

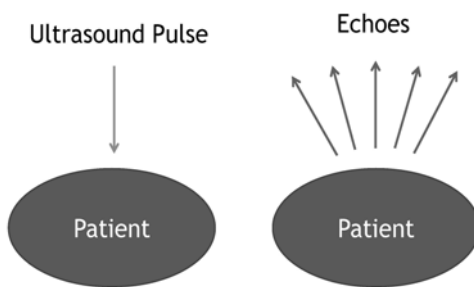
TCD Basic Techniques and Interpretation



이 종 윤

국립중앙의료원 신경과

Pulse-echo technique



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Ultrasound

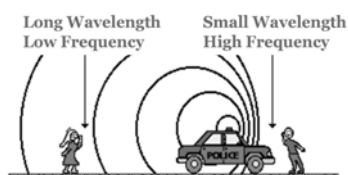
- 주파수 (frequency, Hz) : 초당 발생하는 cycle수
- Infrasound < 가청 주파수 (20 - 20 kHz) < Ultrasound
- Low vs High frequency
 - 투과력 : Low > High
 - 해상력 : Low < High



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Doppler effect

- 움직임에 의한 주파수의 변화
 - 1842년 Christian Doppler
 - Color Doppler, Doppler spectrum
- Doppler Shift
 - 되돌아오는 반사 신호의 주파수와 전송된 주파수의 차이



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Equipment

- Probe
 - 2MHz : PW
 - Trantemporal, Transorbital, Suboccipital Submandibular window
 - 4MHz : PW, CW
 - Submandibular window



2 MHz

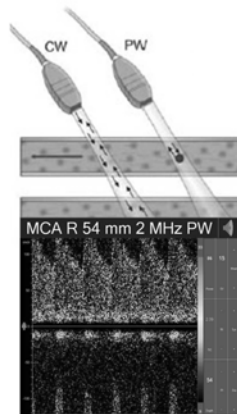


4 MHz

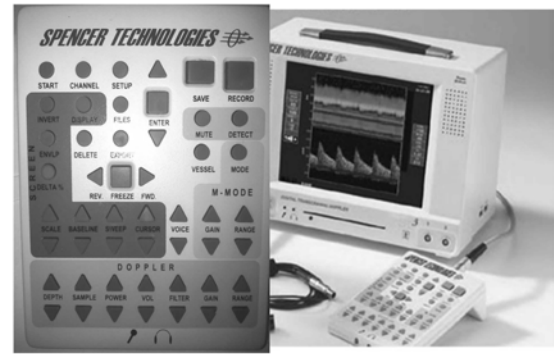
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Type of transducer

- Continuous Wave (CW)
 - Accurate Measure of high velocity
 - Poor range resolution
- Pulse Wave (PW)
 - Good range resolution
 - Limitation on maximum velocity (Aliasing)



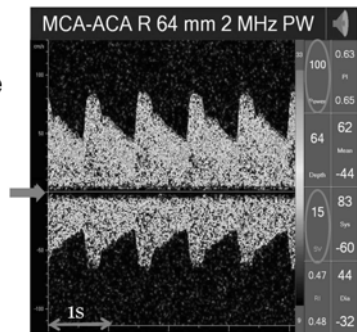
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Basic Setting

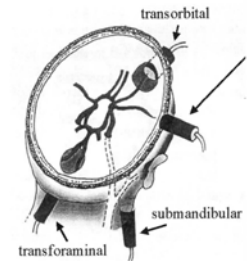
- Sweep Speed
 - 3-5 seconds
- Sample volume
 - 10-15 mm
- Baseline
 - Middle
- Power
 - 100%
 - 안구창 10%



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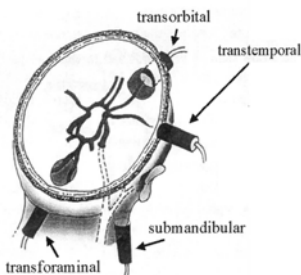
Vessel Identification

- Acoustic window
- Orientation of probe
- Sample volume depth
- Direction of flow
- Contour of waveform



