Computed Tomography (CT) Perfusion Imaging

Medical Policy

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Description
Perfusion imaging using computed tomography (CT) provides an assessment of cerebral blood flow that may assist in the identification of ischemic regions of the brain. This technology is proposed as a method to aid treatment decisions in patients being evaluated for acute ischemic stroke, subarachnoid hemorrhage, cerebral vasospasm, brain tumors, and head trauma.

Stroke: The goal of acute stroke thrombolytic treatment is to rescue the ischemic penumbra, an area of brain that surrounds the infarct core and is hypoperfused but does not die quickly. Multimodal CT and magnetic resonance imaging (MRI) can be used to assess the cerebral parenchyma, vasculature, and tissue viability in the acute ischemic stroke setting and are used to detect ischemic tissue and exclude hemorrhage and other conditions that mimic acute cerebral ischemia.

- Noncontrast CT is used to rule out intracranial hemorrhage, tumor, or infection. MR diffusion-weighted imaging (DWI) demonstrates acute infarction, and a gradient-recalled echo (GRE) sequence excludes intracerebral hemorrhage.
- CT angiography (CTA) and MR angiography (MRA) are used to evaluate intra- and extra-cranial vasculature to detect the vascular occlusion and potentially guide therapy (e.g., intravenous thrombolytics, or intra-arterial or mechanical thrombolysis).

The approved therapy, intravenous tissue plasminogen activator (tPA), requires only a non-contrast CT scan to exclude the presence of hemorrhage (a contraindication to the use of the drug). Current guidelines are to administer tPA within the first 3 hours after an ischemic event, preceded by a CT scan. Many patients, however, do not present within the 3-hour window, and thrombolysis carries a risk of intracranial hemorrhage. Thus, more sophisticated imaging may be needed to select the proper use of intra-arterial thrombolysis or mechanical thrombectomy in patients who present more than 3 hours after an ischemic stroke. Perfusion imaging is also being evaluated in the management of other neurologic conditions, such as subarachnoid hemorrhage and head trauma.
The potential utility of perfusion imaging of acute stroke is described as the following:

- identification of brain regions with extremely low cerebral blood flow, which represents the core
- identification of patients with at-risk brain regions (acutely ischemic but viable penumbra) that may be salvageable with successful intra-arterial thrombolysis beyond the standard 3-hour window
- triage of patients with at-risk brain regions to other available therapies, such as induced hypertension or mechanical clot retrieval
- decisions regarding intensive monitoring of patients with large, abnormally perfused brain regions
- biologically-based management of patients who awaken with a stroke for which the precise time of onset is unknown

Additional potential uses of perfusion CT in acute stroke may include the following:

- detection and differential diagnosis (e.g., excluding stroke mimics such as transient ischemic attack, complex migraine, seizure, conversion disorders, hypoglycemia, or brain tumors)
- determination of stroke subtype
- determination of stroke extent including additional vascular territories at risk
- identification of patients at high early risk for stroke following transient ischemic attack
- determining the need for blood pressure management
- establishing prognosis

Similar information can be provided by CT and MRI in terms of infarct core and penumbra. However, multimodal CT has a short protocol time (5-6 min), and because it can be performed with any modern CT equipment, is more widely available in the emergency setting. CT perfusion is performed by capturing images as an iodinated contrast agent bolus passes through the cerebral circulation and accumulates in the cerebral tissues. (Older perfusion methodologies such as single-photon emission CT [SPECT] and xenon-enhanced CT [XeCT] scanning use a diffusible tracer.) The quantitative perfusion parameters are calculated from density changes for each pixel over time with commercially available deconvolution-based software, in which cerebral blood flow (CBF) is equal to regional cerebral blood volume (CBV) divided by mean transit time (MTT). CT angiography/CT perfusion requires ionizing radiation and iodinated contrast. It is estimated that a typical perfusion CT deposits a slightly greater radiation dose than a routine unenhanced head CT (approximately 3.3 mSv). CT perfusion covers limited areas of the brain. Commonly used 16- to 64-slice CT scanners can detect an area of 2- to 4-cm of brain tissue.

On October 8, 2009, the U.S. Food and Drug Administration (FDA) issued an Initial Communication about excess radiation during perfusion CT imaging to aid in the diagnosis and treatment of stroke from one facility. Together with state and local health authorities, the FDA has identified at least 250 patients who were exposed to excess radiation during CT perfusion scans. The FDA has received reports of possible excess exposures at facilities in other states,
involving more than one manufacturer of CT scanners. In response, the FDA has provided recommendations for facilities and practitioners and is continuing to work with manufacturers, professional organizations, and state and local public health authorities to investigate the scope and causes of these excess exposures and their potential public health impact. A November 2010 update of this issue is available online at: http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm185898.htm.

