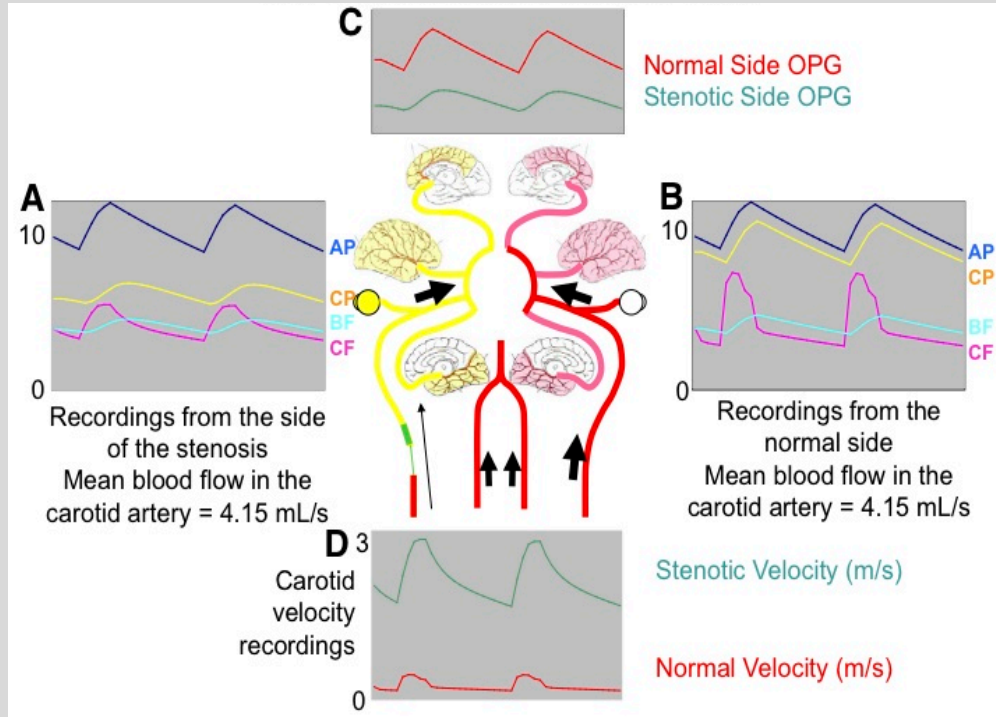


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Intracranial collateralization determines hemodynamic forces for carotid plaque disruption



ITALIAN CHAPTER

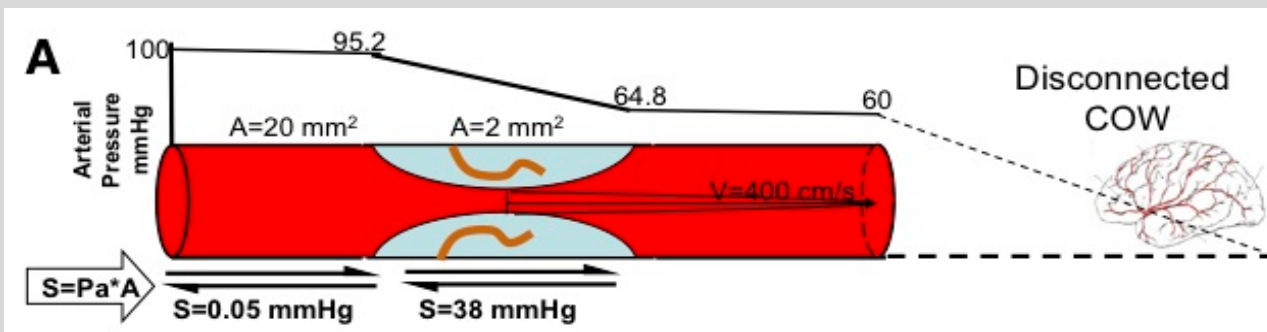
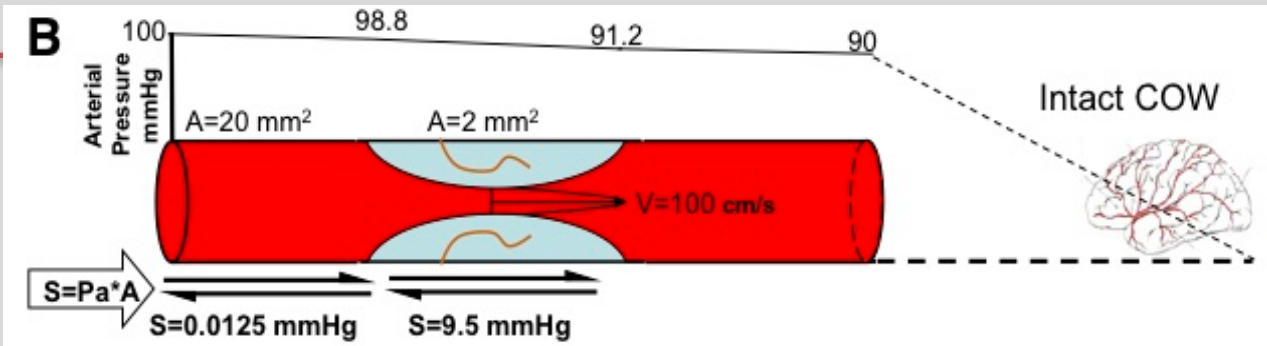




