



# CIGNA MEDICAL COVERAGE POLICY

The following Coverage Policy applies to all plans administered by CIGNA Companies including plans administered by Great-West Healthcare, which is now a part of CIGNA.

**Subject Transcranial Doppler (TCD)  
Ultrasonography**

**Effective Date ..... 11/15/2010**  
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## Hyperlink to Related Coverage Policies

Computed Tomography Angiography (CTA)  
 Functional Magnetic Resonance Imaging (fMRI), Brain  
 Magnetic Resonance Angiography (MRA)

### INSTRUCTIONS FOR USE

Coverage Policies are intended to provide guidance in interpreting certain **standard** CIGNA HealthCare benefit plans as well as benefit plans formerly administered by Great-West Healthcare. Please note, the terms of a participant's particular benefit plan document [Group Service Agreement (GSA), Evidence of Coverage, Certificate of Coverage, Summary Plan Description (SPD) or similar plan document] may differ significantly from the standard benefit plans upon which these Coverage Policies are based. For example, a participant's benefit plan document may contain a specific exclusion related to a topic addressed in a Coverage Policy. In the event of a conflict, a participant's benefit plan document **always supercedes** the information in the Coverage Policies. In the absence of a controlling federal or state coverage mandate, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of 1) the terms of the applicable group benefit plan document in effect on the date of service; 2) any applicable laws/regulations; 3) any relevant collateral source materials including Coverage Policies and; 4) the specific facts of the particular situation. Coverage Policies relate exclusively to the administration of health benefit plans. Coverage Policies are not recommendations for treatment and should never be used as treatment guidelines. Proprietary information of CIGNA. Copyright ©2010 CIGNA

## Coverage Policy

**CIGNA covers transcranial Doppler (TCD) ultrasonography as medically necessary for ANY of the following indications:**

- screening of children age 2–16 years with sickle cell disease for assessing stroke risk
- detection and monitoring of angiographic vasospasm (VSP) after spontaneous subarachnoid hemorrhage (sSaH)
- detection of abnormal cerebral blood flow and/or embolic events during carotid endarterectomy (CEA) as well as in the immediate postoperative period

**CIGNA does not cover TCD ultrasonography for ANY other indication, including but not limited to the following, because it is considered experimental, investigational or unproven :**

- cerebral microembolism detection, for the detection of cerebral microembolic signals in a variety of cardiovascular/cerebrovascular disorders/procedures
- coronary artery bypass graft (CABG) surgery, during CABG for detection of cerebral microemboli and to document changes in flow velocities and carbon dioxide (CO<sub>2</sub>) reactivity during CABG surgery
- vasomotor reactivity (VMR) testing (i.e., vasoreactive study), for the detection of impaired cerebral hemodynamics in individuals with severe (>70%) asymptomatic extracranial internal carotid artery (ICA) stenosis, symptomatic or asymptomatic extracranial ICA occlusion, and cerebral small-artery disease

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## General Background

Transcranial Doppler (TCD) ultrasonography is a noninvasive ultrasonic technique that uses a hand-held low-frequency (i.e., 2–2.5 megahertz [MHz]) sector transducer that sends fixed or pulsed sound waves to measure the velocity of blood flowing in the basal arteries of the brain. Sound waves are transmitted through temporal, orbital, and suboccipital acoustic windows of the skull. When the sound waves come in contact with blood, they are reflected off the red blood cells through the brain and skull to a detector. The velocity of the sound waves reflected to the surface is changed because the blood cells themselves are in motion toward, or away, from the sound wave detector. This is called Doppler shift and is directly related to the velocity and flow of the blood cells. The velocity of the blood cells is faster during systole and slower during diastole. The blood in the center of the lumen moves quicker than the blood near the vessel wall. A spectrum of flow velocities is produced. TCD measurements of flow velocity are commonly made in the middle cerebral artery. Other arteries that may be measured by TCD include the anterior cerebral, anterior communicating, posterior cerebral and communicating, and basilar arteries (Chernecky, et al., 2008).

TCD ultrasonography should not to be confused with echoencephalography which is a type of diagnostic ultrasound that can be used on neonates for determination of ventricular size, delineation of cerebral contents, and detection of fluid masses or other intracranial abnormalities.

TCD is used principally in the evaluation and management of patients with diverse forms of cerebrovascular disease. Conventional or digital subtraction angiography (DSA) are considered to be the reference standard test(s) for evaluating vascular patency and degree of stenosis in intracranial vessels. Direct comparisons of TCD with techniques that image the intracranial circulation [conventional angiography, DSA, computerized tomographic angiography (CTA), and magnetic resonance angiography (MRA)] are variable depending upon the indication and the diagnostic criteria used for correlation purposes in specific disease states. All non-invasive techniques are less than 100% sensitive and specific when compared to conventional angiography. Even where comparative data are available from particular centers, concerns regarding the ability to generalize results, which may be due to operator-dependent factors (which apply to all five techniques) and comparability of relevant pathology in the tested populations, would limit inferring from published reports how these techniques would perform in settings other than those in which they were directly tested.

