

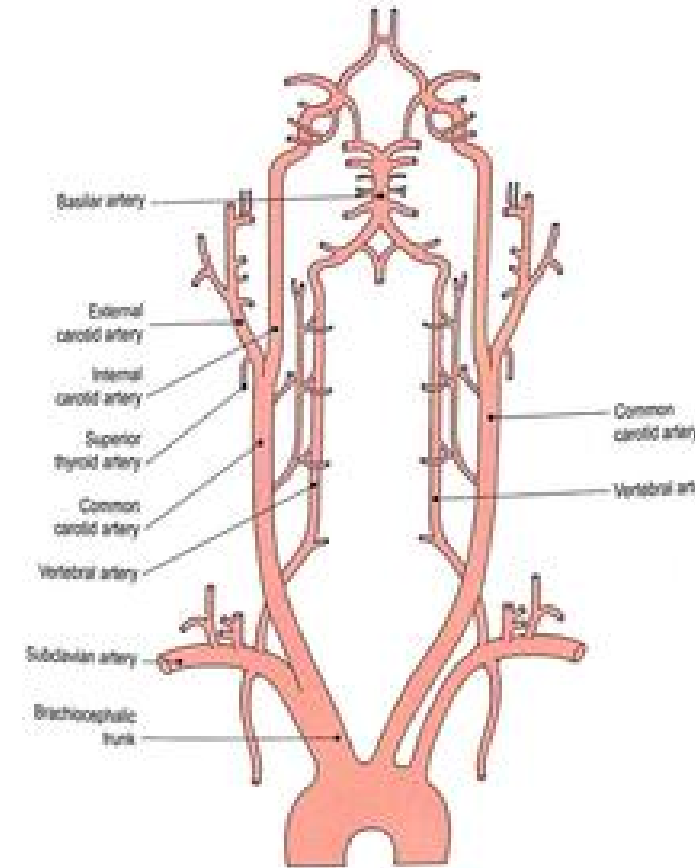
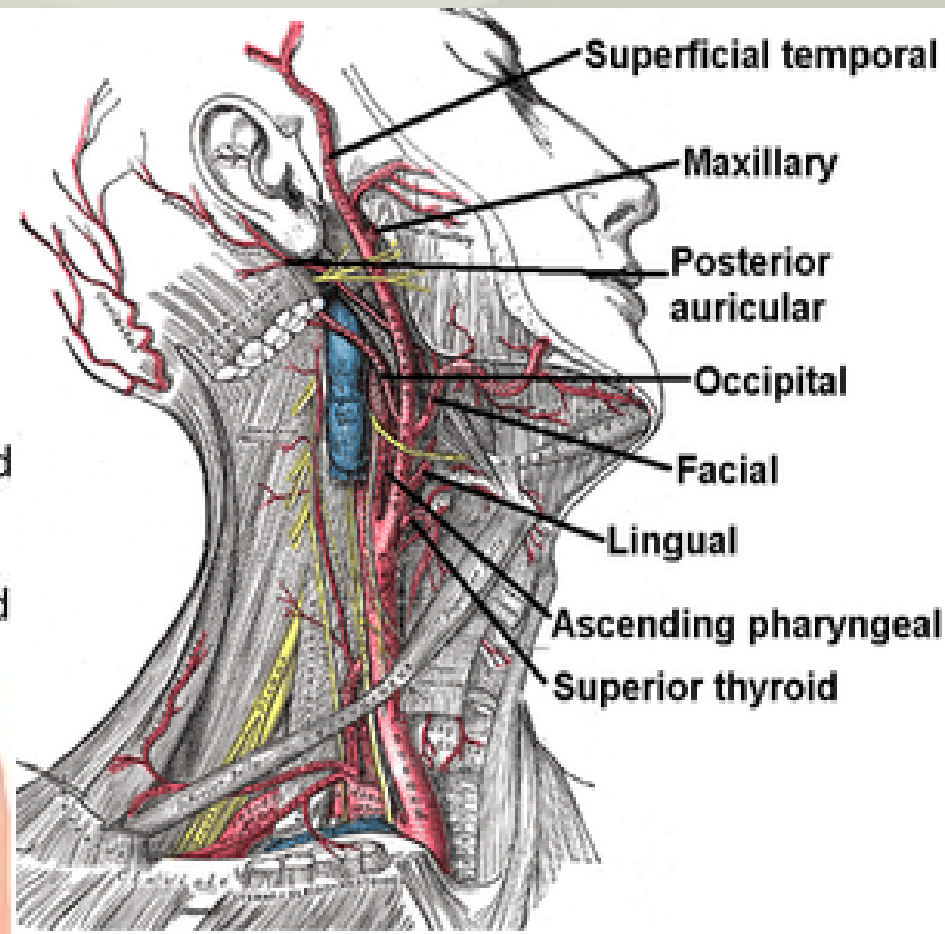
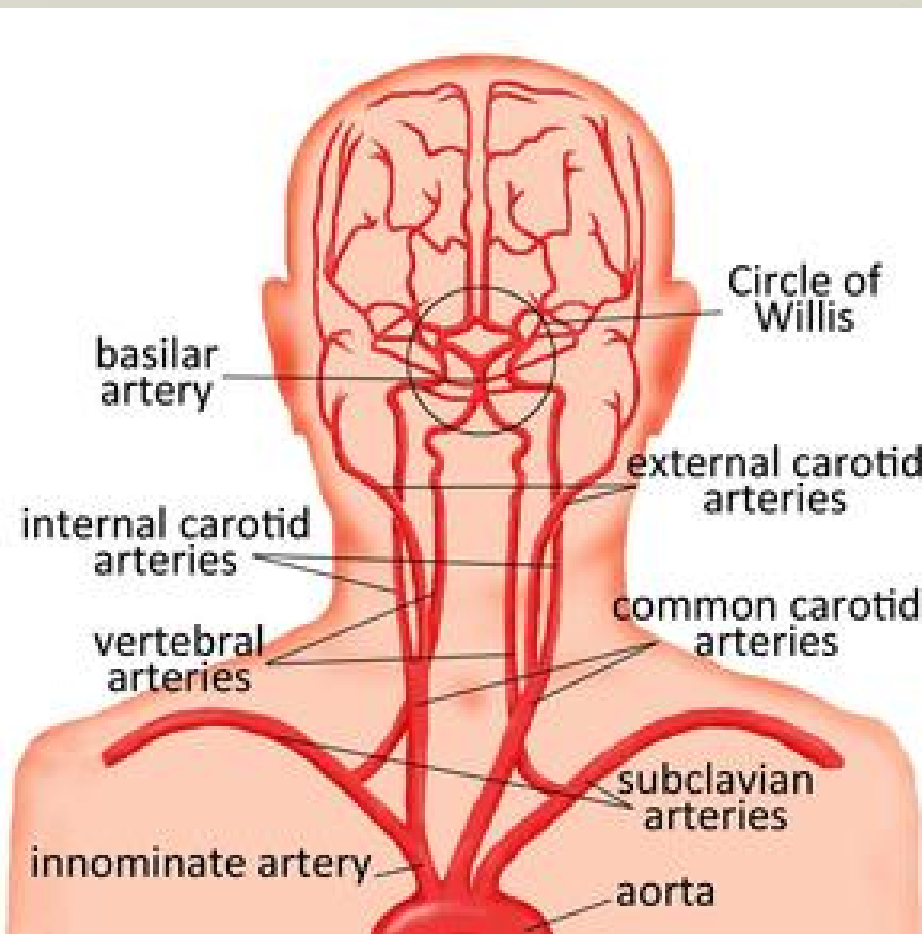
CAROTID VASCULAR ULTRASOUND

Mohammad Syahrir Azizi

Division Cardiovascular, Dept of Internal Medicine

Faculty of Medicine Universitas Indonesia/ Ciptomangunkusumo Hospital

ANATOMY



Carotid Doppler Ultrasound

Edited with the trial version of



To remove this notice, visit
www.flexipdf.com

Carotid Doppler (CD) → Carotid Artery Ultrasound

Indication

1. Transient ischemic attack
2. Reversible ischaemic neurological deficit
3. Mild resolving strokes in younger patients
4. Atypical, non focal symptoms which may have a vascular aetiology
5. Arteriopathy / high risk patients prior to surgery
6. Post endarterectomy
7. Pulsatile neck masses
8. Trauma / dissection
9. Disease screening

Ultrasound Physics

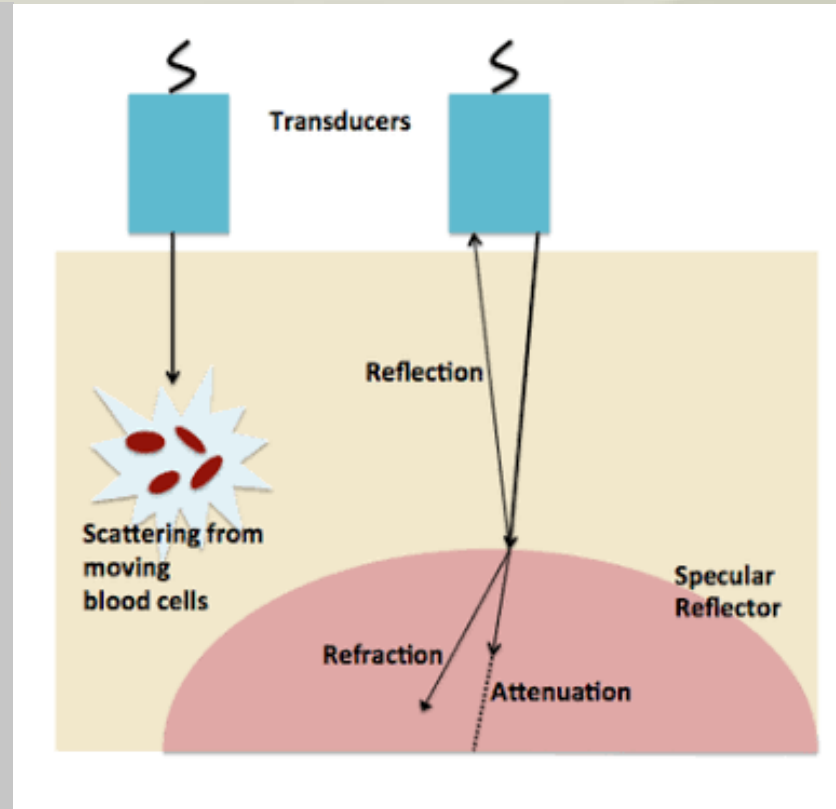
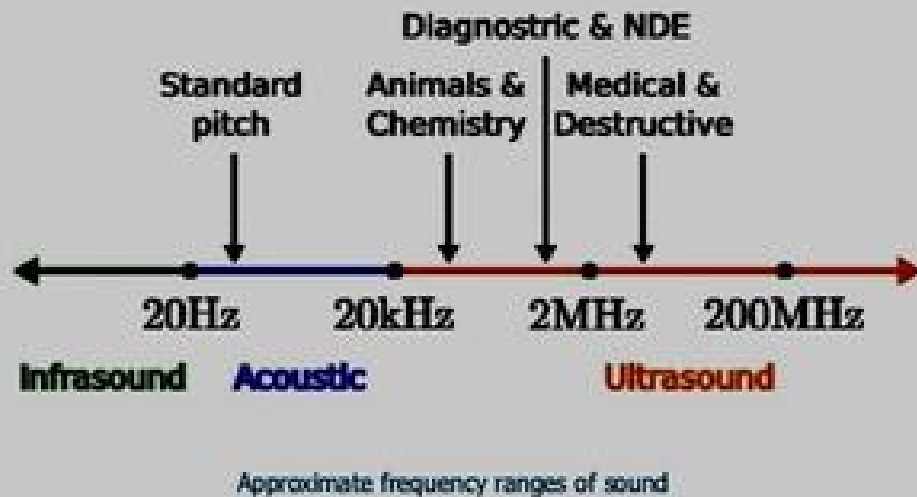
Edited with the trial version of

FlexiPDF

To remove this notice, visit
www.flexipdf.com

Properties of Ultrasound

The frequencies of medical Ultrasound waves are several magnitudes higher than the upper limit of human hearing.