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Acoustic window

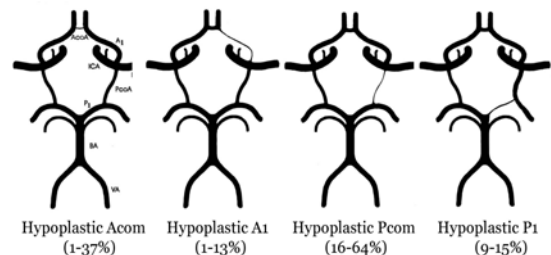


- Submandibular
- Transorbital
- Transtemporal
- Suboccipital

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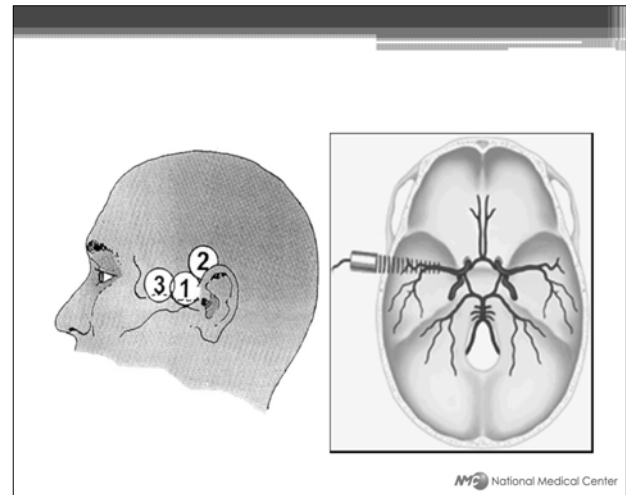
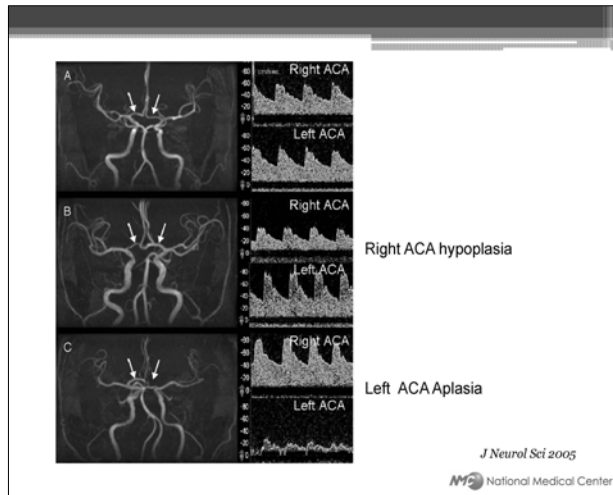
Transtemporal Window

- Circle of Willis Variants

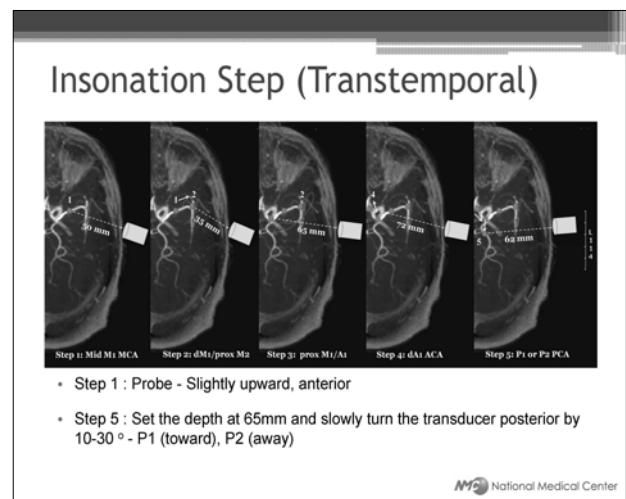


AJNR 2003;24:456

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- Poor temporal windows
 - 15%
 - Old age, Female, Oriental & Black
 - Maximum power and sample volume
 - Shorten the time necessary to find the window
 - Reduce the overall exposure to ultrasound energy
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MCA

- Depth
 - 40-60mm, (M1:45,50,55,60mm)
- Direction
 - M1-Toward, M2-Toward or Away
- Angle
 - Place above the zygomatic arch
 - En face
 - Anterior to the contralateral ear/window
- Normal values (MFV)
 - 30-80cm/sec (50-60 cm/sec)
 - Higher mean flow velocity than any of the other circle vessels

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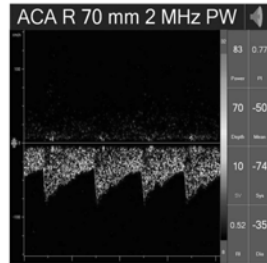
MCA/ACA bifurcation

