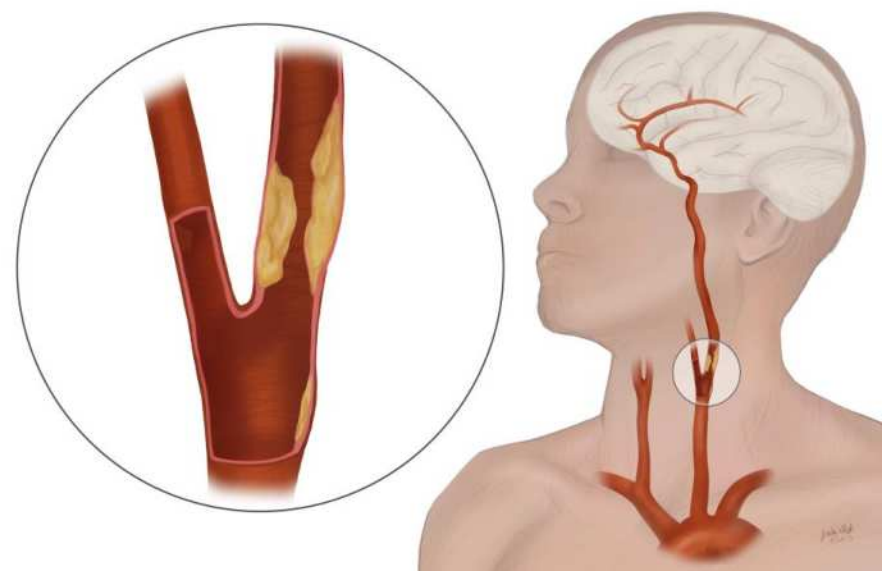


Unearterite stenoos ultraheli uuringul: praktilised nõuanded ja mida raviarstid ootavad radioloogilt

Reinis Zariņš
III aasta radioloogia resident
TÜK
2022



Sissejuhatus

- Pisut füüsikast, teostamistehnikast, seadmete optimeerimisest
- Unearterite normivariandid
- Unearterite stenoos, stenoosi hindamine, oklusioon.
 - Kiirus
 - Turbulentne verevool
 - NASCET/ECST
- Mida raviarstid ootavad meist?
 - *ESVS* ja *ESC* juhised
- CCA ja ECA stenoos?
- *Intima-media* paksus – kas vajalik mõõta?

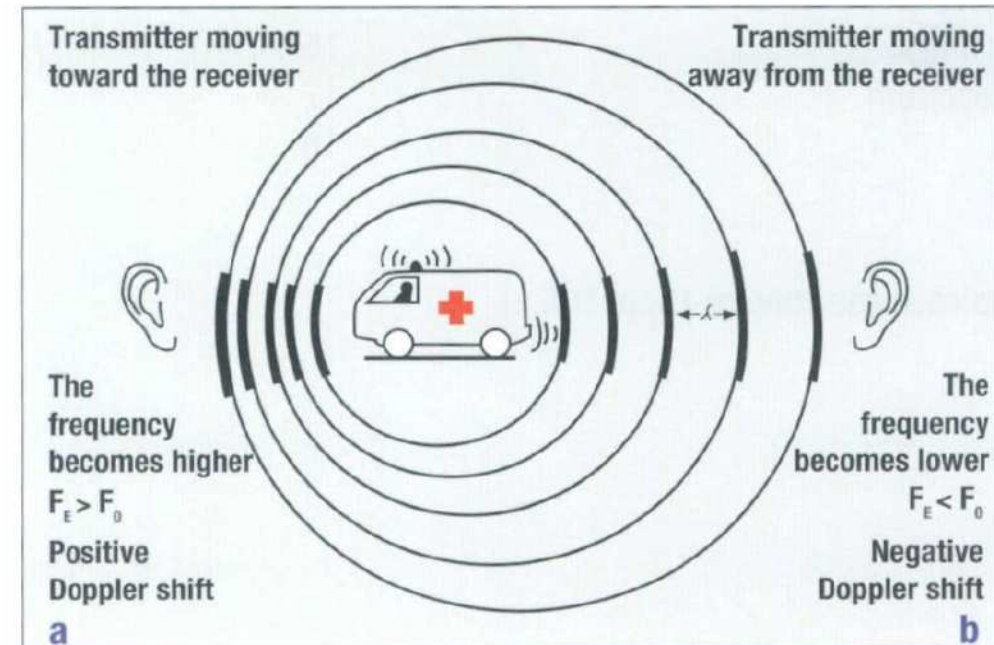
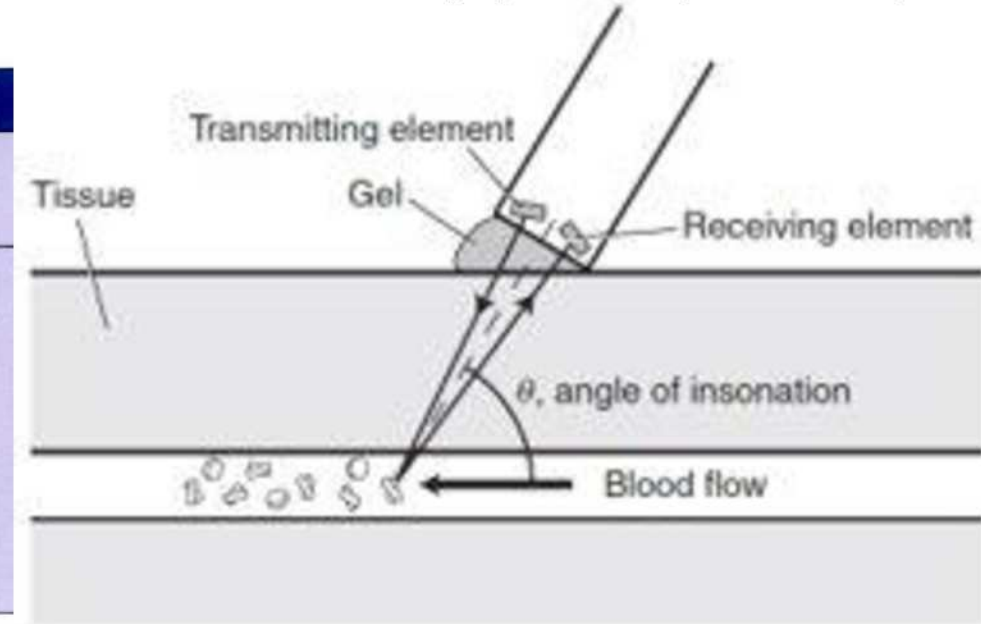
Kasutatud lühendid

- **UH** – ultraheli
- **KT** - Kompuutertomograafia
- **MRT** – Magnetresonatstomograafia
- **CWD** – *continous wave Doppler* - pidevaine Doppler
- **PWD** – *pulsed wave Doppler / power Doppler*- pulsslaine Doppler
- **SV** – *sample volume* - valim maht
- **ICA** – *a.carotis interna*
- **ECA** – *a. carotis externa*
- **CCA** – *a. carotis communis*
- **VA** – *a. vertebralis*
- **PRF** – *pulse repetition frequency* –pulsi kordus sagedus
- **PSV** – *peak systolic velocity* – tipp süstoolne kiirus
- **EDV** – *end diastolic velocity* - lõpp diastoolne kiirus
- **NASCET** - *North American Symptomatic Carotid Endarterectomy Trial*
- **ECST** - *The European Carotid Surgery Trial*
- **BMT** – *best medical treatment* (parim medikamentoosne ravi)
- **ESVS** – *European Society of Vascular Surgery* (Euroopa Veresoontekirurgide Selts)
- **ESC** – *European Society of Cardiology* (Euroopa Kardioloogide Selts)
- **CEA** – karotiid endartektoomia
- **CAS** – karotiidarteri stentimine

Füüsika: Continuous Wave Doppler - pidev-laine Doppler (CWD)

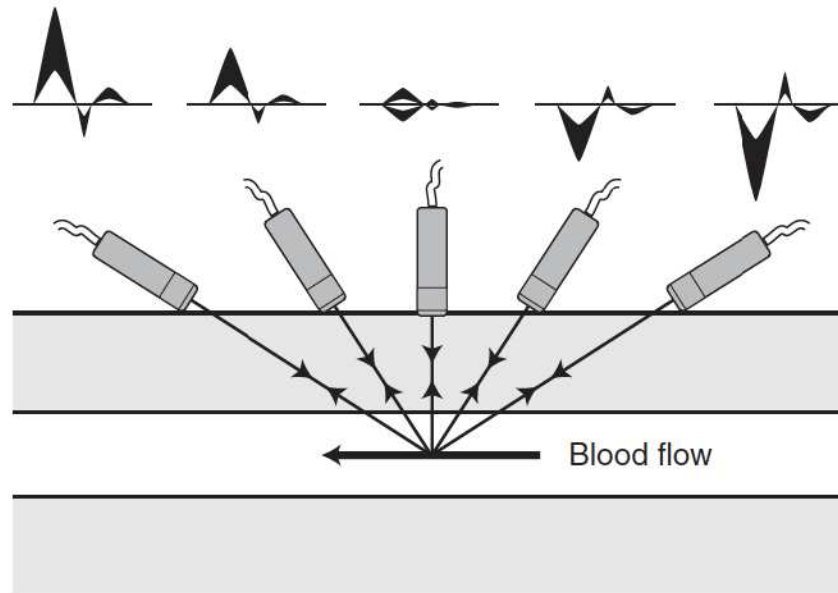
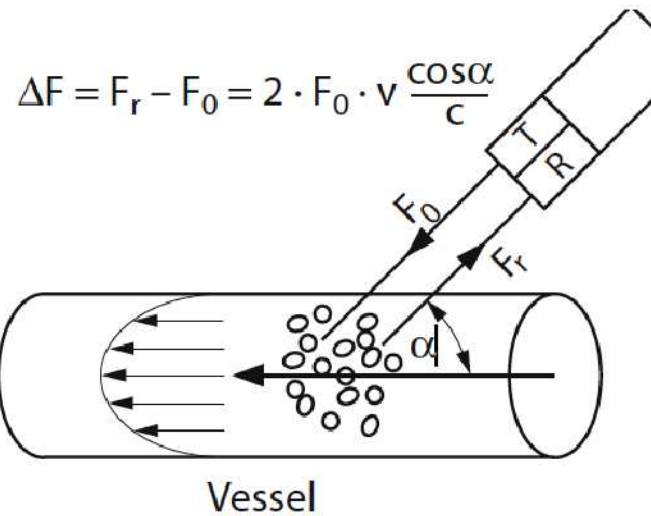
- Registreerib laine sageduse nihet
- Helilaine tuleb pidevalt ühest piezoelektrilisest kristallist ja signaali registreerib teine kristall.
 - Saab registreerida kõrge sageduse nihked
 - Sügaval koel langeb sensitiivsus
 - Nurga-sõltuv

Doppler equation	
$\Delta F = F_E - F_0 = 2 \times F_0 \times \frac{V}{C} \times \cos \alpha$	
F_E	= Frequency of echo
F_0	= Transmitted frequency
V	= Blood flow velocity
C	= Speed of sound in human tissue (approximately 1540 m/s)
α	= Beam-vessel angle

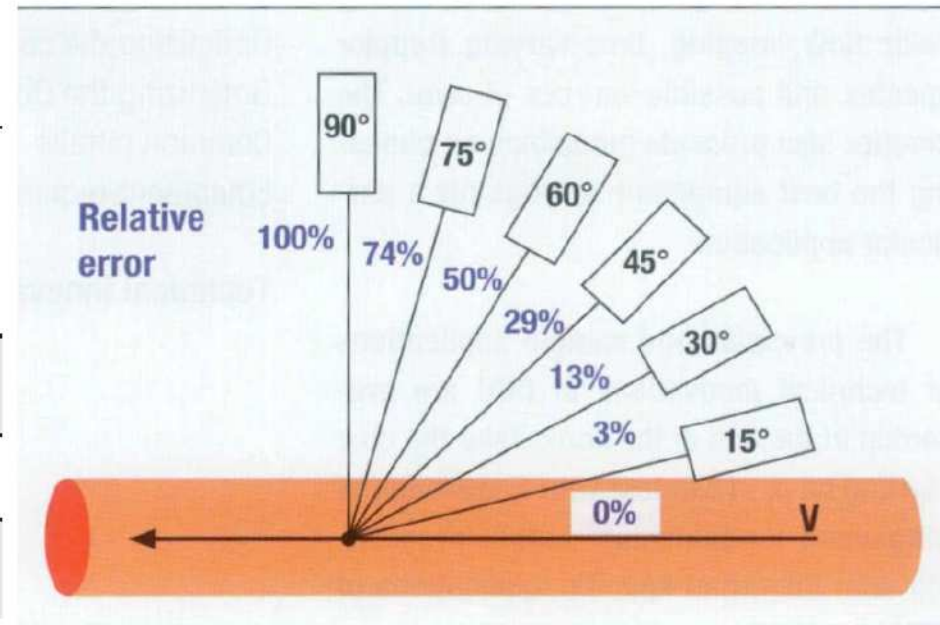


Füüsika: CWD

- Ideaalis tuleks kasutada väikest nurka (<60°)
 - Mõnikord raskes kliinilises seisundis vajadusel saab kasutada ka rohkem, aga langeb signaali ja tulemuse kvaliteet.
- Värvus iseloomustab voolu suunda
 - (mitte veresoonte tüüpi)



θ (°)	$\cos \theta$
0	1
30	0.87
45	0.71
60	0.5
75	0.26
90	0



UH Doppler uuringu optimeerimine

- CWD UH aparaadil, mida saab operaator muuta:
- Värv -
 - **Helivihu suunamine** ("rombi kast")
 - Ja **nurga** korrigeerimine veresoonte suunas
 - **PRF** – pulsi kordussagedus
 - Aliasing*
 - **Gain** (võimsus)
- Spektraalne doppler
 - **Sample Volume** (valimi maht) -
 - Suurus
 - Sügavus
 - **Wall filter** (nn baseline filter)
 - **Gain** (võimsus)

UH CWD arterite uuring

- CWD UH aparaadil, mida saab muuta:
- Värvi Doppler -
 - **Helivihu suunamine** ("rombi kast")
 - Ja **nurga** korrigeerimine veresoonte suunas
 - **PRF** – pulsi kordussagedus
 - Aliasing*
 - **Gain** (võimsus)
- Spektraalne doppler
 - **Sample Volume** (valimi maht) -
 - Suurus
 - Sügavus
 - **Wall filter** (nn baseline filter)
 - **Gain** (võimsus)

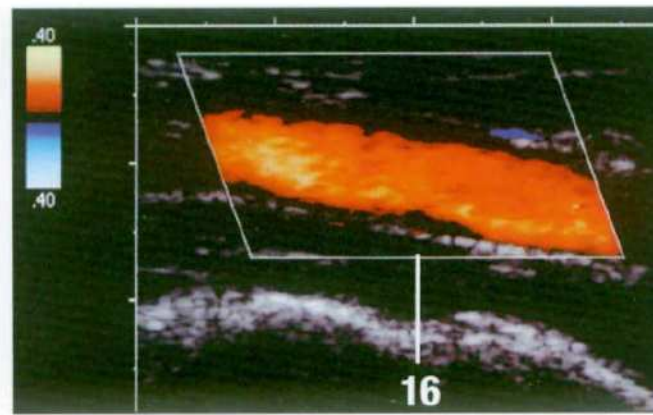


Fig. 16.2 With beam steering

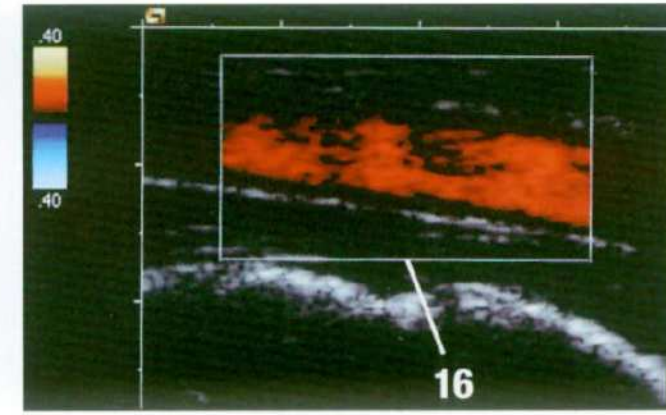


Fig. 16.3 Without beam steering

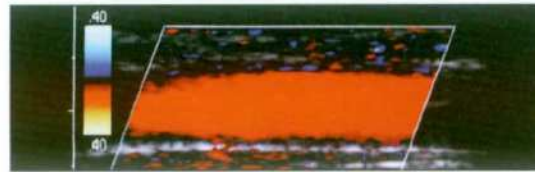


Fig. 16.7 Blooming artifact



Fig. 16.8 Optimum color gain

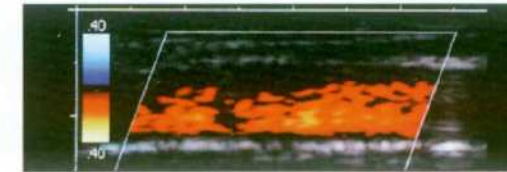


Fig. 16.9 Color gain is too low

UH CWD arterite uuring

- CWD UH aparaadil, mida saab muuta:
- Värv -
 - **Helivihu suunamine** ("rombi kast")
 - Ja **nurga** korigeerimine veresoonte suunas
 - **PRF** – pulsi kordussagedus
 - Aliasing*
 - **Gain** (võimsus)
- Spektraalne doppler
 - **Sample Volume** (valimi maht) -
 - Suurus
 - Sügavus
 - **Wall filter** (nn *baseline filter*;))
 - **Gain** (võimsus)