- Sound wave are longitudinal
- Mechanical radiant energy, converted to heat in tissue

Probe transducer



$$v = \lambda f$$

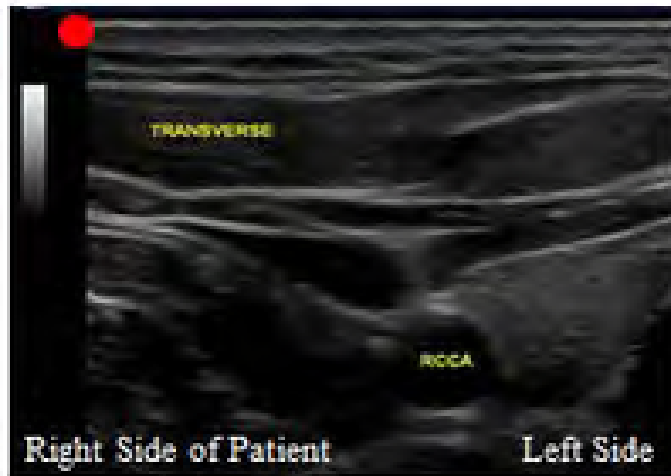
Compromise between resolution and penetration
High frequency \rightarrow less penetration

Probe Orientation

Orientation

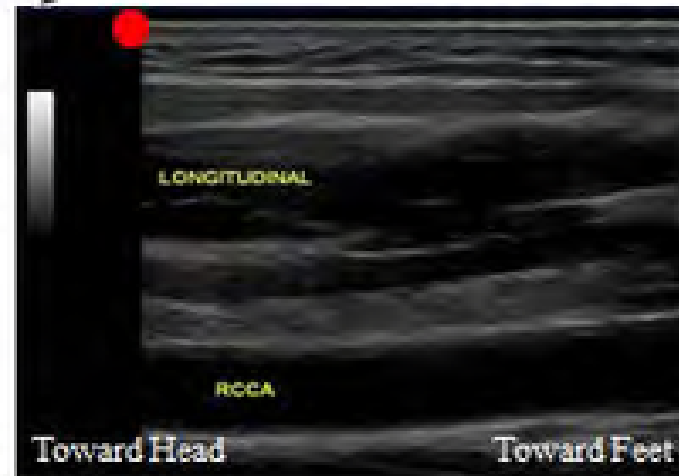


Marker /Logo



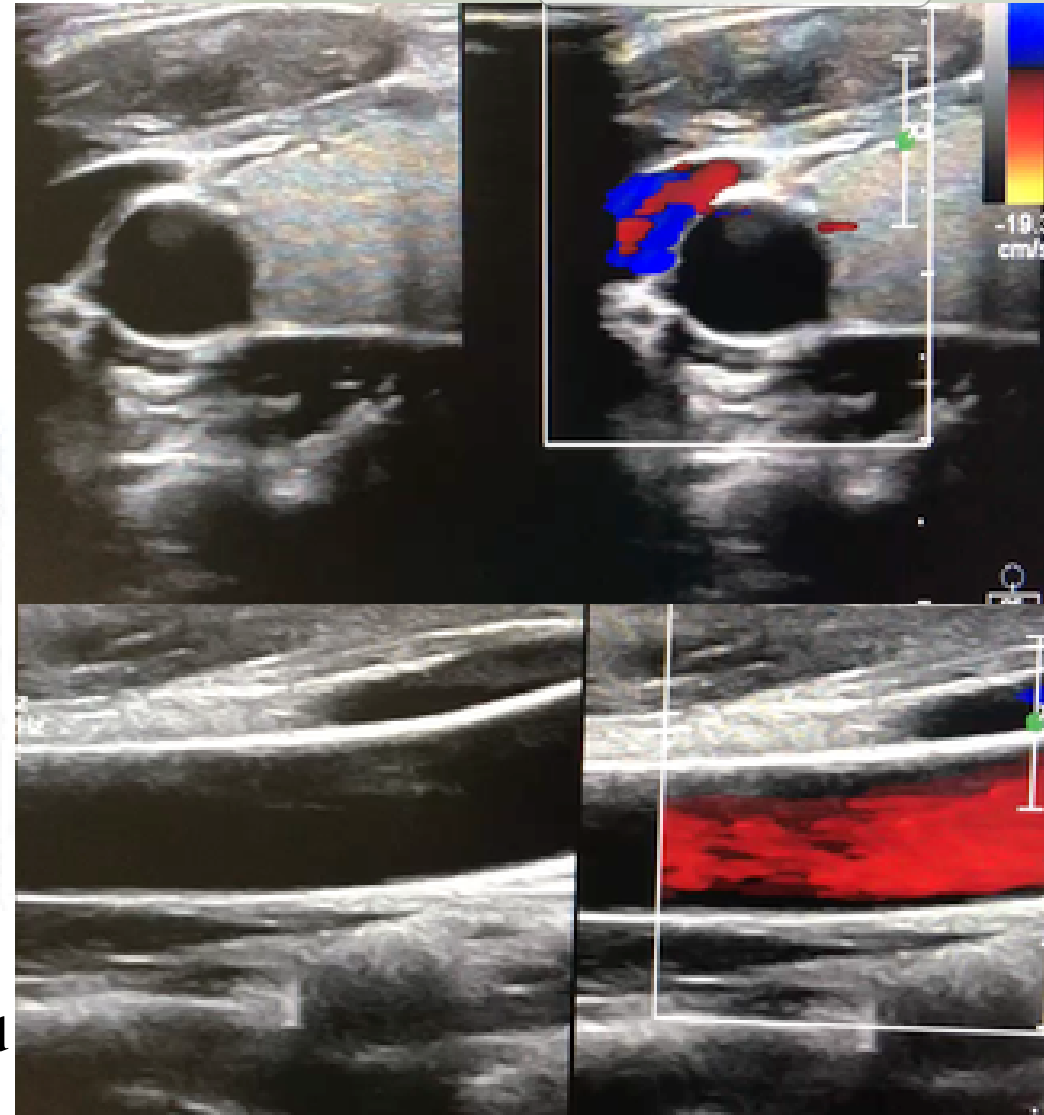
Transverse View

Marker points to patient right side



Longitudinal View

Marker points to patient head



Posture and probe orientation

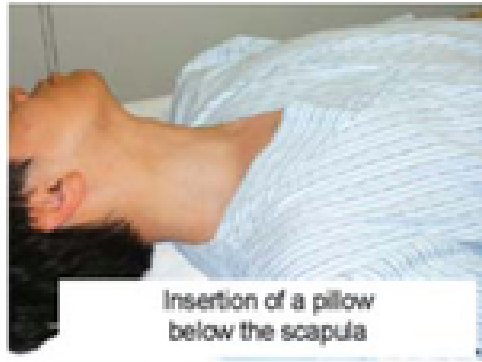
Edited with the trial version of

FlexiPDF

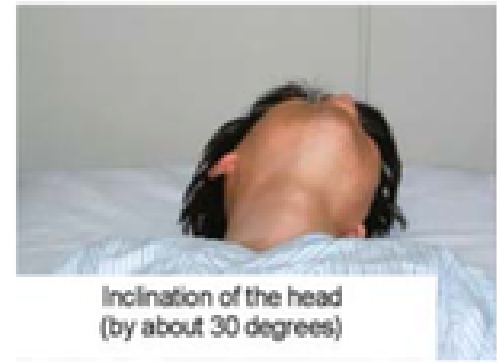
To remove this notice, visit
www.flexipdf.com



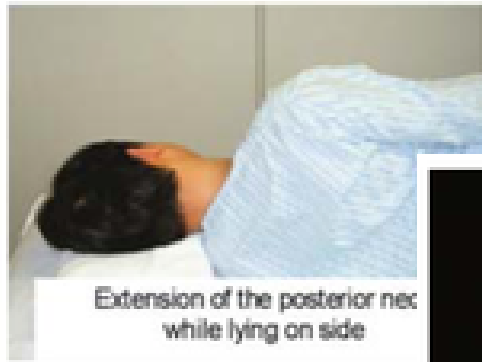
Extension of the area to be checked



Insertion of a pillow below the scapula



Inclination of the head (by about 30 degrees)