- Depth
 - 60-70 (66)mm
- Direction
 - Bidirection

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ACA

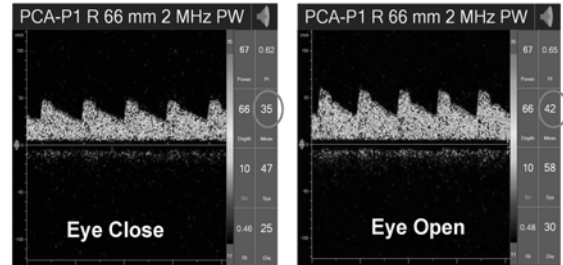
- Depth
 - 66-75mm, (72mm)
- Direction : Away
- Angle
 - Slightly anteriorly
- Normal values (MFV)
 - 30-60cm/sec
 - Less than MCA MFV



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PCA

- Visual Stimulation



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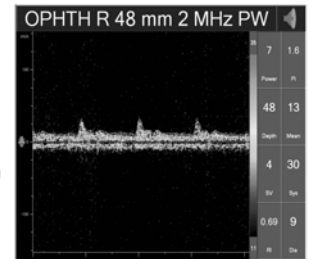
Transorbital Window

- Power
 - Minimum 10% or 17mW/cm²
- Contact lens should be removed
 - After 6 months
- Cataract OP, LASIK and etc.
 - After 6 months
- Minimal pressure on the eye
- Minimal ultrasound gel
- Artificial eye

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Ophthalmic Artery

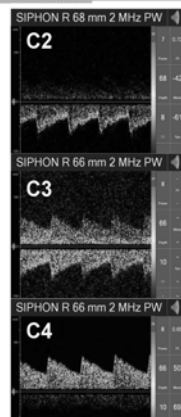
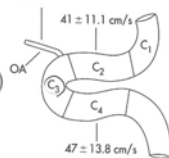
- Depth
 - 40-55mm (48mm)
- Direction
 - Toward
- Angle
 - En Face (Medially)
- Normal values (MFV)
 - 10-30cm/sec
- High PI
 - More than 1.0



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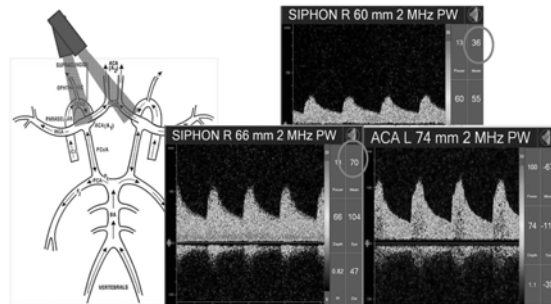
ICA Siphon

- Depth
 - 50-68 mm (64 mm)
- Direction
 - C2(Away)
 - C3(Bidirection)
 - C4(Toward)
- Angle
 - Slightly medial
- Normal values
 - 30-70cm/sec(40-50cm/sec)



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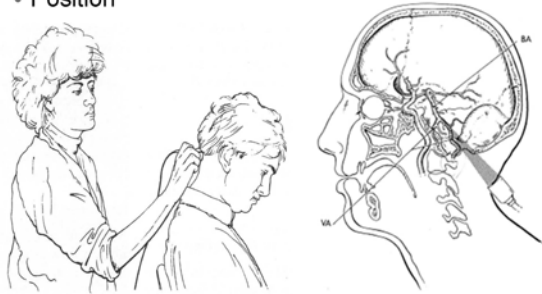
- Ipsilateral ACA or Contralateral ACA, MCA



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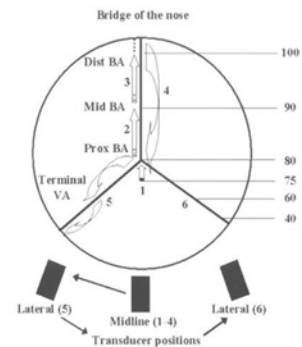
Suboccipital Window

• Position



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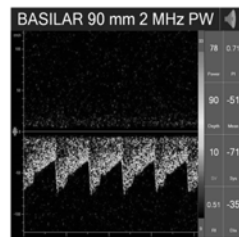
Insonation Step (Suboccipital)



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Basilar Artery

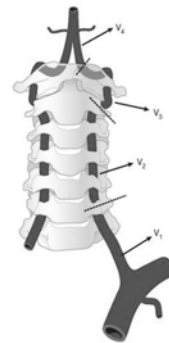
- Depth
 - 80-120mm (Save at 5 or 10mm intervals)
- Direction
 - Away
- Angle
 - Superiorly at midline
- Normal values (MFV)
 - 20-55cm/sec



