Oscar Clinical Guideline: Transcranial Doppler (CG035, Ver. 11)

Transcranial Doppler

Summary

The Plan members with conditions affecting blood flow to the brain may meet the medical necessity for a Transcranial Doppler (TCD). TCD is a non-invasive technique that can be used to evaluate blood flow in the brain. An ultrasound probe is placed against the head, and sound waves detect blood flow. TCD can be used during surgery that involves the blood vessels that supply the brain to make sure that blood flow is not interrupted during surgery.

TCD is also used outside of surgery to detect some rare forms of abnormal blood flow in the brain. When blood vessels are narrowed, have clots, or have other structural irregularities, TCD can sometimes be used to detect these problems. Only specific blood flow problems in certain parts of the brain can be seen with TCD. Only a licensed physician may order and interpret TCD.

If a single test is being ordered for intracranial pathology in adults, computed tomography (CT), magnetic resonance imaging (MRI), Computed Tomographic Angiography (CTA), or Magnetic Resonance Angiogram (MRA) are more generally acceptable first-line tests; in the absence of specific contraindications.

In patients aged 2-16 years with sickle cell disease, current expert recommendation calls for annual screenings with TCD.

Definitions

"Transcranial Doppler (TCD)" is a non-invasive technique that uses ultrasound waves to detect blood flow in the brain's blood vessels.

"Carotid Endarterectomy" is a surgical procedure that corrects narrowing of the carotid artery by removing plaque from the inside of the artery to improve blood flow to the brain and reduce the risk of strokes.

"Arteriovenous Malformation (AVM)" is an abnormality of blood vessels that occurs when there is an abnormal connection between an artery and vein, resulting in the bypassing of the capillary system that normally serves as the bridge between the two systems. AVMs are most often asymptomatic, but can cause pain, neurologic symptoms, and even fatal bleeding in some cases.

"Stenosis" is an abnormal narrowing of any structure such as an artery.

"Carotid Bruit" is a physical exam finding in which abnormal blood flow sounds are heard while listening to the carotid artery with a stethoscope.

"Parkinson's disease" (PD) is a neurodegenerative movement disorder characterized by tremor and muscle rigidity. The later stages may be associated with dementia symptoms, but dementia rarely occurs in isolation. It occurs due to loss of cells in a part of the brain that plays a role in motor function called the substantia nigra. Signs and symptoms suggestive of possible PD include the following:

- Resting tremor
- Shuffling gait
- Slow movements
- Muscle rigidity
- Impaired posture
- Speech changes
- Writing changes

Medical Necessity Criteria for Clinical Review

General Medical Necessity Criteria

The Plan considers Transcranial Doppler medically necessary when ONE of the following criteria is met:

1. Assessing blood flow and/or microemboli of intracranial arteries during carotid endarterectomy; *or*
2. Evaluating blood flow in infants meeting any ONE of the following criteria:
    a. Screening for intraventricular hemorrhage in infants born at 30 weeks' gestation or less; *or*
    b. When cerebrovascular evaluation is needed for evaluating blood flow through the circle of Willis or to evaluate for cerebral sinovenous thrombosis in high-risk infants; *or*
3. Detecting and re-screening stroke risk of patients aged 2-16 with sickle cell disease; *or*
4. Diagnosing dissection of vertebral artery; *or*
5. Diagnosing non-cardiac right-to-left shunt when the member has ONE of the following:
    a. Suspected patent foramen ovale; *or*
    b. Clinical signs of paradoxical embolism; *or*
6. Evaluating and monitoring for vasospasm after non-traumatic subarachnoid hemorrhage; *or*
7. Evaluating collateral circulation in patients known to have severe occlusion or severe stenosis of intracranial vessels, such as in Moyamoya syndrome; *or*
8. Diagnosing stenosis of the major intracranial arteries of the brain and the member has ONE of the following:
    a. Neurologic signs or history of neurological symptoms consistent with a transient ischemic attack (TIA); *or*
    b. Adjunct to carotid duplex ultrasound for symptomatic carotid artery stenosis OR symptomatic carotid bruits; *or*
9. Assessing suspected brain death; *or*
10. Detecting microemboli in cerebral artery embolism.