Subarachnoid Hemorrhage and Cerebral Vasospasm: Cerebral vasospasm is one of the major causes of morbidity and mortality following aneurysmal subarachnoid hemorrhage (ASAH) in patients who survive the initial hemorrhage and can be seen in about two thirds of patients with ASAH. The typical onset of cerebral vasospasm occurs at 3 to 5 days after hemorrhage, with maximal narrowing on digital subtraction angiography at 5-14 days. Currently, the diagnosis of vasospasm and management decisions rely on clinical examination, transcranial Doppler sonography, and digital subtraction angiography. Although symptomatic vasospasm affects 20% to 30% of patients with ASAH, not all patients with angiographic vasospasm manifest clinical symptoms, and the symptoms can be nonspecific. In addition, patients do not always have both clinical and imaging findings of vasospasm. Due to these limitations, more accurate and reliable methods to detect cerebral vasospasm are being investigated. Two methods being evaluated are CTA and CT perfusion.

Brain Tumors: The current standard for tumor grading is histopathologic assessment of tissue. Limitations of histologic assessment include sampling error due to regional heterogeneity and interobserver variation. These limitations can result in inaccurate classification and grading of gliomas. Since malignant brain tumors are characterized by neovascularity and increased angiogenic activity, perfusion imaging has been proposed as a method to assess tumor grade and prognosis. In addition, perfusion imaging can be repeated and may help to assess the evolution of tumors and the treatment response. Traditionally, perfusion imaging of brain tumors has been performed with MRI, which can estimate tumor blood volume, blood flow, and permeability. More recently, CT perfusion has been investigated for glioma grading. Potential advantages, compared with MR perfusion, include the wider availability, faster scanning times, and lower cost. CT perfusion may also be useful in distinguishing recurrent tumor from radiation necrosis.

Regulatory Status

Several post-processing software packages (e.g., Siemens’ syngo Perfusion-CT, GE Healthcare’s CT Perfusion 4, Philips Medical System’s Brain Perfusion Option) have received 510(k) marketing clearance from the U.S. Food and Drug Administration (FDA) for use with a CT system to perform perfusion imaging. The software is being distributed with new CT scanners.

Policy

CT-based perfusion imaging is considered investigational for all indications including the diagnosis and management of acute cerebral ischemia (stroke).

Policy Guidelines

There is a CPT category III code specific to this test:
Rationale

This policy was created in April 2007 and updated periodically with literature review. The most recent update covers the period of March 2011 through July 2012.

Acute Cerebral Ischemia

At the time this policy was created, the literature focused on technical capabilities and feasibility. A number of retrospective studies indicated that blood flow values obtained using a diffusible gas indicator are accurate and that the flow rates correlate with physiologic changes such as the onset of neurologic deficits. (1) The limited availability of medical-grade Xe gas was another issue with this approach to computed tomography (CT) perfusion imaging. Because of more widespread availability, studies were also being done using non-diffusible tracers, i.e., contrast agents. (2, 3) As of 2008, studies were identified that reported on the use of CT perfusion imaging to identify infarcted tissue versus viable tissue (penumbra). (4-7) However, many studies evaluating use of thrombolytic therapy in acute stroke beyond 3 hours of symptom onset were based on magnetic resonance (MR) imaging with perfusion-diffusion mismatching. (8) As Lev commented in an editorial, although many investigators have advocated CT perfusion imaging as a reliable method for detecting both infarct core and penumbra, almost all the major clinical trials aimed at extending the time window for thrombolysis used advanced MR rather than CT imaging for triage. (9) Prospective controlled studies had not been reported that demonstrated that use of perfusion imaging (CT or MR) improved outcomes in patients with acute stroke.

In 2009, the American Heart Association (AHA) Council on Cardiovascular Radiology and Intervention, Stroke Council, and the Interdisciplinary Council on Peripheral Vascular Disease published a scientific statement that included a review of the evidence on CT perfusion. (10) The scientific review determined that:

- Creation of accurate, quantitative CT perfusion has been validated in comparison with xenon-CT, PET [positron emission tomography], and MR perfusion. CT perfusion appears to have greater spatial resolution than MR perfusion, and MR perfusion may be more sensitive to contamination by large vascular structure, leading to the possibility that visual assessment of core/penumbra mismatch is more reliable with CT perfusion than with MR perfusion.

- Studies are evaluating various thresholds to predict the upper and lower limits of final infarct size, and outcome prediction studies suggest that CT perfusion has the potential to serve as a surrogate marker of stroke severity (final size of infarction), possibly exceeding current predictors of outcome such as the National Institutes of Health Stroke Score (NIHSS). Because of the superior quantitative capability compared to MR perfusion imaging, application of specific CT perfusion thresholds to predict tissue survival or infarction appears promising; however, it is essential that these thresholds be validated in larger patient cohorts for which reperfusion status is known.