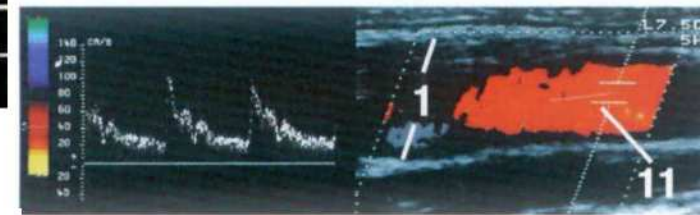
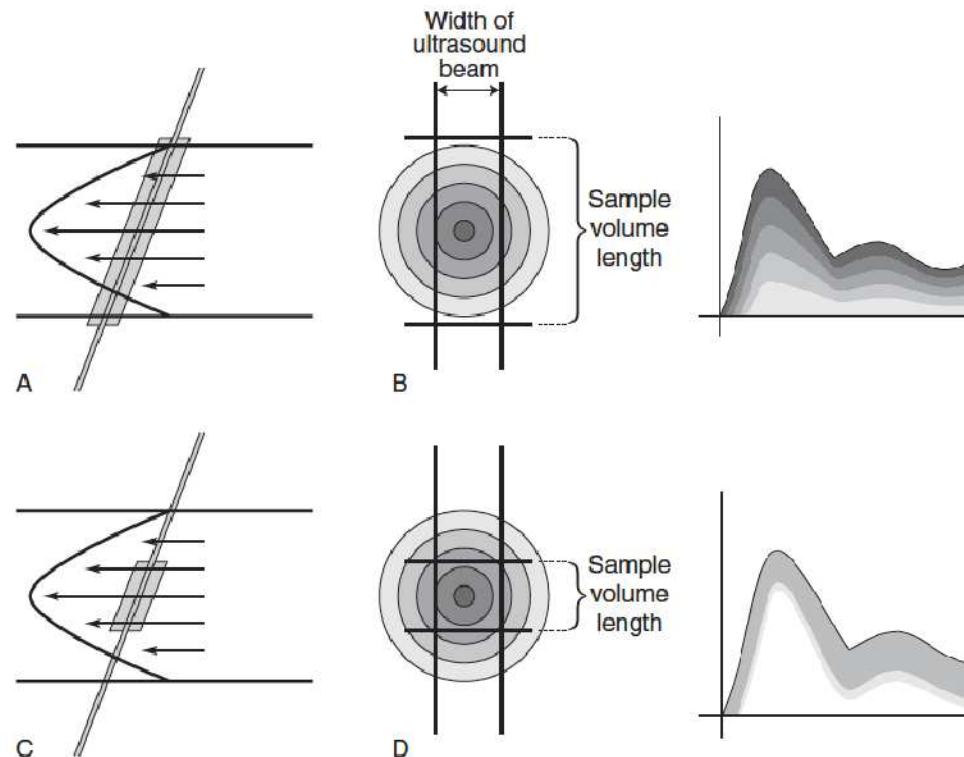
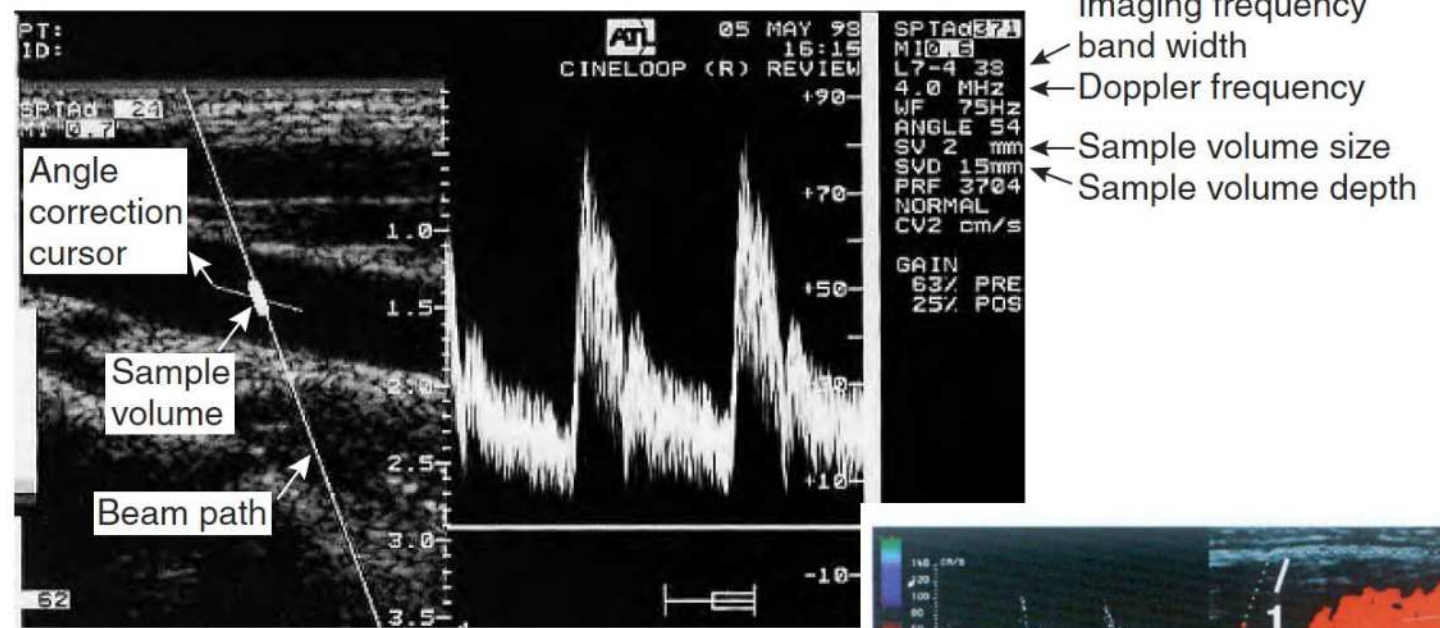


Fig. 17.1 SV in correct position



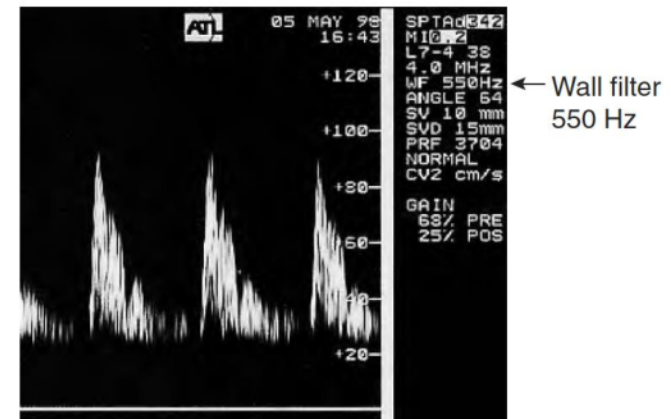
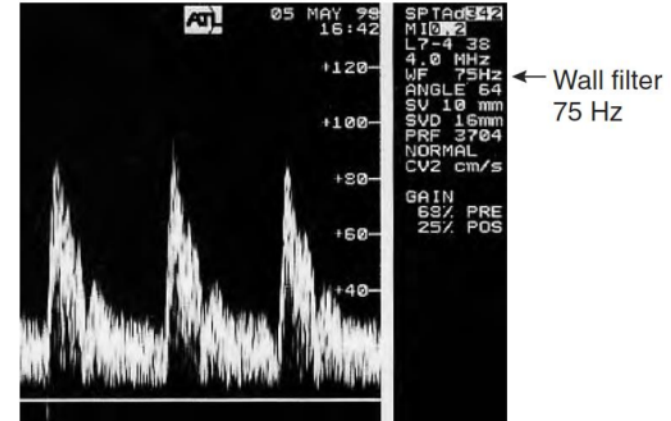
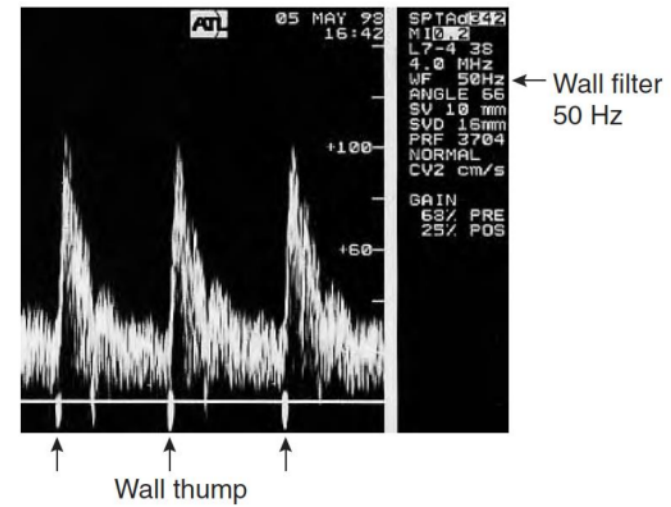
Fig. 17.2 SV off-centered



Fig. 17.3 SV too large

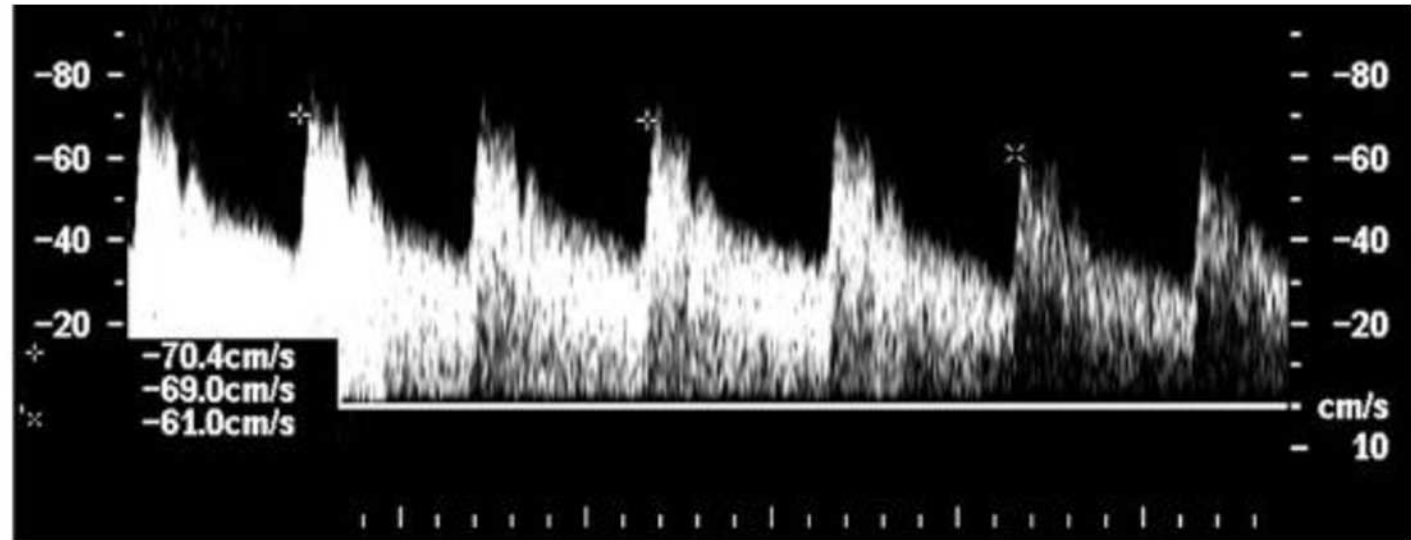
UH CWD arterite uuring

- CWD UH aparaadil, mida saab muuta:
- Värv -
 - **Helivihu suunamine** ("kast")
 - Ja **nurga** korrigeerimine veresoonte suunas
 - **PRF** – pulsi kordussagedus
 - Aliasing*
 - **Gain** (võimsus)
- Spektraalne doppler
 - **Sample Volume** (valimi maht) -
 - Suurus
 - Sügavus
 - **Wall filter** (kõrgpääsfilter, *baseline* filter)
 - **Gain** (võimsus)



UH CWD arterite uuring

- CWD UH aparaadil, mida saab muuta:
- Värv -
 - **Helivihu suunamine** ("rombi kast")
 - Ja **nurga** korrigeerimine veresoonte suunas
 - **PRF** – pulsi kordus-sagedus
 - Aliasing*
 - **Gain** (võimsus)
- Spektraalne doppler
 - **Sample Volume** (valimi maht) -
 - Suurus
 - Sügavus
 - **Wall filter** (nn *baseline* filter)
 - **Gain** (võimsus)



Aliasing - spektraalne moonutus - PRF!

- Spektraalne moonutus on signaali sageduse vale hinnang, mis on tingitud signaali ebapiisavasa salvestamise (*sampling*) tõttu.
- "vaatluse" sagedus liiga väike - tekitab spektraalne moonutus → suurendada PRF
- SM meenutab tagurpidi voolu

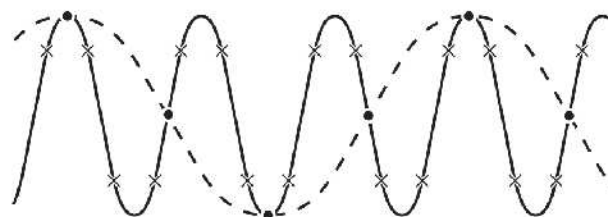
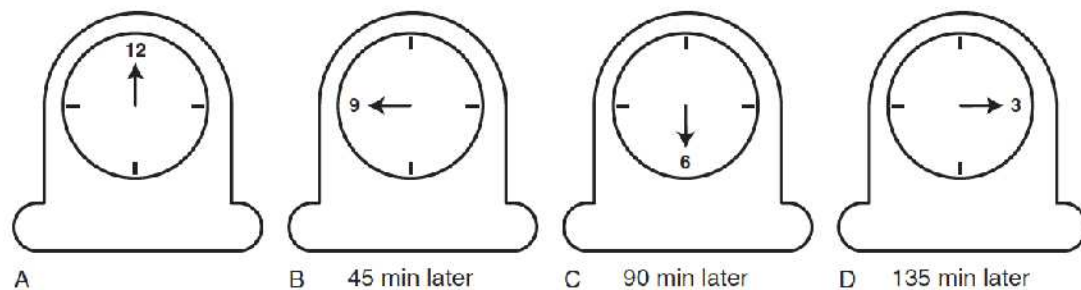
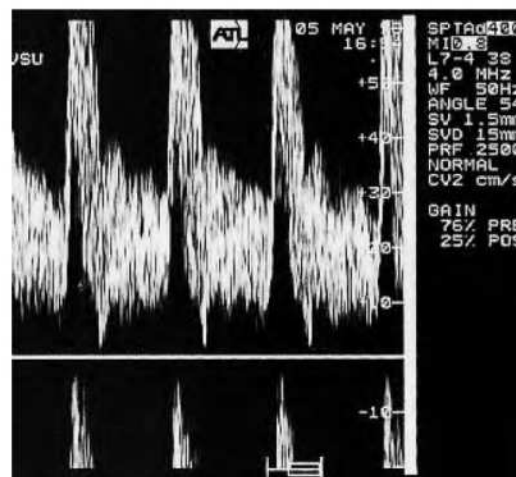
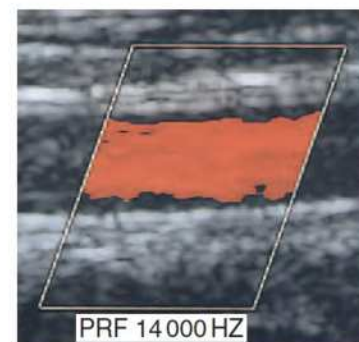
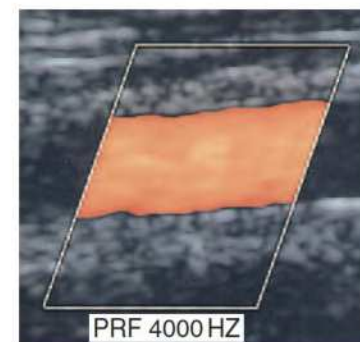
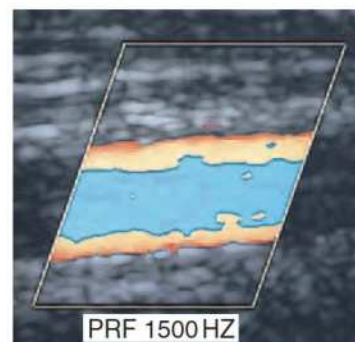
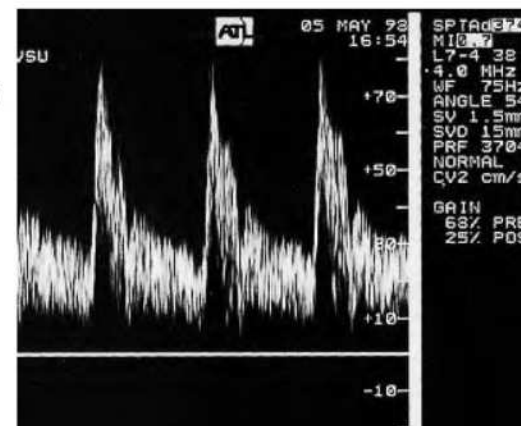


Figure 3.13 Aliasing. The frequency of a simple sine wave (solid line) can be underestimated (dashed line) when the signal is sampled less than twice in a complete cycle.



