Neuro Quiz 29 – Transcranial Doppler Monitoring

This quiz is being published on behalf of the Education Committee of the SNACC

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START

1. Which of the following statements about Transcranial Doppler (TCD) is **TRUE**?

A. Measures the flow through the cerebral capillaries
B. Measures the cerebral blood flow
C. Provides a direct visualization of the large cerebral arteries
D. Measures the mean flow velocity through the cerebral vessels

1.A. Measures the flow through the cerebral capillaries

Sorry!
Try Again!

- TCD measures flow velocity from large basal arteries of the brain, i.e. branches of the Circle of Willis
- The ultrasound examination using the TCD is known as '*INSONATION*'

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1.B. Measures the cerebral blood flow

Sorry!
Try Again!

- TCD does not measure flow directly and therefore cannot provide the absolute Cerebral Blood Flow (CBF)
- CBF = $\frac{Cerebral\ Perfusion\ Pressure\ (CPP)}{Cerebro-Vascular\ Resistance\ (CVR)}$ [Ohm's: $Flow = \frac{Pressure}{Resistance}$]
- Focal and generalized vessel tone determines CVR

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1.C. Provides a direct visualization of the large cerebral arteries

Sorry!
Try Again!

- TCD does not provide a direct visualization of the *insonated* artery like a carotid duplex scan
- A 2Mz ultrasonic beam reflects off the erythrocytes within these vessels and is analyzed
- Using the Doppler principle, the velocity and direction of flow is calculated

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1.D. Measures the mean flow velocity through the cerebral vessels

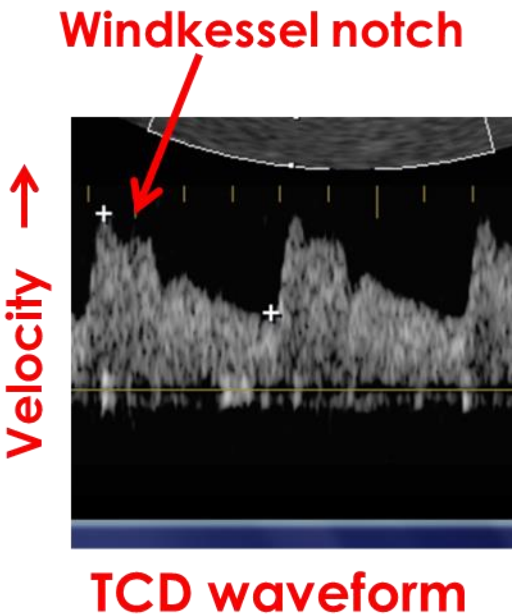
- Using the Doppler principle, the TCD measures the velocity and direction of flow of blood
- The 'Pulsatility Index' (PI)=

$$PI = \frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Mean velocity}}$$

-Gosling equation

-PI denotes arterial distensibility

The 'Windkessel' notch denotes normal arterial distensibility



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2.Which of the following statements about Transcranial Doppler (TCD) is **FALSE**?

A. The TCD probe can be applied to different sites of the cranium
B. The forehead, just above the root of the nose is NOT suitable for probe placement
C. The internal carotid artery can be insonated through the orbit of the eye
D. A burr hole is usually made to get a reliable TCD waveform

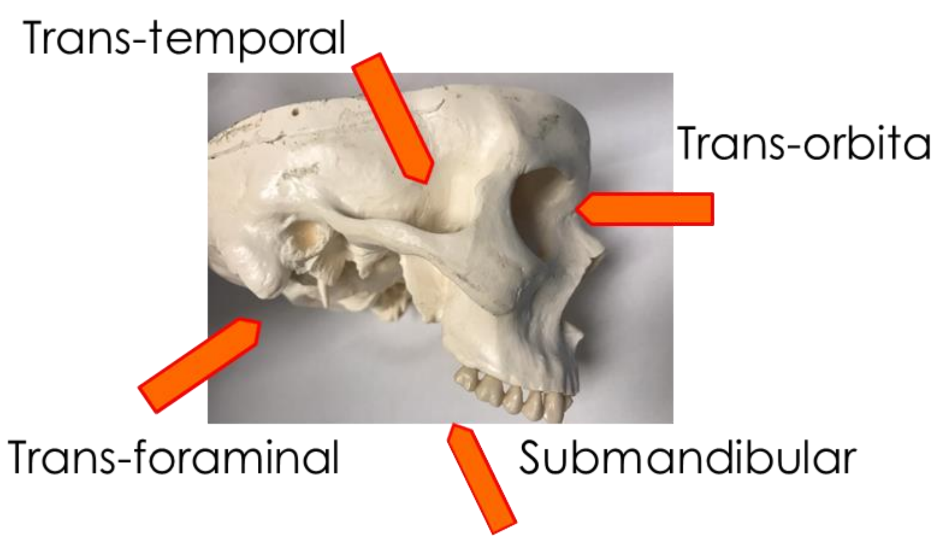
2.A. The TCD probe can be applied to different sites of the cranium

Sorry! Try Again!