Experimental or Investigational / Not Medically Necessary

Transcranial Doppler for any other indication is *not* considered medically necessary by the Plan, as it is considered experimental, investigational, or unproven. Non-covered indications include, but are not limited to, the following:

1. Brain tumors
2. Diagnosing infectious or inflammatory conditions
3. Diagnosing or evaluating response to antithrombotic therapy
4. Diagnosis or evaluation of cerebral arteriovenous malformations
5. Dural arteriovenous fistula
6. Epilepsy
7. Evaluating cerebral aneurysm
8. Evaluating risk of stroke in adults with sickle cell disease
9. Evaluating veins, including but not limited to sinus thrombosis and other conditions that involve venous pathology
10. Following placement or evaluating an intra-cerebral arterial stent
11. Idiopathic intracranial hypertension

12. Managing trauma
13. Migraine headaches
14. Neurofibromatosis
15. Non-parkinsonian dementia (e.g., Alzheimer's dementia) or other neurodegenerative conditions
16. Parkinson's disease, screening asymptomatic patients at risk for Parkinson's disease, or to differentiate between secondary parkinsonism.
17. Predicting outcomes in patients with ischemic infarction (hemorrhagic conversion) or vertebrobasilar stroke
18. Psychiatric disorders
19. Screening for arterial stenosis in patients with fibromuscular dysplasia
20. Screening for carotid stenosis in asymptomatic patients
21. Stroke, either ischemic or hemorrhagic, except as described in clinical indications for medical necessity
22. Diagnosing or evaluating traumatic brain injury

Evidence

Brain tumors

Ickenstein and colleagues conducted a feasibility study in 2008 evaluating the use of TCD combined with a contrast injection to identify the area of involvement in patients with known glioblastoma. Although the technique appeared to have some merit in identifying these tumors and their blood flow, the utility of such information remains unknown. There have been no clinical trials to establish TCD's role in usual clinical care of brain tumors.

Diagnosing infectious or inflammatory conditions

There are very few case reports of clinicians using TCD in the care of patients with intracranial infectious or inflammatory conditions. Most studies involving TCD involve experimental use of TCD to evaluate systemic processes such as sepsis and their effects on intracranial blood flow rather than for direct patient care. Marquez-Romero and colleagues described an extremely rare case of an aneurysm caused by neurocysticercosis. Cantu and colleagues explored the use of TCD in a more common complication of neurocysticercosis, intracranial arteritis. This 1998 study included 9 patients and did find that TCD provides useful information in this very specific group, but even so its use has been overshadowed by widespread availability of magnetic resonance imaging (MRI) and computed tomography.

Diagnosis or evaluation of cerebral arteriovenous malformations

AAN guidelines state that there is "insufficient evidence" to guide the use of TCD in the detection and monitoring of cerebral AVMs. Furthermore, UpToDate guidelines currently recommend MRI, MRA, CT and make no mention of TDU/TCD for the evaluation or workup of these malformations. Further evidence is needed to determine the clinical role of TCD in AVM management.

Epilepsy

TCD does not play a role in the usual management of epilepsy. There are few clinical trials that include both epilepsy and TCD, reflecting its uncommon use even in the research setting. One interesting study did compare TCD to the Wada test. The Wada test (anesthetizing one side of the brain during angiography) is the gold standard for establishing language dominance which becomes an important consideration in patients with refractory epilepsy disease in presurgical planning. Knake and colleagues compared TCD with the Wada test and found TCD to produce similar outcomes with respect to lateralization of the dominant hemisphere. Importantly, 2 of the 13 patients were unable to be evaluated using TCD due to suboptimal imaging.

Evaluating response to antithrombotic therapy

TCD is sometimes used in the research setting to evaluate the effectiveness of antithrombotic therapy following acute ischemic stroke. Its role in clinical practice is yet to be determined. Saqqur and colleagues used TCD as part of a multifaceted program to predict which patients would do poorly after antithrombotic therapy to help stratify patients who may be candidates for interventional therapy. While this approach does appear promising, improved outcomes with this method have yet to be demonstrated. The American Academy of Neurology agreed in its clinical guidelines that TCD probably does provide information in evaluating patients after antithrombotic therapy, but it also stated that the clinical utility of this information remained unclear.

The most exciting use of TCD in recent years has centered on treatment of stroke in combination with antithrombotic therapy. Early studies indicated that use of ultrasound waves may help to expose more of the thrombus to the antithrombotic medication. While some waves were found to be too strong and lead to hemorrhage, milder ultrasound waves appear safe. However, the large multicenter trial evaluating this technique, the CLOTBUST-ER trial, was terminated early after enrolling 675 of the planned 800 patients due to futility of treatment.