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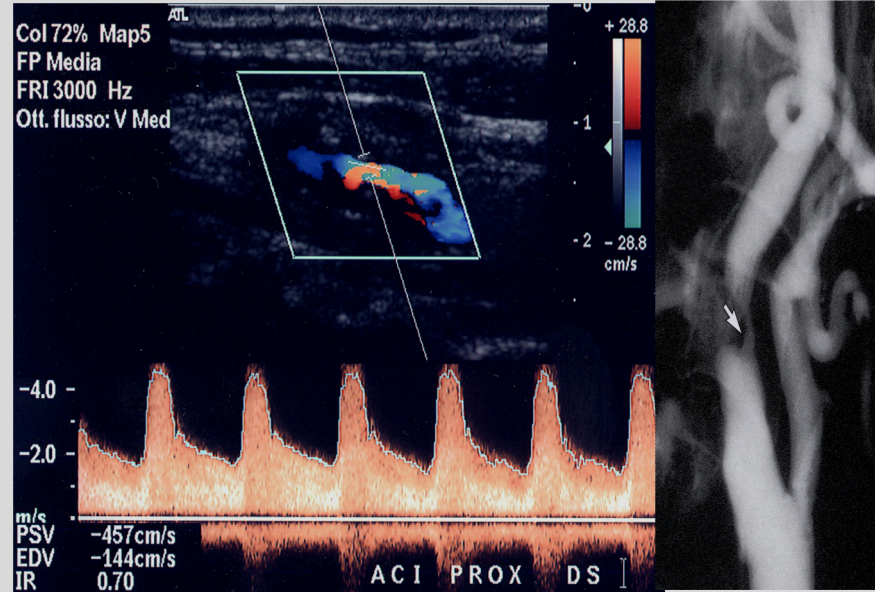
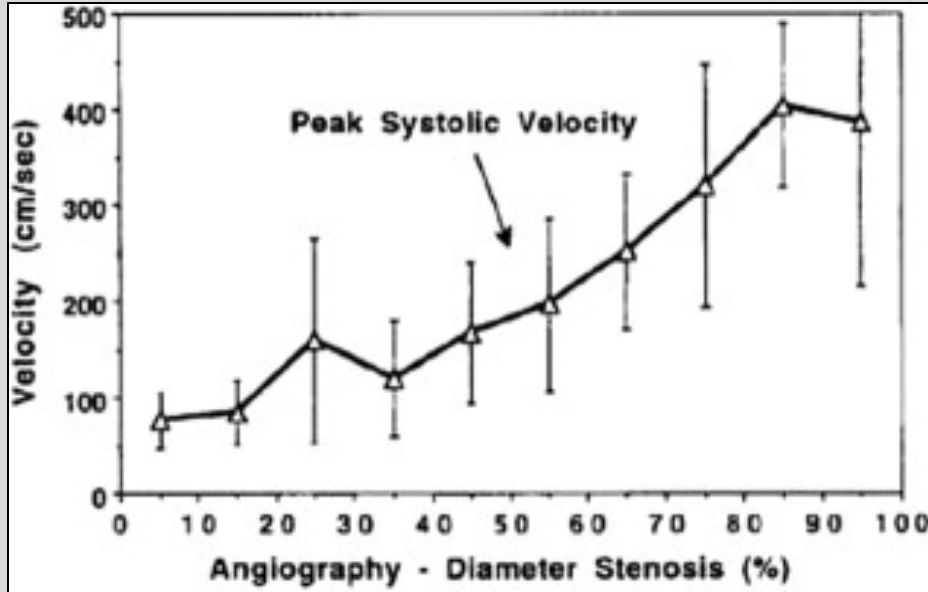
Sleep Apnea - Stroke:

Hypercapnia → Intracranial vasodilation → Carotid Plaque: hemodynamic disruptive forces.

J Vasc Surg 2011;54:1461-71



Roma, 7-10 novembre 2019



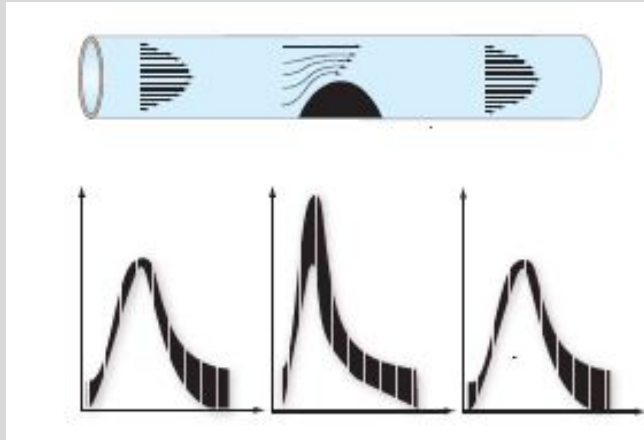
Relationship between mean PSV and % of stenosis as measured arteriographically.
PSV increases with increasing severity of stenosis [GRANT EG Radiology 2000]



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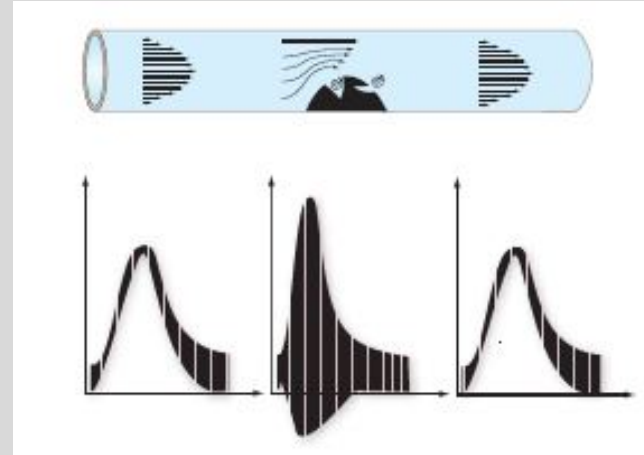


Variazione della curva spettrale nella stenosi lieve ($< 50\%$)



A monte e a valle della stenosi il profilo di flusso e la velocità restano normali, nel punto di stenosi si registra una moderata accelerazione sistolica difficilmente rilevabile e che può essere mascherata dalla impostazione dell'angolo

Variazione della curva spettrale nella stenosi lieve irregolare ($< 50\%$)



A monte e a valle della stenosi il profilo di flusso e la velocità restano normali, nel punto di stenosi i piccoli vortici determinano una modesta dispersione spettrale che si associa a modesto incremento della velocità sistolica e flusso reverse