Natural openings in the cranium and thin bony areas allow passage of ultrasound waves and these 'acoustic windows' are used for TCD probe placement. Commonly used sites are:

- **Temporal**
- **Orbital**
- **Foramen magnum**
- **Submandibular**

TCD probe sites



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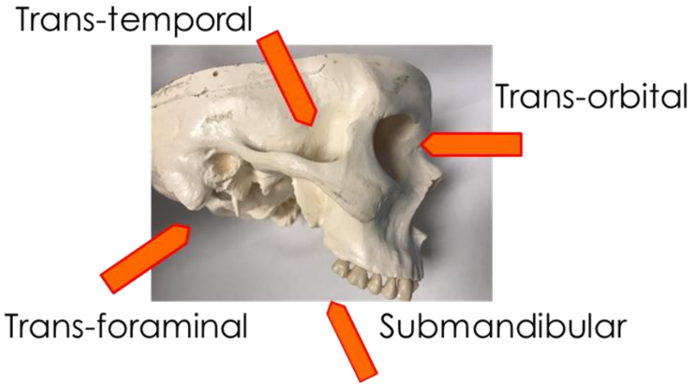
2. B. The forehead, just above the root of the nose is NOT suitable for probe placement

Sorry!
Try Again!

Areas with thin bone or natural openings form the 'acoustic windows'
The thick frontal bone would not be a suitable site and also the presence of air sinus would impede passage of ultrasound waves

TCD probe sites



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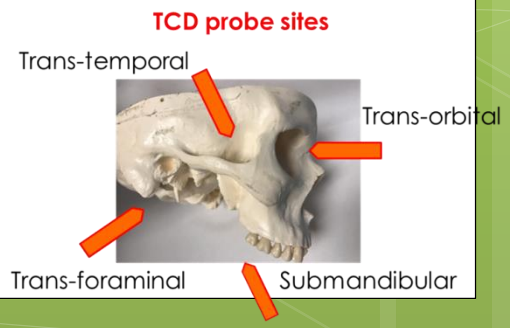
2.C. The internal carotid artery can be insonated through the orbit of the eye

Sorry! Try Again!

According to the probe position, different arteries can be insonated

- **Trans-temporal** – Mid, Ant & Post Cerebral artery, terminal portion of Internal Carotid (IC)
- **Trans-orbital** – Ophthalmic & IC(siphon) artery
- **Trans-foraminal** – vertebral and basilar artery
- **Submandibular** – extracranial IC artery



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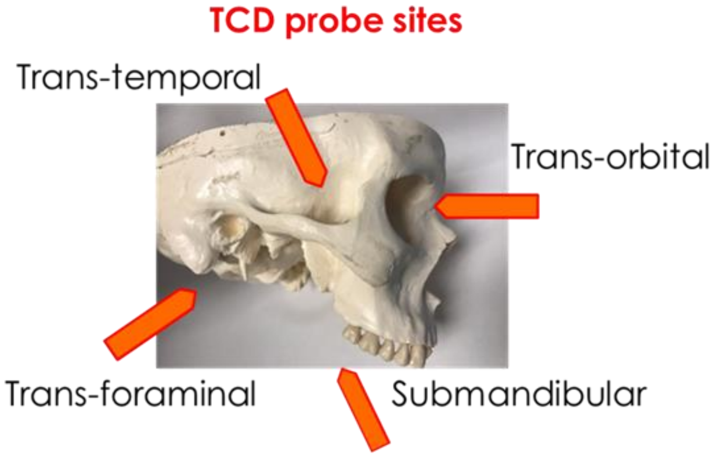
2.D. A burr hole is usually made to get a reliable TCD waveform

Although, a TCD probe can be applied over an existing burr hole, it is not needed

The TCD probe can be placed over different 'acoustic windows'



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3. Well-accepted indications for TCD include all, **EXCEPT**

A. Intraoperative monitoring during Carotid Endarterectomy
B. Intracranial vasospasm following cerebral aneurysmal bleed
C. Predict stroke in sickle cell disease
D. Measure focal cerebral flow during intractable seizure activity

3. A. Intraoperative monitoring during Carotid Endarterectomy

Sorry!
Try Again!

TCD is used as monitoring during surgeries with risk of embolization (both thromboembolic and air) such as Carotid Endarterectomy (CEA) and cardio-pulmonary bypass

Embolization have been implicated for post-operative neurological deficits

During CEA, TCD can provide useful information regarding **shunt function** and/or **embolization during dissection**

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Sorry!
Try Again!