Evaluating veins

While evaluation of the arterial system with TCD is common and established, evaluation of venous pathology is much less common. A 2008 review by Stoltz found that the false negative rate was unacceptably high when using TCD to evaluate cerebral venous thrombosis. Other imaging modalities are more commonly accepted for this application.

Managing trauma

There have been numerous studies citing the potential of TCD to improve clinical outcomes in traumatic brain injury (TBI). This potential has largely been explored in response to TBI becoming the defining injury in recent wars in Iraq and Afghanistan for United States service members. Amyot and colleagues wrote a 2016 review describing the effectiveness of different neuroimaging techniques and found TCD to be useful, especially in the military setting in which access to other less portable modalities is limited.

Use of TCD in the civilian setting in the management of TBI has been described, but clinical outcome studies are lacking. The American Academy of Neurology guidelines note that TCD probably does provide some useful information in evaluating traumatic vasospasm but that its clinical utility remains to be determined. The review by Amyot and colleagues noted that because TCD has the potential to identify vasospasm prior to the development of neurologic deficits, it may offer clinicians a window of time to intervene and prevent neurologic deterioration. While this potential seems clearly worth exploring, to date there are no studies that have demonstrated prevention of stroke or improvement in other outcomes with the use of TCD following TBI. TCD may also be useful in evaluating intracranial pressure following TBI, but it is unlikely to supplant direct pressure monitoring as the gold standard.

Migraine headaches

Because migraines are a vasomotor disorder, TCD provides real-time visualization of one of the underlying processes leading to this type of headaches. TCD has been used in the research setting to evaluate patient response to therapy such as triptan medications, beta blockers and acupuncture. Outside of the experimental setting, though, evidence for its use is lacking.

A 2017 systematic review by Shayestagul and colleagues found that there were no changes in blood flow velocity in the middle cerebral artery during migraine attacks. The data hinted that perhaps there was a decrease in blood flow velocity early on in the attacks, and the authors suggested that future studies should focus on this early phase of migraine attacks when researching TCD and migraine headaches.

Neurofibromatosis

Neurofibromatosis is a hereditary syndrome that is sometimes associated with vasculopathy. A 2013 retrospective analysis by Ghosh and colleagues looking at 312 patients, 15 (4.8%) had evidence of vasculopathy. In this series of patients, magnetic resonance angiography (MRA), the gold standard, was used to evaluate intracranial disturbances in blood flow.

TCD's role in this condition is much less defined. Paschoal and colleagues used TCD to screen patients with Neurofibromatosis for cerebral vascular disease prior to performing MRA. Three of the four patients with abnormal TCDs were confirmed to have disease on confirmatory testing with MRA, resulting in a positive predictive value of only 75%. And because MRA was not done on the patients with a normal TCD, negative predictive value and sensitivity, the numbers typically used to help select a screening test, cannot be calculated.

Parkinson's Disease (PD)

As per UpToDate's last update in 2021, although transcranial doppler is being studied for its potential role for PD, further research is necessary to establish utility and diagnostic accuracy. Furthermore, in the

2015 Movement Disorder Society Clinical Diagnostic Criteria for Parkinson's disease (PD) does not include transcranial doppler.

Psychiatric disorders

The use of TCD in the evaluation or management of psychiatric disorders is experimental and is not a routine use of the technique. Mijajlovic and colleagues in a 2014 review describe a potential research avenue using TCD to evaluate the brainstem for the diagnosis and monitoring of patients with unipolar depression. Schupbach and colleagues performed a 2007 trial evaluating cerebral blood flow changes in patients with schizophrenia. Clinical application of TCD for psychiatric disorders remains rare even in experimental settings, and it currently does not play a clinical role in the diagnosis or management of psychiatric disorders.

Applicable Billing Codes

Table 1	
CPT/HCPCS codes considered medically necessary if criteria are met:	
Code	*Description*
93886	Transcranial Doppler study of the intracranial arteries; complete study
93888	Transcranial Doppler study of the intracranial arteries; limited study
93892	Transcranial Doppler study of the intracranial arteries; emboli detection without intravenous microbubble injection
93893	Transcranial Doppler study of the intracranial arteries; emboli detection with intravenous microbubble injection
93896	Vasoreactivity study performed with transcranial Doppler study of intracranial arteries, complete (List separately in addition to code for primary procedure)

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
D57.00 - D57.819	Sickle Cell Disorders
G20.A1 - G26	Extrapyramidal and movement disorders
G45.0	Vertebro-basilar artery syndrome