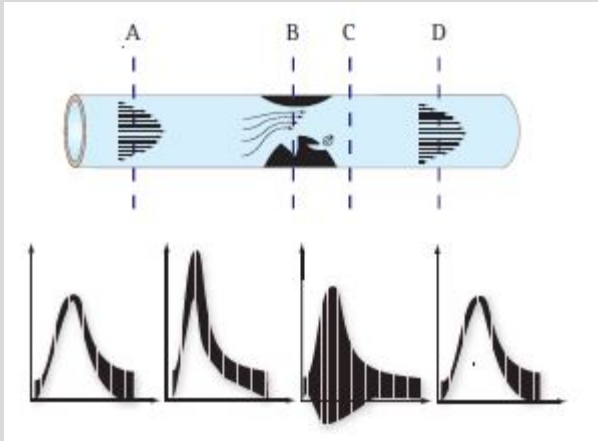
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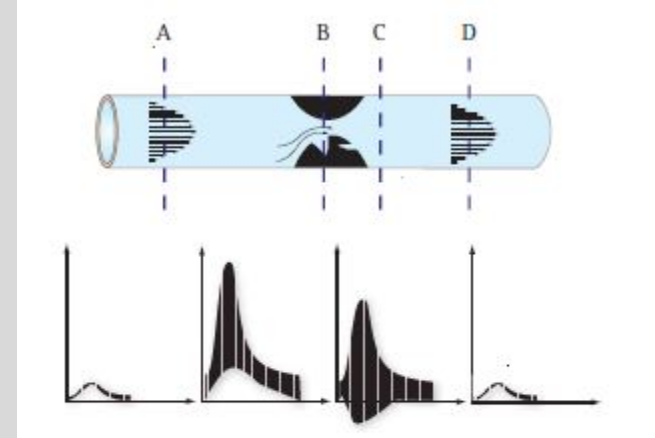


Variazione della curva spettrale nella stenosi 50 >< 90%



Progressivo aumento delle velocità sistoliche e diastoliche. Dispersione dello spettro (flusso vorticoso)
Incremento delle velocità nel punto della stenosi violento e proporzionale all'entità della stenosi.
A valle e monte riduzione ampiezza

Variazione della curva spettrale nella stenosi serrata (> 90%)



Jet sistolico di intensità elevata e irradiata per 2-3 cm a valle. Dispersione accentuata.
A valle e monte riduzione ampiezza mentre il picco sistolico e il fronte di ascensione tendono ad appiattirsi (aspetto *parvus-tardus*)



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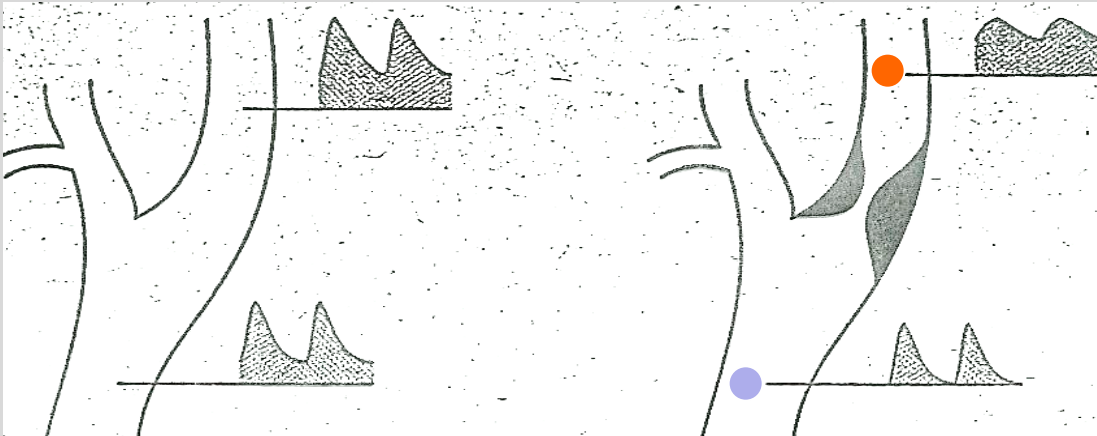


Poststenotic flow

OSTRUZIONE A MONTE ... ONDA DELTA (flusso a basse resistenze)

Prestenotic flow

OSTRUZIONE A VALLE ... (flusso ad alte resistenze, poco diastolico ... fino allo stump flow)



RIDOTTA PULSATILITÀ
con prevalente
riduzione della
componente sistolica

**AUMENTATA
PULSATILITÀ** con
prevalente riduzione
della componente
diastolica



San Francisco
October 2002

GRANT 2003



ITALIAN CHAPTER

Roma, 7-10 novembre 2019

Radiology

Edward G. Grant, MD
Carol B. Benson, MD
Gregory L. Moneta, MD
Andrei V. Alexandrov, MD, RVT
J. Dennis Baker, MD
Edward I. Bluth, MD
Barbara A. Carroll, MD
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Index terms:

Carotid arteries, flow dynamics
Carotid arteries, stenosis or
obstruction, 172.4311, 172.4312,
172.721
Carotid arteries, US, 172.12981,
172.12983, 172.12984
Special Reports

Published online before print
10.1148/radiol.2292030516
Radiology 2003; 229:340-346

Carotid Artery Stenosis: Gray-Scale and Doppler US Diagnosis—Society of Radiologists in Ultrasound Consensus Conference¹

The Society of Radiologists in Ultrasound convened a multidisciplinary panel of experts in the field of vascular ultrasonography (US) to come to a consensus regarding Doppler US for assistance in the diagnosis of carotid artery stenosis. The panel's consensus statement is believed to represent a reasonable position on the basis of analysis of available literature and panelists' experience. Key elements of the statement include the following: (a) All internal carotid artery (ICA) examinations should be performed with gray-scale, color Doppler, and spectral Doppler US. (b) The degree of stenosis determined at gray-scale and Doppler US should be stratified into the categories of normal (no stenosis), <50% stenosis, 50%–69% stenosis, ≥70% stenosis to near occlusion, near occlusion, and total occlusion. (c) ICA peak systolic velocity (PSV) and presence of plaque on gray-scale and/or color Doppler images are primarily used in diagnosis and grading of ICA stenosis; two additional parameters, ICA-to-common carotid artery PSV ratio and ICA end-diastolic velocity may also be used when clinical or technical factors raise concern that ICA PSV may not be representative of the extent of disease. (d) ICA should be

- **PRIMARY PARAMETERS:** PSV, % PLAQUE ESTIMATE
- **ADDITIONAL PARAMETERS:** per i pazienti con basso output cardiaco nei quali l'ICA PSV potrebbe essere sproporzionatamente bassa.

Stenosi	VPS cm/s	riduzione diametro	ICA/CCA VPS ratio	ICA VTD cm/sec.
Normale	< 125	NA	< 2	< 40
< 50	< 125	< 50	< 2	< 40
50-69	125-230	≥ 50	2-4	40-100
70-90	> 230	≥ 70	> 4	> 100
Preocclusione	Variabile	Lume visibile	Variabile	Variabile
Occlusione	assente	Lume non visibile	NA	NA

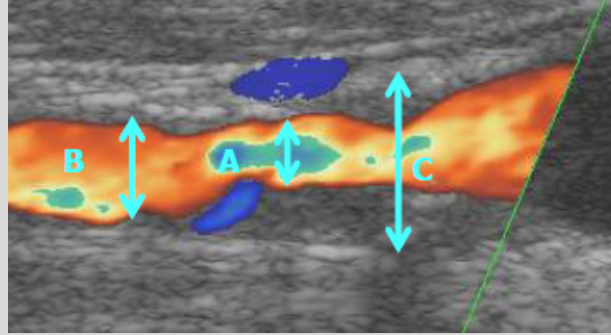
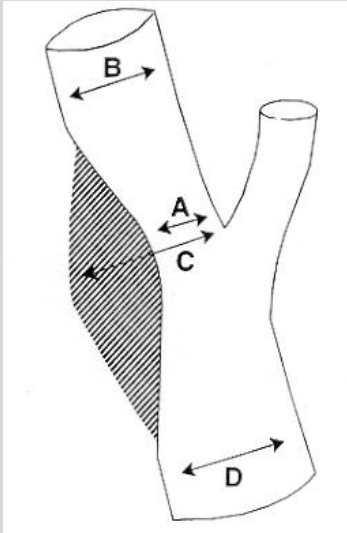
Radiology 2003

MISURAZIONE DELLA STENOSI CAROTIDEA METODO VELOCIMETRICO
Consensus Panel Gray Scale



PERCHÈ NASCET E ANCHE ECST?