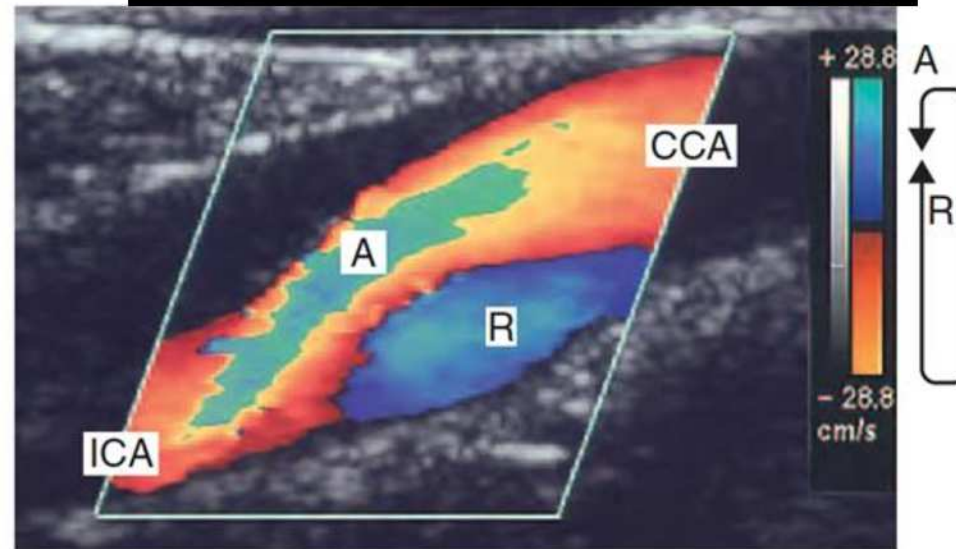
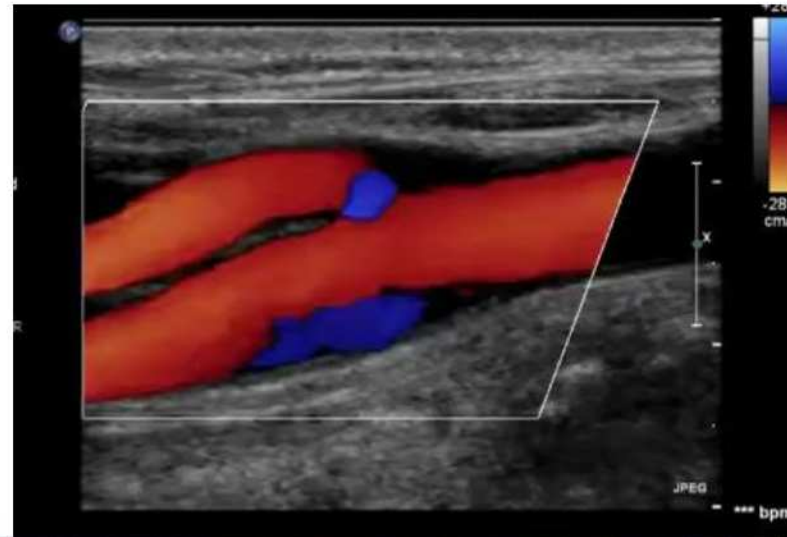
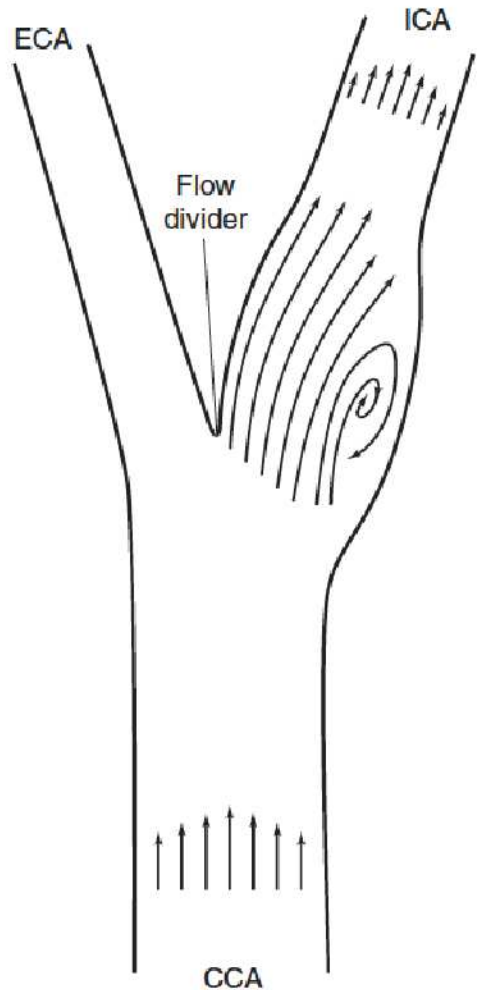
← PRF 2500



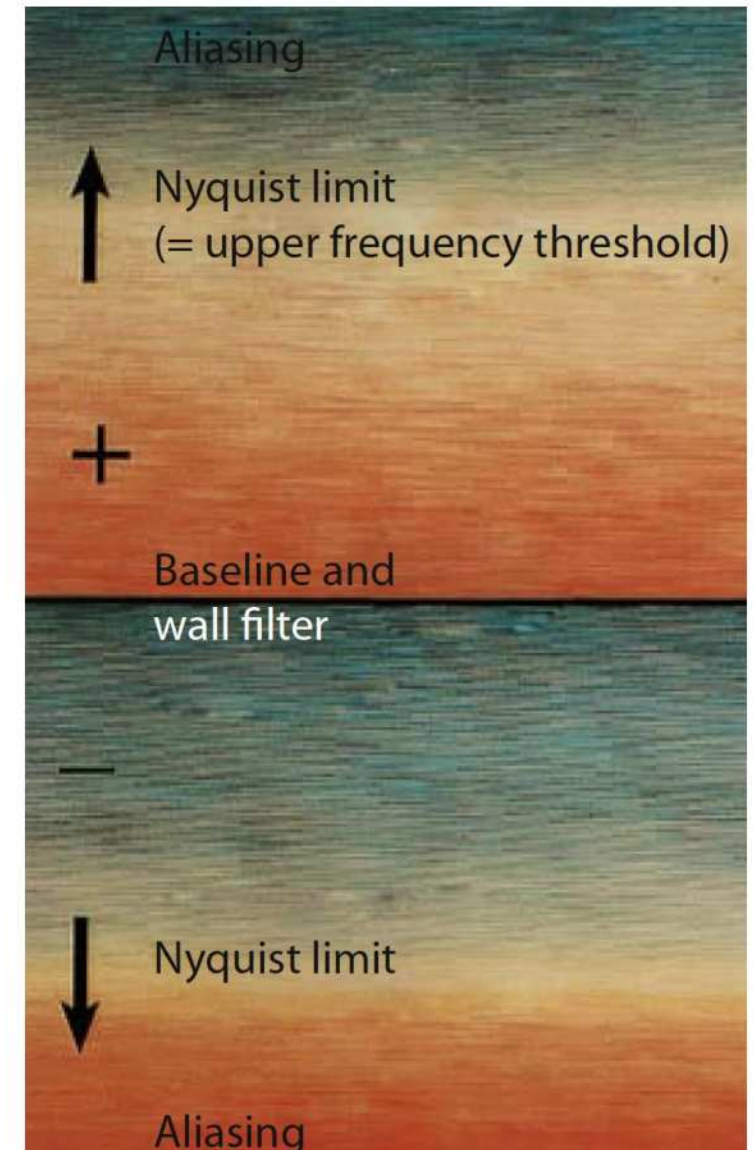
← PRF 3704



Aliasing (spektraalne moonutus)

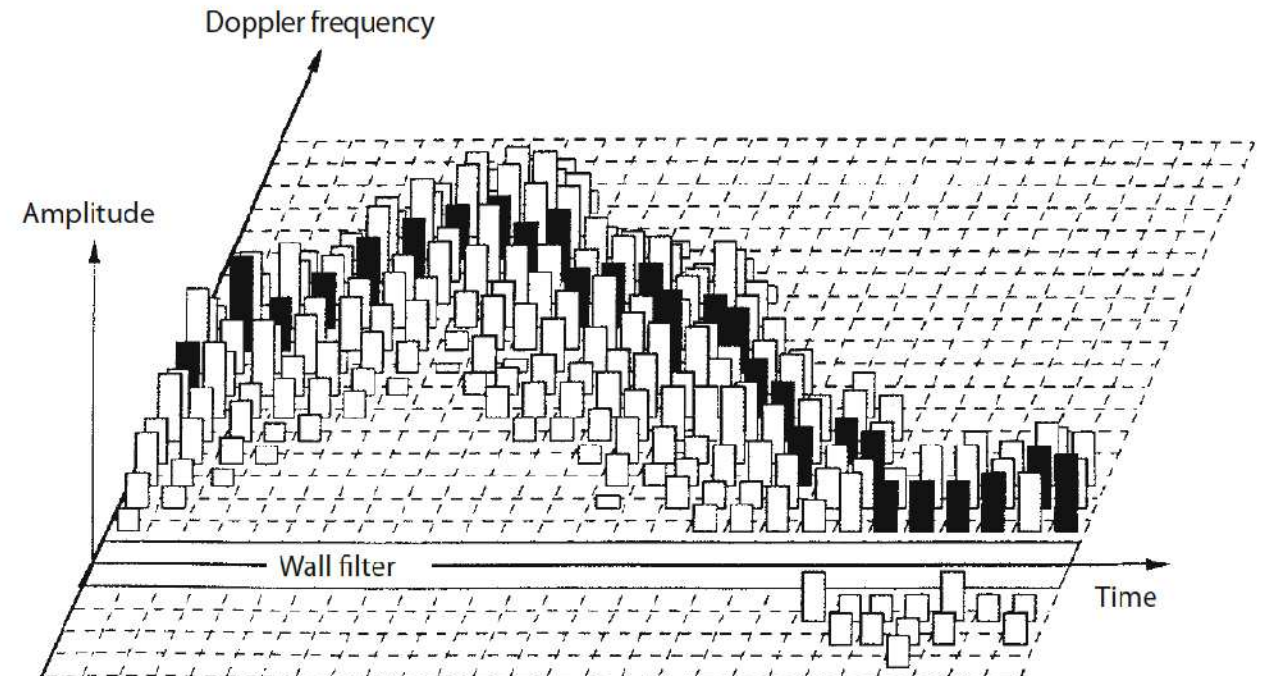
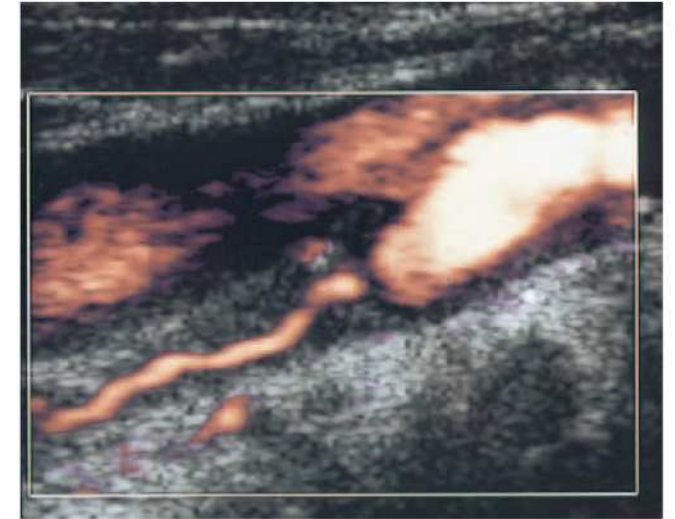
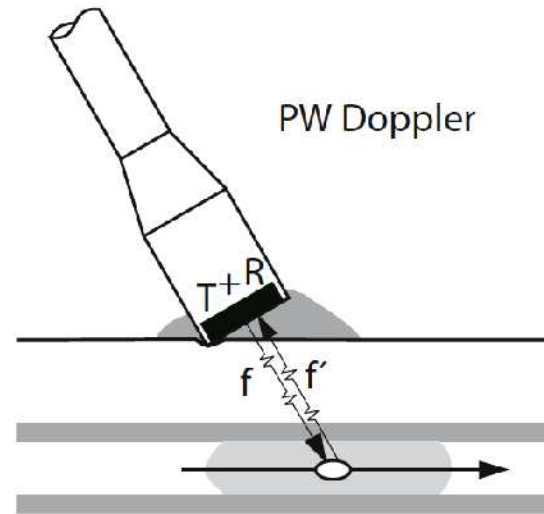


- A – spektraalne moonutus (antegraadne vool)
- R – retrograadne vool



PD – Power/Pulsed Doppler (Pulss Doppler)

- Registreerib laine amplituudi
 - Kvantitatiivne
- On vähem nurgast sõltumatu
- "*Aliasing*" sõltumatu
- Saab registreerida aeglaseid voole
 - Piirangud ülikiirete vooludega
- Ei anna informatsiooni voolu suunast
- Piiratud ülikiire vooludega



CWD vs PD

COLOR DOPPLER EVOLUTION OF CAROTID STENOSIS

ADVANTAGES

- Reduction in examination time.
- Quick identification of areas of stenosis/high velocity, which facilitates spectral analysis to artifacts.
- Improved diagnostic reproducibility and confidence.
- Distinguishes occlusion from “string sign.”
- Simultaneous hemodynamic and anatomic information, velocity, and directional blood flow information.
- Improved accuracy in quantitating stenoses.
- Clarifies pulsed Doppler/image mismatch.

DISADVANTAGES

- Prone to angle dependence.
- Resolution less than with gray scale.
- Less Doppler spectral than pulsed Doppler.
- Slower-frame rates information.
- Use cannot characterize plaque.

POWER DOPPLER EVALUATION OF CAROTID STENOSIS

ADVANTAGES

- No aliasing.
- Potentially increases accuracy of grading stenoses.
- Aids in distinguishing preocclusive from occlusive lesions.
- Potentially superior depiction of plaque surface morphology.
- Increased sensitivity to detecting low-velocity, low-amplitude blood flow.
- Angle independent.

DISADVANTAGES

- Does not provide direction or velocity flow information.
- Very motion sensitive (poor temporal resolution).

