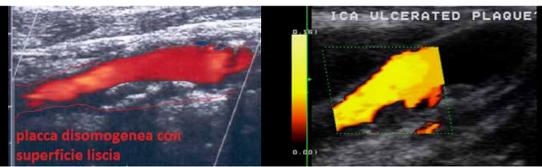


DIAGNOSIS AND TREATMENT OF STENOSIS IN CAROTID CIRCLE

Ultrasound diagnosis

Morphology of atherosclerotic plaque



Surface

- Regular/Smooth
- Irregular: excavation 0.4-2 mm in depth
- Ulcerous: excavation > 2 mm (easily distinguishable in Color Doppler)

Type

(Gray-Weale classification)

1. Homogeneous hypoechoic
2. Mixed, prevalently hypoechoic (> 50%)
3. Mixed, prevalently echogenic (> 50%)
3. Homogeneous hyperechoic
4. Calcified or hard (not classifiable by shadow cone)

Anomalies in course



Tortuosity

- Maintenance of vascular axis
- Tortuous course
- Absence of angulation and stenosis

Coil

- Coiled course along the transverse axis
- Loop, full or not
- Rarely causes stenosis

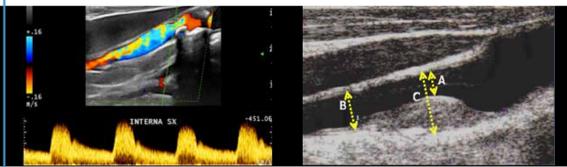
Kinking

- A brusque change in the vascular axis, producing an acute angle of narrow or wide range

Associated with stenosis

- Type I: Slight angle $\geq 60^\circ$
- Type II: Moderate angle $30^\circ \leq x < 60^\circ$
- Type III: Severe angle $< 30^\circ$

Quantization of stenosis

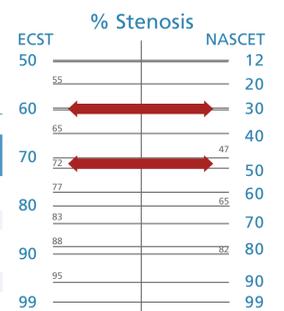


Color-Doppler

- At pulsed Doppler**
- Increased peak velocity of systolic blood flow (PVS) and telediastolic velocity (Vtd)
 - Increased ratio of PVS of the internal carotid artery and common carotid artery
 - Turbulence in flow loss of the central hypoechoic zone in the doppler flow with sample volume set centrally in the blood vessel)
- At Color**
- Aliasing in stenosis point

B-Mode

- NASCET method:**
- B - $A/B \times 100$
 - Bv ICA diameter immediately downstream of stenosis
 - A point of greatest stenosis
- ECST method: $C - A/C \times 100$**
- C original diameter of the blood vessel at the stenosis point
 - A point of greatest stenosis



Indications for carotid:

Absolute

TIA or stroke - the first level screening to identify sources of embolism

Relative

Hypertension, Diabetes, Dyslipidemia, Family history of stroke and TIA, carotid bruit, CAD

ROI angle between 30 and 60°

Degree of stenosis	Peak velocity	End-diastolic velocity	Ratio of internal carotid PVs to common carotid PVs
< 50%	< 125	< 40	< 2.0
50-69%	125-230	40-100	2.0-4.0
> 70 under subocclusion	> 230	> 100	> 4.0
Subocclusion	High, reduced, cannot be sampled	Variable	Variable
Occlusion	Cannot be sampled	Cannot be sampled	Cannot be sampled

Treatment Stenosis of the ICA: stenosis $\geq 50\%$ with NASCET method

Anti-aggregation and anticoagulation in patients with stenosis of the ICA (internal carotid artery)

Asymptomatic patients not subject to correction

- Lifelong low doses of aspirin (ASA) (IIaC), unless there is a high risk of hemorrhage or the patient is taking anticoagulants

Symptomatic patients treated conservatively

- Double anti-platelet therapy (DAPT) with ASA and Clopidogrel within 24 hours of a minor cerebral ischemic event/TIA with continuation for up to 1 month (IIb)
- In the acute phase of a stroke/TIA, a loading dose of 300 mg ASA and/or 300/600 mg Clopidogrel is always recommended

Post CAS (ICA stenting)

- DAPT with ASA and Clopidogrel for one month (IA)
- After the first month, lifelong treatment with ASA only (IA) (except in the case of a recent AMI or stenting within the past year (indicating extension of DAPT)
- A loading dose of 300 mg ASA and/or 300/600 mg Clopidogrel is always recommended during the procedure

Post CEA (carotid endarterectomy)

- ASA only, lifelong or for as long as it is well-tolerated (IA)

Endovascularly revascularized patients undergoing anticoagulant treatment

- Oral anticoagulant only (IIaC). Same degree of evidence (IIaC) for ASA or Clopidogrel with anticoagulant treatment for at least one month if risk of occlusion of the stent/graft \gg risk of hemorrhage

Plaque vulnerability and its assessment by Ultrasound

- Risk of stroke in patients with carotid plaques depends not only on severity of stenosis but also on plaque vulnerability.
- Vulnerable plaque is characterized by a thin fibrous cap a large lipid core and intraplaque hemorrhage.