The main advantages of the non-invasive techniques over conventional or DSA are that they are often faster to perform, are not associated with the morbidity and rare mortality of conventional angiography, and are often less expensive. However, contrast (with its attendant risks) is used with CTA. For certain clinical settings or types of correlations, the most appropriate gold standard may be computed tomographic (CT) scan, magnetic resonance imaging (MRI), diffusion-weighted MRI (DWI), perfusion-weighted MRI (PWI), transesophageal echocardiography, single photon emission computed tomography, positron emission tomography, electroencephalography (EEG), hemodynamic measurements (such as stump pressure), experimental models, pathology, neuropsychological tests or clinical outcomes, such as transient ischemic attack, stroke, mortality, disabling stroke, or hemorrhagic complications. It is recommended that the reference standard against which TCD should be evaluated should be selected according to the clinical setting. It has been recommended that when more than one technique may provide clinically relevant information, clinical judgment (including issues of local access, risk, cost, availability and competence) should guide the choice of the appropriate technique or combination of techniques in particular situations (Sloan, et al., 2004).

A chief limitation of TCD is that it can demonstrate cerebral blood flow velocities only in a limited portion of large intracranial vessels, although large vessel intracranial arterial disease commonly occurs at these locations. In general, TCD is most useful when the clinical question pertains to those vessel segments. However, in some settings, TCD can detect indirect effects, such as abnormal waveform characteristics suggestive of proximal hemodynamic or distal obstructive lesions, which may be clinically informative. The aforementioned limitation also applies to MRA and CTA, depending upon the areas imaged, the algorithms used, and the diligence of the technologist. In addition, DSA and conventional angiography may be inconclusive if all relevant vessels or vessel portions are not imaged, if a critical imaging view is omitted, or if image quality is suboptimal (Sloan, et al., 2004).

Factors that may affect TCD results include (Chernecky, et al., 2008):

- the body habitus of the patient and the technical condition of the equipment
- flow velocity is age-dependent and decreases continuously through adulthood
- detection of small aneurysms is limited by insonation angles and spatial resolution
- intramural calcification may inhibit sound penetration, leading to false-positive results
- accurate transmission and reflection of ultrasonographic signals can be affected by the presence of calcium or gas overlying the vessel
- intracranial pressure, blood pressure and volume, hematocrit, and subarachnoid hemorrhage affect flow velocity
- tobacco and caffeine use

With TCD, false-negative exams of vasospasm are associated with chronic high blood pressure, increased intracranial pressure, severe spasm of the carotid siphon, and distal vasospasm. False-positive and false-negative results have been reported when evaluating for cross flow through the anterior and posterior communicating arteries in patients with occlusive cerebrovascular disease (Chernecky, et al., 2008).

There are many proposed applications for TCD including, but not limited to, the following (Chernecky and Berger, 2008; American Academy of Neurology [AAN], 2004):

- predict the risk of stroke in children with sickle cell anemia
- vasoconstriction as a result of insult
- cerebral dynamics after head injury
- intraoperatively to monitor velocity in the middle portion of the cerebral artery during carotid endarterectomy (CEA)
- evaluate collateral circulation stenosis
- establish brain death in adults
- diagnostic in intracranial aneurysms, arteriovenous malformations, and moyamoya syndrome
- assessment of blood supply in intracranial neoplasms
- cerebral microembolism detection, for the detection of cerebral microembolic signals in a variety of cardiovascular/cerebrovascular disorders/procedures
- coronary artery bypass graft (CABG) surgery, during CABG for detection of cerebral microemboli and to document changes in flow velocities and carbon dioxide (CO<sub>2</sub>) reactivity during CABG surgery
- vasomotor reactivity (VMR) testing (i.e., vasoreactive study), for the detection of impaired cerebral hemodynamics in patients with severe (>70%) asymptomatic extracranial ICA stenosis, symptomatic or asymptomatic extracranial ICA occlusion, and cerebral small-artery disease

### **U.S. Food and Drug Administration (FDA)**

The FDA regulates TCD systems as Class II devices, and the commonly used systems have been approved via the FDA 510(k) process (FDA, 2010).