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
G93.82	Brain death
I60.01-I60.02	Nontraumatic subarachnoid hemorrhage from carotid siphon and bifurcation
I60.11	Nontraumatic subarachnoid hemorrhage from right middle cerebral artery
I60.12	Nontraumatic subarachnoid hemorrhage from left middle cerebral artery
I60.2	Nontraumatic subarachnoid hemorrhage from anterior communicating artery
I60.31	Nontraumatic subarachnoid hemorrhage from right posterior communicating artery
I60.32	Nontraumatic subarachnoid hemorrhage from left posterior communicating artery
I60.4	Nontraumatic subarachnoid hemorrhage from basilar artery
I60.51	Nontraumatic subarachnoid hemorrhage from right vertebral artery
I60.52	Nontraumatic subarachnoid hemorrhage from left vertebral artery
I60.6	Nontraumatic subarachnoid hemorrhage from other intracranial arteries
I60.8	Other nontraumatic subarachnoid hemorrhage
I63.00	Cerebral infarction due to thrombosis of unspecified precerebral artery
I63.011-I63.013	Cerebral infarction due to thrombosis of vertebral artery
I63.02	Cerebral infarction due to thrombosis of basilar artery
I63.031-I63.032	Cerebral infarction due to thrombosis of carotid artery
I63.09	Cerebral infarction due to thrombosis of other precerebral artery
I63.10	Cerebral infarction due to embolism of unspecified precerebral artery
I63.111 - I63.113	Cerebral infarction due to embolism of vertebral artery
I63.12	Cerebral infarction due to embolism of basilar artery
I63.131	Cerebral infarction due to embolism of right carotid artery
I63.132	Cerebral infarction due to embolism of left carotid artery
I63.133	Cerebral infarction due to embolism of bilateral carotid arteries

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
I63.19	Cerebral infarction due to embolism of other precerebral artery
I63.20	Cerebral infarction due to unspecified occlusion or stenosis of unspecified precerebral arteries
I63.211	Cerebral infarction due to unspecified occlusion or stenosis of right vertebral artery
I63.212	Cerebral infarction due to unspecified occlusion or stenosis of left vertebral artery
I63.213	Cerebral infarction due to unspecified occlusion or stenosis of bilateral vertebral arteries
I63.231	Cerebral infarction due to unspecified occlusion or stenosis of right carotid arteries
I63.232	Cerebral infarction due to unspecified occlusion or stenosis of left carotid arteries
I63.233	Cerebral infarction due to unspecified occlusion or stenosis of bilateral carotid arteries
I63.29	Cerebral infarction due to unspecified occlusion or stenosis of other precerebral arteries
I63.311	Cerebral infarction due to thrombosis of right middle cerebral artery
I63.312	Cerebral infarction due to thrombosis of left middle cerebral artery
I63.313	Cerebral infarction due to thrombosis of bilateral middle cerebral arteries
I63.321	Cerebral infarction due to thrombosis of right anterior cerebral artery
I63.322	Cerebral infarction due to thrombosis of left anterior cerebral artery
I63.323	Cerebral infarction due to thrombosis of bilateral anterior cerebral arteries
I63.331	Cerebral infarction due to thrombosis of right posterior cerebral artery
I63.332	Cerebral infarction due to thrombosis of left posterior cerebral artery
I63.333	Cerebral infarction due to thrombosis of bilateral posterior cerebral arteries
I63.341	Cerebral infarction due to thrombosis of right cerebellar artery
I63.342	Cerebral infarction due to thrombosis of left cerebellar artery

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
I63.343	Cerebral infarction due to thrombosis of bilateral cerebellar arteries
I63.39	Cerebral infarction due to thrombosis of other cerebral artery
I63.411	Cerebral infarction due to embolism of right middle cerebral artery
I63.412	Cerebral infarction due to embolism of left middle cerebral artery
I63.413	Cerebral infarction due to embolism of bilateral middle cerebral arteries
I63.421	Cerebral infarction due to embolism of right anterior cerebral artery
I63.422	Cerebral infarction due to embolism of left anterior cerebral artery
I63.423	Cerebral infarction due to embolism of bilateral anterior cerebral arteries
I63.431	Cerebral infarction due to embolism of right posterior cerebral artery
I63.432	Cerebral infarction due to embolism of left posterior cerebral artery
I63.433	Cerebral infarction due to embolism of bilateral posterior cerebral arteries
I63.441	Cerebral infarction due to embolism of right cerebellar artery
I63.442	Cerebral infarction due to embolism of left cerebellar artery
I63.443	Cerebral infarction due to embolism of bilateral cerebellar arteries
I63.511	Cerebral infarction due to unspecified occlusion or stenosis of right middle cerebral artery
I63.512	Cerebral infarction due to unspecified occlusion or stenosis of left middle cerebral artery
I63.513	Cerebral infarction due to unspecified occlusion or stenosis of bilateral middle cerebral arteries
I63.521	Cerebral infarction due to unspecified occlusion or stenosis of right anterior cerebral artery
I63.522	Cerebral infarction due to unspecified occlusion or stenosis of left anterior cerebral artery
I63.523	Cerebral infarction due to unspecified occlusion or stenosis of bilateral anterior cerebral arteries
I63.531	Cerebral infarction due to unspecified occlusion or stenosis of right posterior cerebral artery