3. B. Intracranial vasospasm following cerebral aneurysmal bleed

Presence of blood in the subarachnoid space after trauma or rupture of aneurysm can lead to vasospasm of cerebral vessels
TCD can identify such vasospasm 1-2 days before it becomes clinically significant allowing immediate therapy
Focal narrowing of vessels lead to INCREASED flow velocity

Severity of vasospasm	Mean Flow Velocity (cm/s)	Lindegaard ratio (MCA/ICA)*
Normal	<85	<3
Mild	<120	<3
Severe	150-200	>6
Critical	>200	>6

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*Lindegaard ratio- mean velocity in MCA/ mean velocity in ipsilateral ICA

3. C. Predict stroke in sickle cell disease

Sorry!
Try Again!

Sickle cell disease is associated with progressive occlusion of intracranial (ICA,MCA) vessels
As these arteries are accessible for TCD insonation, TCD can be used to monitor the flow velocity in these arteries
Recent guidelines regard TCD as type A level of evidence
Neurology 2004;62:1468

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3. D. Measure focal cerebral flow during intractable seizure activity

- PET or SPECT scans show CBF alteration during seizures
- Constant movement would make TCD acquisition difficult
- Indications for TCD include
  - Intracranial vasospasm
  - Arterial stenosis / occlusion
  - Monitor for emboli during procedures
  - Brain death – TCD shows ‘reverberating or oscillating’ flow (normal flow during systole and reverse flow during diastole due to high distal resistance, in a ‘brain-dead’ patient)
  - Testing for cerebrovascular autoregulation
  - Sickle cell disease – assess stroke risk
  - Hepatic failure – monitor cerebral edema

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4. The information that can be obtained from a TCD are all, **EXCEPT**

A. Blood flow velocity
B. Direction of blood flow
C. The pulsatility index is a reliable marker of resistance upstream to the insonated site
D. Cerebral vessels are identified depending on the depth and the ‘acoustic window’

4. A. Blood flow velocity

Sorry!
Try Again!

A 2Mz ultrasonic beam reflects off the erythrocytes within these vessels and is analyzed
Using the Doppler principle, the TCD measures the velocity and direction of flow of blood

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4. B. Direction of blood flow

Sorry!
Try Again!

A 2Mz ultrasonic beam reflects off the erythrocytes within these vessels and is analyzed

Using the Doppler principle, the TCD measures the velocity and direction of flow of blood

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4. C. The pulsatility index is a reliable marker of resistance upstream to the insonated site

- ‘Pulsatility Index’ (PI)= $\frac{\text{Peak systolic velocity – End diastolic velocity}}{\text{Mean velocity}}$
- PI is a reliable marker of resistance **distal** to the insonated site and NOT upstream to it
- Focal narrowing at site of insonation – increase in flow velocity (FV)
- Narrowing proximal to insonation site – decrease in FV
- Decrease in CVR distal to insonation site (e.g. AV malformation)– ↑ FV, ↓ PI
- Increase in CVR distal to insonation site (e.g. stenosis)- ↓ FV, ↑ PI
- PI increases in cerebral edema

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4. D. Cerebral vessels are identified depending on the depth and the 'acoustic window'

Sorry!
Try Again!

Artery	Window	Depth (mm)	Direction of flow	Flow Velocity cm/s
MCA	Temporal	30-60	Towards probe	55±12
ACA	Temporal	60-85	Away	50±11
PCA	Temporal	60-70	Bidirectional	40±10
ICA	Orbital	60-80	Bidirectional	45±15
OA	Orbital	40-60	Towards probe	20±10
VA	Foramen	60-80	Away	38±10

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5. Physiological factors that can **decrease** TCD flow velocity include all, **EXCEPT**

A. Increase age
B. Increase blood viscosity
C. Increase $PaCO_2$
D. Increase cardiac output

Sorry!
Try Again!

5. A. Increase age

Physiological factors that **decrease** Flow Velocity

- Increase age
- Increase CSF pressure
- Increased CVP
- Increased CO – to maintain normal CBF
- Increased blood viscosity
- Vasoconstrictors

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5. B. Increase blood viscosity

Sorry!
Try Again!

Physiological factors that **decrease** Flow Velocity

- Increase age
- Increase CSF pressure
- Increased CVP
- Increased CO – to maintain normal CBF
- Increased blood viscosity
- Vasoconstrictors

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5. C. Increase $PaCO_2$

Factors that **increase** Flow Velocity

- Increased $PaCO_2$ – due to vasodilatation
- Anemia (low viscosity)
- Vasodilators

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5. D. Increase cardiac output

Sorry!
Try Again!

Physiological factors that **decrease** Flow Velocity

- Increase age
- Increase CSF pressure
- Increased CVP
- Increased CO – to maintain normal CBF
- Increased blood viscosity
- Vasoconstrictors

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References

- Kassab etal. Transcranial Doppler: an introduction for primary care physician. JAm Board of Family Medicine 2007; 20:65
- Moppett IK, Mahajan RP. Transcranial Doppler ultrasonography in anesthesia and intensive care. BJA 2004; 93: 710
- Clinical Anesthesia, Barash, 7th edition

Q1 Q2 Q3 Q4 Q5