Extension of the posterior neck while lying on side



A



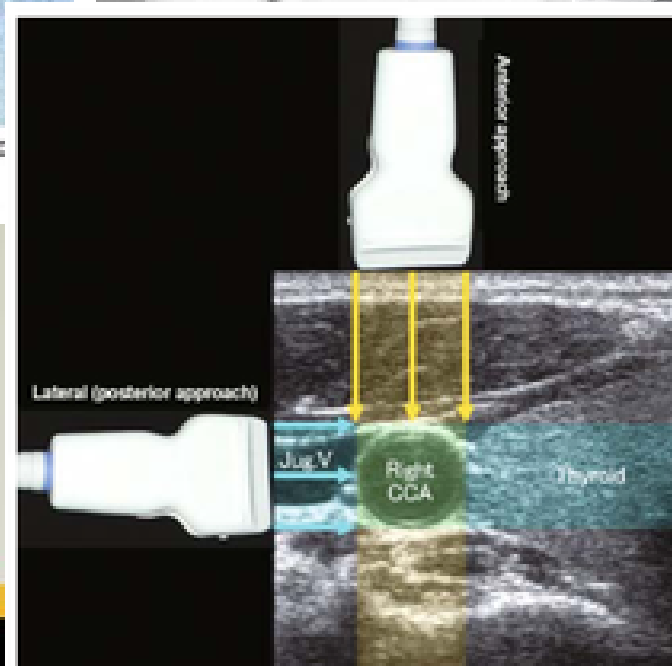
B

Posterolateral



D

anterolateral

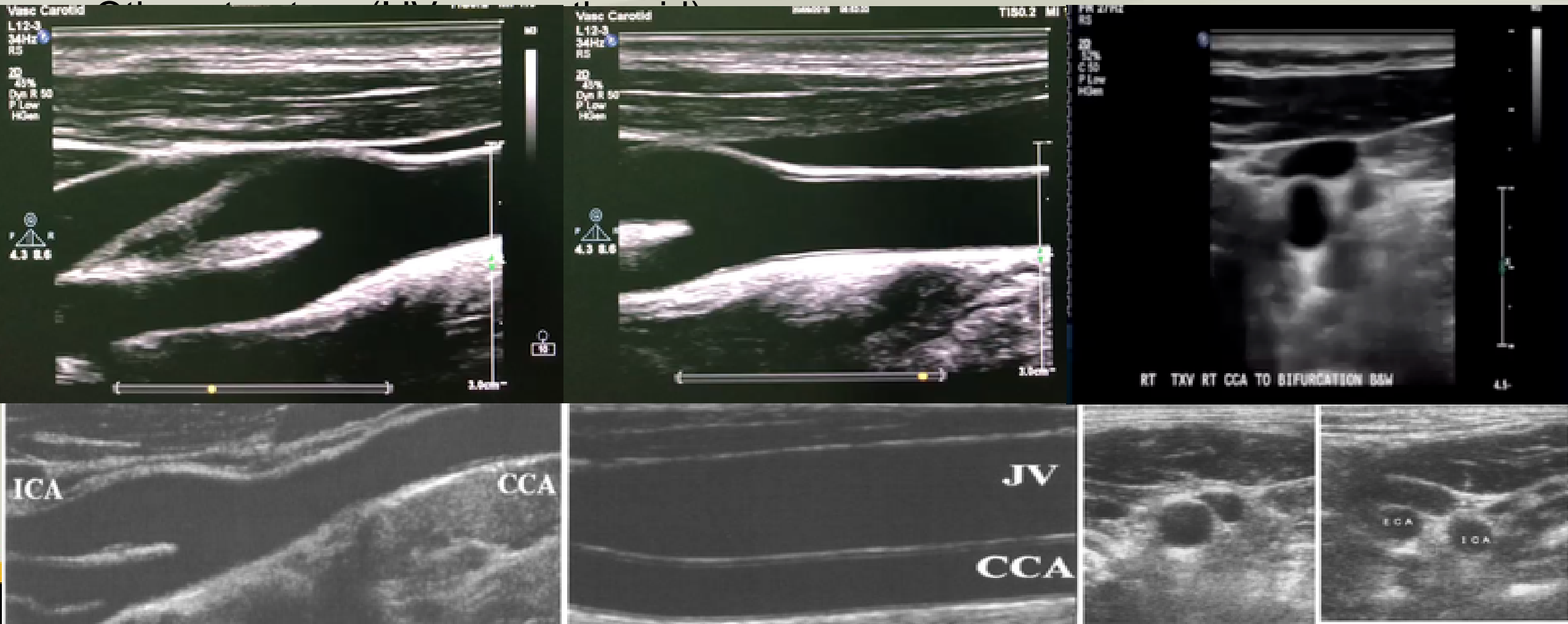


Method of imaging

1. B mode
2. Color doppler
3. Pulse wave doppler
4. Other : M mode, Power doppler, 3D

B Mode B mode (Brightness mode, grayscale,

- Anatomical assessment
 - IMT thickness, plaque, thrombus, stenosis, tortuous

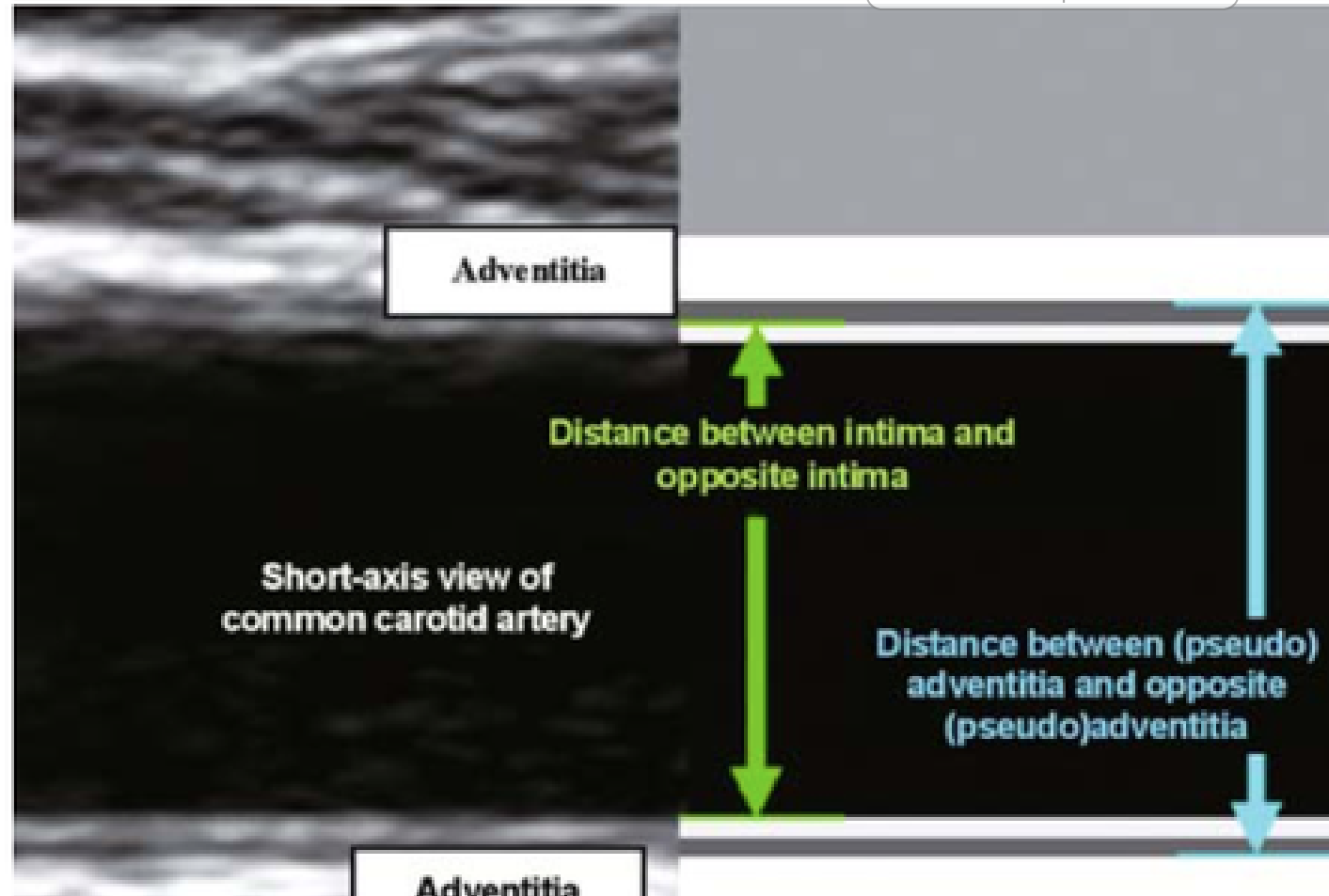
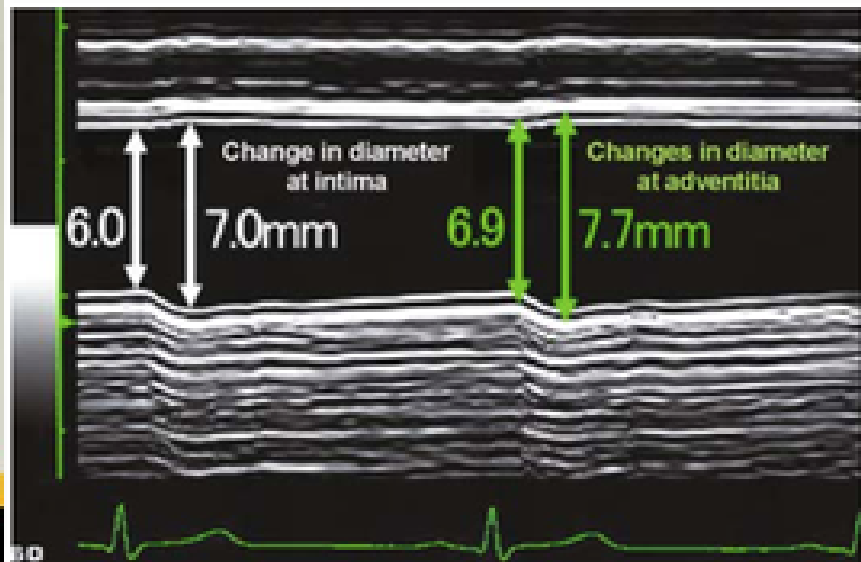


Arterial diameter

B mode



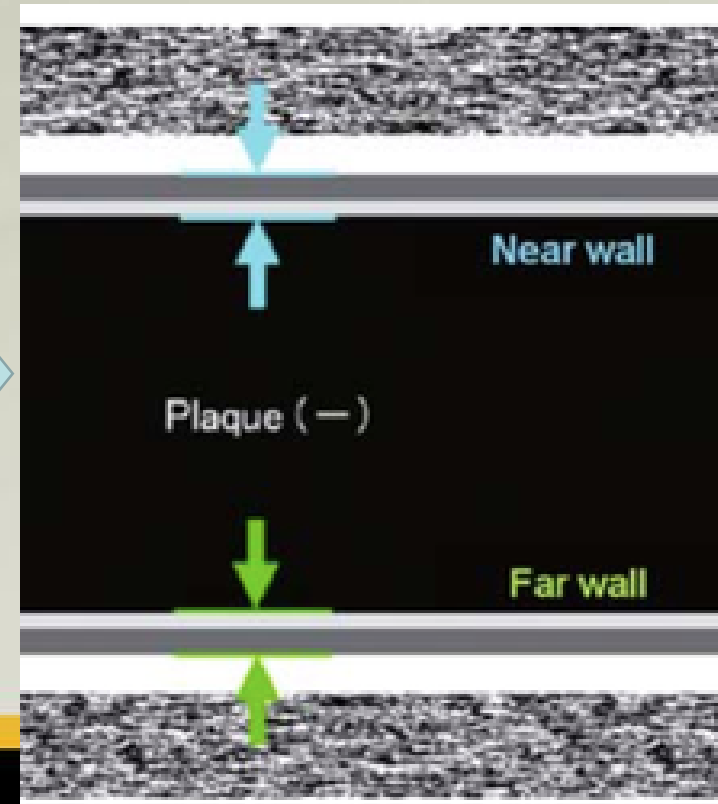
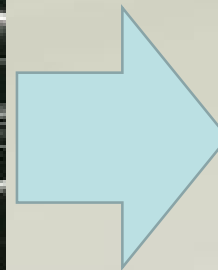
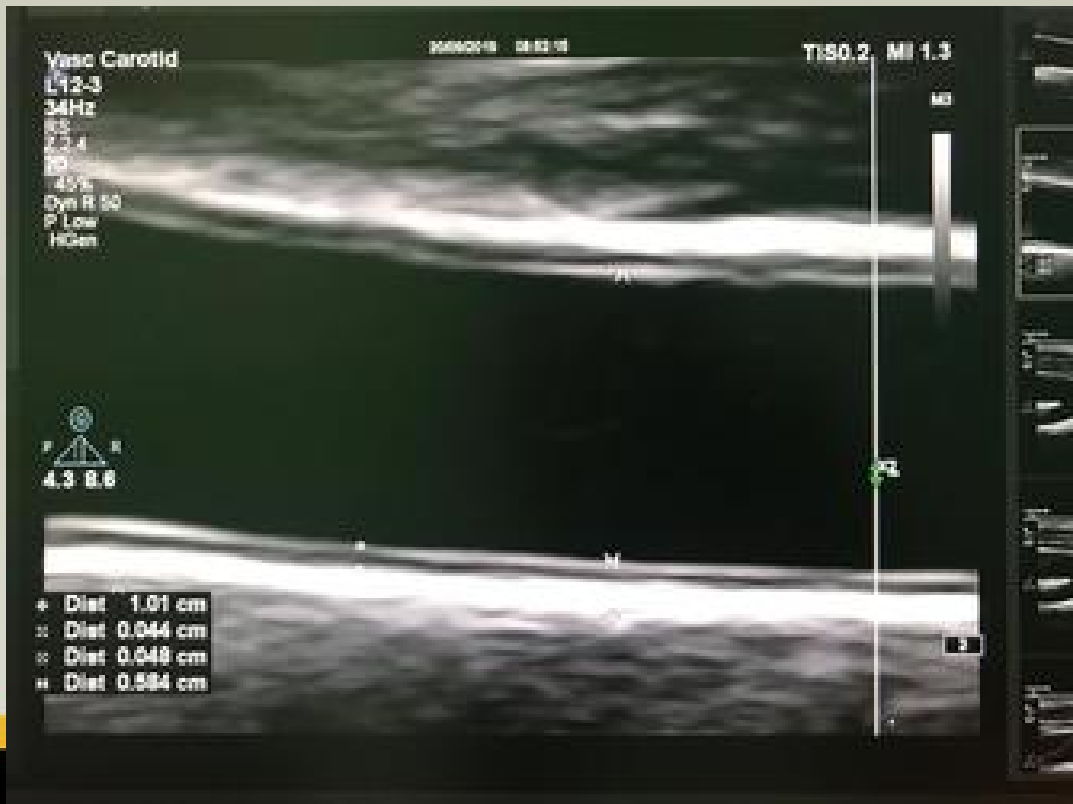
M mode



Measure in contraction phase (late diastolic)

Intima Media Thickness

- IMT is defined as a double-line pattern visualised by echo 2D on both walls of the common carotid artery (CCA) in a longitudinal view.
- Two parallel lines (leading edges of two anatomical boundaries) form it: lumen-intima and media-adventitia interfaces
- Damage is defined as the presence of IMT >0.9 mm or plaque (ESC)