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
I63.532	Cerebral infarction due to unspecified occlusion or stenosis of left posterior cerebral artery
I63.533	Cerebral infarction due to unspecified occlusion or stenosis of bilateral posterior cerebral arteries
I63.541	Cerebral infarction due to unspecified occlusion or stenosis of right cerebellar artery
I63.542	Cerebral infarction due to unspecified occlusion or stenosis of left cerebellar artery
I63.543	Cerebral infarction due to unspecified occlusion or stenosis of bilateral cerebellar arteries
I63.59	Cerebral infarction due to unspecified occlusion or stenosis of other cerebral artery
I63.6	Cerebral infarction due to cerebral venous thrombosis, nonpyogenic
I63.81	Other cerebral infarction due to occlusion or stenosis of small artery
I63.89	Other cerebral infarction
I65.01 - I65.03	Occlusion and stenosis of right vertebral artery - Occlusion and stenosis of bilateral vertebral arteries
I65.1	Occlusion and stenosis of basilar artery
I65.21 - I65.23	Occlusion and stenosis of right carotid artery - Occlusion and stenosis of bilateral carotid arteries
I65.8	Occlusion and stenosis of other precerebral arteries
I65.9	Occlusion and stenosis of unspecified precerebral artery [appropriate to bill prior to procedure, inappropriate to bill post procedure]
I66.01 - I66.03	Occlusion and stenosis of right middle cerebral artery - Occlusion and stenosis of bilateral middle cerebral arteries
I66.11 - I66.13	Occlusion and stenosis of right anterior cerebral artery - Occlusion and stenosis of bilateral anterior cerebral arteries
I66.21 - I66.23	Occlusion and stenosis of right posterior cerebral artery - Occlusion and stenosis of bilateral posterior cerebral arteries
I66.3	Occlusion and stenosis of cerebellar arteries

Table 2	
ICD-10 codes considered medically necessary with Table 1 codes if criteria are met:	
Code	*Description*
I66.8	Occlusion and stenosis of other cerebral arteries
I67.841 -I67.848	Cerebral vasospasm and vasoconstriction
I77.74	Dissection of vertebral artery
R09.89	Other specified symptoms and signs involving the circulatory and respiratory systems
Z48.812	Encounter for surgical aftercare following surgery on the circulatory system

Table 3	
ICD-10 codes considered experimental, investigational or not medically necessary:	
Code	*Description*
C71.0 - C71.9	Malignant neoplasm of brain
C79.31 - C79.32	Secondary malignant neoplasm of brain and cerebral meninges
C79.40 - C79.49	Secondary malignant neoplasm of other and unspecified parts of nervous system
D33.0	Benign neoplasm of brain, supratentorial
D33.1	Benign neoplasm of brain, infratentorial
D33.2	Benign neoplasm of brain, unspecified
D43.0	Neoplasm of uncertain behavior of brain, supratentorial
D43.1	Neoplasm of uncertain behavior of brain, infratentorial
D43.2	Neoplasm of uncertain behavior of brain, unspecified
D43.3	Neoplasm of uncertain behavior of cranial nerves
D43.4	Neoplasm of uncertain behavior of spinal cord
D49.6	Neoplasm of unspecified behavior of brain
E75.00 - E75.09	GM2 gangliosidosis
E75.10 - E75.19	Other and unspecified gangliosidosis
E75.23	Krabbe disease