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NASCET: DIAMETRO DISTALE (valuta gli EFFETTI EMODINAMICI)

ECST: DIAMETRO LOCALE (valuta il PLAQUE BURDENING)

metodo NASCET $(B-A/B \times 100) = 50\%$
metodo ECST $(C-A/C \times 100) = 70\%$

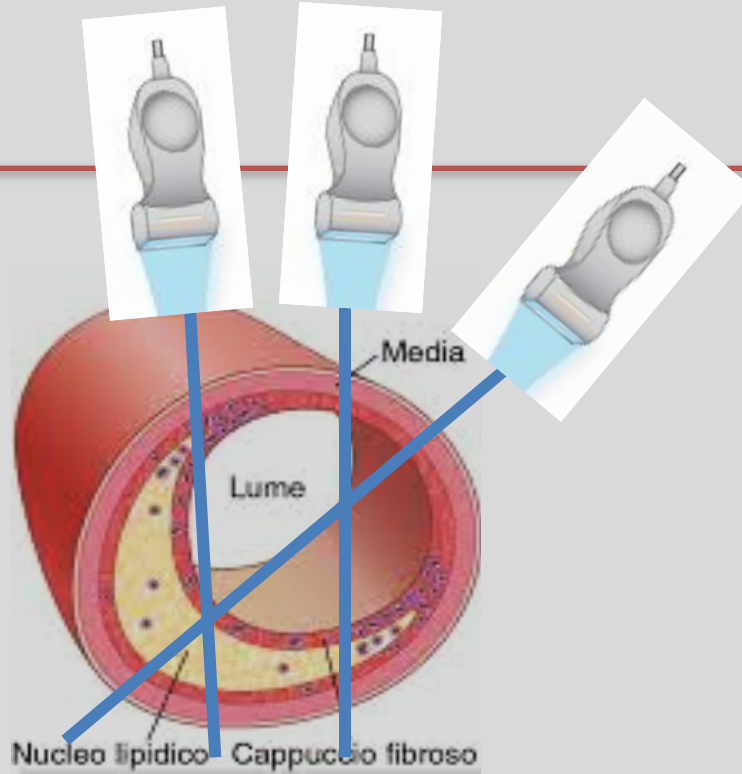
NASCET non è correttamente applicabile nei casi di stenosi SEVERA dove c'è una diminuzione del flusso post-stenotico che porta a un grado di stenosi calcolato più basso.



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PLACCHE CONCENTRICHE: diametro e area di riduzione sono simili ... ma ... nelle **PLACCHE ECCENTRICHE** il grado di stenosi misurato come % di riduzione è maggiore della riduzione del diametro



DEGUM 2010



Roma, 7-10 novembre 2019

Stenosegrad (NASCET-Definition) (%)		10	20 – 40	50	60	70	80	90	Verschluss	
Stenosegrad alt (ECST-Definition) (%)		45	50 – 60	70	75	80	90	95	Verschluss	
Hauptkriterien	1. B-Bild	+++	+							
	2. Farbdoppler-Bild	+	+++	+	+	+	+	+	+++	
	3. Systolische Spitzengeschwindigkeit im Stenosemaximum (cm/s) ca.			200	250	300	350 – 400	100 – 500		
	4. Systolische Spitzengeschwindigkeit poststenotisch (cm/s)					>50	<50	<30		
	5. Kollateralen und Vorstufen (Periorbitalarterien/ACA)					(+)	++	+++	+++	
	Zusatzkriterien									
	6. Diastolische Strömungsverlangsamung prästenotisch (ACC)					(+)	++	+++	+++	
	7. Strömungsstörungen poststenotisch			+	+	++	+++	(+)		
	8. Enddiastolische Strömungsgeschwindigkeit im Stenosemaximum (cm/s) ca.			bis 100	bis 100	über 100	über 100			
	9. Konfetti-Zeichen				(+)	++	++			
10. Stenoseindex ACI/ACC			≥ 2	≥ 2	≥ 4	≥ 4				