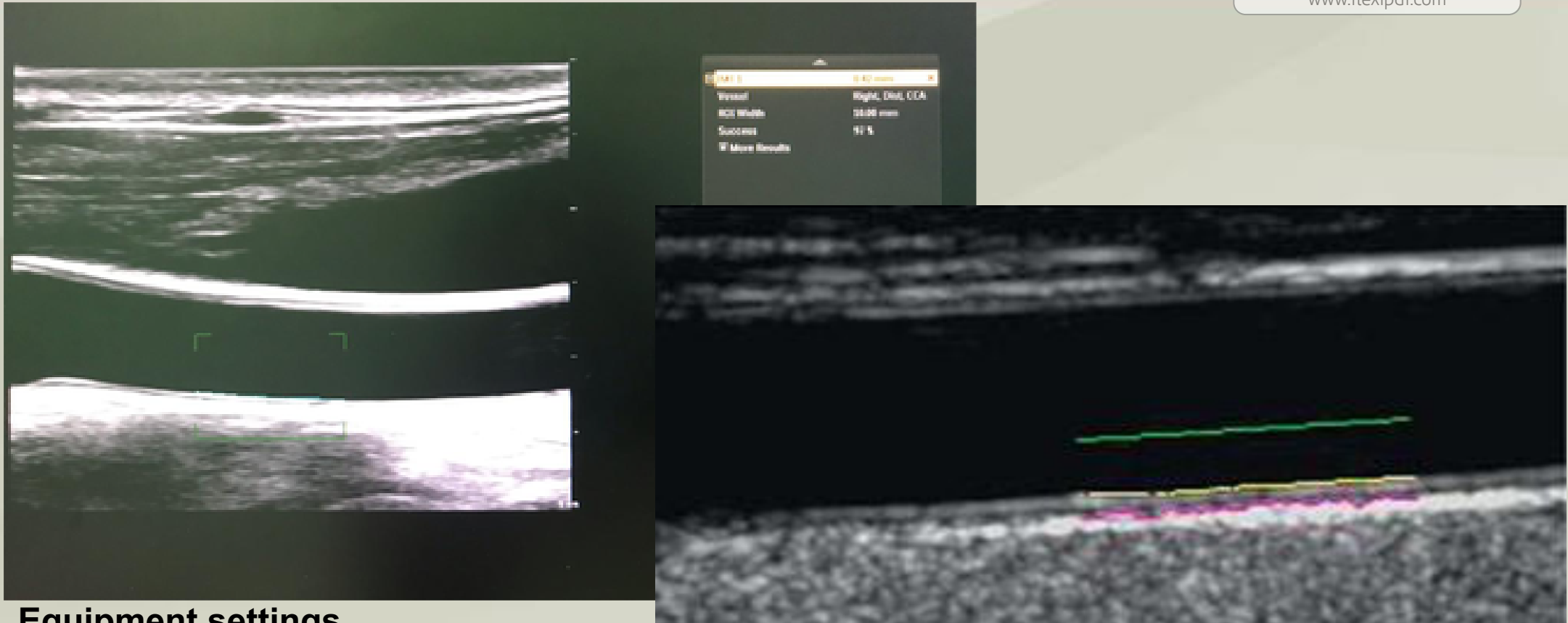


Computerized IMT

Edited with the trial version of

 FlexiPDF

To remove this notice, visit
www.flexipdf.com

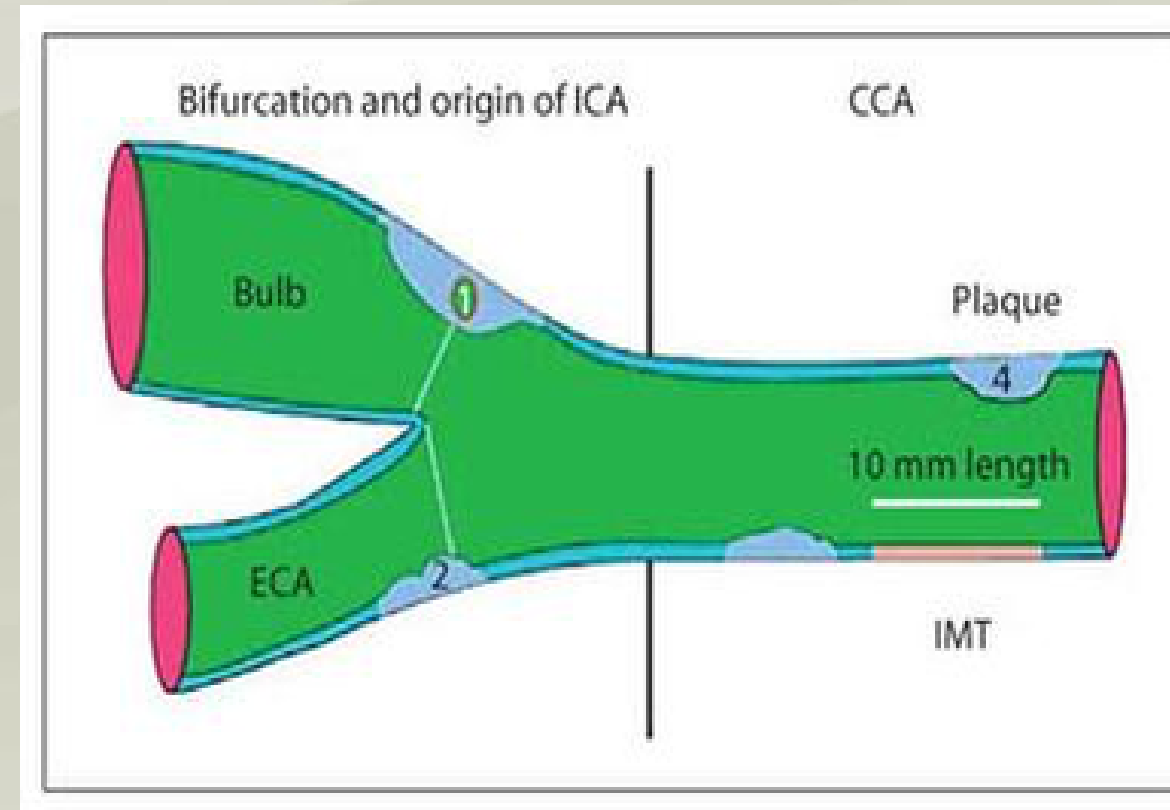


Equipment settings

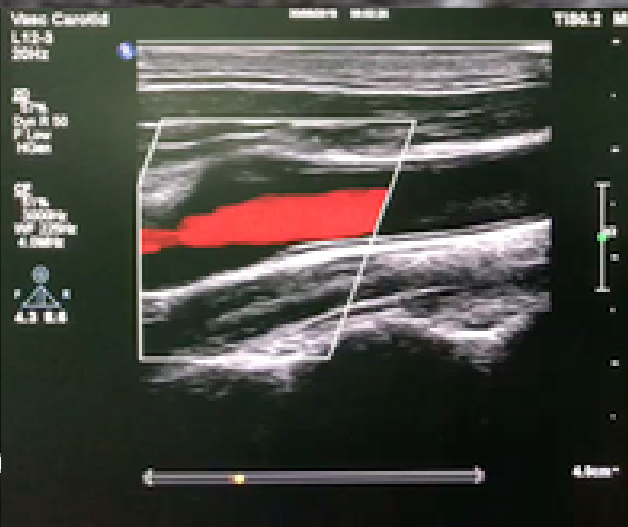
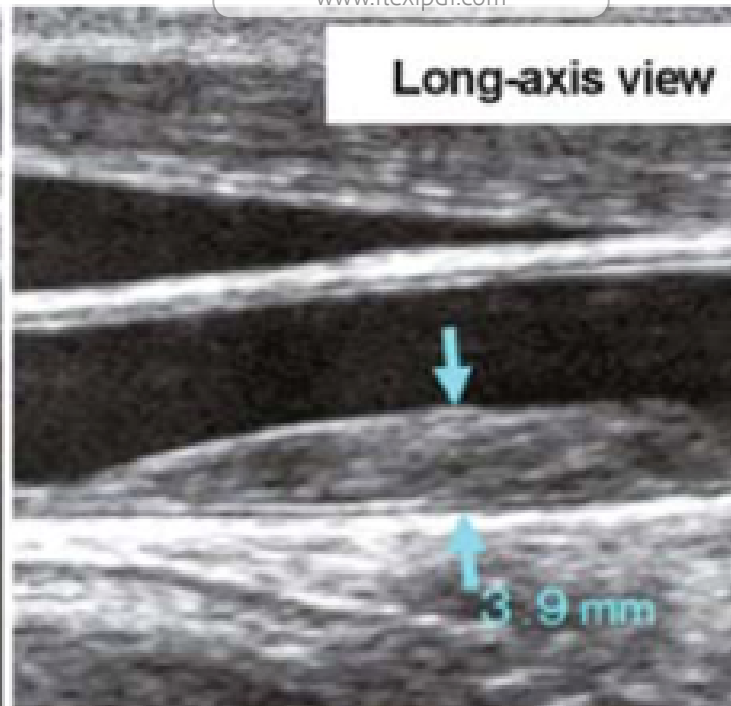
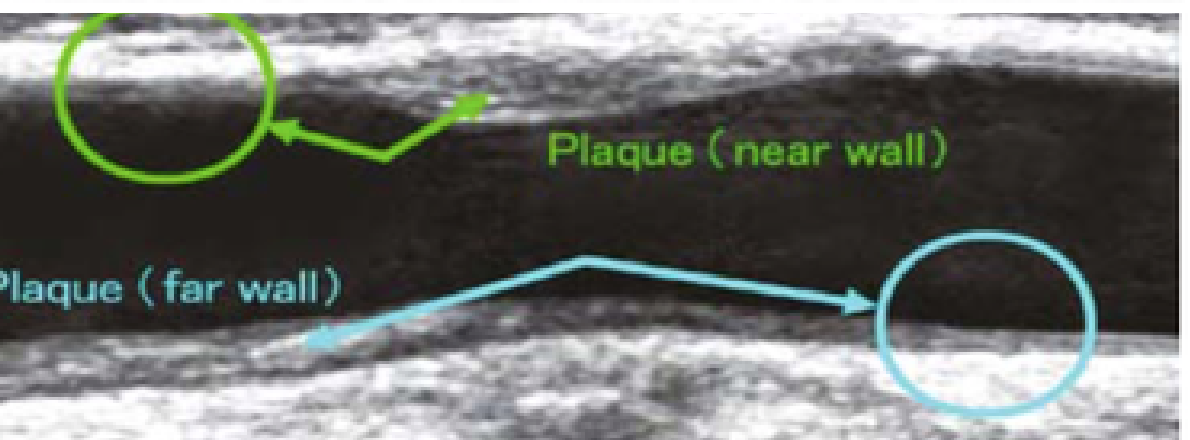
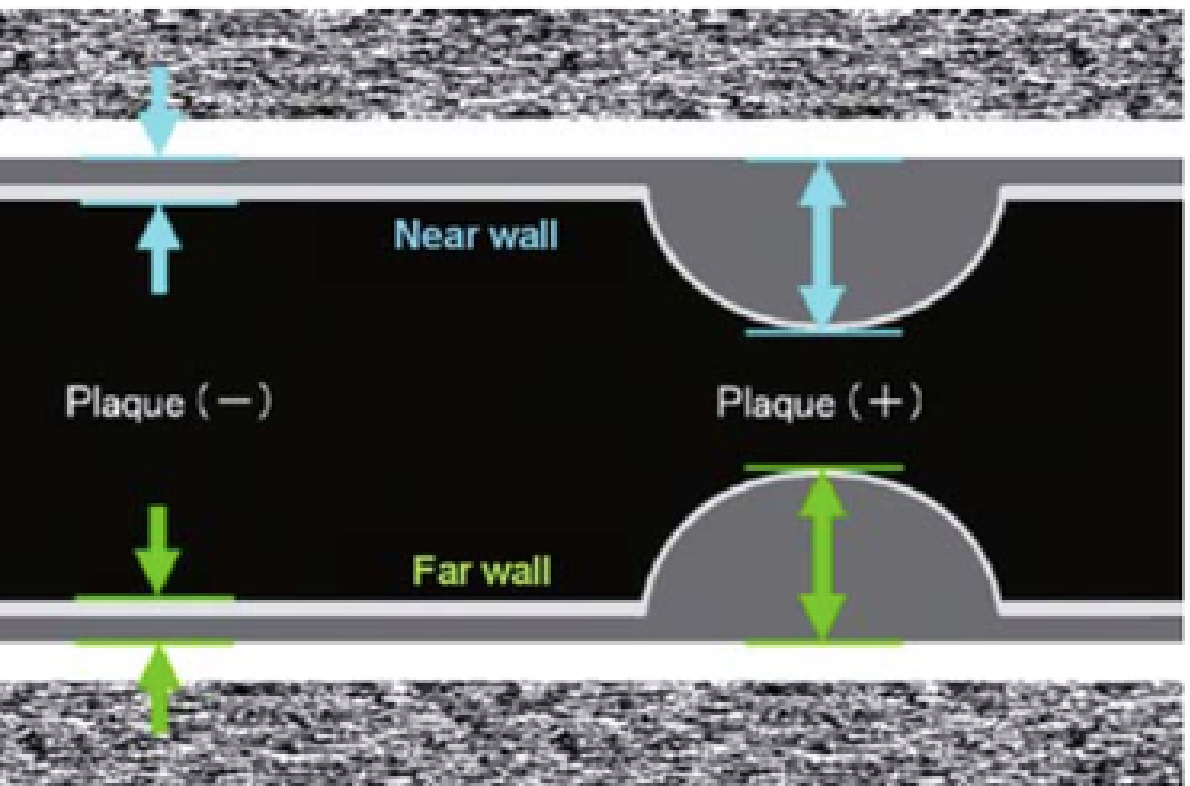
- Focus depth (30-40 mm), frame rate (>15-25 Hz)
- Gain settings adjusted optimally to facilitate edge detection;
- Clear 3-lead electrocardiographic signal;
- **Use of a zoom function is discouraged** (most of the studies have not used zoomed images);

IMT measurement

- **At least 5 mm** below the distal end of CCA, could also be measured at
 - the carotid bifurcation and internal carotid artery bulb, but the values should be given separately
- **free of atherosclerotic plaque** with clearly defined lumen-intima and media-adventitia interfaces
- **10-mm-in-length straight** arterial segment is required;
- The **far wall** of the common carotid artery is preferred
- **IMT measured at end-diastole** (R wave);
- Automatic or semi-automatic IMT measurement, online or offline
 - **Point-to-point measurement of IMT is not recommended;**
- **IMT values averaged** (higher values at left side)



Plaque and stenosis



Classification of plaque

Echogenicity

• Hyperechoic



• Isoechoic



• Hypoechoic



• Anechoic



Table 1. Classification of Plaque

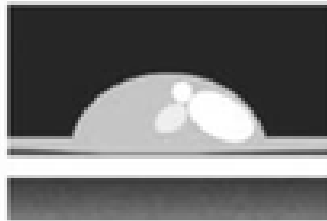
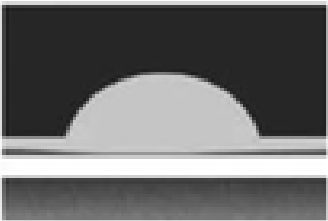
Hemodynamic (% Stenosis Diameter)	Morphologic	By Surface
H1, mild (<50%)	P1, homogeneous	S1, smooth
H2, moderate (50%–69%)	P2, heterogeneous	S2, irregular (defect <2 mm)
H3, severe (70%–95%)		S3, ulcerated (defect >2 mm)
H4, critical (95%–99%)		
H5, occluding (100%)		

From Thiele et al.¹⁹

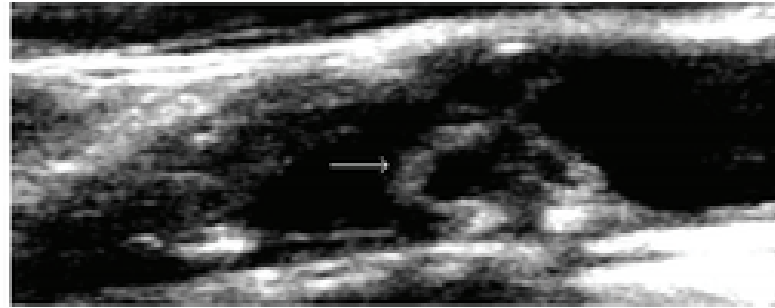
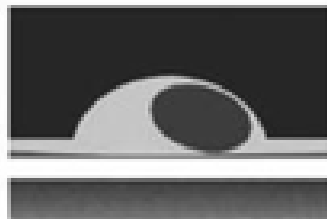
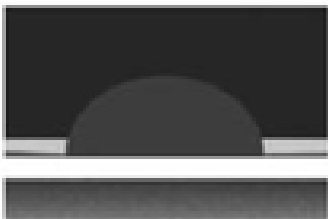
calcified



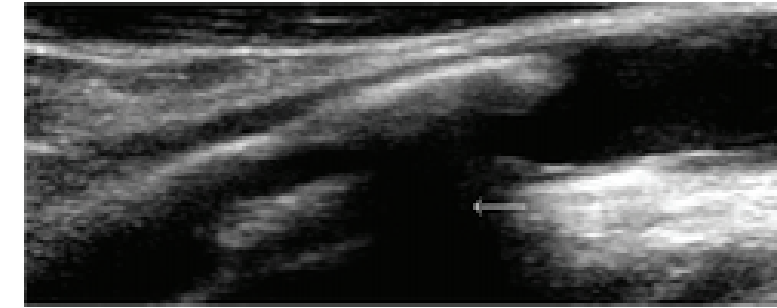
iso echoic



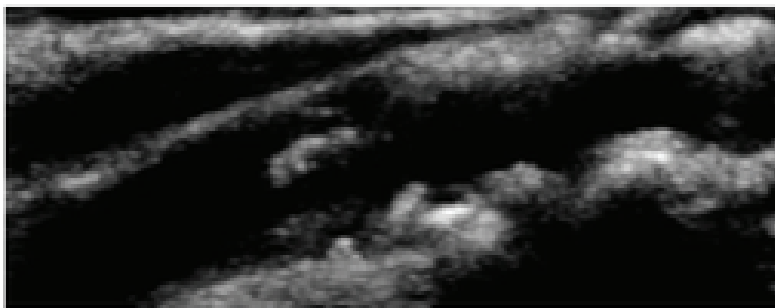
low echo or hypoechoic



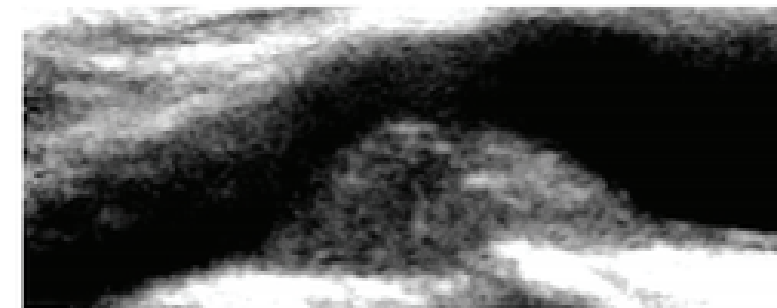
(a) Hemorrhagic plaque (dark lipid core, white arrow)