### **Literature Review**

**Sickle Cell Disease:** Sickle cell disease is an autosomal recessive disorder associated with thrombotic occlusions of the large intracranial arteries which may lead to a stroke in young adults (Sila, et al., 2007). These arteries are accessible to TCD, and TCD can be used to monitor flow velocity over time (Kassab, et al., 2007). Evidence in the published, peer-reviewed medical literature supports the diagnostic utility of TCD in identifying children with sickle-cell disease at high risk for stroke and the efficacy of transfusion in reducing risk of stroke. A large cohort study showed that elevated time-averaged mean maximum blood flow velocity of  $\geq 200$  cm/s in the ICA or MCA by TCD is strongly associated with stroke risk. With use of this flow velocity criterion, the Stroke Prevention Trial in Sickle Cell Anemia showed that periodic blood transfusion therapy to lower the hemoglobin S concentration to <30% of total hemoglobin concentration in children between 2 and 16 years of age resulted in a 92% reduction in stroke risk compared to standard care (Adams, 1998; Lee, et al., 2006).

**Intracranial Vasospasm after Subarachnoid Hemorrhage (SAH):** Intracranial vasospasm is the constriction of cerebral blood vessels due to the presence of blood in the subarachnoid space after a rupture of cerebral aneurysm or trauma. The vasospasm may result in ischemia to the brain. The subarachnoid hemorrhage (SAH) can be identified by TCD up to 1–2 days before it becomes clinically symptomatic, allowing for initiation of triple H therapy (i.e., hypervolemia, hypertension, and hemodilution) (Kassab, et al., 2007). Evidence in the published, peer-reviewed medical literature also supports the diagnostic utility of TCD for detection and

monitoring of angiographic vasospasm after SaH. The comparator is conventional angiography. The specificity and sensitivity of TCD varies with each intracranial artery.

Data from a meta-analysis of TCD studies concluded that in general, data vary by vessel and by diagnostic criteria, disease prevalence, and timing of correlative angiography. Specific causes of false-positive and false-negative TCD examinations have been identified for each intracranial vessel and their impact on the approach to test performance and interpretation described. TCD flow velocity criteria appear most reliable for detecting angiographic middle cerebral artery vasospasm and basilar artery vasospasm. The specificity of TCD can be optimized by increasing the flow velocity criteria and sensitivity by the timing of the angiographic correlation for the diagnosis of vasospasm (Sloan, et al., 2004).

**Carotid Endarterectomy (CEA):** Evidence in the peer-reviewed medical literature supports the diagnostic utility of TCD for detection of abnormal cerebral blood flow and/or embolic events during CEA as well as in the immediate postoperative period (Ogasawara, et al., 2005; Ackerstaff, et al., 2000).

#### **Other Conditions:**

There is evidence in the peer-reviewed scientific literature has stated that TCD has some utility in various settings (e.g., coronary artery bypass graft surgery, monitoring for heart shunts, intracranial steno-occlusive disease; brain death, Parkinsons disease) but data are insufficient regarding the clinical impact of TCD compared with other diagnostic tools (e.g., angiography, electroencephalography, magnetic resonance imaging, neuropsychological testing) (Gaenslen, et al., 2008; Feldman, et al., 2007; Tsivgoulis, et al., 2007; Navarro, et al., 2007; Rodriguez, et al., 2006; Souteyrand, et al., 2006; Frietas, et al., 2006; Monteiro, et al., 2006; Yatsu, 2005; Navarro, et al., 2004; AAN, 2004; Sloan, et al., 2004; Felberg, et al., 2002; Hirsch, et al., 2002).

#### **Professional Societies/Organizations**

**American Academy of Neurology (AAN):** The Therapeutics and Technology Assessment Subcommittee of the AAN Assessment: Transcranial Doppler Ultrasonography reviewed the sensitivity and specificity of TCD and transcranial color-coded sonography (TCCS) for various disease states (AAN, 2004; Sloan, et al., 2004). This technology assessment was reaffirmed in 2007. The major recommendations of the AAN's technology assessment of TCD ultrasonography are listed below:

- Settings in which TCD ultrasonography is able to provide information and in which its clinical utility is established:
  - Screening of children age 2–16 years with sickle-cell disease for assessing stroke risk. The sensitivity is 86% and specificity 91%. The reference standard is conventional angiography.
  - Detection and monitoring of angiographic VSP spontaneous subarachnoid hemorrhage (sSaH). The sensitivity and specificity varies based on each intracerebral artery. The-reference standard is conventional angiography.
- Settings in which TCD is able to provide information, but in which its clinical utility, compared with other diagnostic tools, remains to be determined:
  - Intracranial steno-occlusive disease: TCD is probably useful for the evaluation of occlusive lesions of intracranial arteries in the basal cisterns, especially the ICA siphon and middle cerebral artery. Data are insufficient to recommend replacement of conventional angiography with TCD. The sensitivity and specificity varies based on intracerebral artery. The reference standard is conventional angiography.
  - Cerebral circulatory arrest (adjunctive test in the determination of brain death): If needed, TCD can be used as a confirmatory test, in support of a clinical diagnosis of brain death. The reference standard is conventional angiography, EEG and clinical outcome.
- Settings in which TCD is able to provide information, but in which its clinical utility remains to be determined:
  - Cerebral thrombolysis: TCD is probably useful for monitoring thrombolysis of acute middle cerebral artery occlusions. The reference standard is conventional angiography, MRA and clinical outcome.