Steps of Image Optimization

B-mode image

- Step 1 Angle the probe relative to the vessel axis
- Step 2 Place just one focal zone at the center of the vessel lumen
- Step 3 Set the B-mode gain to a low level

Color flow image

- Step 4 Use beam steering to improve the beam-vessel angle (angled away from 90°, see p. 8)
- Step 5 Adjust the PRF to the prevailing flow velocity
- Step 6 Increase the color gain until blooming occurs, then lower the gain until color signals are confined to the vessel lumen (no extravascular color pixels)

Doppler spectrum

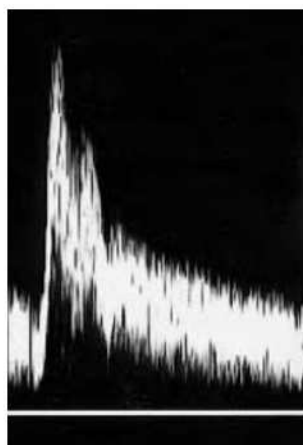
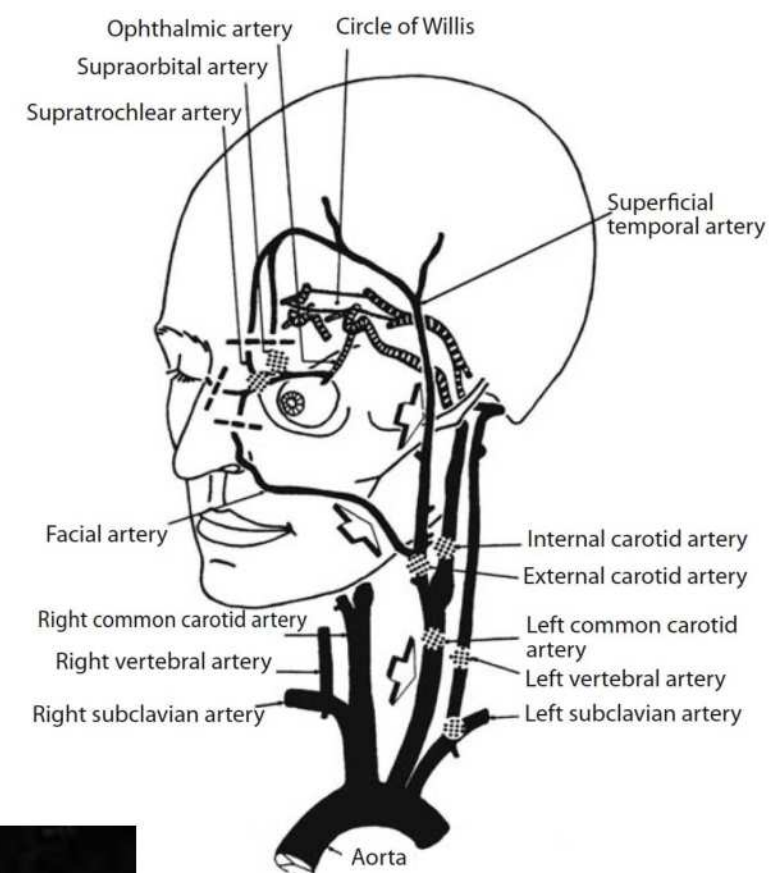
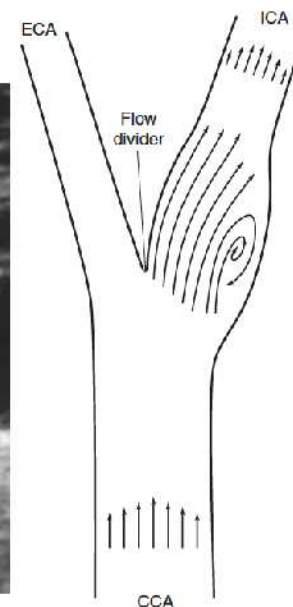
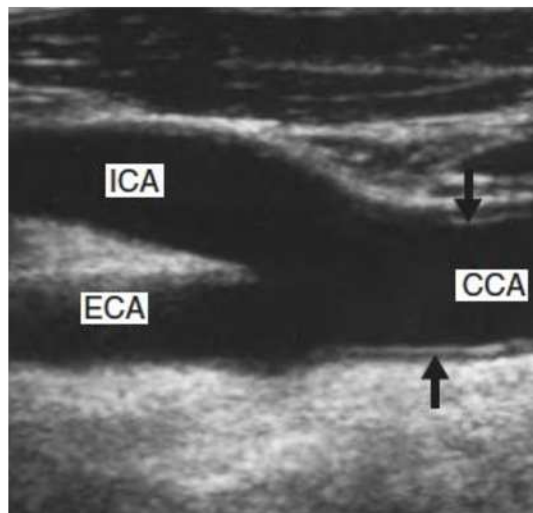
- Step 7 Position the sample volume (SV) at the center of the vessel and set the SV size at $\frac{1}{2}$ to $\frac{2}{3}$ of the luminal diameter
- Step 8 Adjust the baseline level for spectral components above or below the baseline to eliminate waveform cutoff at the top or bottom
- Step 9 Adjust the velocity range (PRF_{PW}). If aliasing still occurs:
Doppler trace too short $\Rightarrow PRF_{PW} \downarrow \Rightarrow$ to expand the trace vertically
Doppler trace too high $\Rightarrow PRF_{PW} \uparrow \Rightarrow$ to compress the trace vertically
- Step 10 Adjust the PW gain to obtain a good contrast-to-noise ratio:
Try to get a dark background without noise pixels, but do not set the gain too low (for automatic envelope curve detection)
- Step 11 Remember to enter the insonation angle!

Lõksud

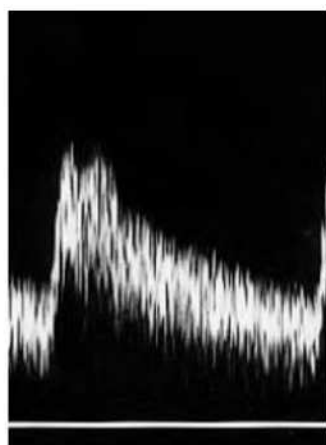
- Errors in angle determination (primarily with angles $> 60^\circ$), chiefly in curved vessels and branchings
- Errors in determining vessel diameter (blooming effect, diameter variation during cardiac cycle)
- Limitation of maximum velocity detectable (Nyquist limit)
- Limitation of minimum velocity detectable (wall filter, inadequate PRF)
- Position and size of sample volume
- Inclusion of accompanying vessels (high PRF, CW Doppler, large sample volume)
- Overmodulation resulting from unfavorable signal-to-noise ratio (gain)
- Impairment by scattering structures (plaque, intestinal gas, edema)

Normaalne verevoolu spekter kaela arterites

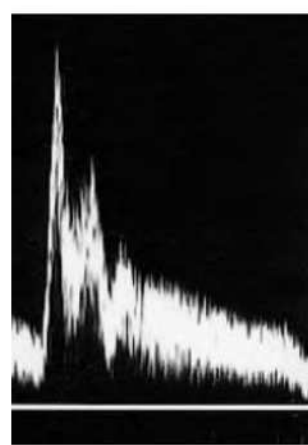
- Madala resistentsusega arterid
 - Retrograadset diastoolset voolu pole



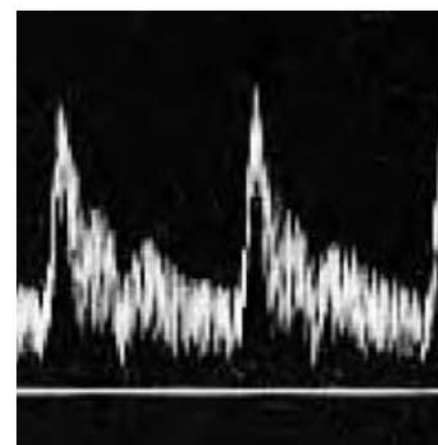
CCA



ICA



ECA



VA

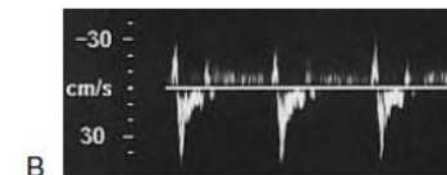
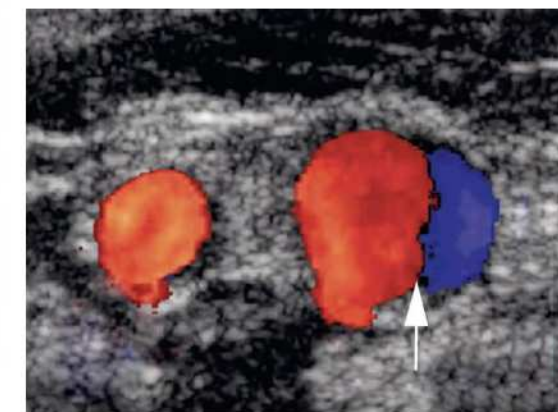
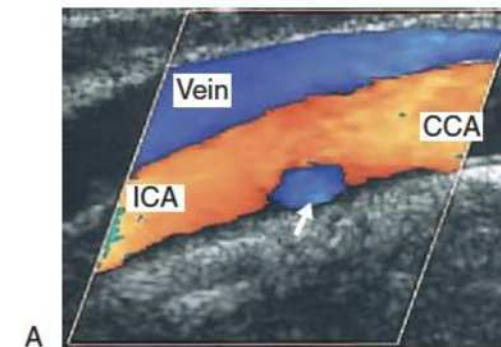
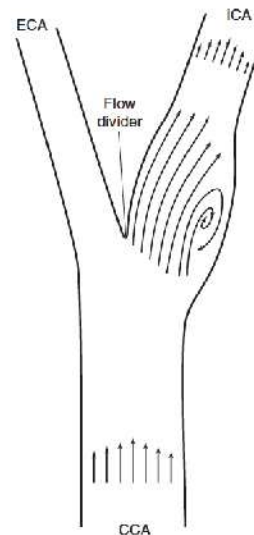
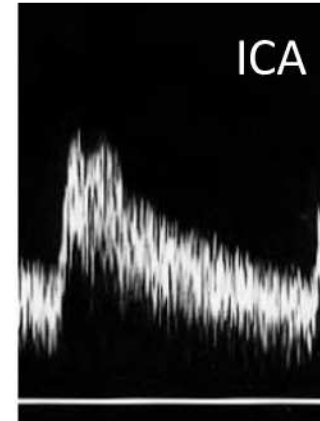
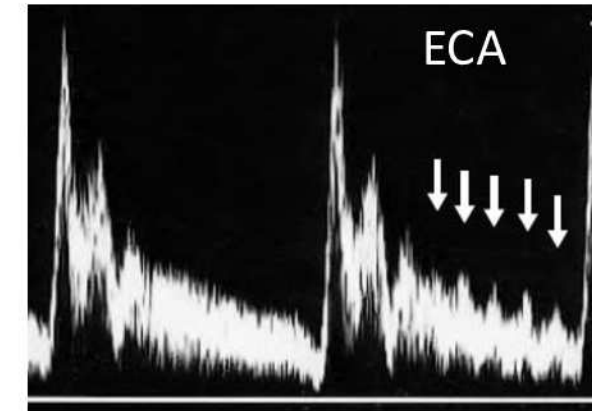
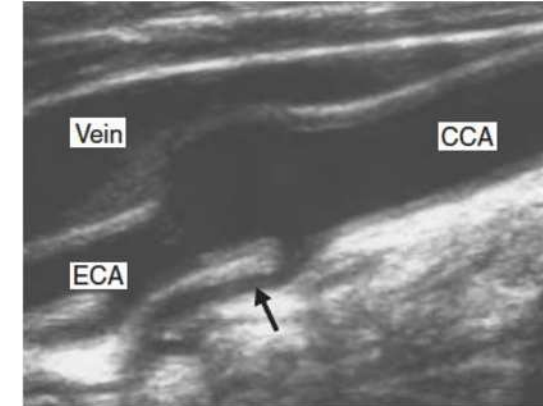
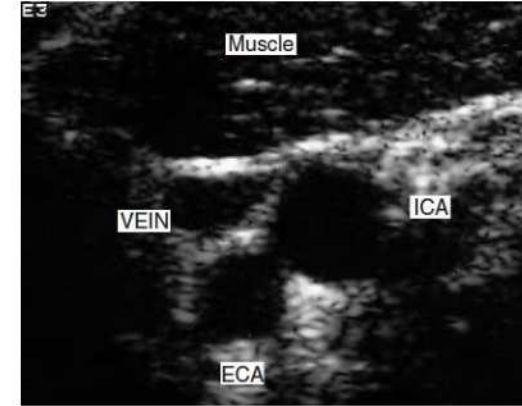
Kuidas eristada ICA vs ECA

- ECA (vs ICA):

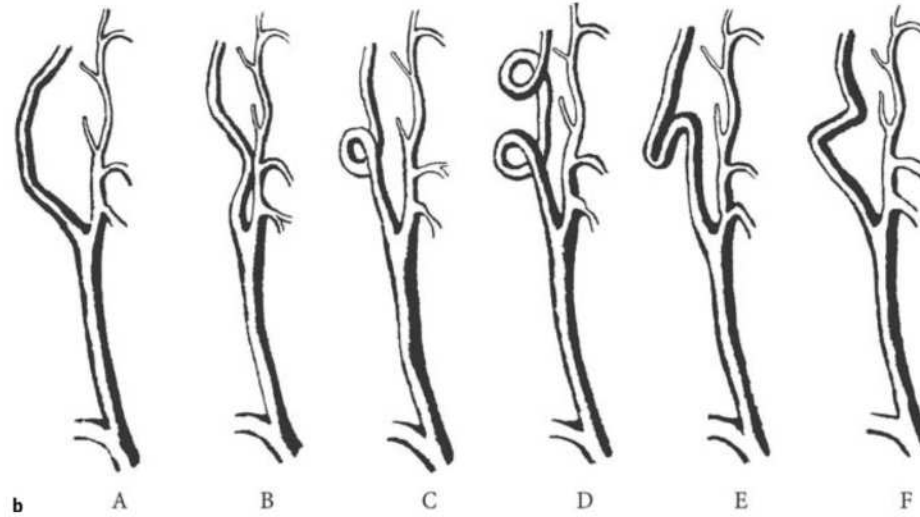
- Tavaliselt posterio-mediaalsem
- Laine kuju "pulsatiilsem"
- Läbimõõt tavaliselt väiksem
- Laine kuju sarnasem CCA-le
- Madalam diastoolne vool
- Temporalarteri palpatsioon – tekib sakilisus
 - Normis mõnikord võib olla ka tri-faasiline

- ICA eripärad *bulbuse* osas:

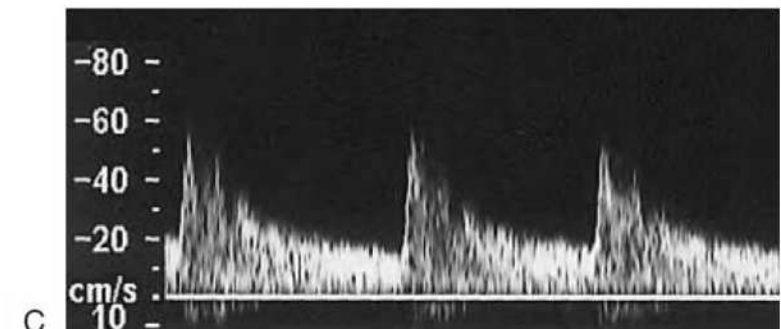
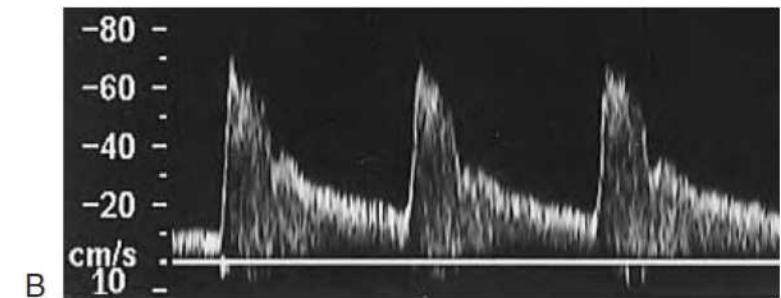
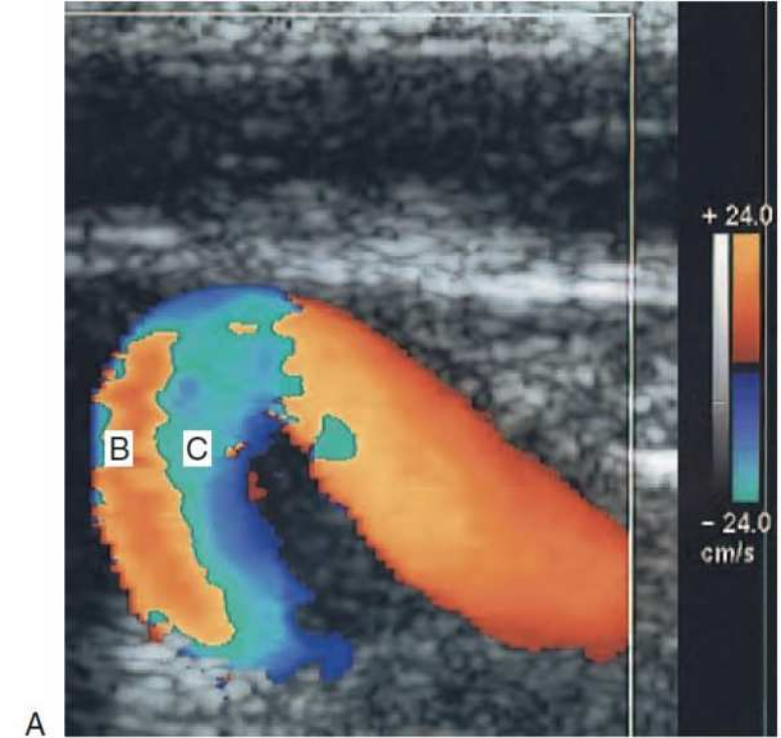
- Retrograadne vool lateraalsemal
- kiirused kõige suuremad seinapidiselt bifurkatsiooni läheduses mediaalsel



Looklev ICA



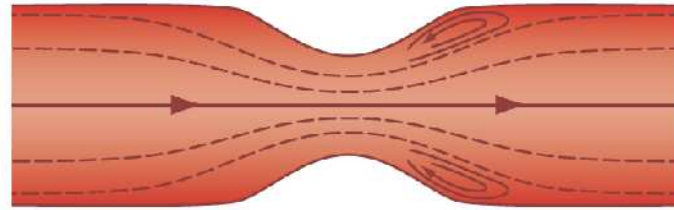
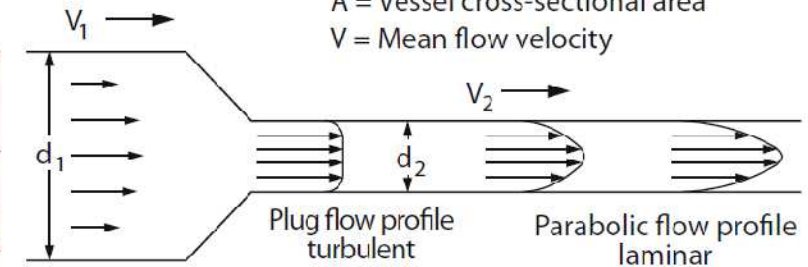
- Kui vedelik voolab mööda kõverat toru, on seinaga vastasmõjus nii tsentrifugaaljõud kui ka viskoossus anuma seinale ning nende jõudude kombinatsiooni tulemuseks on sekundaarne vool.
- Vool on kiirem kurvi väliskülje suunas