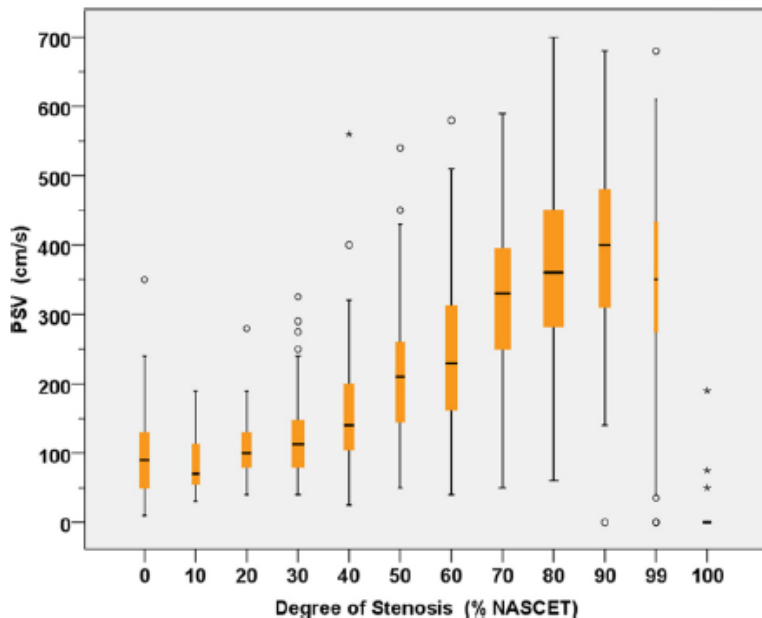
Ultraschallkriterien zur Graduierung von Stenosis der A. carotis interna



Roma, 7-10 novembre 2019

Grading Carotid Stenosis Using Ultrasonic Methods

Gerhard-Michael von Reutem, 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



Fillinger MF 1996, Hunink MG 1993,
Koga M 2001, Moneta GL 1995.

PSV average vs %
STENOSI NASCET in 977
pazienti (box plot chart)

*Considerable scattering of
the results ...*



PSV

**(SOGLIA, THRESHOLD E MEDIA, AVERAGE)
NON PUÒ ESSERE CONSIDERATO
L'UNICO E ASSOLUTO PARAMETRO
PERCHÉ TROPPO SPESSO IN
DISACCORDO CON IL REPERTO
ANGIOGRAFICO**



STROKE 2012 (NEUROSONOLOGY RESEARCH GROUP)



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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

MAIN CRITERIA: informazioni essenziali morfologiche ed emodinamiche

ADDITIONAL CRITERIA: elementi di supporto, generalmente più difficili da quantificare

APPROCCIO MULTIPARAMETRICO

ANGOLO DI INSONAZIONE: “the lowest possible”

NASCET come standard ma ECST in aggiunta

DISTINZIONE TRA PSV THRESHOLD (SOGLIA) E AVERAGE (MEDIA)



STROKE 2012



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- **LOW DEGREE OF STENOSIS (0%-40% NASCET)**: valutazione in B-mode, valutazione della riduzione % del diametro, del lume residuo e dell'IMT;
- **MODERATE STENOSIS (50%-60% NASCET)**: valutazione in B-mode, PSV < 230 cm/sec, in assenza di circoli collaterali;
- **HEMODYNAMICALLY RELEVANT STENOSIS $\geq 70\%$ NASCET**: PSV > 230 cm/sec, presenza di circoli collaterali, aumento dell'EDV. Valutazione del FLUSSO POST-STENOTICO che permette di categorizzare stenosi 70%-80%-90%.



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Main characteristics	The consensus of the society of radiologists in ultrasound (2003)	The degum revision (2010)	The Neurosonology Research Group criteria (2012)
Easy to interpret and immediate	+++	+	+
Multi-parametric approach	+	++	+++
NASCET + ECST method	Only NASCET	+++	Only NASCET
% Detailed ICA degree of stenosis (grading in multiple steps)	+	+++	+++
Congruence of PSV values with angiogram curves and clinical management	+	+++	+++
Post-stenotic PSV evaluation	-	+++	+++
Clear concept of “near occlusion”	+++	-	-
Concept of “PSV average”	-	+	++
Insonation angle (very precise indications about)	-	-	-

DEGUM Deutsche Gesellschaft für Ultraschall in der Medizin, *NASCET* North American Symptomatic Carotid Endoarterectomy Study, *ECST* European Carotid Surgery Trial, *ICA* internal carotid artery, *PSV* peak systolic velocity; + only in part considered and explained; ++: considered and explained; +++: considered and explained with particular attention; -: not mentioned nor substantially considered



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Searching the perfect ultrasonic classification in assessing carotid artery stenosis: comparison and remarks upon the existing ultrasound criteria

Chiara Mozzini¹ · Giuseppe Roscia² · Alder Casadei³ · Luciano Cominacini¹



ITALIAN CHAPTER



Società Italiana di Ultrasonologia in Medicina e Biologia

Table 2 The Doppler criteria for grading the internal carotid stenosis according to the Authors' proposal