(b) Calcific plaque (acoustical shadowing, white arrow)



(c) Irregular surface (heterogeneous)



(d) Smooth surface (homogeneous)

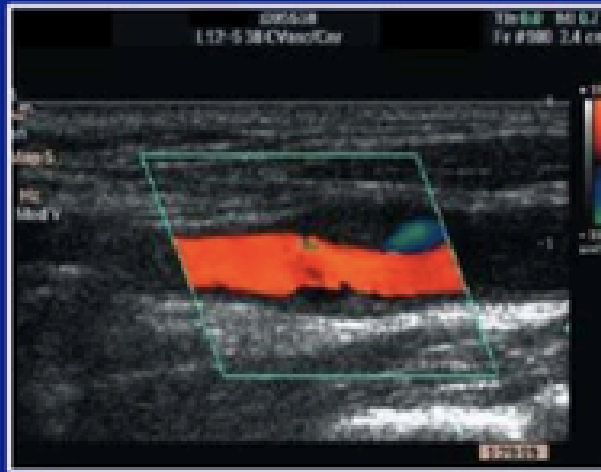
Appearance of atheromatous plaques

Edited with the trial version of

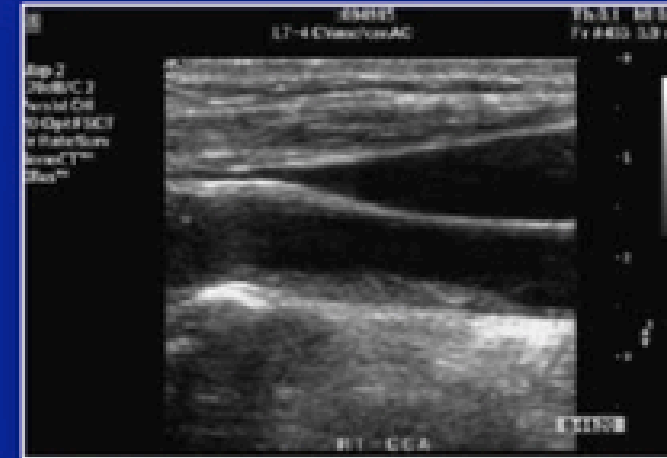
FlexiPDF

To remove this notice, visit
www.flexipdf.com

Homogeneous echolucent



Homogeneous echogenic



Heterogeneous plaque



Cauliflower' calcification



Ulcerated Plaque

Sources of error in ulcer diagnosis

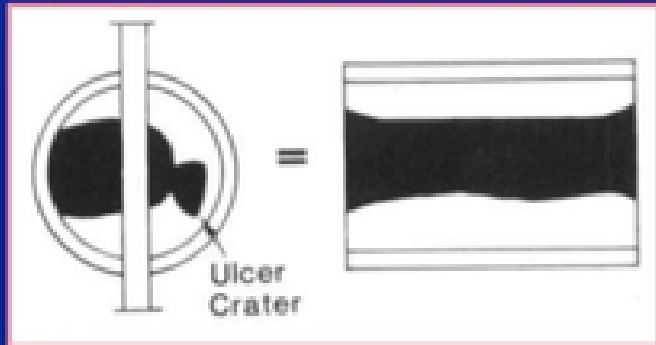
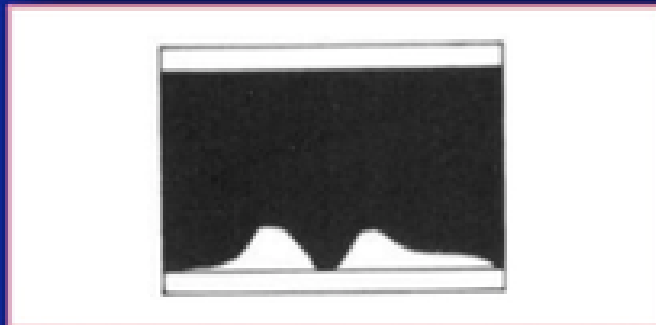


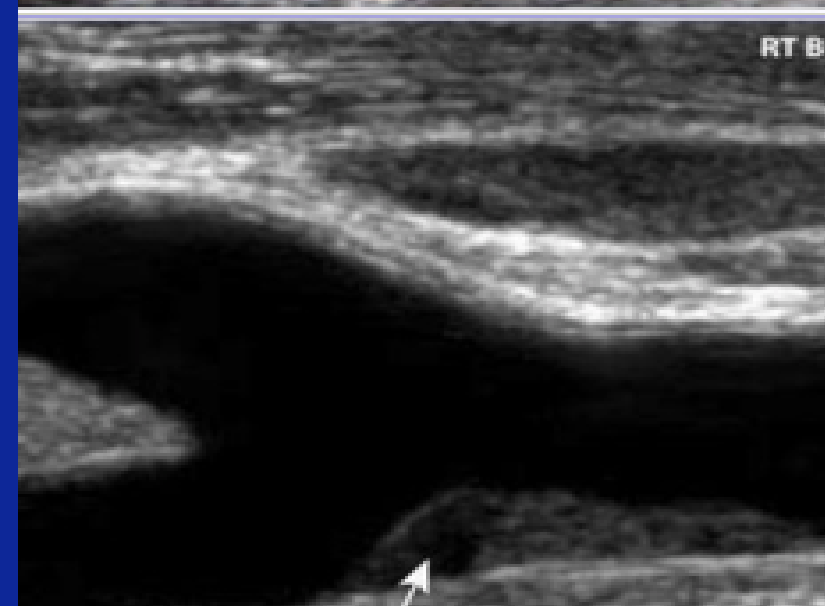
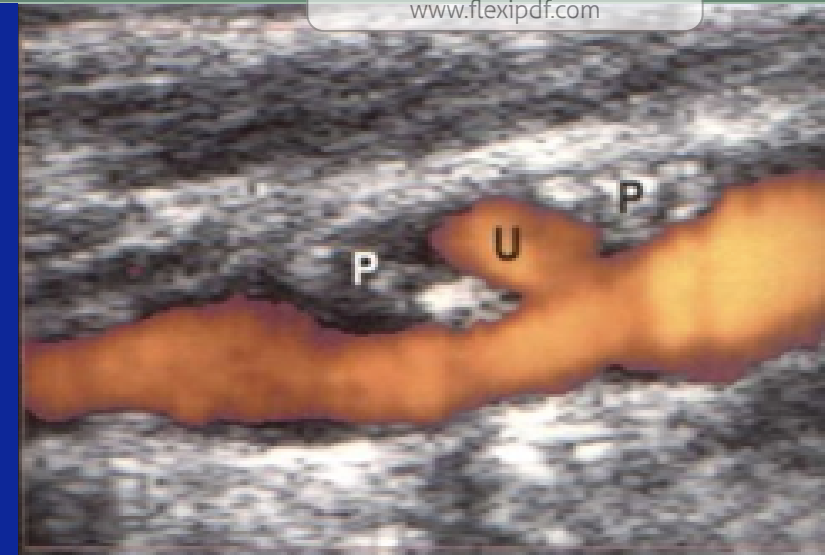
Image plan does not include
the ulcer



Adjacent plaque
simulate ulceration

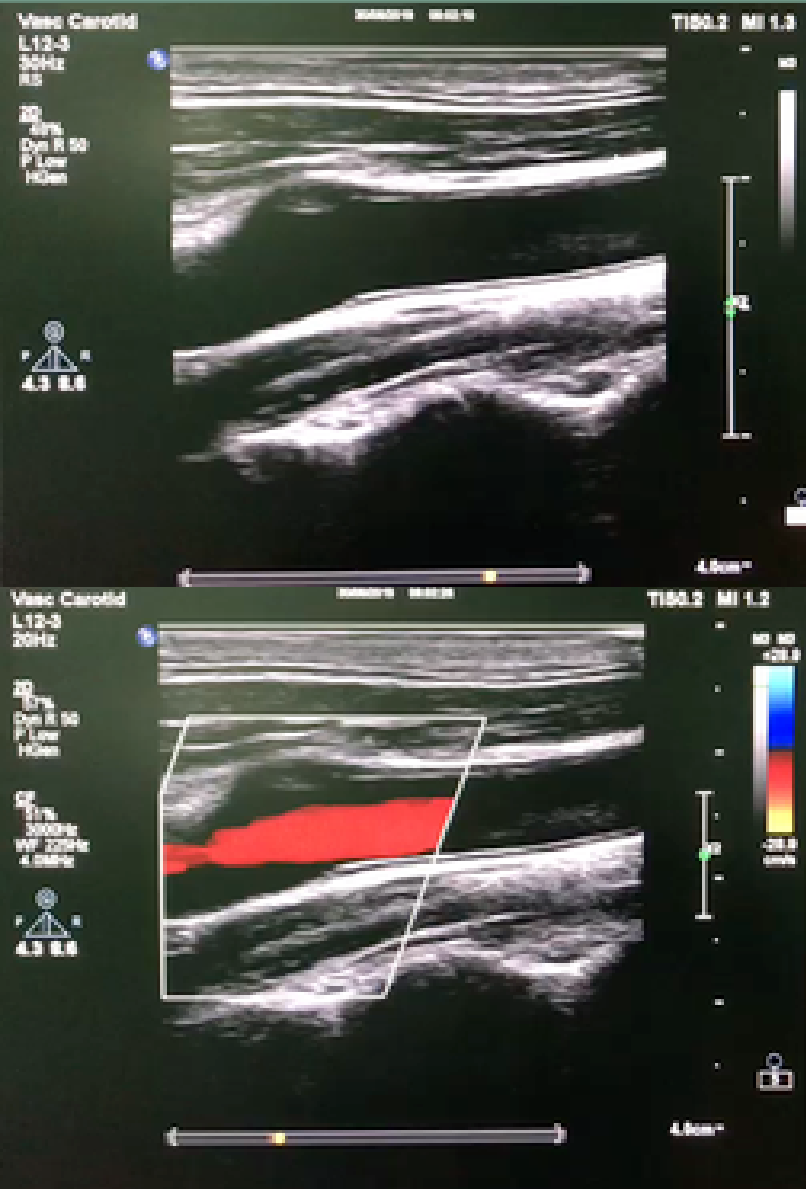


Plaque surface irregular
but not ulcerated

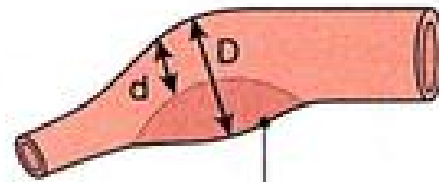


Intraplaque hemorrhage

Plaque and stenosis degree



1. ECST method



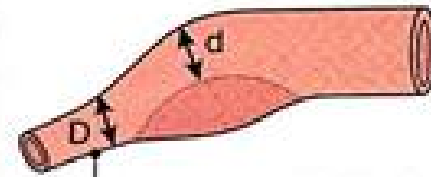
Margin of bulb estimated from arteriogram for D