Voolu stenoosi kohal – kiirus, turbulents

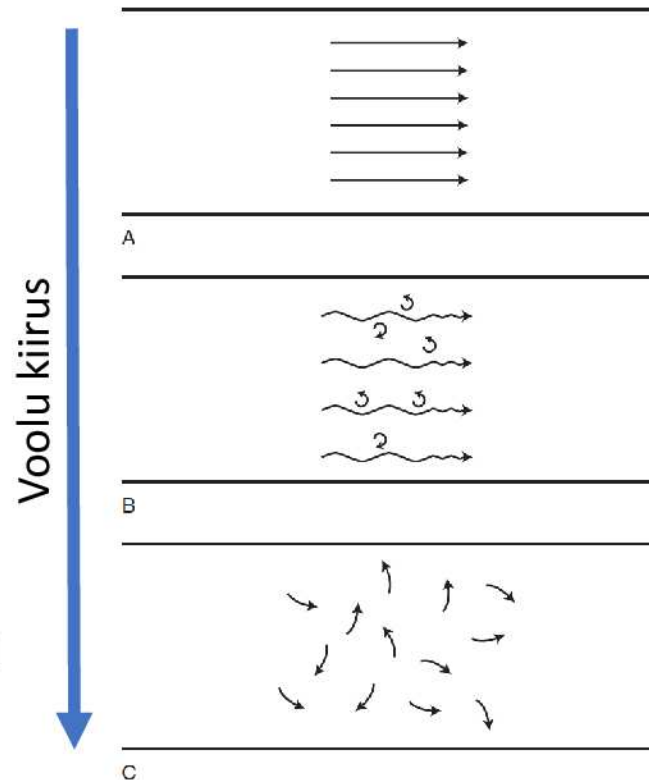
Continuity law: $\frac{A_1}{A_2} = \frac{V_2}{V_1}$

A = Vessel cross-sectional area
V = Mean flow velocity



Artery	Reynolds number
Ascending aorta	1500
Abdominal aorta	640
Common carotid	217*
Superficial femoral	200
Posterior tibial	35*

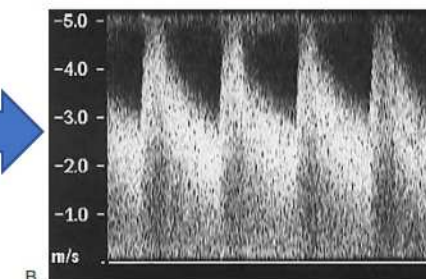
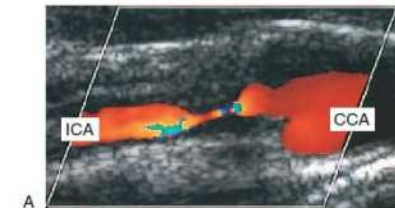
* Estimated values.



$$Re = \frac{dV\rho}{\mu}$$



Laminaarne vool



Turbulentne vool

- Stenoosi kohal verevoolu kiirus suureneb
- Kriitiline verevoolu kiirus põhjustab turbulentsi
 - Spektraaldoppleris tekib spektraalne laienemine
 - Valepositiivne, kui valesti paigaldatud *sample volume*
- Turbulents
 - Tekib kriitilise voolukiiruse tõttu
 - *Raynolds* arve
 - UH: Spektraalne laienemine

Pre-stenoosi, stenoos ja post-stenoosi vool (ICA-s)

- **Pre-stenoos (1) -**

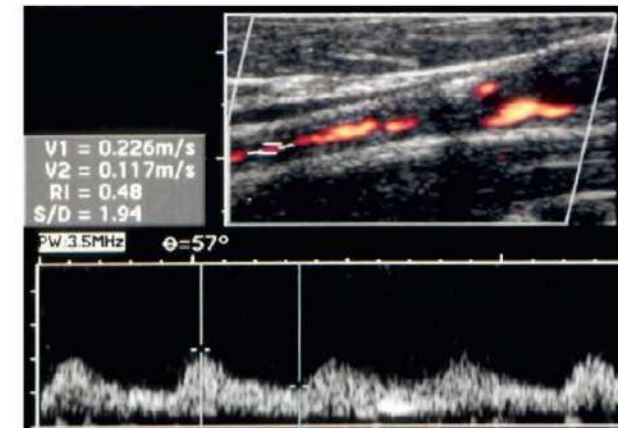
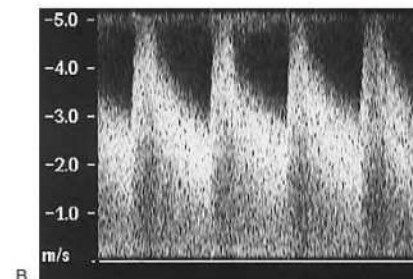
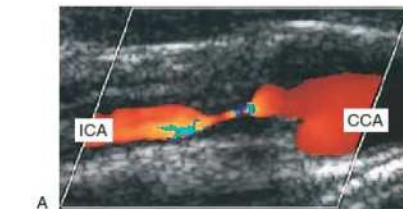
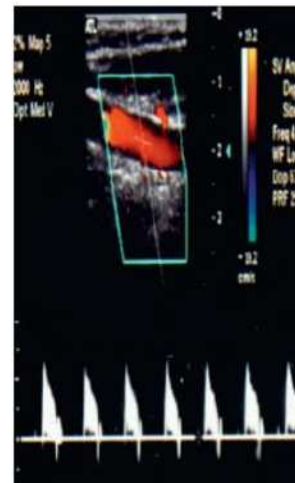
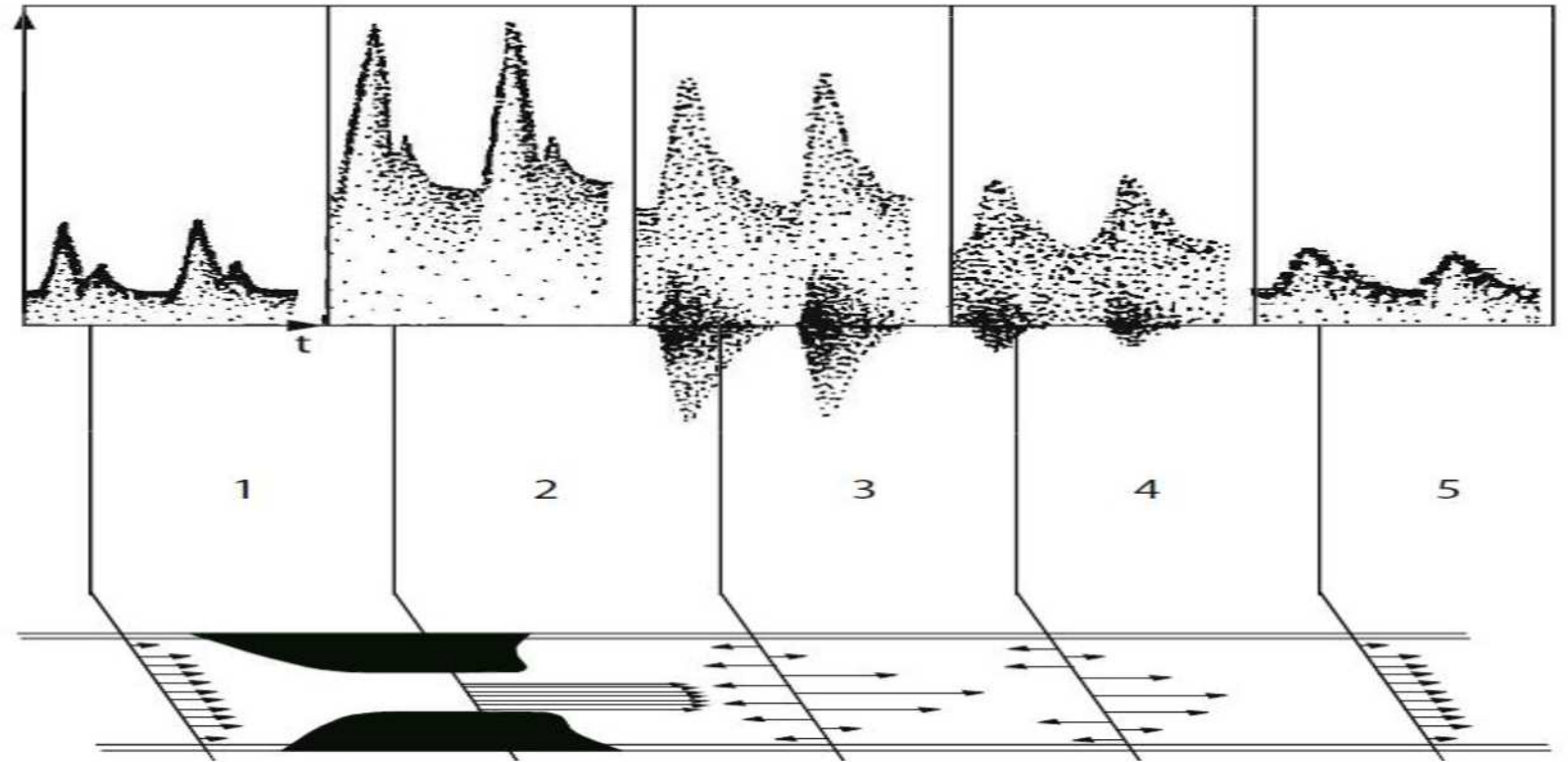
- Normaalne kuni kõrge arteri resistentsuse spekter (indeks)

- **Stenoos (2)-**

- Suur kiirus
- Spektraalne laienemine (turbulents)

- **Post stenoos(ist)-**

- Lähedal – spektraalne laienemine (3-4)
- Kaugel -madal arteri resistentsus (4-5)
 - *parvus-tardus* (5)



ICA stenoosi hindamine – NASCET ja ECST

- **NASCET** – 1991,1998
 - *North American Symptomatic Carotid Endarterectomy Trial Collaborators*
- **ECST** 1998
 - *European Carotid Surgery Trialists' Collaborative Group*
- **NASCET** ja **ECST** on põhjendatud angiograafia alusel (valendiku läbimõõtu hindamiseks)

Method used in NASCET and VA309

$(1-N/D) \times 100 = \% \text{ stenosis}$

eg, $N=2.5$

$D=5.0$

$(1-2.5/5.0) \times 100 = 50\%$

Method used in ECST

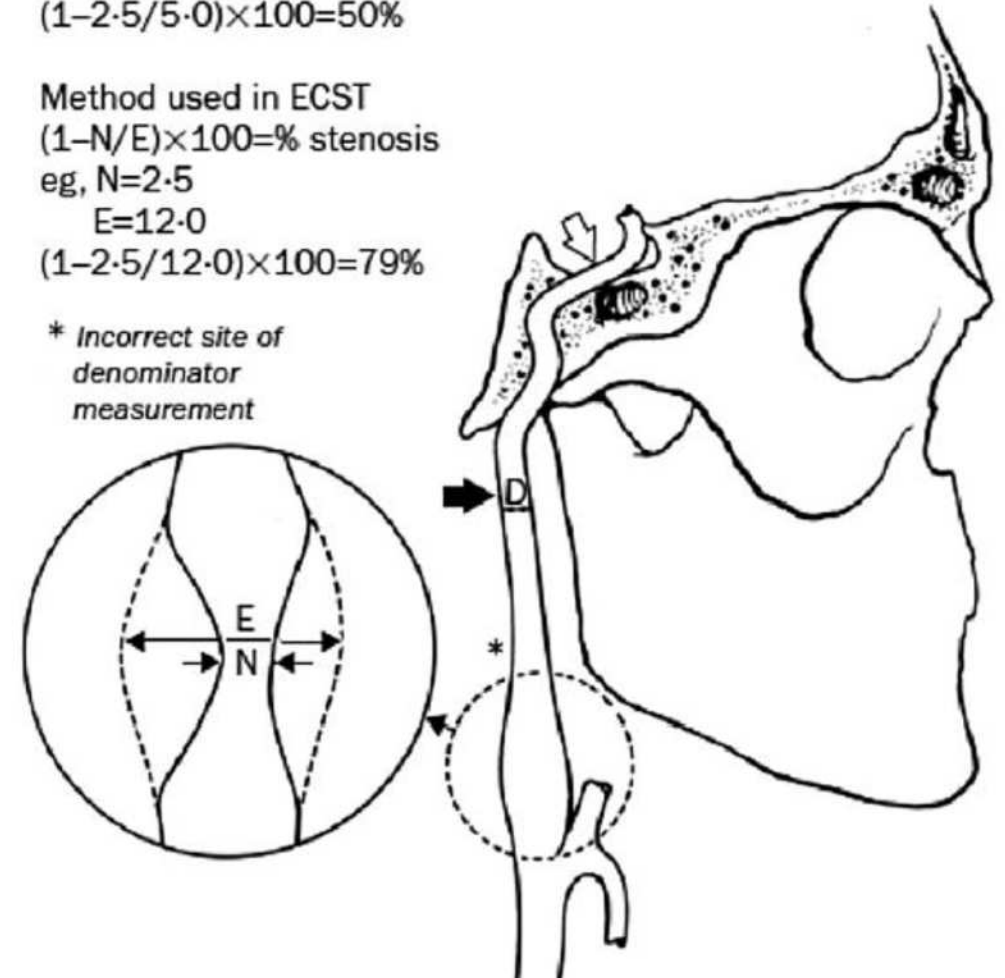
$(1-N/E) \times 100 = \% \text{ stenosis}$

eg, $N=2.5$

$E=12.0$

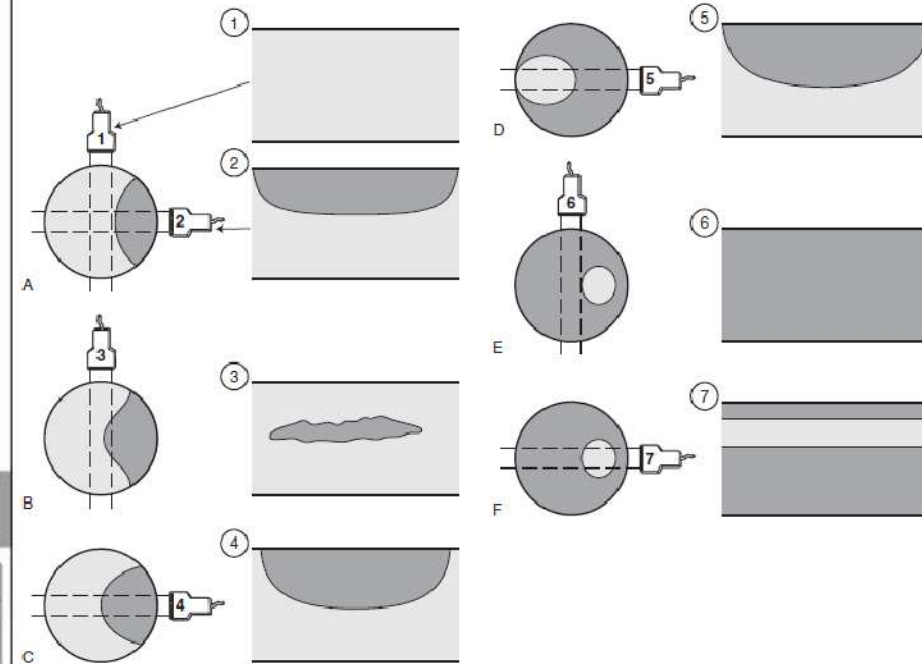
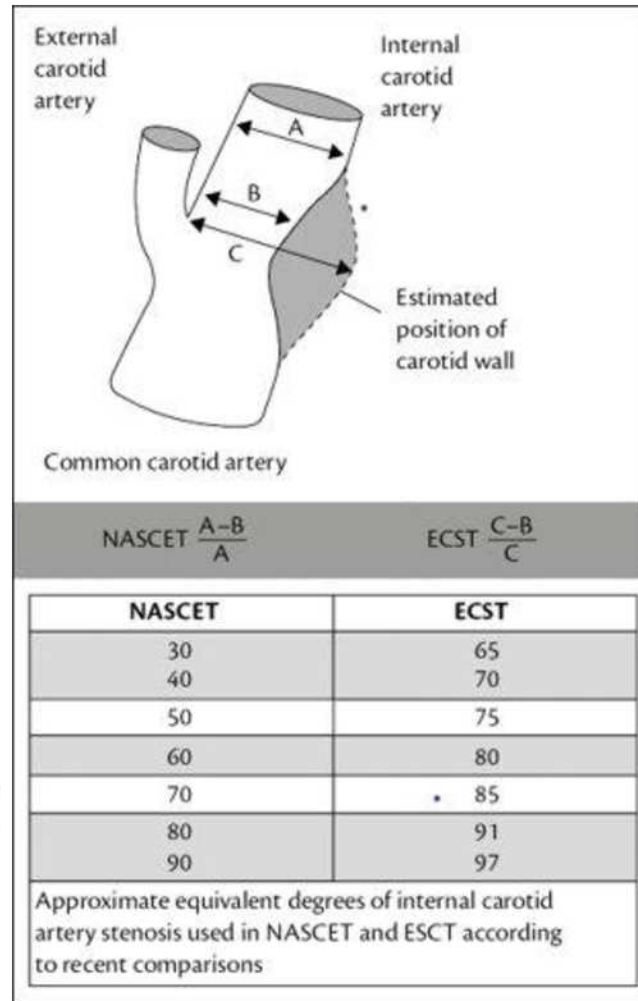
$(1-2.5/12.0) \times 100 = 79\%$

* *Incorrect site of denominator measurement*



ICA stenoosi hindamine – NASCET ja ECST

- **NASCET** ja **ECST** on põhjendatud angiograafia alusel (valendiku läbimõõdu hindamiseks)
- **UH B mode**– stenoosi hindamine on raskendatud
 - Täpsus vaieldav¹⁰
- UH doppleruuringul mõõdetud voolukiirused on võrdelised NASCETi stenoosi astmega¹³
- **Euroopa Veresoontekirurgide Seltsi (ESVS)** viimases juhises (2017)¹¹ on kasutatud stenoosi hindamist NASCET järgi.