- Cerebral microembolism detection: TCD monitoring is probably useful for the detection of cerebral microembolic signals in a variety of cardiovascular/cerebrovascular disorders/procedures. Data do not support the use of this TCD technique for diagnosis or monitoring response to antithrombotic therapy in ischemic cerebrovascular disease. The reference standard is experimental model, pathology, MRI and neuropsychological testing.
  - CEA: TCD monitoring is probably useful to detect hemodynamic and embolic events that may result in perioperative stroke during and after CEA in settings where monitoring is felt to be necessary. The reference standard is EEG, MRI or clinical outcomes.
  - Coronary artery bypass surgery (CABG) surgery: TCD monitoring is probably useful during CABG for detection of cerebral microemboli. TCD is possibly useful to document changes in flow velocities and carbon dioxide (CO<sub>2</sub>) reactivity during CABG surgery. Data are insufficient regarding the clinical impact of this information. Data are presently insufficient regarding the clinical utility of this information, particularly in patients at various levels of predicted risk for stroke or encephalopathy. No reference standard is noted.
  - VMR testing: TCD is probably useful for the detection of impaired cerebral hemodynamics in patients with severe (>70%), asymptomatic extracranial ICA stenosis; symptomatic or asymptomatic extracranial ICA occlusion; and cerebral small-artery disease. How the results from these techniques should be used to influence therapy and affect patient outcomes remains to be determined
  - VSP after traumatic subarachnoid hemorrhage (tSAH): TCD is probably useful for the detection of VSP following tSAH, but data are needed to show its accuracy and clinical impact in this setting.
  - TCCS: TCCS is possibly useful for the evaluation and monitoring of space-occupying ischemic middle cerebral artery infarctions. More data are needed to show it has value versus CT and MRI scanning and if its use affects clinical outcomes.
- Settings in which TCD is able to provide information, but in which other diagnostic tests are typically preferable:
    - Right-to-left cardiac shunts: Whereas TCD is useful for detection of right-to-left cardiac and extracardiac shunts, TEE is superior, as it can provide direct information regarding the anatomical site and nature of the shunt.
    - Extracranial ICA stenosis: TCD is possibly useful for the evaluation of severe extracranial ICA stenosis or occlusion but, in general, carotid duplex and MRA are the diagnostic tests of choice.
    - Contrast-enhanced TCCS: Contrast-enhanced TCCS may provide information in patients with ischemic cerebrovascular disease and aneurysmal subarachnoid hemorrhage (aSAH). Its clinical utility versus CT scanning, conventional angiography, or non-imaging TCD is unclear.

The current practice parameter on neuroimaging of the neonate by the AAN states routine screening cranial ultrasonography should be performed on all infants < 30 weeks' gestation once between 7–14 days of age and should be optimally repeated between 36–40 weeks' postmenstrual age. This strategy detects lesions such as intraventricular hemorrhage, periventricular leukomalacia, and low-pressure ventriculomegaly. Currently ultrasound, CT, and MRI represent the major imaging modalities for evaluation of critically ill infants (Ment, et al., 2002). It appears that these recommendations have not been updated since 2002. According to the guideline developer, this guideline has been reviewed and is still considered to be current as of October 2005.

**American College of Radiology (ACR):** The 2007 ACR Practice Guideline for the Performance of TCD Ultrasound for Adults and Children states that TCD is a noninvasive technique that assesses blood flow within the circle of Willis and the vertebrobasilar system in children who have a closed anterior fontanelle and in adults. The ACR indications for a TCD ultrasound examination include, but are not limited to:

#### Adults

- Detection of stenosis or occlusion in a major intracranial artery in the circle of Willis and vertebrobasilar system, including monitoring thrombolytic therapy for acute stroke patients.
- Follow-up of patients with known stenosis or occlusion of a major intracranial artery in the circle of Willis and vertebrobasilar system.
- Detection and monitoring of vasospasm in patients with subarachnoid hemorrhage.

- Detection of circulating emboli in a major intracranial artery in the circle of Willis and vertebrobasilar system.
- Detection of right-to-left shunts using agitated saline injection.
- Assessment of vasomotor reactivity.
- Confirmation of the clinical diagnosis of brain death by detection of complete cerebral circulatory arrest.
- Intraoperative and periprocedural monitoring to detect embolization, thrombosis, hypoperfusion, and hyperperfusion.