Table 3	
ICD-10 codes considered experimental, investigational or not medically necessary:	
Code	*Description*
E75.25	Metachromatic leukodystrophy
E75.29	Other sphingolipidosis
E75.4	Neuronal ceroid lipofuscinosis
F01.50 - F99	Mental, Behavioral and Neurodevelopmental disorders
G00.0 - G09	Inflammatory diseases of the central nervous system
G10 - G12.9, G13.8	Systemic atrophies primarily affecting the central nervous system
G20.A1 - G20.C	Parkinson's disease
G21.0 - G21.9	Secondary parkinsonism
G30.0 - G30.9	Alzheimer's disease
G31.0 - G31.9	Other degenerative diseases of nervous system, not elsewhere classified
G32.0 - G32.89	Other degenerative disorders of nervous system in diseases classified elsewhere
G40.001 - G40.919	Epilepsy and recurrent seizures
G43.001 - G43.919	Migraine
G80.3	Athetoid cerebral palsy
G90.01 - G90.B	Disorders of autonomic nervous system
G91.0 - G91.9	Hydrocephalus
G93.7	Reye's syndrome
G93.89	Other specified disorders of brain
G93.9	Disorder of brain, unspecified
G94	Other disorders of brain in diseases classified elsewhere
G95.0 - G95.9	Other and unspecified diseases of spinal cord
G99.0 - G99.8	Other disorders of nervous system in diseases classified elsewhere
I63.30 - I63.39	Cerebral infarction due to thrombosis of cerebral arteries

Table 3	
ICD-10 codes considered experimental, investigational or not medically necessary:	
Code	*Description*
I66.01 - I66.9	Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction
I72.0 - I72.9	Other aneurysm
I77.3	Arterial fibromuscular dysplasia
Q85.00 - Q85.9	Phakomatoses, not elsewhere classified
R56.1	Post traumatic seizures
R56.9	Unspecified convulsions
S02.0xxA - S02.0xxS	Fracture of vault of skull
S02.101A - S02.19xS	Fracture of base of skull
S02.2xxA - S02.2xxS	Fracture of nasal bones
S02.30xA - S02.32xS	Fracture of orbital floor
S02.400A - S02.42xS	Fracture of malar, maxillary and zygoma bones
S02.600A - S02.69xS	Fracture of mandible
S02.80xA - S02.85xS	Fractures of other specified skull and facial bones
S02.91xA - S02.92xS	Fracture of unspecified skull and facial bones
S04.011A - S04.049S	Injury of cranial nerve
S04.20xA - S04.22xS	Injury of trochlear nerve
S04.30xA - S04.32xS	Injury of trigeminal nerve
S04.40xA - S04.42xS	Injury of abducent nerve

Table 3	
ICD-10 codes considered experimental, investigational or not medically necessary:	
Code	*Description*
S04.50xA - S04.52xS	Injury of facial nerve
S04.60xA - S04.62xS	Injury of acoustic nerve
S04.70xA - S04.72xS	Injury of accessory nerve
S04.811A - S04.899S	Injury of other cranial nerves
S06.0X0A - S06.A1xS	Intracranial injury

References

1. American College of Radiology. 2021 ACR Appropriateness Criteria. Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage. Acr.org. https://acsearch.acr.org/docs/3149013/Narrative/
2. American College of Radiology. 2023 ACR Appropriateness Criteria. Cerebrovascular Diseases-Stroke and Stroke-Related Conditions. Acr.org. https://acsearch.acr.org/docs/3149012/Narrative/
3. Andersen CR, Fitzgerald E, Delaney A, Finfer S. A Systematic Review of Outcome Measures Employed in Aneurysmal Subarachnoid Hemorrhage (aSAH) Clinical Research. Neurocrit Care. 2019;30:534-541.
4. Antipova D, Eadie L, Macaden AS, Wilson P. Diagnostic value of transcranial ultrasonography for selecting subjects with large vessel occlusion: a systematic review. Ultrasound J. 2019;11:29.
5. Chou, K. (2021, Apr 13). Diagnosis and differential diagnosis of Parkinson disease. *UpToDate*. https://www.uptodate.com/contents/diagnosis-and-differential-diagnosis-of-parkinson-disease?search=Diagnosis%20and%20differential%20diagnosis%20of%20Parkinson%20disease&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1
6. Estcourt LJ, Kimber C, Hopewell S, Trivella M, Doree C, Abboud MR. Interventions for preventing silent cerebral infarcts in people with sickle cell disease. Cochrane Database Syst Rev. 2020 Apr 6;4:CD012389.
7. Ickenstein GW, Valaikiene J, Koch H, Hau P, Erban P, Schlachetzki F. Ultrasonic contrast agents in transcranial perfusion sonography (TPS) for follow-up of patients with high grade gliomas. Ultrason Sonochem. 2008 Apr;15(4):510-6. Epub 2007 Sep 14.