Karotiidarterite stenoosi hindamise soovitusel (ESVS)^{11,12}

Recommendation 1	Class	Level
Duplex ultrasound (as first-line), computed tomographic angiography and/or magnetic resonance angiography are recommended for evaluating the extent and severity of extracranial carotid stenoses	I	A
Recommendation 2		
When carotid endarterectomy is being considered, it is recommended that Duplex ultrasound stenosis estimation be corroborated by computed tomographic angiography or magnetic resonance angiography, or by a repeat Duplex ultrasound performed by a second operator	I	A
Recommendation 3		
When carotid stenting is being considered, it is recommended that any Duplex ultrasound study be followed by computed tomographic angiography or magnetic resonance angiography which will provide additional information on the aortic arch, as well as the extra- and intracranial circulation	I	A
Recommendation 4		
Units who base management decisions on Duplex ultrasound stenosis measurement should state which measurement method is being used	I	C
Recommendation 5		
Intra-arterial digital subtraction angiography should not be performed in patients being considered for revascularisation, unless there are significant discrepancies on non-invasive imaging	III	A

ICA stenoosi hindamine UH-s – ESVS juhised (NASCET alusel)^{11,13}

Eur J Vasc Endovasc Surg (2018) 55, 3–81

- **ESVS** – ICA stenoosi diagnostilised kriteeriumid UH-s (2017)

Editor's Choice — Management of Atherosclerotic Carotid and Vertebral Artery Disease: 2017 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS)

A.R. Naylor^a, J.-B. Ricco^a, G.J. de Borst^a, S. Debus^a, J. de Haro^a, A. Halliday^a, G. Hamilton^a, J. Kakisis^a, S. Kakkos^a, S. Lepidi^a, H.S. Markus^a, D.J. McCabe^a, J. Roy^a, H. Sillesen^a, J.C. van den Berg^a, F. Vermassen^a,
ESVS Guidelines Committee^b, P. Kolh, N. Chakfe, R.J. Hinchliffe, I. Koncar, J.S. Lindholt, M. Vega de Ceniga, F. Verzini,
ESVS Guideline Reviewers^c, J. Archie, S. Bellmunt, A. Chaudhuri, M. Koelemay, A.-K. Lindahl, F. Padberg, M. Venermo

Table 1 Diagnostic criteria to be applied

Percentage stenosis (NASCET)	Internal carotid peak systolic velocity cm/sec	Peak systolic velocity ratio ICA _{PSV} /CCA _{PSV}	St Mary's ratio ^c ICA _{PSV} /CCA _{EDV}
<50	<125 ^a	<2 ^a	<8
50–59	>125 ^a	2–4 ^a	8–10
60–69			11–13
70–79	>230 ^a	>4 ^a	14–21
80–89			22–29
>90 but less than near occlusion	>400 ^b	>5 ^b	>30
Near occlusion	High, low – string flow	Variable	Variable
Occlusion	No flow	Not applicable	Not applicable

^a NACC¹⁷.

^b Filis et al.³⁷.

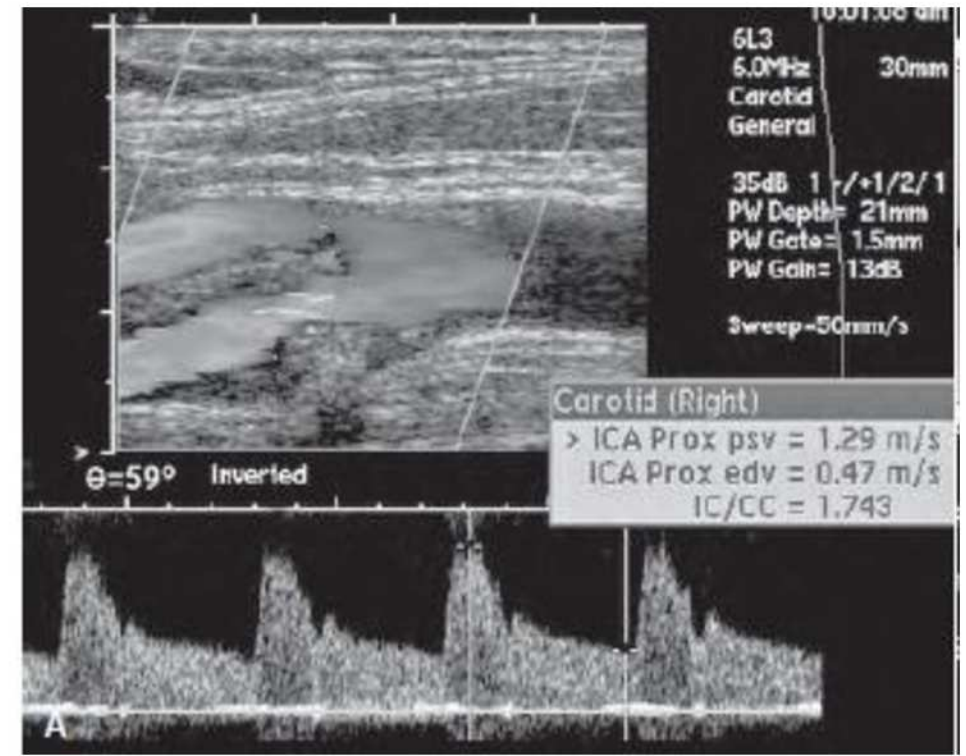
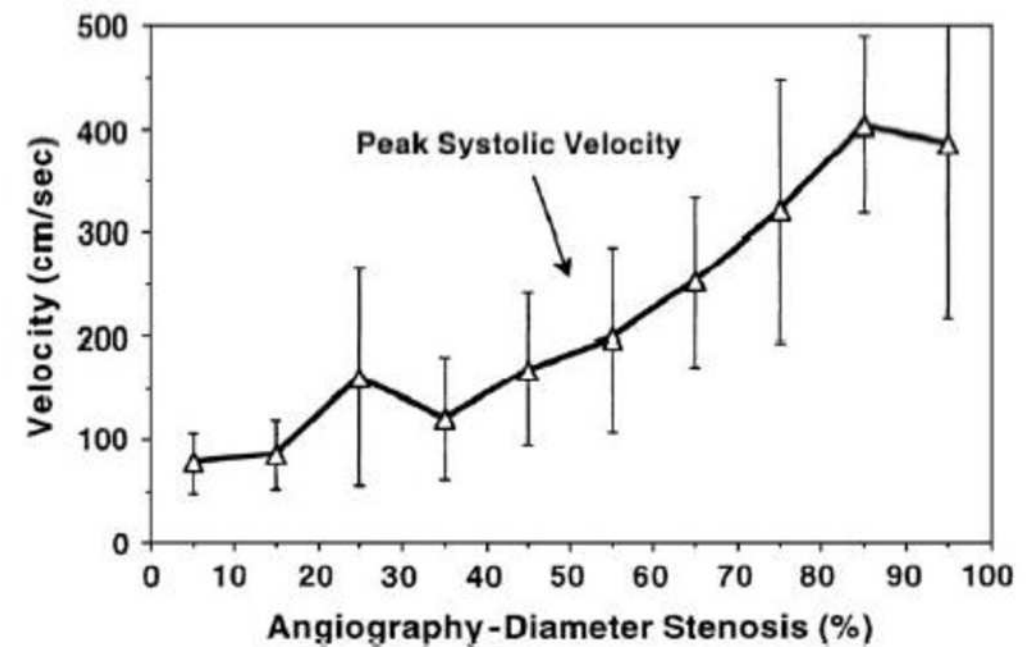
^c Nicolaides et al.³³.

PSV – tipp süstoolne kiirus

EDV – lõpp diastoolne kiirus

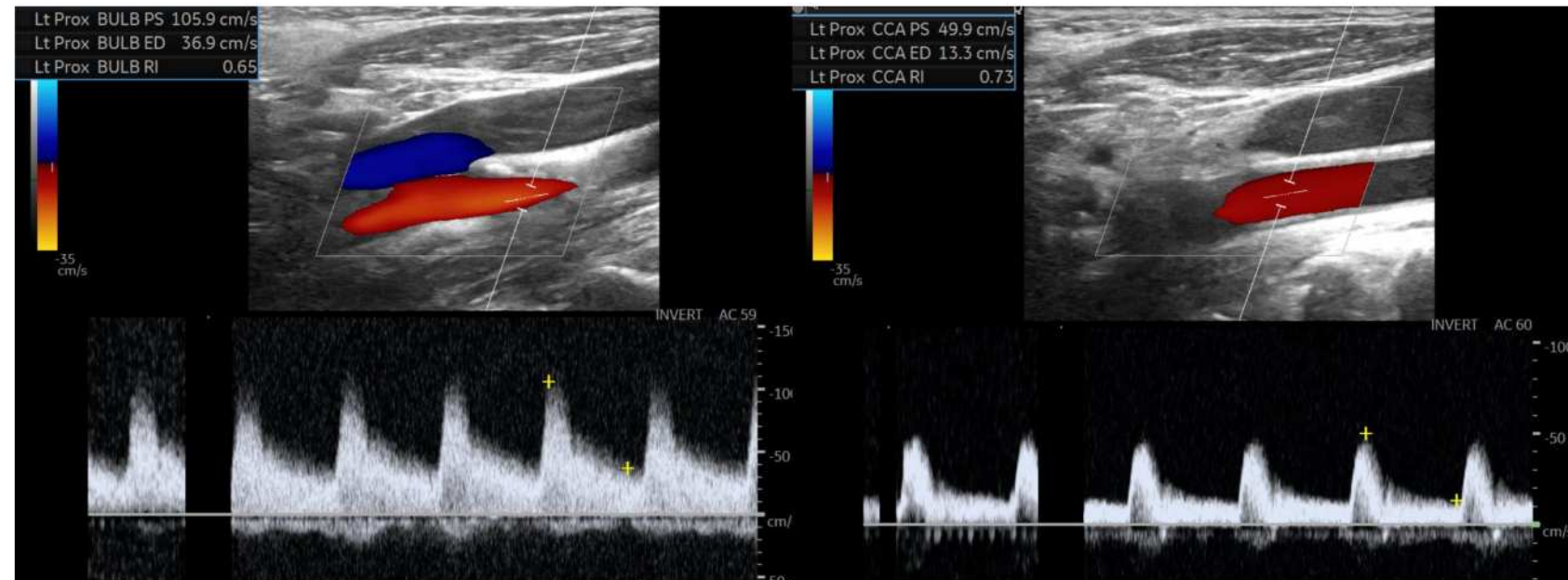
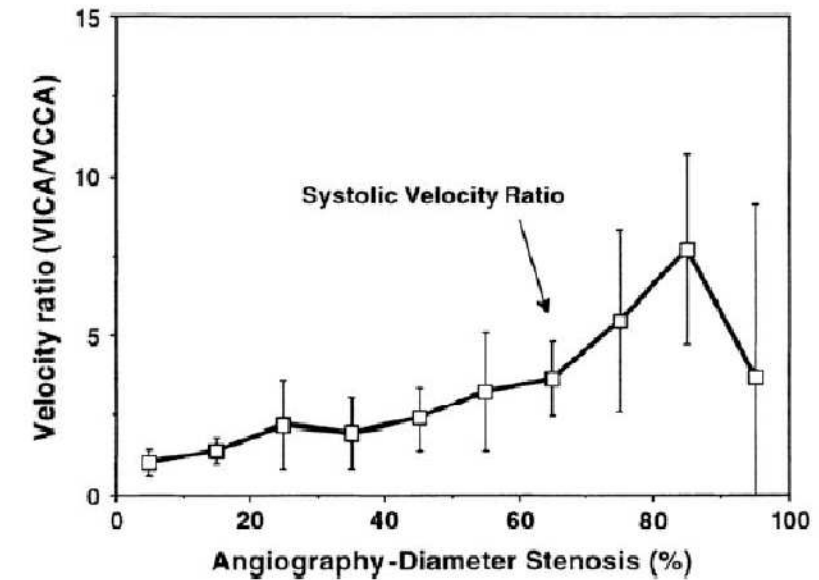
ICA stenoos – PSV¹³

- UH Doppler uuringul PSV stenoosi kohal on primaarne kriteerium stenoosi hindamiseks
 - >50% stenoos = > 125 cm/s PSV
- Lisafaktorid, mis võivad mõjutada tulemusi
 - *Bulbuse* suurus, bifurkatsiooni geomeetria
 - Veresoonte suuruse erinevus
 - Muutused pt. vanuse ja vererõhu seoses
 - Füüsilised parameetrit
 - sõltuvad UH-aparaadist
 - Teised



ICA stenoos- ICA/CCA PSV suhe¹³

- Lisakriteerium
 - >50% stenoos = suhe >2
- Aitab kinnitada diagnoosi ja stenoosi ulatust
- Kui ICA PS voolukiirus on ebamäärane (valepositiivsed/negatiivsed tulemused)
 - Aeglustunud sissevool (nt südamepuudulikkus)
 - Kiirenenud sissevool (nt. Arteriaalne hüpertensioon)



PSV –tipp süstoolne kiirus
EDV –lõpp diastoolne kiirus

ICA stenosis- St. Mary's suhe (ICA-PSV/CCA-EDV)¹³

- Lisakriteerium

- >50% stenosis = suhe >8
- Annab teoreetiliselt võimaluse eristada stenootsi üle või alla 60%.

- Suhe võib olla vähem usaldusväärne :

- Retrograadne diastoolne vool aordiklapi haiguse tõttu
- Suurenenud arterite resistentsus vanuse tõttu
- Ebatavalised või seletamatud lainekujud

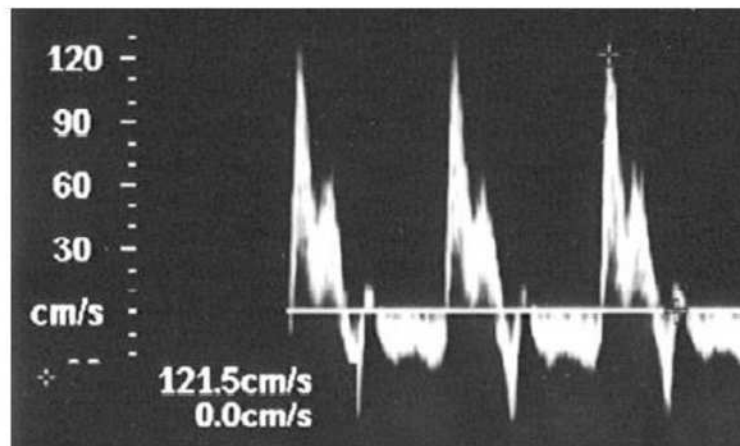


Illustration of CCA retrograde diastolic flow in the presence of aortic valve regurgitation.