$$\frac{D-d}{D} = \% \text{ diameter stenosis}$$

Example

$$\frac{10-2}{10} = 80\% \text{ diameter stenosis}$$

2. NASCET method

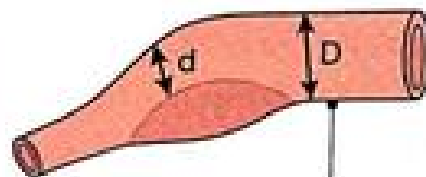


Diameter of ICA taken for D

Example

$$\frac{4-2}{4} = 50\% \text{ diameter stenosis}$$

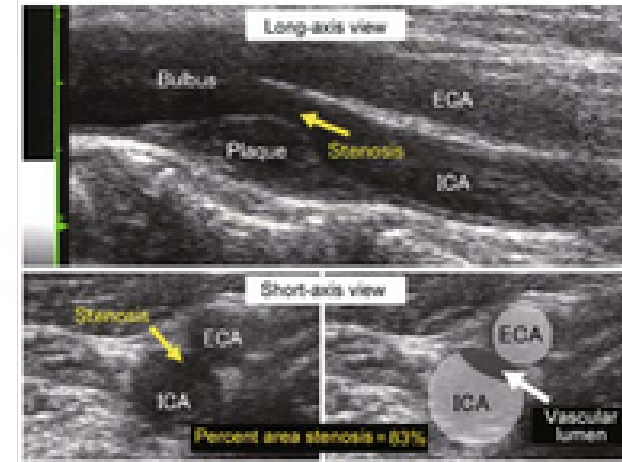
3. Common carotid diameter method



Diameter of upper CCA is taken for D

Example

$$\frac{8-2}{8} = 75\% \text{ diameter stenosis}$$

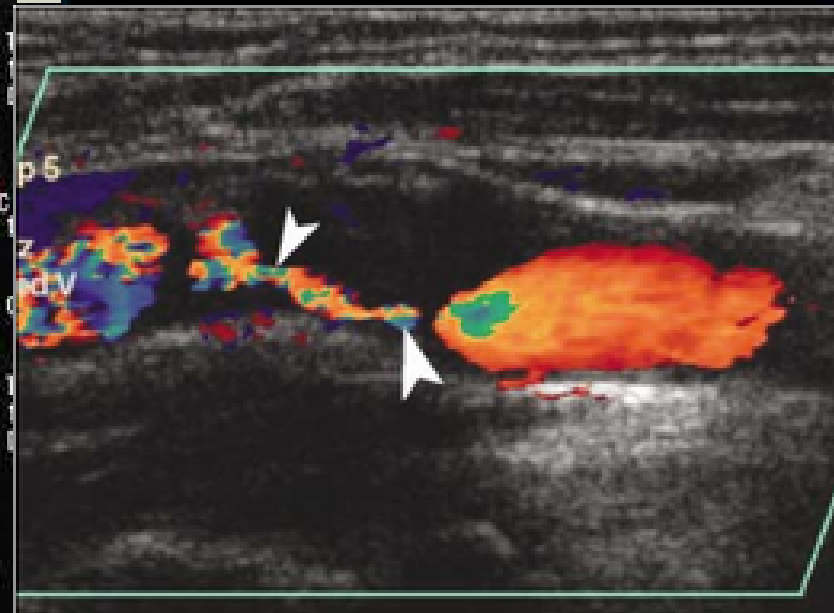
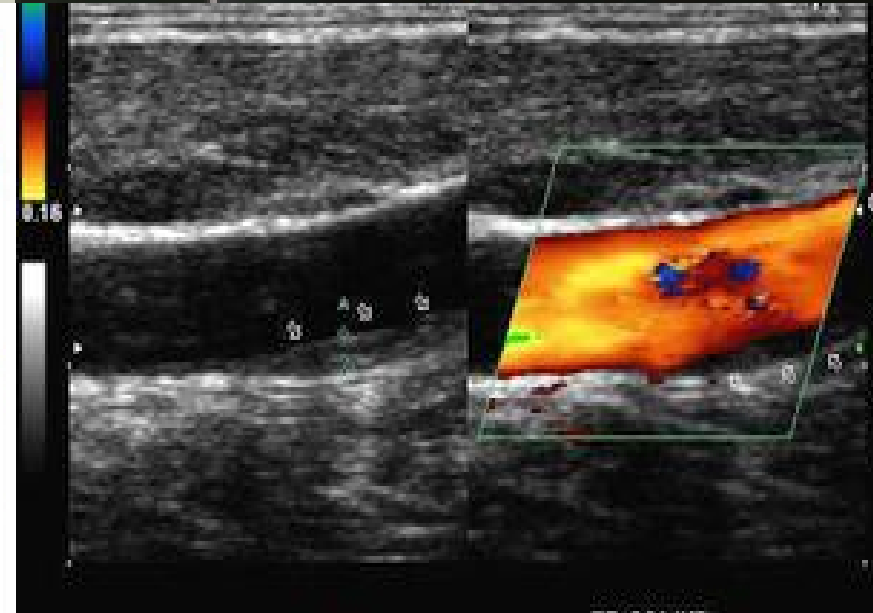
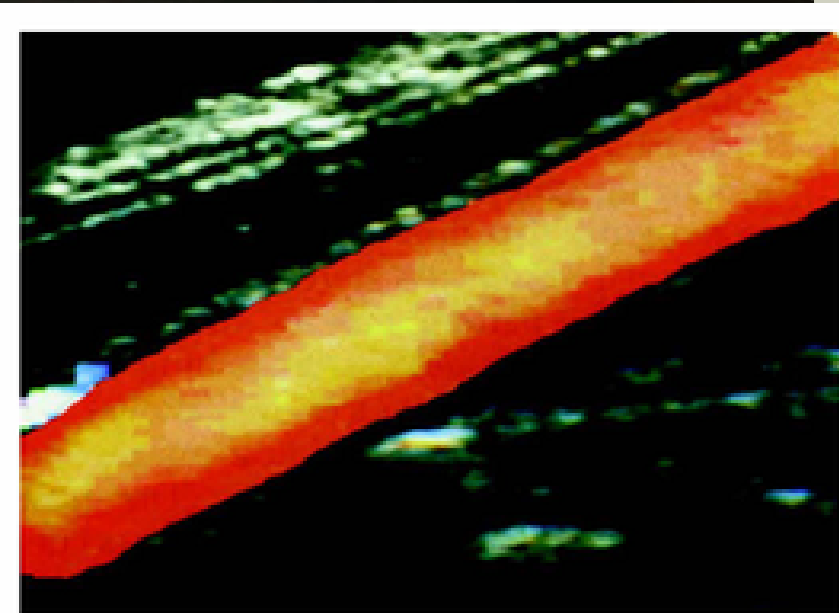
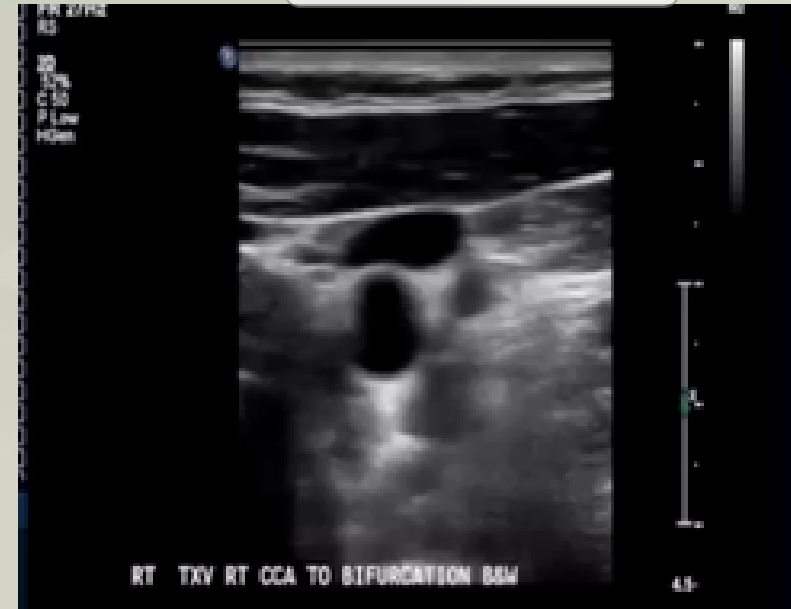
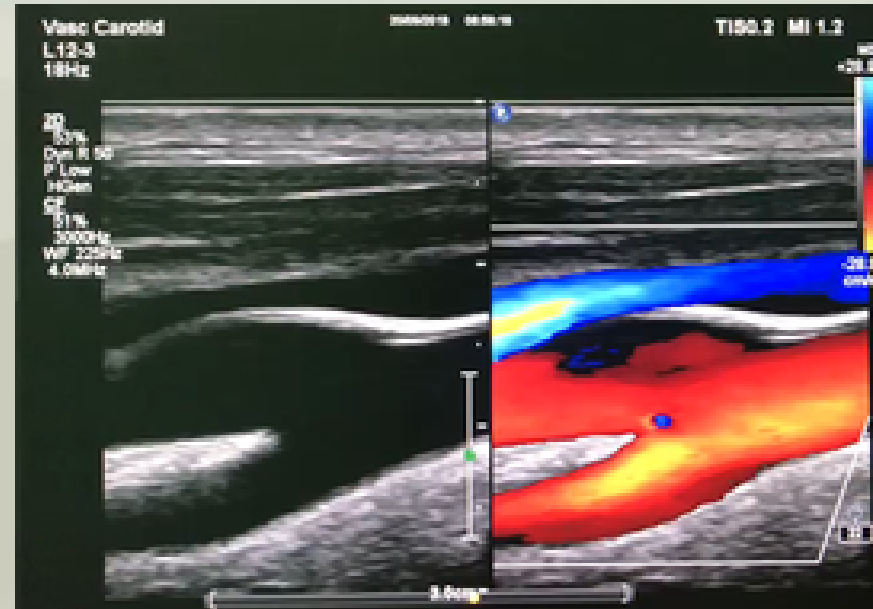
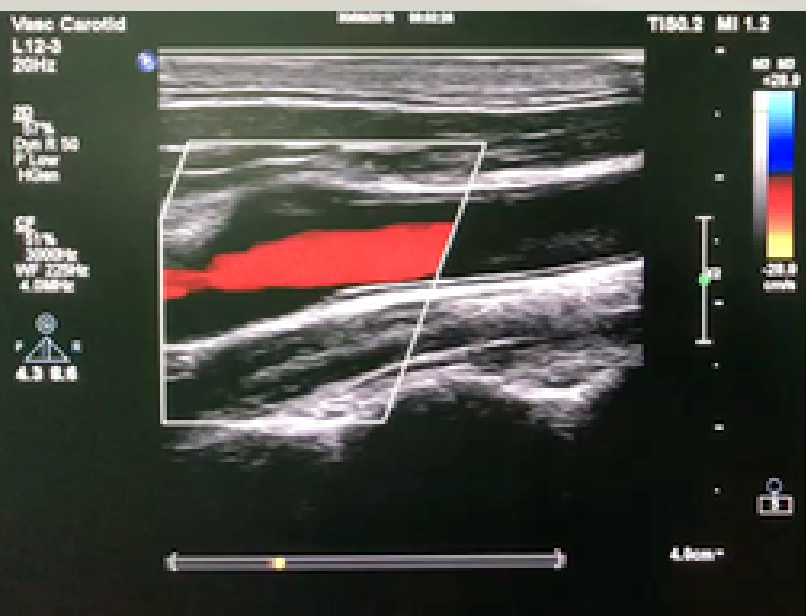


Color Doppler Imaging

Edited with the trial version of

FlexiPDF

To remove this notice, visit
www.flexipdf.com



Pulse Wave Doppler

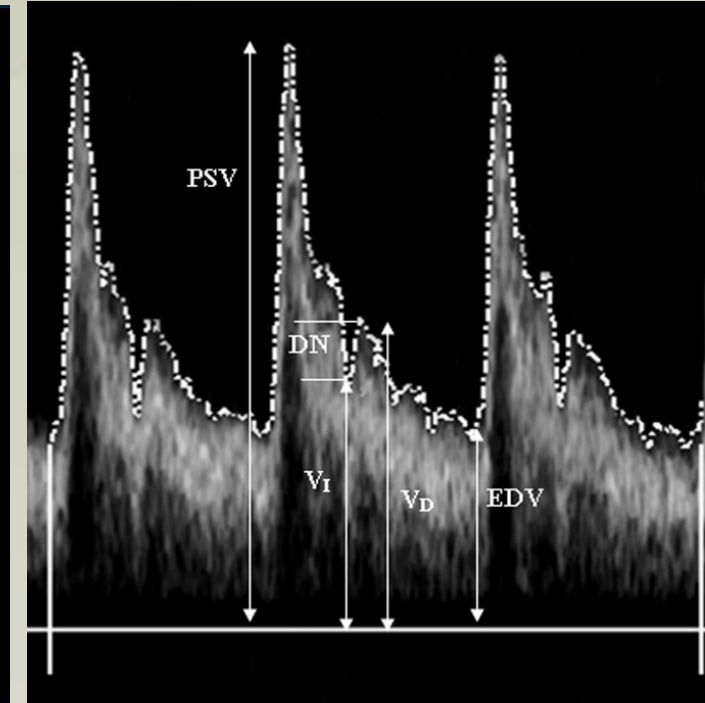
A Spectrum Doppler Waveform

Edited with the trial version of

FlexiPDF

To remove this notice, visit
www.flexipdf.com

- Spectrum waveform are used primarily to quantify velocity and stenosis.

