TCD in Intensive Care

Background:

Transcranial Doppler (TCD) ultrasonography is a technique that uses a hand-held Doppler transducer (placed on the surface of the cranial skin) to measure the velocity and pulsatility of blood flow within the intracranial and the extracranial arteries. Introduced by Rune Aaslid in 1982, it has become indispensable in clinical practice. The main obstacle to ultrasound penetration of the skull is bone. Low frequencies, 1-2 MHz, reduce the attenuation of the ultrasound wave caused by bone. Transcranial Doppler also provides the advantage of acoustic windows representing specific points of the skull where the bone is thin enough to allow ultrasounds to penetrate. It has its main application in the diagnosis and monitoring of vasospasm in patients with subarachnoid hemorrhage.

Literature:

Transcranial Doppler identifies a malfunctioning extraventricular drain.

Author	Mayans DR[1], Meads DB, Reynolds PS.
Content/Summary Abstract	Transcranial Doppler (TCD) is an invaluable tool allowing real-time monitoring of physiologic blood flow velocity changes. We present a case where TCD monitoring for vasospasm after subarachnoid hemorrhage identified blood flow velocity changes consistent with sudden increased intracranial pressure (ICP) due to a malfunctioning extraventricular drain. The primary team was alerted to these findings, and immediately revised her shunt with normalization of ICP and TCD. Serial TCD monitoring allowed identification of an imminently fatal complication in time to allow a life saving intervention.
Comment	Number of patients not known but very important study
Doppler-device	Not known
Quantification	TCD is a portable, inexpensive, real-time tool providing important physiologic data regarding blood flow velocities and intracranial pressure that is crucial to the care of critically ill patients.

Assessment of cerebral blood flow changes in nonconvulsive status epilepticus in comatose patients: a pathophysiological transcranial Doppler study.

Author	Merceron S[1], Geeraerts T[2], Montlahuc C[3], Bedos JP[1], Resche-Rigon M[3], Legriel S[4].
Content/Summary Abstract	**PURPOSE:** We assessed the accuracy of transcranial Doppler (TCD) in helping to diagnose nonconvulsive status epilepticus (NCSE) in comatose patients admitted to the intensive care unit (ICU) for acute neurological disorders at high risk for NCSE. **METHODS:** A 2-year prospective observational study in 38 consecutive patients requiring continuous electroencephalography (EEG) monitoring and intracranial pressure monitoring with TCD. **RESULTS:** Of the 38 patients, 10 (26.3%) had NCSE by continuous EEG monitoring. Bilateral mean and maximal systolic and diastolic TCD velocities were significantly different between patients with and those without NCSE. Areas under the receiver-operating characteristic (ROC) curves of mean and maximal systolic velocities by TCD were 0.82 (95% CI, 0.64-1.00) and 0.79 (95% CI, 0.62-0.95) with cutoffs of 95 cm/s and 105 cm/s, respectively. Areas under the ROC curves of mean and maximal diastolic velocities were 0.76 (95% CI, 0.56-0.95) and 0.78 (95% CI, 0.60-0.96) with cutoffs of 31 cm/s and 40 cm/s, respectively. For none of the velocity parameters did the areas under the ROC curves differ significantly between the left and right sides. The best performance was obtained using mean systolic (SV) and a cutoff of 95 cm/s, which yielded a positive likelihood ratio of 3.8 and a negative likelihood ratio of 0.25.
Comment	small number of patients
Doppler-device	Not known
Quantification	AUTHORS preliminary results showed a significant association between increased TCD velocities and NCSE in comatose patients. However, the likelihood ratios suggested a limited role for TCD in helping to diagnose seizure activity. Further studies with larger samples of NCSE patients are warranted to determine the exact contribution of TCD for NCSE detection in comatose ICU patients.

Transcranial Doppler after traumatic brain injury: is there a role?

Author	Bouzat P[1], Oddo M, Payen JF.
Content/Summary Abstract	**PURPOSE OF REVIEW:** To present the practical aspects of transcranial Doppler (TCD) and provide evidence supporting its use for the management of traumatic brain injury (TBI) patients.
Comment	TCD measures systolic, mean, and diastolic cerebral blood flow (CBF) velocities and calculates the pulsatility index from basal intracranial arteries. These variables reflect the brain circulation, provided there is control of potential confounding factors. TCD can be useful in patients with severe TBI to detect low CBF, for example, during intracranial hypertension, and to assess cerebral autoregulation. In the emergency room, TCD might complement brain computed tomography (CT) scan and clinical examination to screen patients at risk for further neurological deterioration after mild-to-moderate TBI.
Doppler-device	**Not known**
Quantification	The diagnostic value of TCD should be incorporated into other findings from multimodal brain monitoring and CT scan to optimize the bedside management of patients with TBI and help guide the choice of appropriate therapies.