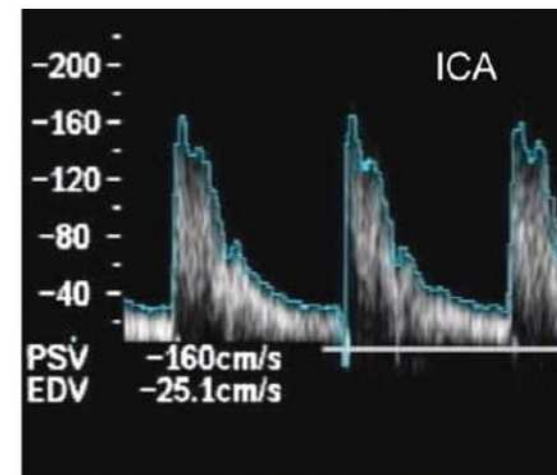
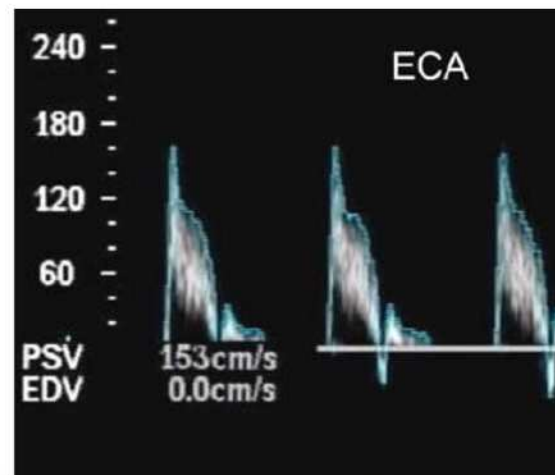
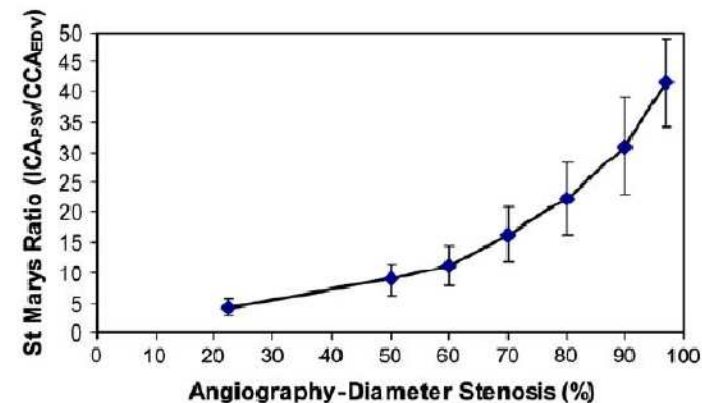


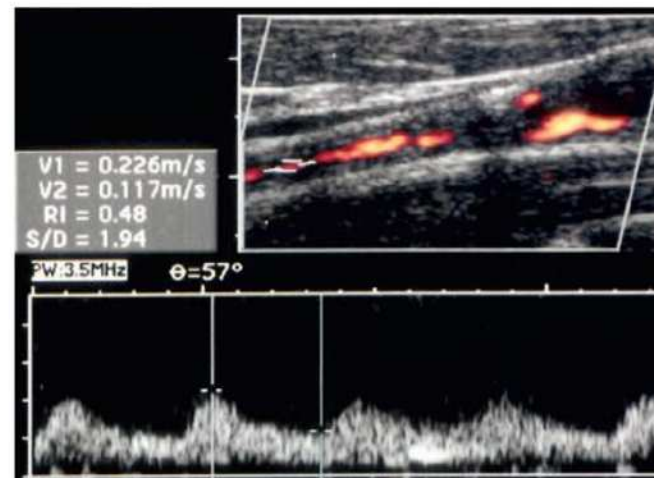
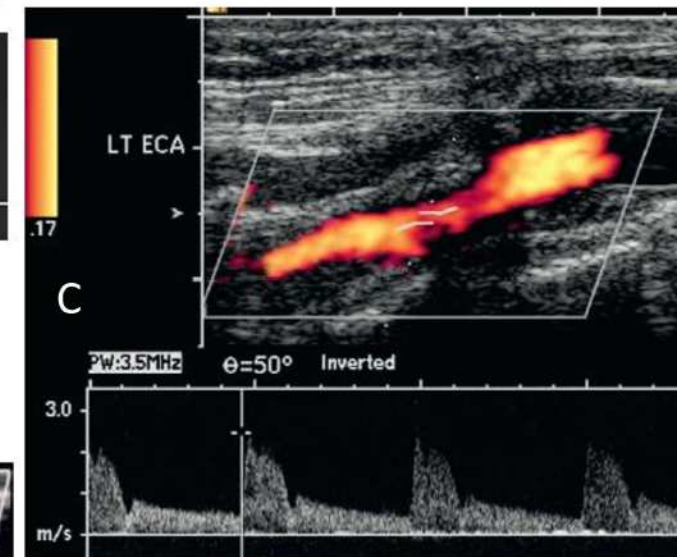
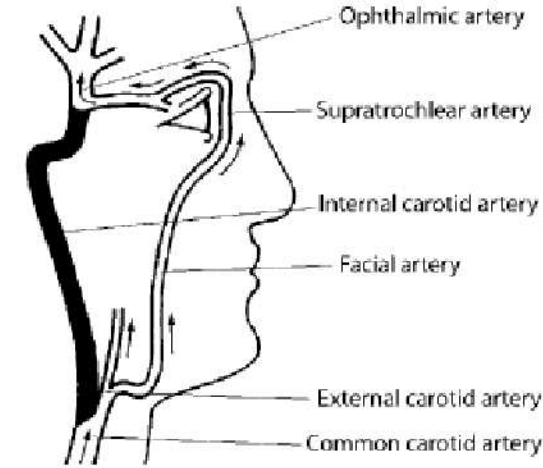
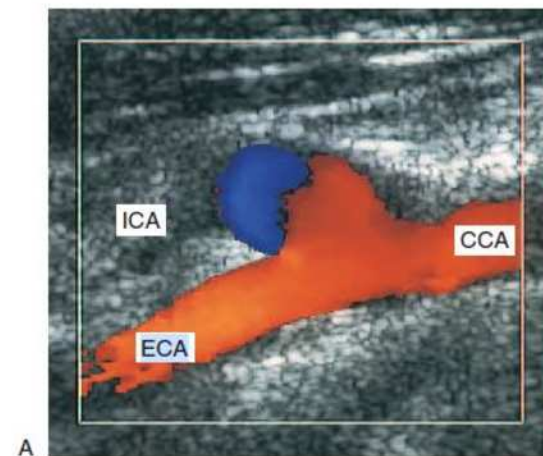
Illustration of waveforms from an elderly subject showing arteriosclerosis. Note the raised peak systolic velocities and reduction in end-diastolic velocity in both ECA and ICA waveform

PSV –tipp süstoolne kiirus

EDV –lõpp diastoolne kiirus

ICA oklusioon vs sub-oklusioon

- Oklusioon (100%)
 - ICA-s verevool ei ole jälgitav distaalsemal
 - Proksimaalsel retrograadne vool oklusiooni tupikust (A)
 - **CCA** vool kõrge RI, madala spektriga/kiirusega (B)
 - **ECA** "**internalisatsioon**" - tekkib, kui kollateraalsüsteemid on avatud (C)
 - Võib valesti arvata, et ECA on ICA
- Pre-oklusioon (sub-totaalne oklusioon) -
 - defineeritud kui 95–99% stenoos koos distaalse ICA kollapsiga või kitsa kaliibriga valendik "tilkuva-aeglase vooluga")



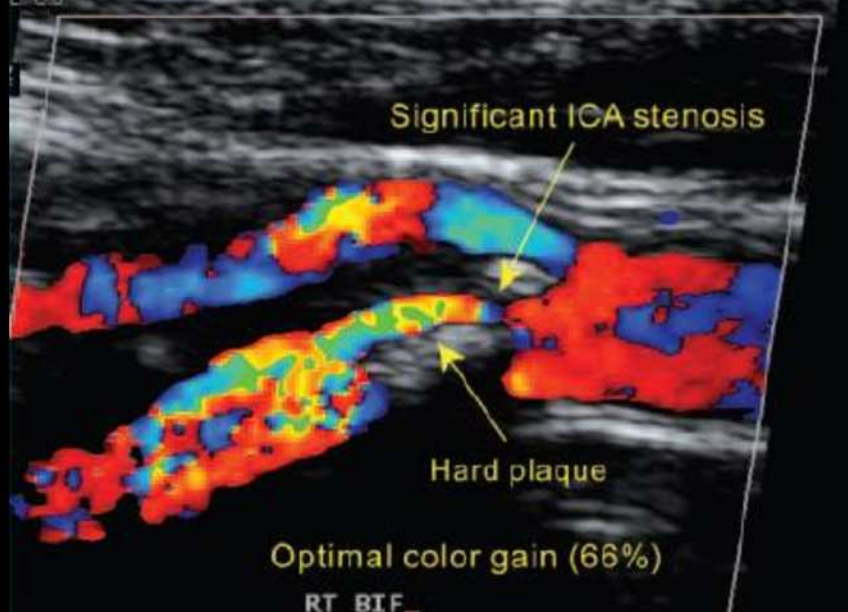
Ateroomi tüübid ja kliiniline tähtsus. Naastude morfoloogia

- Arterite seinapidiste naastude iseloomustamine on oluline embolismi ja infarkti riski hindamiseks
- Esinevad mitmeid klassifikatsioonid ateroomide iseloomustamiseks
- UH tunnuse alusel on võimalik iseloomustada ja ennustada naastu stabiilsust
 - **Hüperehhogeensed**, homogeensed ja predominantelt lubjastunud (tihedad) naastud on stabiilsed
 - **Hüpoehhogeensed**, heterogeensed, haavandunud ja hemorraagilised ateroomid üldiselt on ebastabiilsemad, suurema embolisatsiooni riskiga
 - **Suurus**

Favorable in prognosis:	Fairly hyperechoic and homogeneous plaque Plaque surface smooth and clearly delineated Calcification Short plaque (< 1 cm) Thin plaque (< 4 mm)
Unfavorable in prognosis:	Mostly hypoechoic internal signal with plaque suggested only by a small intraluminal area of low echogenicity; surface poorly delineated Long plaque (> 1 cm) Plaque diameter > 4 mm Longitudinal pulsatile movement of the plaque in a cranial direction



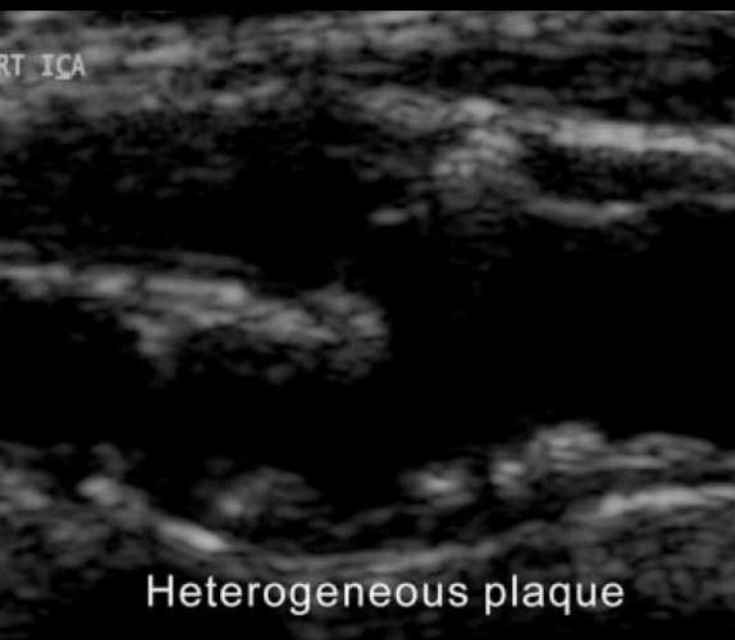
1. Homogeene, pehme naast; CVR ↓



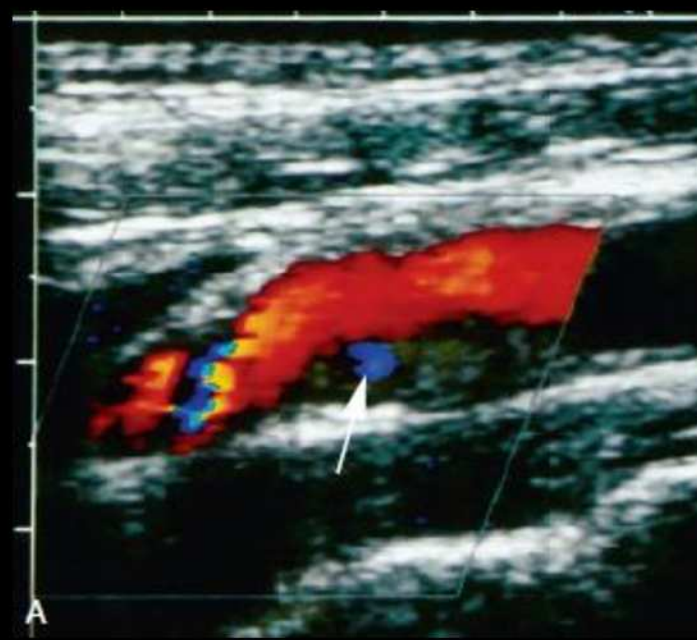
2. Tihe, valdavalt lubinaast; CVR ↓



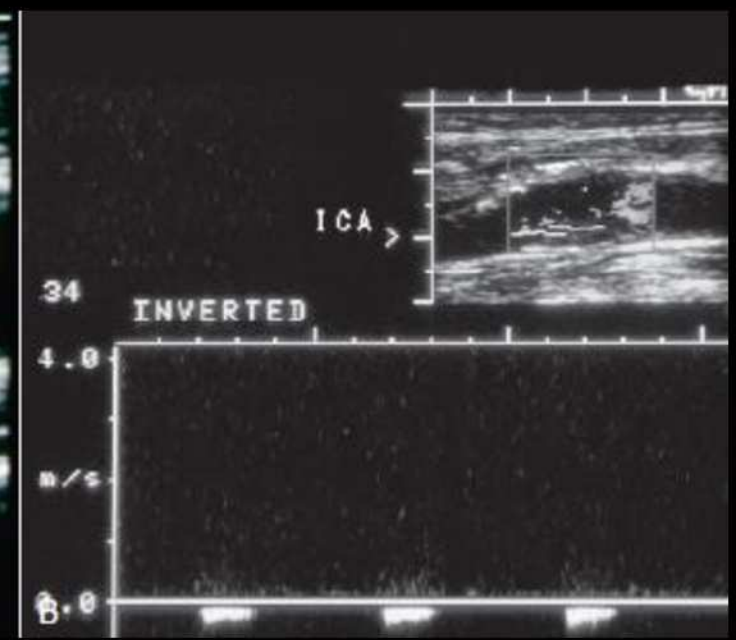
3. Naastu sees hemoraagia ala, CVR ↑



4. Heterogeene, ebaregulaarse servaga naast, CVR ↑



4. Haavandunud naast, CVR ↑



Mida ootavad veresoontekirurgid radioloogilt?

- Peamine küsimus saatekirjal - kas on oluline stenoos?
- Raviküsimus (veresoontekirurgilt) - "tabletid" (BMT) või kirurgiline revaskularisatsioon (endartektoomia vs stent) + BMT?
- *ESVS* 2017 juhise järgi ICA stenoos UH-s on
 - Kerge stenoos
 - NASCET järgi on $< 50\%$ → farmakoloogiline (BMT – *best medical treatment*)
 - Oluline stenoos 50-99% (NASCET) → kaalutakse revaskularisatsiooni:
 - Sümptomaatilistel patsientidel $> 50\%$
 - Asümptomaatilistel patsientidel $> 60\%$
 - Pre-oklusioon* ja oklusioon (95-100 %) → BMT

*Pre oklusioon -defineeritud kui 95–99% stenoos koos distaalse ICA kollapsiga või kitsa kaliibriga lumen "tilkuva-aeglase vooluga")

ESVS ja ESC seltsi algoritm - ravistrateegiaid sümptomaatilise ja asümptomaatilise aterosklerootilise ekstrakraniaalse unearteri stenoosiga patsientidel.^{11,12}

- CAS – karotiidarteri stentimine
- CEA – karotiidarteri endartektoomia
- BMT- parim medikamentoosne ravi
 - (Farmatseutiline + elustiil)

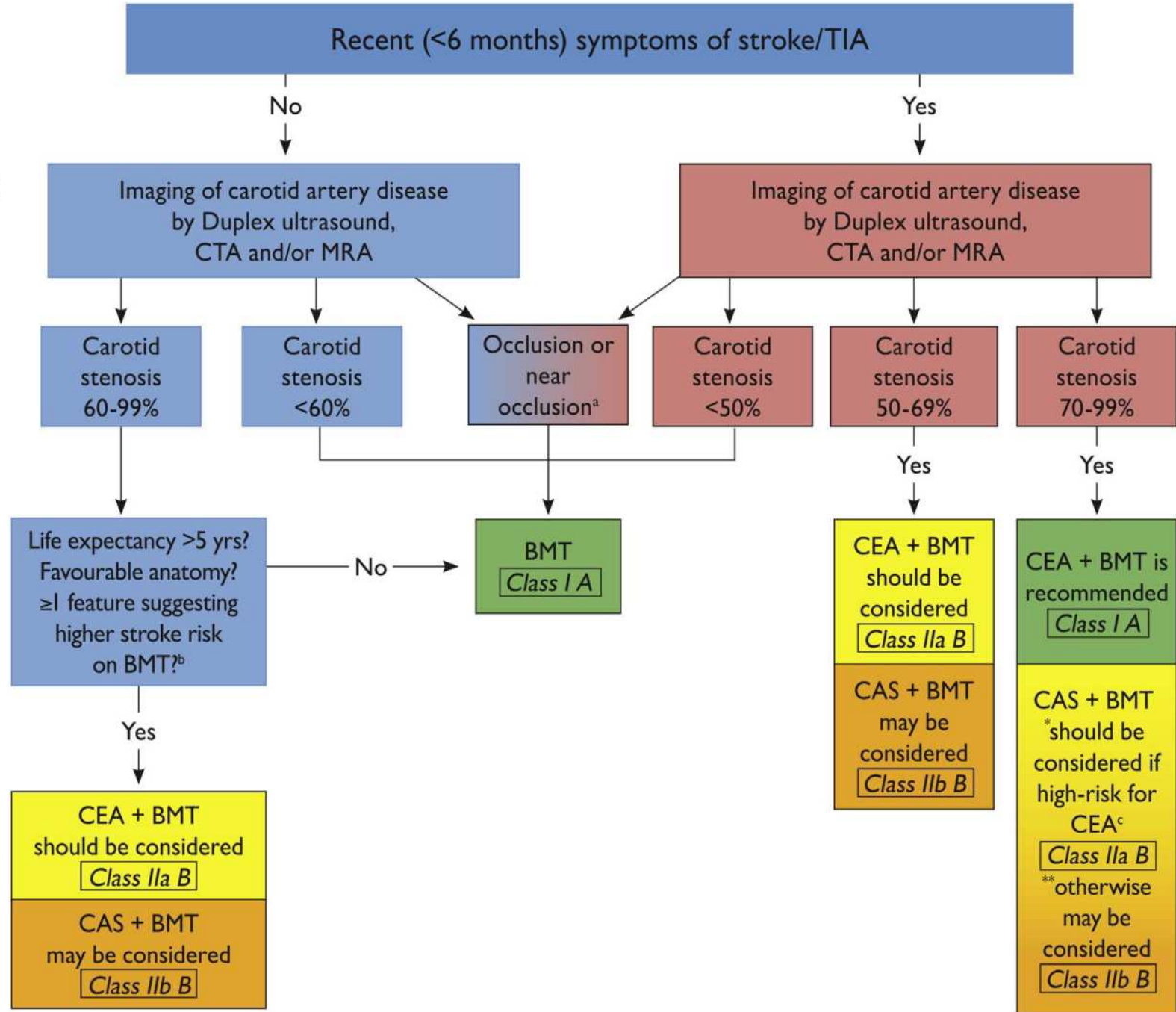


Table 5. Clinical/imaging features associated with an increased risk of late stroke in patients with asymptomatic 50–99% stenoses treated medically.