#### Children

- Evaluation of stenosis or occlusion in the circle of Willis and vertebrobasilar system in patients with sickle cell anemia to determine the need for and continuation of blood transfusions.
- Follow-up of patients with known stenosis or occlusion of an artery in the circle of Willis and vertebrobasilar system in patients with sickle cell anemia.
- Detection of vasculopathy, such as moyamoya.
- Assessment of arteriovenous malformations.
- Confirmation of the clinical diagnosis of brain death by detection of complete cerebral circulatory arrest in infants more than six months of age.

The ACR Practice Guideline for the Performance of Neurosonography in Neonates and Young Children (2009) states that neurosonographic examinations should be conducted with a real-time scanner, preferably with transducers that can fit within and image through the anterior fontanelle. If the anterior fontanelle is not available, imaging may be performed through other sutural openings or by using a transcranial approach, usually with a lower-frequency transducer penetrating the squamosal portion of the temporal bone. The transducer or scanner should be adjusted to operate at the highest clinically appropriate frequency, recognizing that there is a trade-off between resolution and beam penetration. Doppler sonography or color Doppler sonography may be used to evaluate intracranial blood flow in selected cases. The guideline notes that neonatal sonographic examinations should be performed on the neonate or young child (defined primarily as those who have had no closure of the anterior fontanelle) for a valid reason, such as to determine the presence or absence of hemorrhage, parenchymal abnormalities, ventricular dilation, congenital abnormalities and vascular abnormalities.

**American Society of Neuroimaging:** The American Society of Neuroimaging Practice Guidelines Committee, international neurosonological organizations, and experts in TCD have developed a practice standard for TCD which is the first part of a series of practice standards for TCD. The authors report that “scanning protocols, number of vessels, depth ranges for routine evaluation as well as reporting of TCD examination vary between institutions. Given the emphasis on accreditation of vascular laboratories, there is a need for standardization of scanning and interpretation processes.” Subsequent parts of the series will detail specific TCD procedures, diagnostic criteria for interpretation of abnormal studies as well as competency standards for neurovascular sonographers and interpreting physicians (Alexandrov, et al., 2007).

#### Summary

The American Academy of Neurology's (AAN) Assessment: Transcranial Doppler (TCD) Ultrasonography (2004) concluded that TCD is of established value in the screening of children age 2–16 years with sickle-cell disease for stroke risk and the detection and monitoring of angiographic vasospasm (VSP) after spontaneous subarachnoid hemorrhage (sSAH). The AAN report states that TCD monitoring is able to provide information and is probably useful to detect hemodynamic and embolic events that may result in perioperative stroke during and after carotid endarterectomy (CEA). Additionally, there is evidence in peer-reviewed published studies and textbook literature that TCD is an accepted method for monitoring cerebral blood flow to detect embolic events during and after CEA.

Although TCD may be able to provide some information, the diagnostic utility of TCD compared to that of other established diagnostic tools remains to be determined for the evaluation of intracranial steno-occlusive disease and in the determination of cerebral circulatory arrest/brain death. According to the AAN report, the clinical utility of TCD has not been established for cerebral thrombolysis, cerebral microembolism detection, coronary artery bypass graft (CABG) surgery, vasomotor reactivity (VMR) testing (i.e., vasoreactive study), vasospasm after

traumatic subarachnoid hemorrhage, and transcranial color-coded sonography. Other diagnostic tests are typically preferable for right-to-left cardiac shunts and extracranial internal carotid artery (ICA) stenosis.

## Coding/Billing Information

**Note:** This list of codes may not be all-inclusive.

**Covered when medically necessary:**

CPT®* Codes	Description
93886	Transcranial Doppler study of the intracranial arteries; complete study
93888	Transcranial Doppler study of the intracranial arteries; limited study

ICD-9-CM Diagnosis Codes	Description
282.60– 282.69	Sickle-cell disease
430	Subarachnoid hemorrhage
852.00– 852.09	Subarachnoid hemorrhage following injury without mention of open intracranial wound
852.10– 852.19	Subarachnoid hemorrhage following injury, with open intracranial wound

**Experimental/Investigational/Unproven/Not Covered:**

CPT* Codes	Description
93890	Transcranial Doppler study of the intracranial arteries; vasoreactivity 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

ICD-9-CM Diagnosis Codes	Description
433.00– 433.91	Occlusion and stenosis of precerebral arteries
434.00– 434.91	Occlusion of cerebral arteries
435.0–435.9	Transient cerebral ischemia
436	Acute, but ill-defined, cerebrovascular disease
437.0	Cerebral atherosclerosis
437.1	Other generalized ischemic cerebrovascular disease
	All other codes

\*Current Procedural Terminology (CPT®) © 2010 American Medical Association: Chicago, IL.