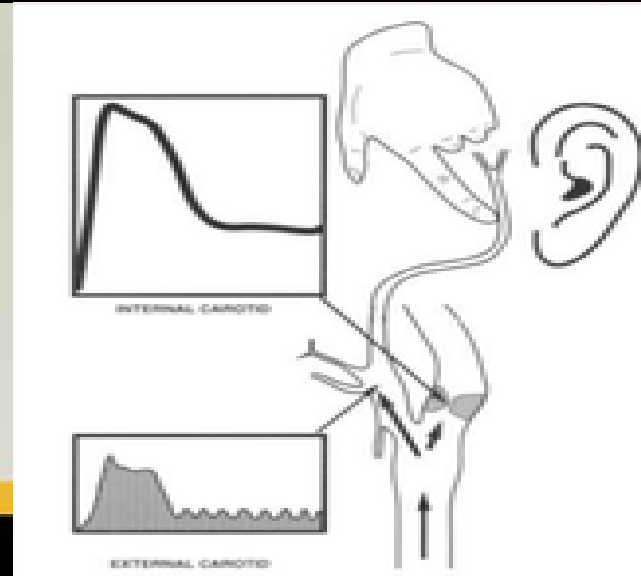
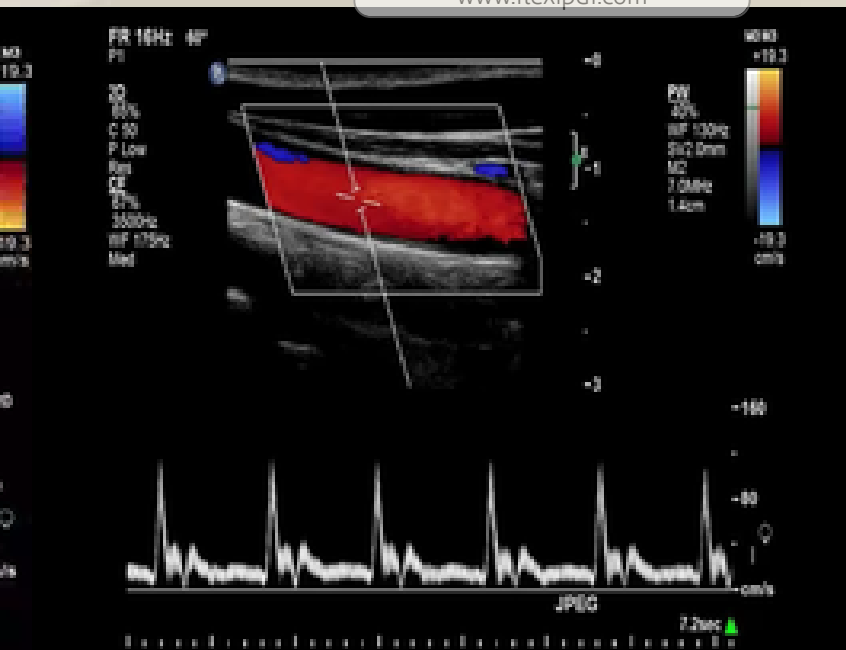
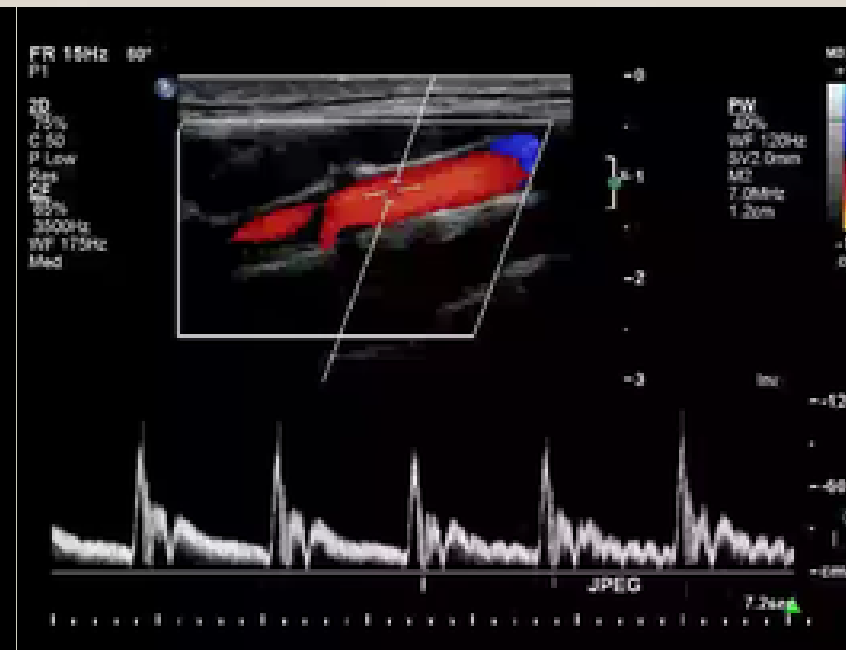
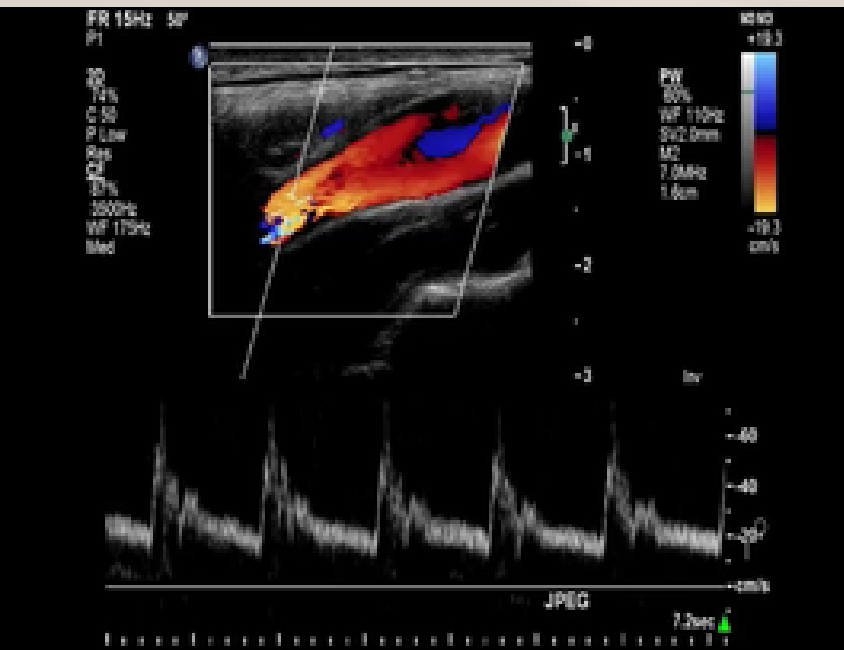


- Color box
- Sample volume
- Spectral doppler

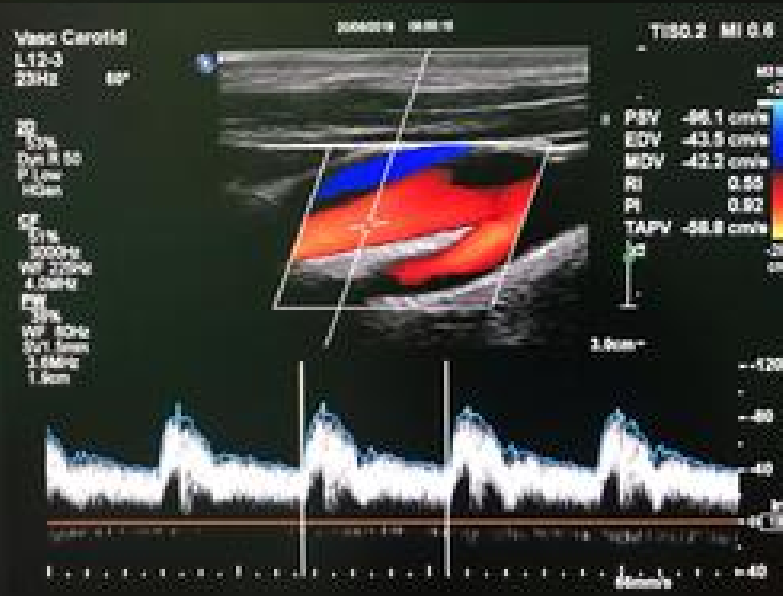
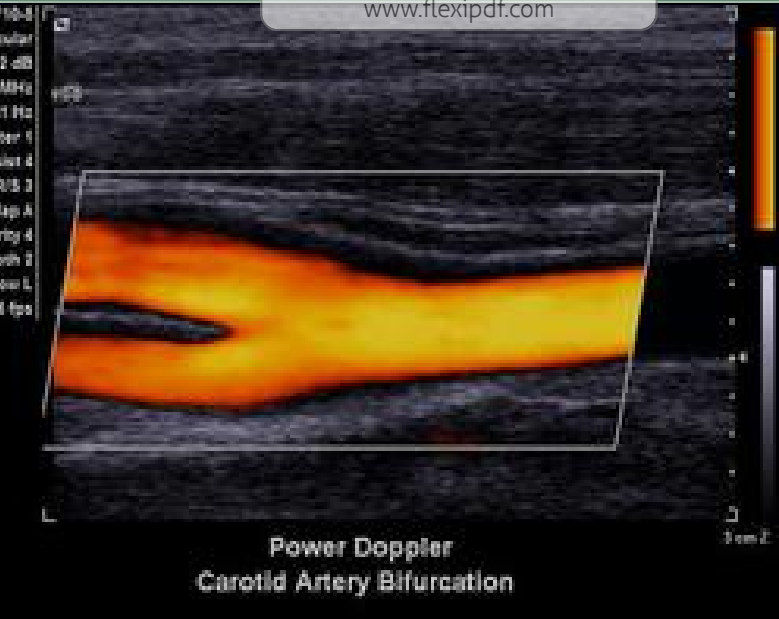
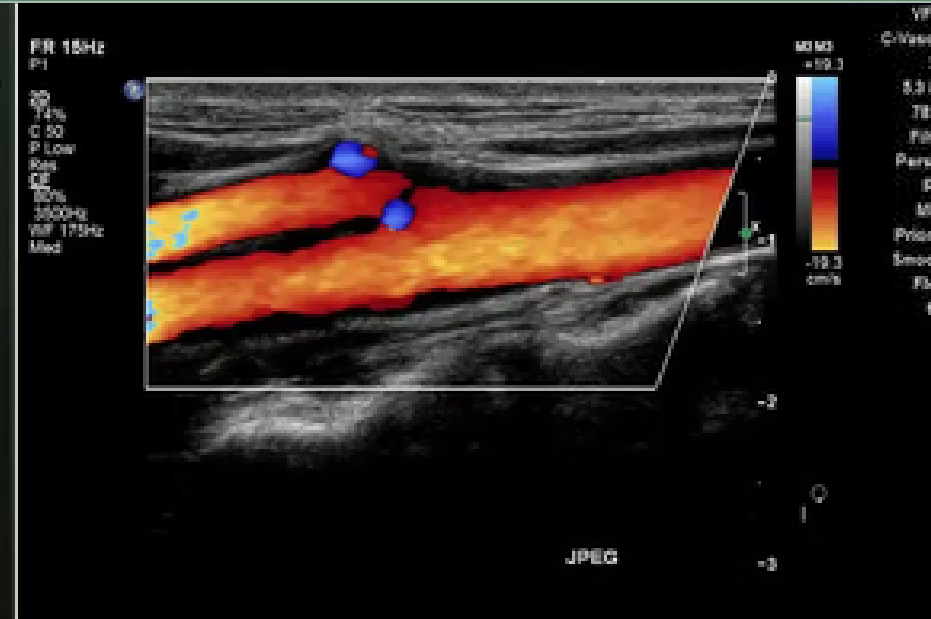
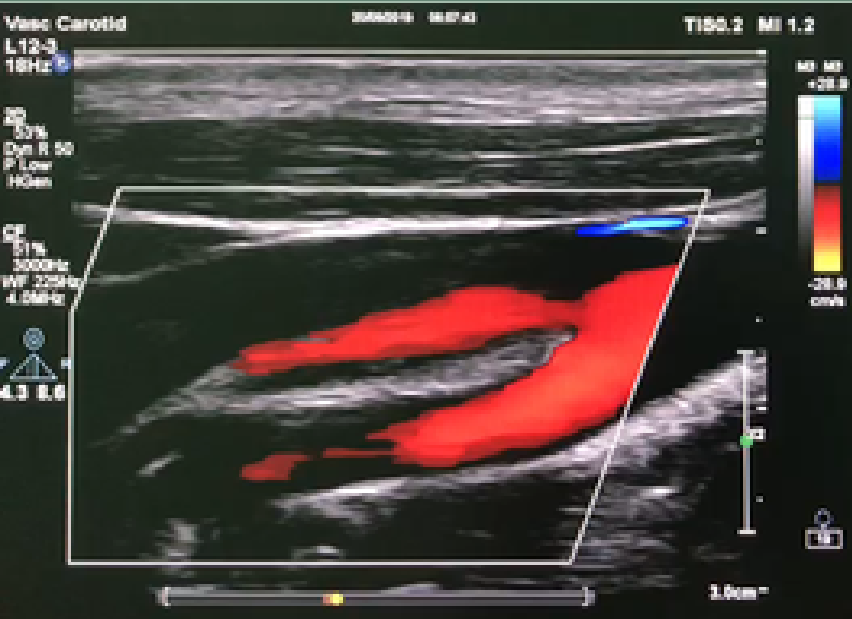
- PSV
- EDV
- MDV

- RI
- PI
- TAPV

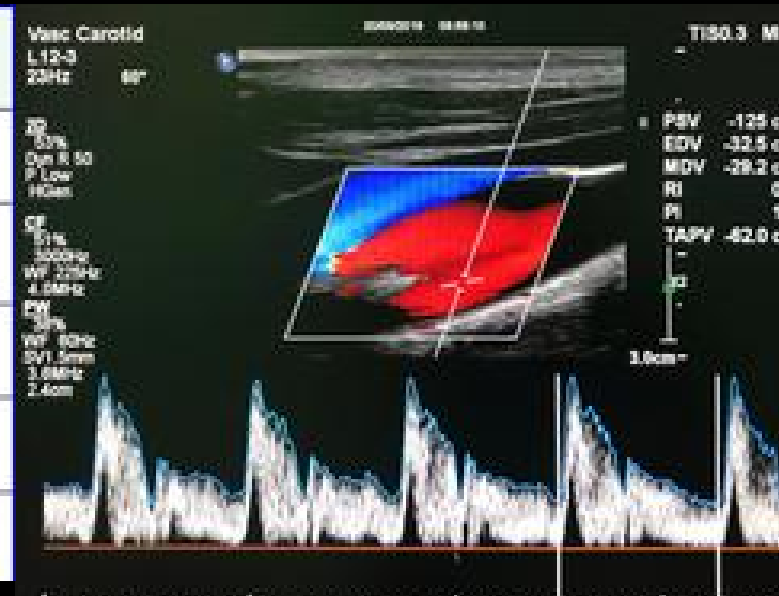
Carotid Spectral Waveform



ICA vs ECA



Features	ICA	ECA
① Size	Usually larger	Usually smaller
② Branches	Rarely	Yes
③ Orientation	Posterior	Anterior
④ Pulsed Doppler	Low resistance	High resistance
⑤ Temporal tap	Usually negative	Usually positive