Assessment of plaque vulnerability could help in therapeutic decision-making in following situations:

- Symptomatic patients with intermediate plaque
- Asymptomatic patients with stenosis $> 60\%$
- High-risk patients (dyslipidemia, diabetes mellitus, chronic kidney disease) with any grade of stenosis
- Stenting versus endarterectomy

Assessment of plaque vulnerability by US:

- 2-D ultrasound - echolucent plaques
- Contrast ultrasound - plaque neovascularization
- Radiofrequency-based ultrasound
- Shear wave elastography

Huibers A, et al. ACS:1 collaborative group. Plaque Echolucency and the Risk of Ischemic Stroke in Patients with Asymptomatic Carotid Stenosis Within the First Asymptomatic Carotid Surgery Trial (ACS:1). Eur J Vasc Endovasc Surg. 2016;51(3):614-621.

Morero PR, et al. Plaque neovascularization is increased in ruptured atherosclerotic lesions of human aorta: implications for plaque vulnerability. Circulation. 2004;110(14):2032-2038.

Elov L, et al. Accurate detection of human vulnerable carotid plaques using a novel ultrasound-based plaque structure analysis (UPSA). Atherosclerosis. 2015.

Zaman M, et al. Advanced ultrasound methods in assessment of carotid plaque instability: a prospective multimodal study. BMC Neurol. 2010; 10: 29 (2010).

Asymptomatic patients

(absence of symptoms/symptoms more than 6 months after diagnosis)

Stenosis < 60%, near-occlusion/total occlusion

Maximum medical treatment (IA)

- Low dose aspirin^{1,2} (ASA) (IIaC), statins (LDL < 70 mg/dl), antihypertensive medications

1. Unless there is a high risk of hemorrhage or undergoing anticoagulant treatment 2. Clopidogrel in the event of intolerance (IIaC)

60-99% stenosis Maximum medical treatment (IA) and:

- Carotid endarterectomy (CEA) (IIaB) with intermediate surgical risk:
 - life expectancy > 5 years
 - favorable anatomy
 - ≥ 1 stroke risk element (Table 1)
- "CAS" stenting of the ICA in patients at high risk of CEA (table 2) (IIaB) or as an alternative in patients with indication for CEA (IIbB)

Pre CAS

- An imaging test (CT or NMR) is recommended to permit optimal assessment of the aortic arch and the intra and extracranial circle (IB)
- Use of digital subtraction angiography is rarely recommended during the stenting procedure (in case of discrepancy between various imaging methods or to reveal other forms of vascular pathology)

Pre CEA

- An imaging test (CT or NMR) is recommended to confirm the diagnosis of severe stenosis (unless an ultrasound examination is performed in a highly experienced center) (IB)

CAS vs CEA

- The global death/stroke rate is higher for CAS than for CEA due to the greater number of minor strokes due to CAS
- Risk of IMA, hematoma and damage to the cranial nerves is greater in CEA than in CAS
- Age > 70 is a predictor of perioperative stroke in CAS more than in CEA (higher incidence of pathologies of the aortic arch in these patients)
- At 30 days, the event rate is practically the same for CEA and CAS, and so it will be the individual patient's overall perioperative risk that guides the choice between the two techniques (refer to Table 2)

Table 1

Stroke risk factors in asymptomatic patients treated with medication

Clinical	Contralateral TIA/stroke
Cerebral imaging	Ipsilateral silent heart attack
	Progression of stenosis (> 20%)
	Positive transcranial ultrasound
	Altered cerebral vascular reserve
	Very large plaques (> 40 mm ² in digital analysis)
	Echolucent plaques
	More hypochoic plaques in luminal interface
NMR	Intraplaque hemorrhage
	Lipid-rich core of necrotic plaque

Age > 75 is not a predictor of adverse events. Stenosis severity % is not correlated with delayed stroke risk.

2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS), Victor Aboyans, et al. European Heart Journal, Volume 39, Issue 9, 01 March 2018, Pages 763-816.

US after CEA:

- Normal US scan early after CAE is indicative for absence of future restenosis. Only 2.8% of subjects with normal early postoperative US developed a significant restenosis and only 0.4% underwent a reintervention.

(Al Shakhachi J J Vasc Surgery 2016)

Symptomatic patients

(presence of symptoms/symptoms appearing less than 6 months after diagnosis)

< 50% stenosis, near-occlusion/total occlusion

Maximum medical therapy (IA) only

- Low dose aspirin^{1,2} (ASA) (IIaC), statins (LDL < 70 mg/dl), antihypertensive medication

1. Unless there is a high risk of hemorrhage or undergoing anticoagulant treatment 2. Clopidogrel in the event of intolerance (IIaC)

50-69% stenosis Maximum medical therapy (IA) and:

- Carotid endarterectomy (CEA) in patients at intermediate risk (IIaB) within 14 days of the appearance of symptoms (IA)
- ICA stenting (CAS) in patients at high risk for CEA (IIaB) or as an alternative in patients with an intermediate risk for CEA (IIbB)

70-90% stenosis Maximum medical treatment (IA) and:

- CEA (IA)
- CAS in patients at high risk for CEA (IIaB) or as an alternative in patients with an intermediate risk for CEA (IIbB)

Table 2

Definition of high risk for CEA

Age > 80
Clinically relevant heart disease
Severe pulmonary hypertension
Contralateral ICA occlusion
Recurrent contralateral paralysis of the laryngeal nerve
History of radical neck surgery or radiation therapy
Recurrent stenosis following CEA

Modified by 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS) doi:10.1093/eurheartj/ehw095.

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