## References

1. Ackerstaff RG, Moons KG, van de Vlasakker CJ, Moll FL, Vermeulen FE, Algra A, et al. Association of intraoperative transcranial Doppler monitoring variables with stroke from carotid endarterectomy. *Stroke*. 2000 Aug;31(8):1817-23.
2. Adams H, Adams R, Del Zoppo G, Goldstein LB; Stroke Council of the American Heart Association; American Stroke Association. Guidelines for the early management of patients with ischemic stroke: 2005 guidelines update a scientific statement from the Stroke Council of the American Heart Association/American Stroke Association. *Stroke*. 2005 Apr;36(4):916-23.
3. Adams RJ, McKie VC, Hsu L, Files B, Vichinsky E, Pegelow C, et al. Prevention of a first stroke by transfusions in children with sickle cell anemia and abnormal results on transcranial Doppler ultrasonography. *N Engl J Med*. 1998 Jul 2;339(1):5-11.
4. Alexandrov AV, Molina CA, Grotta JC, Garami Z, Ford SR, Alvarez-Sabin J, et al.; CLOTBUST Investigators. Ultrasound-enhanced systemic thrombolysis for acute ischemic stroke. *N Engl J Med*. 2004 Nov 18;351(21):2170-8.
5. Alexandrov AV, Sloan MA, Wong LK, Douville C, Razumovsky AY, Koroshetz WJ, et al; American Society of Neuroimaging Practice Guidelines Committee. Practice standards for transcranial Doppler ultrasound: part I--test performance. *J Neuroimaging*. 2007 Jan;17(1):11-8.
6. American Academy of Neurology (AAN). Practice Guidelines. Transcranial Doppler Ultrasonography. May 2004. Reaffirmation 2007. Accessed September 27, 2010. Available at URL address: <http://www.aan.com/go/practice/guidelines>
7. American College of Radiology (ACR) practice guideline for the performance of transcranial Doppler ultrasound for adults and children. Effective October 1, 2007. Accessed September 27, 2010. Available at URL address: [http://www.acr.org/SecondaryMainMenuCategories/quality\\_safety/guidelines/us.aspx](http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/us.aspx)
8. American College of Radiology (ACR) practice guideline for the performance of neurosonography in neonates and young children. Effective January 1, 1999. Revised 2009. Accessed September 27, 2010. Available at URL address: [http://www.acr.org/s\\_acr/bin.asp?CID=539&DID=12261&DOC=FILE.PDF](http://www.acr.org/s_acr/bin.asp?CID=539&DID=12261&DOC=FILE.PDF)
9. American College of Radiology (ACR) practice guideline for performing and interpreting diagnostic ultrasound examinations. Effective Oct 1, 2006. Revised 2006. Accessed September 27, 2010. Available at URL address: [http://www.acr.org/s\\_acr/bin.asp?CID=539&DID=12267&DOC=FILE.PDF](http://www.acr.org/s_acr/bin.asp?CID=539&DID=12267&DOC=FILE.PDF)
10. Bedell EA, Prough DS. Cerebral Blood Flow Monitoring. In: Irwin RS, Rippe JM, editors. *Irwin and Rippe's Intensive Care Medicine*. 6<sup>th</sup> ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008. Ch 28.
11. Bos MJ, Koudstaal PJ, Hofman A, Wittteman JC, Breteler MM. Transcranial Doppler hemodynamic parameters and risk of stroke: the Rotterdam study. *Stroke*. 2007 Sep;38(9): 2453-8.
12. Chernecky CC, Berger BJ. Doppler Ultrasonographic Flow Studies (Includes Carotid Doppler, Carotid Artery Echography, Carotid Artery Ultrasonography, Duplex Ultrasonography, Transcranial Doppler Ultrasonography)—Diagnostic. In: *Laboratory Tests and Diagnostic Procedures*. 5<sup>th</sup> ed. St Louis, MO: Saunders Elsevier; 2008.
13. de Freitas GR, Andre C. Sensitivity of transcranial Doppler for confirming brain death: a prospective study of 270 cases. *Acta Neurol Scand*. 2006 Jun;113(6):426-32.
14. Demchuk AM, Saqqur M, Alexandrov AV. Transcranial Doppler in acute stroke. *Neuroimaging Clin N Am*. 2005 Aug;15(3):473-80.
15. Felberg RA, Christou I, Demchuk AM, Malkoff M, Alexandrov AV. Screening for intracranial stenosis with transcranial Doppler: the accuracy of mean flow velocity thresholds. *J Neuroimaging*. 2002 Jan;12(1):9-14.

