Morphological duplex ultrasound criteria – how to assess and report echolucency, inhomogeneity and ulceration

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Disclosure

Speaker name:
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I have the following potential conflicts of interest to report:

☐ Consulting
☐ Employment in industry
☐ Stockholder of a healthcare company
☐ Owner of a healthcare company
☐ Other(s)

☐ I do not have any potential conflict of interest
  
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Carotid Plaque

Focal structure that encroaches into the arterial lumen

- of at least 0.5 mm
- 50% of the surrounding IMT value
- thickness of \( \geq 1.5 \) mm (measured from the media-adventitia interface to the intima-lumen interface)
Vulnerable atherosclerotic Plaque

Inflammation
Macrophages infiltration
14±10% in the fibrous cap (ref. 24)

Thin fibrous cap
<65 μm (ref. 23)

Spotty calcifications

Large necrotic core occupying 23±17% of the plaque area (ref. 22)

Expansive outward remodeling
Remodeling index > 1.1

Neoangiogenesis
Adventitial vasa vasorum proliferation
Intraplaque hemorrhage
Carotid Plaque Analysis on Carotid Ultrasound

- Plaque echogenicity (hypoechoic / hyperechoic)
- Plaque homogeneity (homogenous/inhomogenous)
- Plaque ulceration
Morphology and plaque stability

• Indicators for instability
  - hypoechoic (echolucent) (lipid core, hemorrhage, inflammation, thrombus)
  - heterogeneous (hemorrhage, calcifications)
  - ulceration (irregular border)

• Indicators for stability
  - hyperechoic (echodense) (fibrous plaque, calcifications)
  - homogeneous (lipid core, fibrous plaque)

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Qualitative Assessment of Plaque Echogenicity

Type 1: uniformly echolucent
Type 2: predominantly echolucent
Type 3: predominantly echogenic
Type 4: uniformly echogenic or extensively calcified

Limitations:

- Different ultrasound settings
  - Gain
  - Dynamic range
  - Frequency / probe
  - Ultrasound system

- Reader dependency
Quantitative Assessment of Plaque Echogenicity

• Gray scale (histogram):

• Gray scale median (GSM):
  - Normalized criterion for gray scale (e.g. 0 for blood and 190 for adventitia)

GSM >30

GSM <30
Morphology of the carotid plaque as predictor for vascular events

- Hypoechoic (echolucent) plaque as predictor for stroke (OR 3.1 95%CI 1.3-7.3) and myocardial infarction (OR 7.0 95%CI 2.3-21.4)
- Meta-analysis of 7 studies including 7557 patient with asymptomatic carotid stenosis/plaque
  - Mean follow-up of 37.2 months
  - Hypoechogenic plaque versus echodense plaque
  - Endpoint ipsilateral stroke
Heterogeneous echotexture

- Mixture of hypoechoic, isoechoic and hyperechoic lesions
- Heterogeneity in Gray-Scale-Median scores with mixture of hyperechoic, hypoechoic and isoechoic lesions

- Computerized plaque texture analysis using specific software
  - e.g. Spatial gray level dependence matrices (SGLDM)

- Uncertain association of heterogeneous echotexture with vulnerable plaque
Plaque ulceration

- Irregular surface: irregular plaque surface with recesses less than 2mm in depth

- Ulceration: Plaque surface crater measuring 2 mm or more or concavity with an echogenic line at the plaque base
Ultrasound based carotid plaque risk-index

- Degree of stenosis (DOS)
- Surface irregularity indices (SII)
- Plaque grayscale median (GSM)
- Carotid plaque risk index (CRPI) = (DOS*SII)/(1+GSM)

In patient with carotid plaque the severity of stenosis and lesion morphology on B-mode ultrasound are important for risk stratification.

Plaque echolucency, heterogeneous echotexture and surface irregularity / ulceration are associated with vulnerability.

In clinical practice the assessment of plaque characteristics on ultrasound mostly rely on visual analysis.

More prospective studies using computational quantitative analysis of plaque characteristics for standardized assessment are needed.