Transcranial Doppler to assess sepsis-associated encephalopathy in critically ill patients.

Author	Pierrakos C[1], Attou R[1], Decorte L[2], Kolyviras A[1], Malinverni S[1], Gottignies P[1], Devriendt J[1], De Bels D[1].
Content/Summary Abstract	**BACKGROUND:** Transcranial Doppler can detect cerebral perfusion alteration in septic patients. We correlate static Transcranial Doppler findings with clinical signs of sepsis-associated encephalopathy. **METHODS:** Forty septic patients were examined with Transcranial Doppler on the first and third day of sepsis diagnosis. The pulsatility index (PI) and cerebral blood flow index (CBFi) were calculated by blood velocity in the middle cerebral artery (cm/sec). Patients underwent a daily cognitive assessment with the Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) test. **RESULTS:** Twenty-one patients (55%) were found to present confusion. The majority of the patients presented a PI > 1.1 (76%). PI on the first day (but not the third day) could predict a positive CAM-ICU test in septic patients (PI cut-off: 1.3, AUC: 0.905, $p < 0.01$, sensitivity: 95%, specificity: 88%, AUC: 0.618, $p = 0.24$). Multivariable analysis showed that PI on the first day is related to a positive CAM-ICU test independent of age and APACHE II score (OR: 5.6, 95% CI: 1.1-29, $p = 0.03$). A decrease of the PI on the third day

	was observed in the group that presented initially high PI (>1.3) (2.2 ± 0.71 vs. 1.81 ± 0.64; p = 0.02). On the other hand, an increase in PI was observed in the other patients (1.01 ± 0.15 vs. 1.58 ± 0.57; p < 0.01). On only the first day, the mean blood velocity in the middle cerebral artery and CBFi were found to be lower in those patients with a high initial PI (36 ± 21 vs. 62 ± 28 cm/sec; p < 0.01, 328 ± 101 vs. 581 ± 108; p < 0.01, respectively).
Comment	Forty septic patients were examined with Transcranial Doppler
Doppler-device	Not known
Quantification	Cerebral perfusion disturbance observed with Transcranial Doppler could explain clinical symptoms of sepsis-associatedencephalopathy.

Transcranial doppler microembolic signals detection in patients treated with veno-venous extracorporeal membrane oxygenation

Author	*A. Gallerini*[1], *S. Trapani*[1], *A. Cramaro*[1], *L. Gucci*[1], *L. Tadini Buoninsegni*[2], *M. Bonizzoli*[2], *A. Peris*[2], *M. Marinoni*[1] [1] Neurosonology Lab, Department of Biomedical Sperimental and Clinical Sciences, University of Florence, Italy [2] Intesive Care Unit, Careggi Hospital, Florence, Italy
Content/Summary	Veno – Venous (VV) Extracorporeal Mem- brane Oxygenation (ECMO) is a temporary respiratory support for patients with acute lung failure. **The aim of the study** is to detect the possible presence of Microembolic Signals (MES) in patients treated with VV ECMO by Transcranial Doppler (TCD). **Methods:** A 60 minutes bilateral and continuous TCD monitoring of Middle Cerebral Arteries was performed in patients with VV ECMO treatment during hospitalization in our Intensive Care Units (ICUs). monitoring was performed at the start of ECMO treatment and every 48 hours or every 24 hours in case of MES re- cording. The authors excluded patients with possible source of microembolism (cardiac right-to-left shunt or internal carotid stenosis ≥70%) and/or bilateral inadequate acoustic windows (IAW).
Comment	Interesting study where TCD was used to prove how safe ECMO is regarding microembolism
Doppler-device	Not known
Quantification	No data are published on emboli detection in patients treated with VV ECMO. Our data suggest that VV ECMO is a relatively safe procedure concerning the embolic risk, because of the low incidence of embolism

The relevance of daily transcranial doppler monitoring in clinical management of patients with subarachnoid haemorrhage

Author	*S. Trapani*[1], *V. Saia*[1], *A. Cramaro*[1], *A. Gallerini*[1], *M. Marinoni* [1] [1] Neurosonology Lab, Department of Biomedical Sperimental and Clinical Sciences, University of Florence, Italy
Content/Summary	The utility of Transcranial Doppler (TCD) in patient with Subarachnoid Hemorrhage (SAH) is still debated. The aim of our study is to evaluate the clinical relevance of daily TCD monitoring in patients with SAH. **Methods:** Authors enrolled consecutive patients admitted to the Intensive Care Units (ICUs) of our hospital because of SAH during a 12 months period. All the evaluated patients showed a brain TC scan positive for SAH at the admition in ICU. The presence of the hemorrhagic aneurysm was confirmed by cerebral angiography. Patients with bilateral inadequate acustic windows were excluded. Diagnosis and grading of vasospasm were assessed according to Aaslid criteria. All patients were daily followed up by TCD since their admission in ICU until the 15th day or until vasospasm resolution in case of persisting hemodynamic pattern of vasospasm.
Comment	Daily TCD monitoring allows to detect real time hemodynamic changes before the appearance of clinical signs related to vasospasm. A correlation between clinical scales and clinical outcome was found. The original datum of this study is the utility of TCD daily monitoring in modifying treatment strategy of SAH patients aimed at preventing SAH complications.
Doppler-device	Not known
Quantification	