16. Feldmann E, Wilterdink JL, Kosinski A, Lynn M, Chimowitz MI, Sarafin J, et al. The Stroke Outcomes and Neuroimaging of Intracranial Atherosclerosis (SONIA) Trial Investigators. The Stroke Outcomes and Neuroimaging of Intracranial Atherosclerosis (SONIA) trial. *Neurology*. 2007 Jun 12;68(24):2099-106.
17. Gaenslen A, Unmuth B, Godau J, Liepelt I, Di Santo A, Schweitzer KJ, et al. The specificity and sensitivity of transcranial ultrasound in the differential diagnosis of Parkinson's disease: a prospective blinded study. *Lancet Neurol*. 2008 May;7(5):417-24.
18. Hirsch W, Hiebsch W, Teichler H, Schluter A. Transcranial Doppler sonography in children: review of a seven-year experience. *Clin Radiol*. 2002 Jun;57(6):492-7.
19. Kassab MY, Majid A, Farooq MU, Azhary H, Hershey LA, Bednarczyk EM, et al. Transcranial Doppler: an introduction for primary care physicians. *J Am Board Fam Med*. 2007 Jan-Feb;20(1):65-71.
20. Kim D, Liebeskind DS. Neuroimaging advances and the transformation of acute stroke care. *Semin Neurol*. 2005 Dec;25(4):345-61.
21. Kincaid MS. Transcranial Doppler ultrasonography: a diagnostic tool of increasing utility. *Curr Opin Anaesthesiol*. 2008 Oct;21(5):552-9.
22. Kirkness CJ. Cerebral blood flow monitoring in clinical practice. *AACN Clin Issues*. 2005 Oct-Dec;16(4):476-87.
23. Kunz A, Hahn G, Mucha D, Müller A, Barrett KM, von Kummer R, Gahn G. Echo-enhanced transcranial color-coded duplex sonography in the diagnosis of cerebrovascular events: a validation study. *AJNR Am J Neuroradiol*. 2006 Nov-Dec;27(10):2122-7.
24. Lee MT, Piomelli S, Granger S, Miller ST, Harkness S, Brambilla DJ, Adams RJ; STOP Study Investigators. Stroke Prevention Trial in Sickle Cell Anemia (STOP): extended follow-up and final results. *Blood*. 2006 Aug 1;108(3):847-52.
25. Markus HS, MacKinnon A. Asymptomatic embolization detected by Doppler ultrasound predicts stroke risk in symptomatic carotid artery stenosis. *Stroke*. 2005 May;36(5):971-5.
26. Ment LR, Bada HS, Barnes P, Grant PE, Hirtz D, Papile LA, et al. Practice parameter: neuroimaging of the neonate: report of the Quality Standards Subcommittee of the American Academy of Neurology and the Practice Committee of the Child Neurology Society. *Neurology*. 2002 Jun 25;58(12):1726-38.
27. Monteiro LM, Bollen CW, van Huffelen AC, Ackerstaff RG, Jansen NJ, van Vught AJ. Transcranial Doppler ultrasonography to confirm brain death: a meta-analysis. *Intensive Care Med*. 2006 Dec;32(12):1937-44.
28. Navarro JC, Lao AY, Sharma VK, Tsivgoulis G, Alexandrov AV. The accuracy of transcranial Doppler in the diagnosis of middle cerebral artery stenosis. *Cerebrovasc Dis*. 2007;23(5-6):325-30.
29. Navarro JC, Mikulik R, Garami Z, Alexandrov AV. The accuracy of transcranial Doppler in the diagnosis of stenosis or occlusion of the terminal internal carotid artery. *J Neuroimaging*. 2004 Oct;14(4):314-8.
30. Nissl J. A-Z health guide from WebMD: medical tests. Doppler ultrasound. Updated January 5, 2009. Accessed September 27, 2010. Available at URL address: [http://www.webmd.com/hw/health\\_guide\\_atoz/hw4477.asp](http://www.webmd.com/hw/health_guide_atoz/hw4477.asp)
31. Ogasawara K, Inoue T, Kobayashi M, Endo H, Yoshida K, Fukuda T, et al. Cerebral hyperperfusion following carotid endarterectomy: diagnostic utility of intraoperative transcranial Doppler ultrasonography compared with single-photon emission computed tomography study. *AJNR Am J Neuroradiol*. 2005 Feb;26(2):252-7.