8. Jiang XX, Song Y, Hu CR, Wang LH, Liu L, Zhang YJ. Impact of contrast-enhanced transcranial Doppler ultrasound diagnosis for young adult with cryptogenic stroke: A protocol of systematic review. Medicine (Baltimore). 2019;98:e18236.
9. Marquez-Romero JM, Santana-López JM, Espinoza-López DA, Zermeño F. Conservative treatment of a ruptured inflammatory infectious aneurysm caused by neurocysticercosis. Clin Neurol Neurosurg. 2012 Jul;114(6):810-1.
10. Mattioni A, Cenciarelli S, Eusebi P, Brazzelli M, Mazzoli T, Del Sette M, Gandolfo C, Marinoni M, Finocchi C, Saia V, Ricci S. Transcranial Doppler sonography for detecting stenosis or occlusion of intracranial arteries in people with acute ischaemic stroke. Cochrane Database Syst Rev. 2020 Feb 19;2:CD010722.
11. Cantú C, Villarreal J, Soto JL, Barinagarrementeria F. Cerebral cysticercotic arteritis: detection and follow-up by transcranial Doppler. Cerebrovasc Dis. 1998 Jan-Feb;8(1):2-7.
12. Knake S, Haag A, Hamer HM, Dittmer C, Bien S, Oertel WH, Rosenow F. Language lateralization in patients with temporal lobe epilepsy: a comparison of functional transcranial Doppler sonography and the Wada test. Neuroimage. 2003 Jul;19(3):1228-32.
13. Saqqur M, Ghrooda E, Ahmad A, Khan K, Hussain MS, Shuaib A. The Combination of Clinical Features, Transcranial Doppler, and Alberta Stroke Program Early Computed Tomography Score (Computed Tomography Angiography) in Predicting Outcome in Intravenous Recombinant Tissue Plasminogen Activator-Treated Patients. J Stroke Cerebrovasc Dis. 2016 Aug;25(8):2019-23.
14. Oliveira-Filho J, Lansberg MG. Neuroimaging of acute ischemic stroke. *UpToDate*. Last updated June 21, 2022. Retrieved on June 27, 2022 from https://www.uptodate.com/contents/neuroimaging-of-acute-ischemic-stroke?search=transcranial%20doppler&source=search_result&selectedTitle=1~48&usage_type=default&display_rank=1#H560441613
15. Schellinger PD, Alexandrov AV, Barreto AD, Demchuk AM, Tsivgoulis G, Kohrmann M, Alleman J, Howard V, Howard G, Alexandrov AW, Brandt G, Molina CA; CLOTBUSTER Investigators. Combined lysis of thrombus with ultrasound and systemic tissue plasminogen activator for emergent revascularization in acute ischemic stroke (CLOTBUST-ER): design and methodology of a multinational phase 3 trial. Int J Stroke. 2015 Oct;10(7):1141-8.
16. Stolz EP. Role of ultrasound in diagnosis and management of cerebral vein and sinus thrombosis. Front Neurol Neurosci. 2008;23:112-21.
17. Amyot F, Arciniegas DB, Brazaitis MP, Curley KC, Diaz-Arrastia R, Gandjbakhche A, Herscovitch P, Hinds SR, Manley GT, Pacifico A, Razumovsky A, Riley J, Salzer W, Shih R, Smirniotopoulos JG, Stocker D. A Review of the Effectiveness of Neuroimaging Modalities for the Detection of Traumatic Brain Injury. J Neurotrauma. 2015 Nov 15; 32(22): 1693–1721.
18. Kincaid MS. Transcranial Doppler ultrasonography: a diagnostic tool of increasing utility. Curr Opin Anaesthesiol. 2008 Oct;21(5):552-9.