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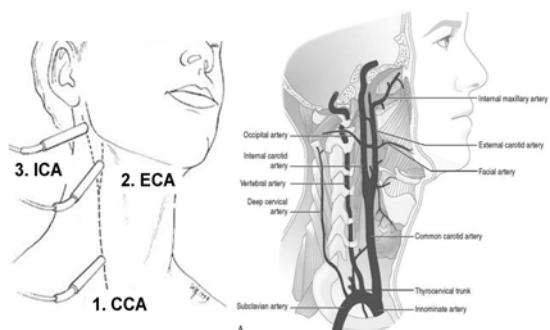
Vertebral Artery

- V4 segment
- Depth
 - 45-75mm (56 mm)
- Direction
 - Away
- Angle
 - Superiorly and obliquely
- Normal values (MFV)
 - 20-55cm/sec
- PICA
 - Toward



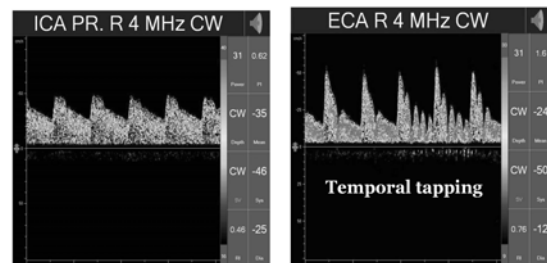
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Insonation Step (Submandibular)



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ICA vs ECA



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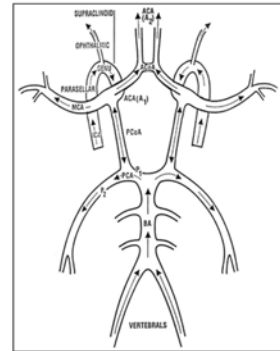
Practical advice

- 측두창에서 probe의 과도한 입사각은 피한다.
- 가장 높은 속도의 혈류를 찾으도록 한다.
- Depth등 조절 시 찾은 혈류를 놓치지 않도록 한다..
- Window별 검사가 완료되기 전 probe를 검사부위에서 떼지 않도록 한다.
- Transducer의 위치와 각도를 기억하라.
- 편측 측두창만 검사에 용이하지 않을 때는 반대편 측두창으로부터 중앙선을 넘어서 검사하도록 한다.
- 강한 Signal에서 overgain하지 말라.
- 혈류 신호가 약한 경우 gain을 조절하고 필요한 경우 수기로 속도를 측정하도록 한다.
- 협착 등의 병변이 의심되는 부위에서는 Sample volume을 줄이고 gain을 증가시켜 본다.

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TCD Interpretation

- Flow direction
- Flow velocity
- Pulsatile index
- Wave form



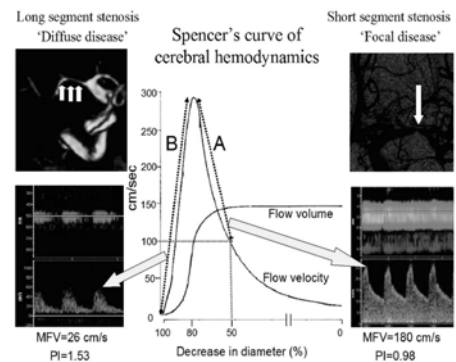
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Flow velocity

- Increased flow velocity
 - : stenosis, dissection, vasospasm; usually with turbulence on Doppler spectral waveform
 - : young age, anemia, severely increased BP, hyperthyroidism, increased CO₂, acetazolamide, mannitol
- MCA>ACA>PCA>BA and VA
- Significant side to side difference: > 30 %

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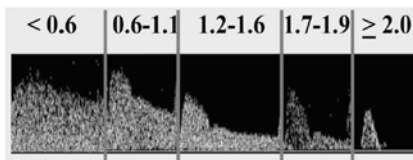
Spencer's curve



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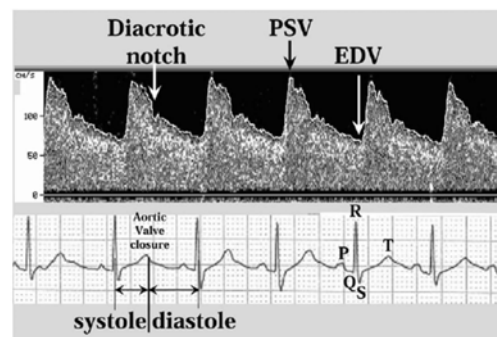
Pulsatile index