Degree of stenosis (NAS CET) (%)	10	20–40	50	60	70	80	90	Occlusion
Degree of stenosis (ECST) (%)	40	50–60	70	75	80	90	95	Occlusion
Intra-stenotic PSV threshold (cm/s)		115–160	200	250	300	350–400	100–500	
Intra-stenotic end diastolic flow velocity (cm/s)				100	100	>100	>100	
Post-stenotic PSV (cm/s)					>50	<50	<30	
Carotid ratio (ICA/CCA)				≥2	≥2	≥4	≥4	
Pre-stenotic diastolic flow (cm/s)					Possibly reduced	Reduced	Reduced	Reduced

NAS CET North American Symptomatic Carotid Endoarterectomy Study, *ECST* European Carotid Surgery Trial, *PSV* peak systolic velocity, *ICA* internal carotid artery, *CCA* common carotid artery

... come **DEGUM** e **STROKE**...

- APPROCCIO MULTIPARAMETRICO;
- STRETTA GRADAZIONE % DELLA STENOSI;
- come **DEGUM** valutazione NAS CET e ECST (% stenosi distale e locale).

THRESHOLD (SOGLIA) PSV 200 cm/sec negli ASINTOMATICI.

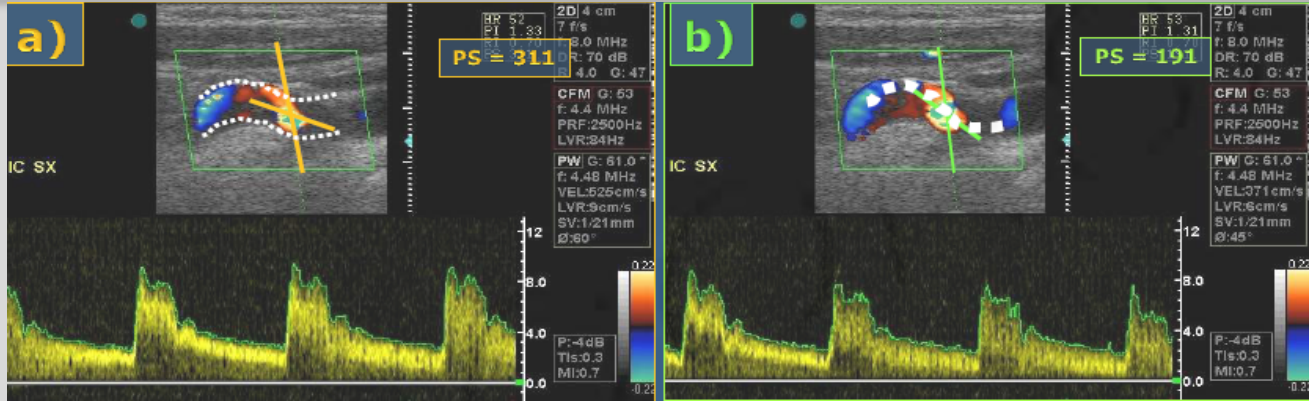
THRESHOLD (SOGLIA) PSV 160 cm/sec nei SINTOMATICI ove PSV > 160 ma < 200 deve allertare l'operatore nel sospettare una stenosi NAS CET del 50%.





L'ANGOLO

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ANGOLO 60°

ANGOLO 45°

PSV 311 cm/sec. Stenosi (NASCET) 70%-80%

PSV 191 cm/sec. Stenosi NASCET 50%-60%

- Il possibile errore è maggiore, maggiore è l'angolo perché **AUMENTA LA PSV MISURATA**
- **NON REALISTICO <30° PER DIFFICILE ACQUISIZIONE**

≤ 60°

As
lowest
as
possible

≤ 45°



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- Sede
- Estensione e spessore (in mm in trasversale e/o longitudinale)
- Superficie (liscia, irregolare, molto irregolare)
- Gray-Weal classificazione ecogenicità
- Riduzione in area o diametro (NASCET e ECST con chiara indicazione)
- PSV s EDF intra-stenotico e PSV pre e post stenotico
- PSV ratio ICA/CCA
- Valutazione dei flussi collaterali
- Angolo di insonazione Doppler
- Valutazione TCCD