19. Shayestagul NA, Christensen CE, Amin FM, Ashina S, Ashina M. Measurement of Blood Flow Velocity in the Middle Cerebral Artery During Spontaneous Migraine Attacks: A Systematic Review. Headache. 2017 May 3.
20. Ghosh PS, Rothner AD, Emch TM, Friedman NR, Moodley M. Cerebral vasculopathy in a Chinese family with neurofibromatosis type I mutation. Neurosci Bull. 2013 Dec;29(6):708-14.
21. Oliveira-Filho, J. & Lansberg, M.G. (2024). Neuroimaging of acute stroke. *UpToDate*. https://uptodate.com/contents/neuroimaging-of-acute-stroke.
22. Paschoal JK, Paschoal FM Jr, de Lima FT, Pinho RS, Vilanova LC, Bor-Seng-Shu E, Masruha MR. Detection of Cerebral Vasculopathy by Transcranial Doppler in Children With Neurofibromatosis Type 1. J Child Neurol. 2016 Mar;31(3):351-6.
23. Pilotto A, Yilmaz R, Berg D. Developments in the role of transcranial sonography for the differential diagnosis of parkinsonism. Curr Neurol Neurosci Rep. 2015 Jul;15(7):43.
24. Walter U. Substantia nigra hyperechogenicity is a risk marker of Parkinson's disease: no. J Neural Transm (Vienna). 2011 Apr;118(4):607-12.
25. Mijajlovic MD, Tsivgoulis G, Sternic N. Transcranial brain parenchymal sonography in neurodegenerative and psychiatric diseases. J Ultrasound Med. 2014 Dec;33(12):2061-8.
26. Schuepbach D, Weber S, Kawohl W, Hell D. Impaired rapid modulation of cerebral hemodynamics during a planning task in schizophrenia. Clin Neurophysiol. 2007 Jul;118(7):1449-59.
27. Yawn BP, Buchanan GR, Afenyi-Annan AN, Ballas SK, Hassell KL, James AH, Jordan L, Lanzkron SM, Lottenberg R, Savage WJ, Tanabe PJ, Ware RE, Murad MH, Goldsmith JC, Ortiz E, Fulwood R, Horton A, John-Sowah J. Management of sickle cell disease: summary of the 2014 evidence-based report by expert panel members. JAMA. 2014 Sep 10;312(10):1033-48.
28. AAN Clinical Guideline Supplement: Practical Guideline. Determining brain death in adults. 2010. Reaffirmed July 16, 2022. American Academy of Neurology. Available at: https://www.aan.com/Guidelines/home/GuidelineDetail/431
29. Advances in Transcranial Doppler US: Imaging Ahead RadioGraphics 2013; 33:E1–E14.
30. AIUM Practice Parameter for the Performance of a Transcranial Doppler Ultrasound Examination for Adults and Children 2012 by the American Institute of Ultrasound in Medicine Parameter developed in conjunction with the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU).
31. Marsili, L., Giovannie, R., Colosimo, C. (2018). Diagnostic Criteria for Parkinson's Disease: From James Parkinson to the Concept of Prodromal Disease. *Front. Neurol.* https://doi.org/10.3389/fneur.2018.00156
32. McCarron, M.O., Goldstein, L.B., Matchar, D.B. (2021, April). Screening for asymptomatic carotid artery stenosis. *UpToDate*. https://www.uptodate.com/contents/screening-for-asymptomatic-carotid-artery-stenosis?search=carotid%20bruits&source=search_result&selectedTitle=1~38&usage_type=default&display_rank=1

33. Sturzenegger M, Mattle HP, Rivoir A, Rihs F, Schmid C. Ultrasound findings in spontaneous extracranial vertebral artery dissection. Stroke. 1993;24:1910-1921. Available at: https://www.ncbi.nlm.nih.gov/pubmed/7902621
34. Li, D.-H. et al. Diagnostic Accuracy of Transcranial Sonography of the Substantia
35. Nigra in Parkinson's disease: A Systematic Review and Meta-analysis. Sci. Rep. 6, 20863; doi: 10.1038/srep20863 (2016).
36. Postuma RB, Berg D, Stern M, Poewe W, Olanow CW, Oertel W, et al. MDS clinical diagnostic criteria for Parkinson's disease. Mov Disord (2015) 30:1591–601. doi:10.1002/mds.26424.
37. Bartels E1, Flügel KA. Stroke. 1996 Feb;27(2):290-5. Evaluation of extracranial vertebral artery dissection with duplex color-flow imaging.
38. Lang E. Dissection, vertebral artery. eMedicine Emergency Medicine Topic 832, Omaha, NE: eMedicine.com; updated Feb 21, 2019. Available at: http://www.emedicine.com/emerg/topic832.htm.
39. U.S. Preventive Servies Task Force. (2021). Asymptomatic Carotid Artery Stenosis: Screening. https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/carotid-artery-stenosis-screening
40. Zhang XH, Liang HM. Systematic review with network meta-analysis: Diagnostic values of ultrasonography, computed tomography, and magnetic resonance imaging in patients with ischemic stroke. Medicine (Baltimore). 2019;98:e16360

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