- $PI = PV - EDV / MV$
- High pulsatile waveform
 - High resistance distally, IICP, multifocal or diffuse atherosclerosis, also in aortic insufficiency
- PI 0.6-1.1 (normotensive)
 - Can be ≥ 1.2 (OA or chronic HTN)



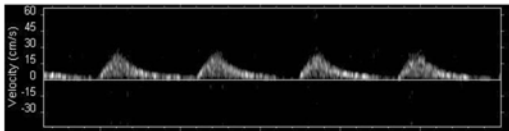
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Wave form

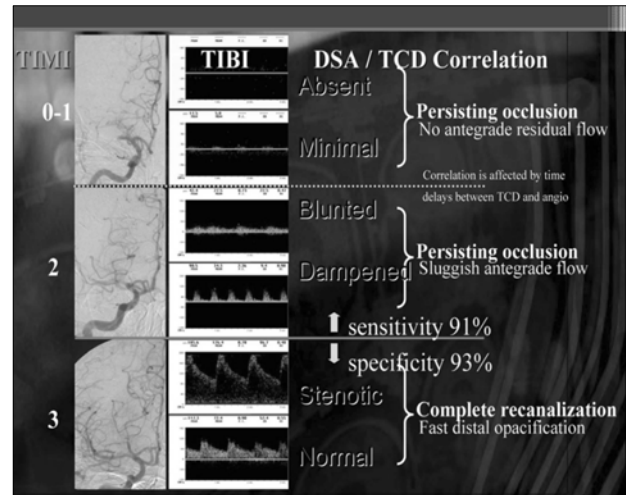


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- Proximal stenosis or occlusion
 - Delayed systolic acceleration with dampened velocity with low pulsatility



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Normal Findings

Artery	Depth(mm)	Direction	Children	Adults
M1	45-65	towards	<170cm/s	32-82cm/s
A1	62-75	away	<150	18-82
Siphon	60-64	bidirection	<130	20-77
OA	50-62	towards	variable	variable
PCA	60-68	bidirection	<100	16-58
BA	80-100+	away	<100	12-66
VA	45-80	away	<80	12-66

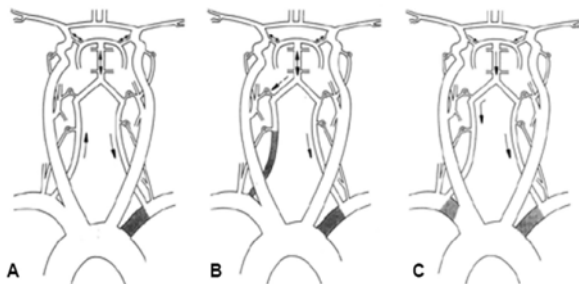
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Normal TCD criteria

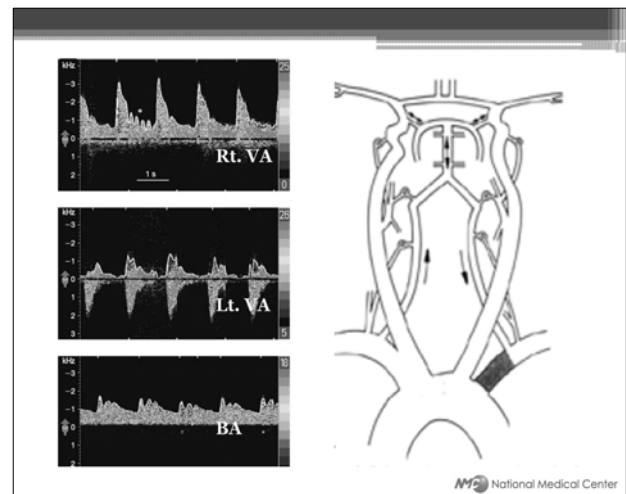
- Normal flow direction
- Velocity/ pulsatility symmetry L:R diff < 30%
- MFV < 100 cm/s (normal Hb and Ht)
- Velocity hierarchy
 - $MCA \geq ACA \geq PCA \geq ICA \geq BA \geq VA$
- PI 0.6-1.1 (normotensive)
 - Can be ≥ 1.2 (OA or chronic HTN)

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Subclavian steal phenomenon



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