Applications of ultrasound in the intensive care unit

Author	(Harding u. a., 2011)
Content/Summary	
Comment	German Article
Doppler-device	none
Quantification	Article about ultrasound at ICU in general

Monitoring of brain function in anesthesia and intensive care.

Author	(Grocott u. a., 2010)
Content/Summary	
Comment	Review
Doppler-device	None
Quantification	Using a comprehensive cerebral monitoring strategy may optimize outcomes in anesthetic and intensive care.

Author	(Geeraerts u. a., 2008)
Content/Summary	The pulsativity index (PI; normal values for the middle cerebral artery=1.0+/-0.2) and end diastolic velocity (EDV; normal values for the middle cerebral artery=40+/-10 cm/s) give important information to evaluate the resistance status of small downstream arteries. A high PI (>1.4) with a low EDV (<20 cm/s) indicates a low blood flow with a high ischemic risk due to low cerebral perfusion pressure. TCD can also detect cerebral vasospasm after subarachnoid hemorrhage, but sensitivity and specificity for vasospasm diagnosis are low compared to angiography. However, a day-to-day increase in arterial blood cell velocities can help determine the vasospasm risk and/or indicate that angiography should be done.
Comment	Review, Article in French
Doppler-device	None
Quantification	TCD applications at neurosurgical ICUs are mentioned

Transcranial Doppler monitoring in subarachnoid hemorrhage: a critical tool in critical care.

Author	(Rigamonti u. a., 2008)
Content/Summary	Currently, the gold standard for vasospasm diagnosis is cerebral angiography. Transcranial Doppler ultrasonography is a relatively new, non-invasive tool, allowing for bedside monitoring to determine flow velocities indicative of changes in vascular calibre. Transcranial Doppler ultrasonography can be useful pre-, intra- and post-operatively, while helping to recognize the development of cerebral vasospasm before the onset of its clinical effects.
Comment	Review 1980 to August 2007

Doppler-device	None
Quantification	Transcranial Doppler ultrasonography assists in the clinical decision-making regarding further diagnostic evaluation and therapeutic interventions. When performed in isolation, the contribution of TCD to improving patient outcome has not been established. Nevertheless, TCD has become a regularly employed tool in neurocritical care and perioperative settings.

Transcranial Doppler ultrasonography in intensive care.

Author	(Rasulo u. a., 2008)
Content/Summary	
Comment	Review
Doppler-device	None
Quantification	A very good summary. One of the most often cited articles related to TCD.

Author	(Alvarez-Fernández und Pérez-Quintero, 2007)
Content/Summary	Additional applications to them, mentioned in White et al., 2006. Emboli detection, RLS detection, CCA diagnosis
Comment	Letter to the editor
Doppler-device	none
Quantification	Very nice addition

Role of transcranial Doppler in neurocritical care.

Author	(Saqqur u. a., 2007)
Content/Summary	Transcranial Doppler has several practical applications in neurocritical care. It has its main application in the diagnosis and monitoring of vasospasm in patients with subarachnoid hemorrhage. In addition, it holds promise for the detection of critical elevations of intracranial pressure. Its ability to measure CO2 reactivity and autoregulation may ultimately allow intensivists to optimize cerebral perfusion pressure and ventilatory therapy for the individual patient. Transcranial Doppler findings of brain death are well described and can be useful as a screening tool.
Comment	Review
Doppler-device	none
Quantification	Summary

Applications of transcranial Doppler in the ICU: a review.

Author	(White und Venkatesh, 2006)
Content/Summary	Technological advances such as M mode, colour Doppler and three-dimensional power Doppler ultrasonography have extended the scope of TCD to include other non-critical care applications including assessment of cerebral emboli, functional TCD and the management of sickle cell disease.
Comment	Review
Doppler-device	None
Quantification	Despite publications suggesting concordance between TCD velocity measurements and cerebral blood flow there are few randomized controlled studies demonstrating an improved outcome with the use of TCD monitoring in neurocritical care. Newer developments in this technology include venous Doppler, functional Doppler and use of ultrasound contrast agents.

Summary:

Here are some reviews of literature listed, which concern TCD in intensive care medicine and summarize potential applications of TCD.
For further research information on special ICU applications as brain injury or cardiac arrest, read in these chapters.

Experts:

none

Literature

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