Imaging/clinical parameter and stenosis severity Type of study	Annual rate of ipsilateral stroke	OR/HR (95% CI) <i>p</i> =
Silent infarction on CT ⁸⁴ 60–99% stenoses Multicentre, observational	Yes = 3.6% No = 1.0%	3.0 (1.46–6.29) <i>p</i> = .002
Stenosis progression ⁸⁵ 50–99% stenoses Multicentre, observational	Regression = 0.0% Unchanged = 1.1% Progression = 2.0%	1.92 (1.14–3.25) <i>p</i> = .05
Stenosis progression ⁸⁶ 70–99% stenoses Multicentre, RCT	Regression No change Progression 1 Progression 2 stenosis grades	0.7 (0.4–1.3) Comparator 1.6 (1.1–2.4) 4.7 (2.3–9.6)
Plaque area on computerised plaque analysis ⁸⁷ 70–99% stenoses Multicentre, observational	<40 mm ² = 1.0% 40–80 mm ² = 1.4% 70–99% = 4.6%	HR 1.0 2.08 (95% CI 1.05–4.12) 5.81 (95% CI 2.67–12.67)
JBA on computerised plaque analysis ⁸⁸ 50–99% stenoses Multicentre, observational	<4 mm ² = 0.4% 4–8 mm ² = 1.4% 8–10 mm ² = 3.2% >10 mm ² = 5.0%	Trend <i>p</i> < .001
Intra-plaque haemorrhage on MRI ⁸⁹ 50–99% stenoses Meta-analysis	Yes vs. no	OR 3.66 (2.77–4.95) <i>p</i> < .01
Impaired CVR ⁹⁰ 70–99% stenoses Meta-analysis	Yes vs. no	OR 5.14 (95% CI 1.27–29.5) <i>p</i> = .02
Plaque lucency on Duplex US ⁹¹ 50–99% stenoses Meta-analysis	Predominantly echolucent 4.2% Predominantly echogenic 1.6%	OR 2.61 (95% CI 1.47–4.63) <i>p</i> = .001
Spontaneous embolisation on TCD ⁹² 50–99% stenoses Meta-analysis	Yes vs. no	OR 7.46 (95% CI 2.24–24.89) <i>p</i> = .001
Spontaneous embolisation plus uniformly or predominantly echolucent plaque ⁹³ 70–99% stenoses Multicentre, observational	Yes = 8.9% No = 0.8%	OR 10.61 (95% CI 2.98–37.82) <i>p</i> = .0003
Contralateral TIA/stroke ⁹⁴ 50–99% stenoses Multicentre, observational	Yes = 3.4% No = 1.2%	OR 3.0 (95% CI 1.9–4.73) <i>p</i> = .0001

Asümptomaatile pt., ICA stenoos >60%

- Kaalutakse revaskularisatsiooni, kui lisaks:
 - 5 a elulemuse tõenäosus
 - sobiv arterite anatoomia
 - Suurem infarkti risk (vähemalt 1 tunnus)
 - Kliiniline risk
 - Radioloogiline leid (KT, MRT, UH)
- Radioloogiline UH-is:¹¹
 - Naastu ehhoogeensus (predominantselt hüper- vs hüpoehhoogene)

Table 5. Clinical/imaging features associated with an increased risk of late stroke in patients with asymptomatic 50–99% stenoses treated medically.

Imaging/clinical parameter and stenosis severity Type of study	Annual rate of ipsilateral stroke	OR/HR (95% CI) <i>p</i> =
Plaque lucency on Duplex US ⁹¹ 50–99% stenoses Meta-analysis	Predominantly echolucent 4.2% Predominantly echogenic 1.6%	OR 2.61 (95% CI 1.47–4.63) <i>p</i> = .001

Sümptomaatiline pt, ICA stenoos >50%

- 50-69% → revaskularisatsioon (CEA / CAS) kaalutud
- 70-99% →
 - Endarterektoomia (CEA) + BMD soovitatav
 - Stentimine (CAS) + BMD tuleks kaaluda, kui pt. kõrge riskiga CEA-le:
 - Kliinilised tunnused
 - Vanus >80
 - Soodne veresoonte anatoomia
 - Kontralateraalne ICA oklusioon
 - Re-stenoos peale CEA

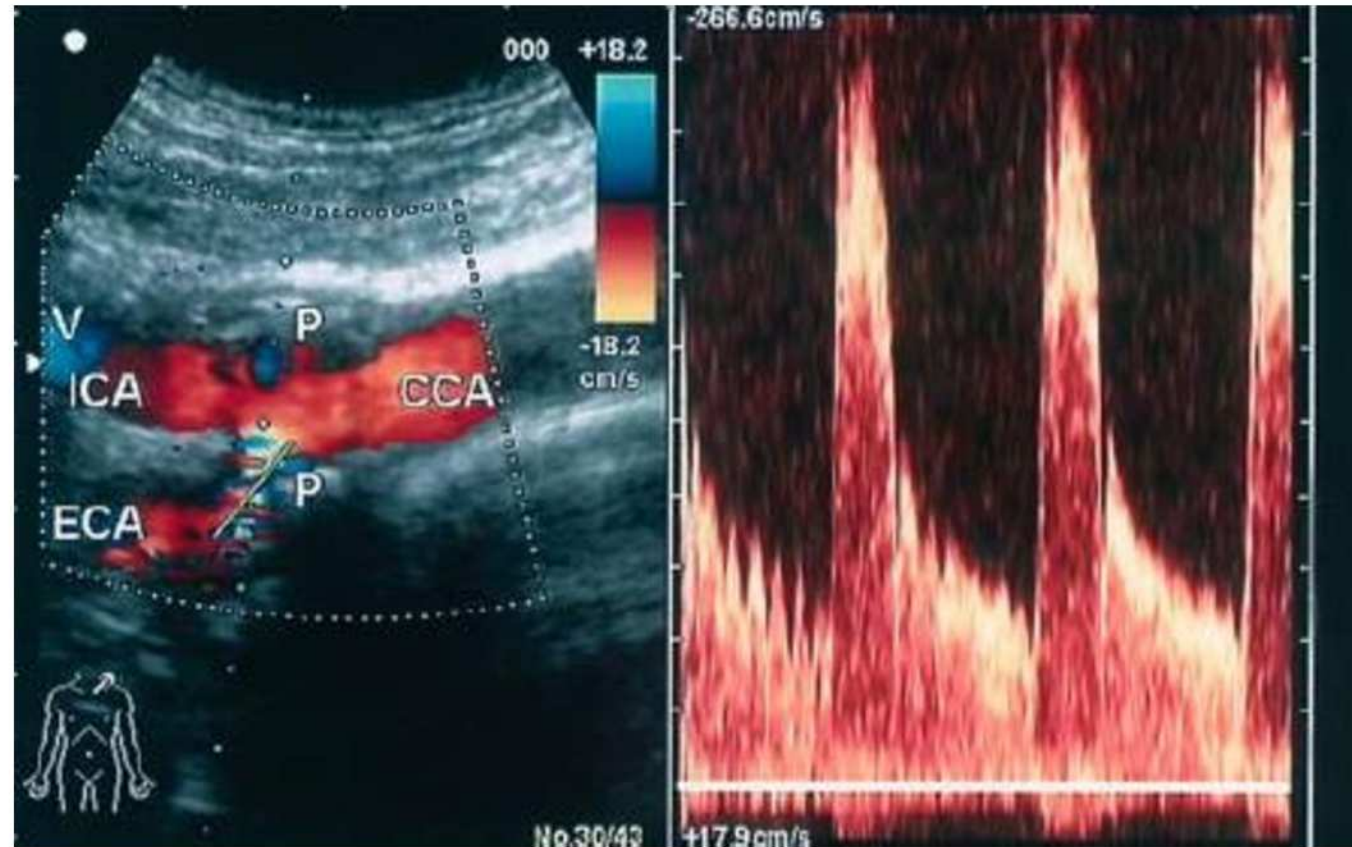
ESVS: kas revaskularisatsioon on vajalik <50% stenoosi korral?¹¹

- Ei! , aga
 - Sümptomaatilisel patsientidel, kellel püsivad sümptomid sõltumatu BMT optimeerimist, võib kaaluda kirurgilist revaskularisatsiooni.

2.3.8. Is there a subgroup with <50% stenosis who might benefit from surgery? An individual patient meta-analysis of symptomatic patients with <50% stenoses who were randomised within ECST, NASCET, and the VA trials^{172,173} showed that CEA conferred no benefit over BMT (Section 2.3.3). The 5-year risk of stroke in 1746 patients with <30% stenoses who were randomised to CEA was 18.4%, compared with 15.7% on BMT. The 5-year risk of stroke in 1429 patients with 30–49% stenoses who were randomised to CEA was 22.8%, compared with 25.5% on BMT.¹⁷³ However, a small cohort of patients with <50% stenoses will still continue to suffer recurrent symptoms (despite BMT). In a recent review of outcomes in previously symptomatic patients with 20–49% stenoses at baseline, the risk of recurrent ipsilateral stroke at 3 years was 7.4%.²⁵⁴

ECA stenoos UHs - on t htis?

- ECA stenooside klassifitseerimise kriteeriume ei ole kehtestatud.
 - Kui kiirused ei ulatu $>200\text{cm/s}$, olulist stenoosi ei sedasta
 - Operaatori/radioloogi visuaalne hindamine
- Suurt kliinilist tähtsust ei ole⁸
- Hindamine abistab avastada sekundaarse tunnustega stenoosi ICA-s



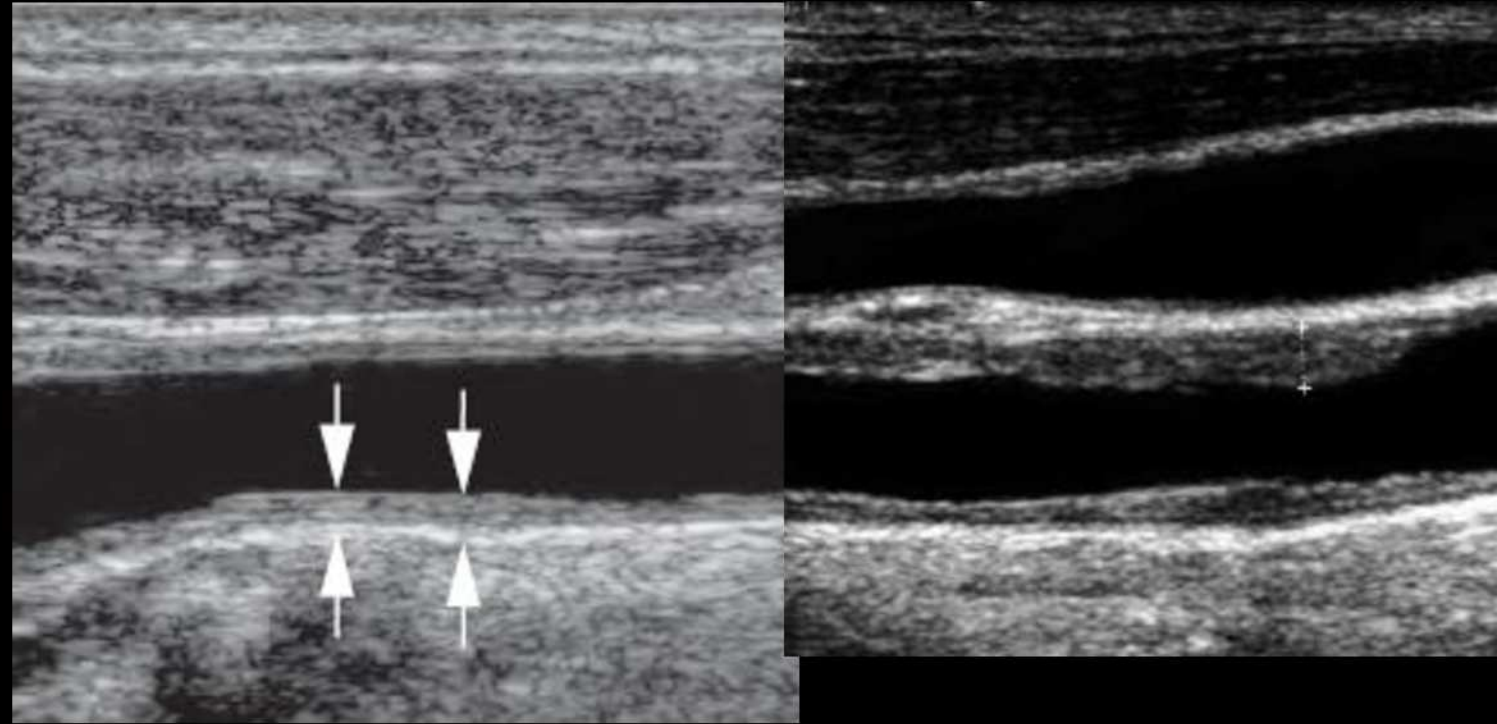
CCA stenoos?

- Isoleeritud CCA stenoos või oklusioon esineb suhteliselt harva.
- Stenoosi hindamine UH-s on operaator- ja kogemuse sõltuv (objektiivsel kombineeritud radioloogiliste tunnuste põhjal hindamine UH-s)
 - Voolu spektrid
 - Voolu kiirused
 - Naastu olemasolu
 - Luumeni läbimõõt jne.
- Sümptomaatilisel patsientidel või kaaluda revaskularisatsiooni¹¹

Recommendation 93	Class	Level	References
Open or endovascular interventions to treat proximal common carotid artery or innominate artery stenoses/occlusions are not recommended in asymptomatic patients	III	C	
Recommendation 94			
Most proximal common carotid artery and innominate stenoses should be considered for treatment via open retrograde angioplasty and stenting	IIa	C	424

ACC *intima-media* paksus (IM) – kas vajalik mõõta?¹⁵

- Arteri kogu seina või fokaalse prolabeerunud seina tsoon hüperehhogeensete joonte vahel – kombineeritud *tunica intima* ja *media* paksus.
 - Abnormaalne >1.5mm
- Skriiningu meetod kardiovaskulaarse riski hindamiseks
- **Euroopa Kardioloogide Seltsi (ESC) 2021a** augusti uuemaid juhised:



3.3.3.3 Carotid ultrasound

Systematic use of intima-media thickness (IMT) to improve risk assessment **is not recommended** due to the lack of methodological standardization, and the absence of added value of IMT in predicting future CVD events, even in the intermediate-risk group.¹²¹

Although the evidence is less extensive than it is for CAC, carotid artery plaque assessment using ultrasonography probably also reclassifies CVD risk,^{104,122} and **may be considered as a risk modifier** in patients at intermediate risk when a CAC score is not feasible.

Kokkuvõte

- Karotiidarterite stenoosi hindamisel esmane valik on UH Doppler uuring
 - Millele järgnev vajadusel KT- ja/või MRT angiograafia
- Karotiidarterite korrektne stenoosi hindamine muudab ravitaktikat
 - Kui voolukiiruste alusel on oluline stenoos, siis soovitav seda võimalusel täpsustada NASCETi stenoosi väärtusega.
- ICA stenoosi kohal naastude morfoloogia hindamine võib mõjutada ravitaktikad
- ECA stenoosi/oklusiooni hindamisel suurt kliinilist tähtsust ei ole
- ESC- suurt kasu *intima-media* paksuse mõõtmisest skriiningu jaoks ei ole.

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