ICA stenosis

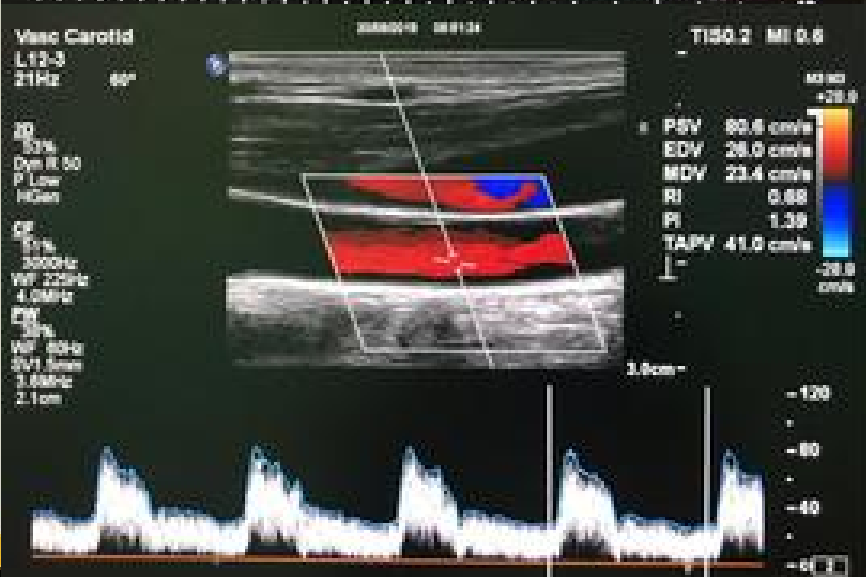
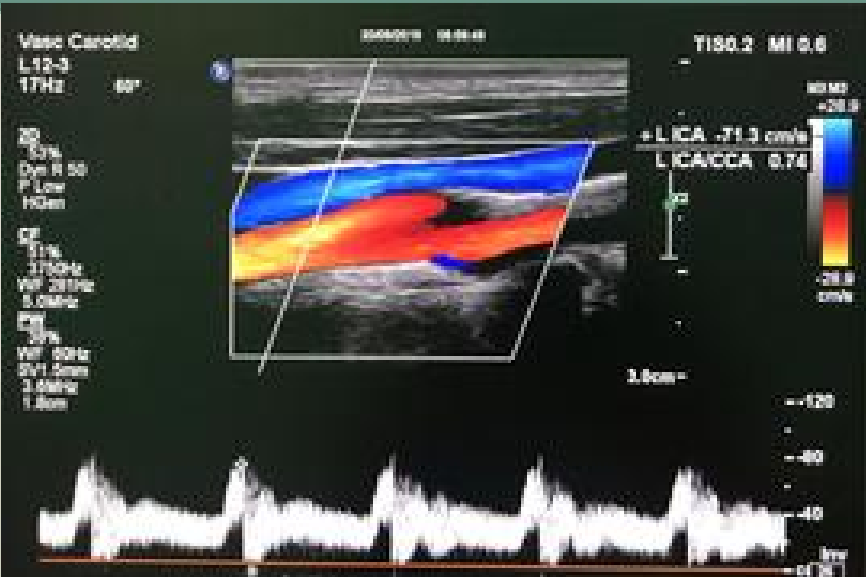
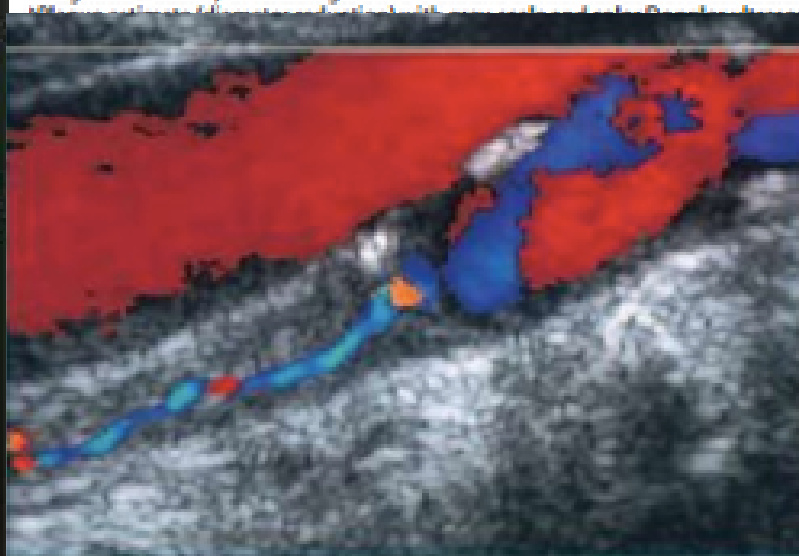


TABLE 1: Society of Radiologists in Ultrasound Criteria for the Diagnosis of Internal Carotid Artery (ICA) Stenosis*

Degree of Stenosis (%)	Primary Parameters		Additional Parameters	
	ICA PSV (cm/s)	Plaque Estimate (%) ^b	ICA/CCA Ratio	ICA EDV (cm/s)
Normal	< 125	None	< 2.0	< 40
< 50	< 125	< 50	< 2.0	< 40
50–69	125–230	≥ 50	2.0–4.0	40–100
≥ 70 but less than near occlusion	> 230	≥ 50	> 4.0	> 100
Near occlusion	High, low, or undetectable	Visible	Variable	Variable
Total occlusion	Undetectable	Visible, no detectable lumen	Not applicable	Not applicable

Note—PSV = peak systolic velocity, CCA = common carotid artery, EDV = end-diastolic velocity.

*Reprinted with permission from the Radiological Society of North America [28]: Grant EG, Benson CB, Moneta GL, et al. Carotid artery stenosis: gray-scale and Doppler US diagnosis—Society of Radiologists in Ultrasound Consensus Conference. *Radiology* 2003; 229:340–346.



High grade "string sign" stenosis



Tardus-Parvus waveform

Tardus: Long rise time

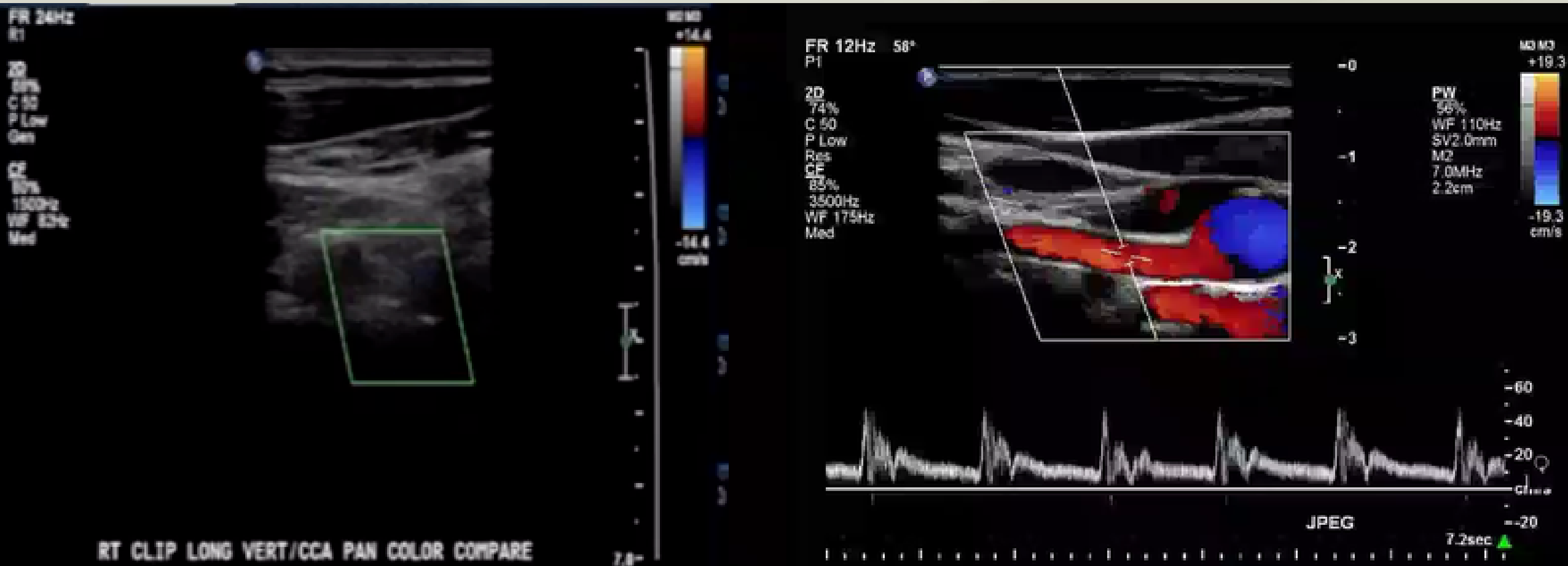
Parvus: Low PSV

Vertebral Artery Waveform

Edited with the trial version of

FlexiPDF

To remove this notice, visit
www.flexipdf.com



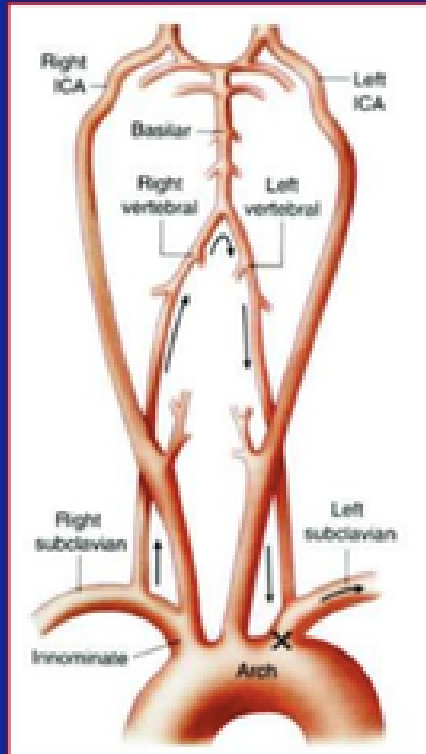
Vertebral artery abnormality

Edited with the trial version of



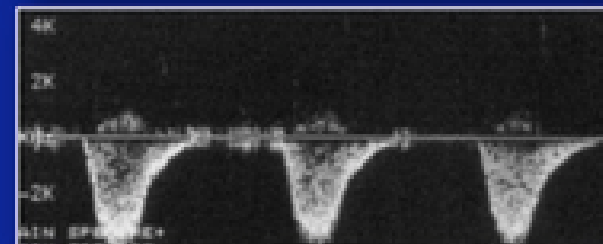
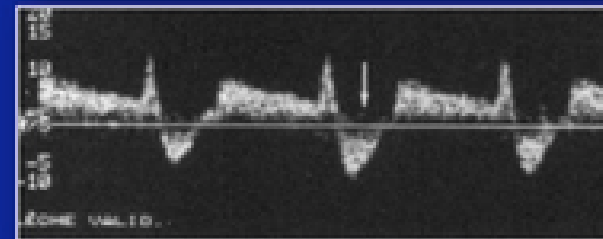
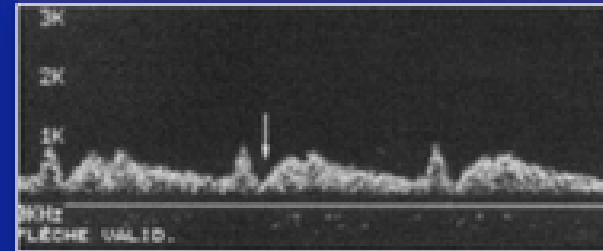
To remove this notice, visit
www.flexipdf.com

Route of flow in left vertebral steal



Zwiebel WL. Introduction to vascular ultrasonography.
W.B. Saunders, Philadelphia, USA, 4th edition, 2000.

Vertebral-to-subclavian steal



Compared to bunny in profile



Incomplete steal

Complete steal

Rohren EM et al. Am J Roentgenol 2003 ; 181 : 1695 – 1704.

How to report?

1. Data pasien
2. Patensi CCA, ICA, ECA
3. Variasi anatomi
4. Rasio peak systoli IC / CC (kanan – kiri)
5. Derajat stenosis, tipe plak, permukaan plak
6. Panjang stenosis
7. Diameter ICA diatas stenosis
8. Arteri vertebralis (terlihat? Arah aliran? Abnormalitas?)

RSCM
RSUPN Dr. Cipto Mangunkusumo
J. Diponegoro No. 71, Jakarta 10430
Telp (021) 4740001 Fax (021) 2-4881

Date :
Diagnosis :
Machine :
Inpatient room :

CAROTID DOPPLER REPORT

LEFT				Location	RIGHT			
PSV cm/sec	EDV cm/sec	Diameter (cm)	T. Intima (cm)		PSV cm/sec	EDV cm/sec	Diameter (cm)	T. Intima (cm)
				PROXIMAL CCA				
				MID CCA				
				DISTAL CCA				
				BULB				
				ICA				
				ECA				
				VERTEBRAL				
				SUBCLAVIAN				
				ARC AORTA				

LL ICA / LL CCA : _____ RL ICA / RL CCA : _____
* Those values with asterisk have been edited

History :
Indication :
Symptoms :
Comments :

Conclusion :
Advice :

Supervisor,
Consultant of Cardiologist

Examining Doctor

Please attach patient label

Vascular Laboratory
Royal Infirmary of Edinburgh - Little France
51 Little France Crescent
Edinburgh
EH16 4SA

Tel: _____

Duplex ultrasound carotid and vertebral assessment

Summary Right			
	CCA	ICA	ECA
PSV (m/s)	0.7 m/s	3 m/s	1.4 m/s
EDV (m/s)		1 m/s	
ICA/CCA	= 4.3		
% stenosis	< 50%	> 70%	< 50%
Plaque appearance	mixed smooth	mixed smooth	mixed smooth
Vertebral			
PSV (m/s)	0.5 m/s		
Direction	Antegrade		
Left			
	CCA	ICA	ECA
PSV (m/s)	0.8 m/s	1.7 m/s	1.0 m/s
EDV (m/s)		0.4 m/s	
ICA/CCA	= 2.1		
% stenosis	< 50%	50-69%	< 50%
Plaque appearance	mixed smooth	mixed smooth	mixed smooth
Vertebral			
PSV (m/s)	0.6 m/s		
Direction	Antegrade		

Signature
Please print name and designation :
Date

Syukron