32. Polito A, Ricci Z, Di Chiara L, Giorni C, Iacoella C, Sanders SP, Picardo S. Cerebral blood flow during cardiopulmonary bypass in pediatric cardiac surgery: the role of transcranial Doppler--a systematic review of the literature. *Cardiovasc Ultrasound*. 2006 Dec 13;4:47.
33. Poularas J, Karakitsos D, Kouraklis G, DeGroot E, Kalogeromitros A, Bilalis D, et al. Comparison between transcranial color Doppler ultrasonography and angiography in the confirmation of brain death. *Transplant Proc*. 2006 Jun;38(5):1213-7.
34. Rodriguez RA, Rubens F, Rodriguez CD, Nathan HJ. Sources of variability in the detection of cerebral emboli with transcranial Doppler during cardiac surgery. *J Neuroimaging*. 2006 Apr;16(2):126-32.
35. Saqqur M, Zygun D, Demchuk A. Role of transcranial Doppler in neurocritical care. *Crit Care Med*. 2007 May;35(5 Suppl):S216-23.
36. Saqqur M, Shuaib A, Alexandrov AV, Hill MD, Calleja S, Tomsick T, et al. Derivation of transcranial Doppler criteria for rescue intra-arterial thrombolysis: multicenter experience from the Interventional Management of Stroke study. *Stroke*. 2005 Apr;36(4):865-8.
37. Sarkar S, Ghosh S, Ghosh SK, Collier A. Role of transcranial Doppler ultrasonography in stroke. *Postgrad Med J*. 2007 Nov;83(985):683-9.
38. Sila CA, Furlan AJ, Yadav JS. Cerebrovascular Disease. In: Topol EJ, editor. *Textbook of Cardiovascular Medicine*. 3<sup>rd</sup> ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007. Ch 107.
39. Sloan MA, Alexandrov AV, Tegeler CH, Spencer MP, Caplan LR, Feldmann E, et al.; Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Assessment: transcranial Doppler ultrasonography: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology*. 2004 May 11;62(9):1468-81. Accessed September 27, 2010. Available at URL address: <http://www.neurology.org/cgi/reprint/62/9/1468.pdf>
40. Sloan MA. Prevention of ischemic neurologic injury with intraoperative monitoring of selected cardiovascular and cerebrovascular procedures: roles of electroencephalography, somatosensory evoked potentials, transcranial Doppler, and near-infrared spectroscopy. *Neurol Clin*. 2006 Nov;24(4):631-45.
41. Smith M. Perioperative uses of transcranial perfusion monitoring. *Anesthesiol Clin*. 2007 Sep;25(3):557-77, ix-x.
42. Souteyrand G, Motreff P, Lusson JR, Rodriguez R, Geoffroy E, Dauphin C, et al. Comparison of transthoracic echocardiography using second harmonic imaging, transcranial Doppler and transesophageal echocardiography for the detection of patent foramen ovale in stroke patients. *Eur J Echocardiogr*. 2006 Mar;7(2):147-54.
43. Trinidad EM, Hlatky R. Critical Care of the Patient with Traumatic Brain and Spine Injury. In: Rippe JM, editor. *Rippe's Intensive Care Medicine*. 6<sup>th</sup> ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008. Ch 166.
44. Tsivgoulis G, Sharma VK, Lao AY, Malkoff MD, Alexandrov AV. Validation of transcranial Doppler with computed tomography angiography in acute cerebral ischemia. *Stroke*. 2007 Apr;38(4):1245-9.
45. U.S. Food and Drug Administration (FDA). Center for Devices and Radiological Health (CDRH). 510(K) Database. Updated September 7, 2010. Accessed September 27, 2010. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm>
46. Wolf O, Heider P, Heinz M, Poppert H, Sander D, Greil O, et al. Microembolic signals detected by transcranial Doppler sonography during carotid endarterectomy and correlation with serial diffusion-weighted imaging. *Stroke*. 2004 Nov;35(11):e373-5.

47. Young GB, Shemie SD, Doig CJ, Teitelbaum J. Brief review: the role of ancillary tests in the neurological determination of death. *Can J Anaesth.* 2006 Jun;53(6):620-7.
48. Zetola VF, Lange MC. The utility of transcranial doppler in the acute ischemic stroke. *Arq Bras Cardiol.* 2006 Dec;87(6):795-8.
49. Zipper S, DSaposnik G, Weber S. Transcranial color-coded sonography (TCCS): a helpful tool in clinical neurology. *The Internet Journal of Neurology.* 2001;1(1). Accessed September 27, 2010. Available at URL address: <http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijn/vol1n1/tccs.xml>

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## Policy History

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<u>Pre-Merger Organizations</u>	<u>Last Review Date</u>	<u>Policy Number</u>	<u>Title</u>
CIGNA HealthCare	11/15/2007		Transcranial Doppler (TCD) Ultrasonography

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Connecticut General Life Insurance Company has acquired the business of Great-West Healthcare from Great-West Life & Annuity Insurance Company (GWLA). Certain products continue to be provided by GWLA (Life, Accident and Disability, and Excess Loss). GWLA is not licensed to do business in New York. In New York, these products are sold by GWLA's subsidiary, First Great-West Life & Annuity Insurance Company, White Plains, N.Y.