0042T: Cerebral perfusion analysis using computed tomography with contrast administration, including post-processing of parametric maps with determination of cerebral blood flow, cerebral blood volume, and mean transit time.
• There is increasing but as yet indirect evidence that even relatively imprecise measures of core/penumbra mismatch may be used to select patients for treatment beyond a strict 3-hour time window for intravenous thrombolysis. Multimodal CT may also determine suitability for other therapies, such as mechanical clot retrieval and intra-arterial thrombolysis, and increase patient access to new treatments.

A systematic review from 2011 examined definitions and thresholds for MR and CT perfusion imaging. (11) Twenty papers on CT perfusion met the inclusion criteria for analysis of definitions, and 10 papers on CT perfusion (median sample size of 22) provided thresholds. The quality of the studies was generally poor. There were multiple definitions for tissue states. For example, there were 8 different definitions of at-risk tissue, resulting in many-fold differences in the extent of tissue defined as tissue at risk. There was also considerable variability in quantitative thresholds. The review concluded that CT perfusion thresholds in stroke are derived from small numbers of patients, variable perfusion analysis methods and definitions of tissue states. As indicated in the 2009 AHA statement, thresholds should be validated in larger patient cohorts for which reperfusion status is known. Assessment of functional outcomes is also needed to evaluate if CT perfusion improves clinical outcomes.

Four relevant cohort studies have been identified that were published after the AHA review. One of these studies attempted to define the technical CT parameters that best detect perfusion mismatches. In 2011, Bivard et al. reported a prospective clinical validation study of perfusion CT for acute (<6 hr) ischemic stroke in 314 consecutive patients. (12) If eligible, patients were treated with intravenous thrombolysis. All patients underwent baseline multimodal CT examination and follow-up MRI at 24 hours, with MRI used as the gold standard for tissue perfusion. The most accurate CT perfusion threshold at defining infarct core was determined to be cerebral blood flow less than 40% of contralateral with a relative delay time less than 2 sec (area under the curve [AUC] of 0.86). Using this threshold, the correlation between extent of CT perfusion mismatch tissue (the volume of “at-risk” tissue) salvaged from infarction and clinical improvement was $R^2=0.59$ at 24 h (NIHSS) and $R^2=0.42$ at 90 days (Rankin scale).

Obach et al. compared outcomes of 106 patients with acute stroke who were assessed with multimodal CT (CT/CT angiography[CTA]/CT perfusion) versus a cohort of 262 patients with acute stroke who were assessed without full multimodal brain imaging during a 5-year period. (13) Clinical and imaging data were collected prospectively, and all imaging studies were assessed by investigators blinded to prognostic data. The two groups were comparable at baseline, with the exception of a greater percentage of patients with a time-to-treatment of greater than 3 hours (28% vs. 16%) and a greater percentage treated with endovascular therapy (26% vs. 11%, both respectively) in the multimodal CT group. Good outcome (modified Rankin scale score $\leq 2$) at 3 months was increased in the multimodal group compared with controls (adjusted odds ratio [OR] of 2.88) in models adjusted for age, gender, NIHSS, glucose, and treatment delay or modality. Fifty-six percent of patients assessed by multimodal CT had a Rankin score equal to or less than 2 in comparison with 41% of controls ($p=0.008$). In a sensitivity analysis, multimodal-assisted thrombolysis yielded superior benefits in those patients treated after 3 hours (adjusted OR, 4.48) than for patients treated within 3 hours (adjusted OR, 1.31). For patients treated after 3 hours, 63% of patients assessed by multimodal CT had a Rankin score equal to or less than 2 in comparison with 24% of controls. Mortality (14% and 15%) and symptomatic hemorrhage (5% and 7%, both respectively) were similar in the 2 groups.
Sztriha et al. evaluated whether CT perfusion imaging mismatch could help to select ischemic stroke patients for thrombolysis between 3 and 6 hours. (14) A cohort of 254 thrombolysed patients were studied; 174 (69%) were thrombolysed at 0-3 hours using non-contrast CT, and 80 (31%) were thrombolysed at 3-6 hours by using CT perfusion mismatch criteria, defined as a cerebral blood volume ASPECTS [Alberta Stroke Program Early CT Score] of at least 7 and an ASPECTS mismatch of at least 2. Baseline characteristics were comparable in the 2 groups. Efficacy endpoints included disability at 3 months, as assessed by the Rankin score. Safety endpoints included overall mortality, any intracerebral hemorrhage, and symptomatic intracerebral hemorrhage. At 3 months, there were no differences between patients thrombolysed at 0-3 hours or at 3-6 hours in symptomatic intracerebral hemorrhage (3% vs. 4%), or in any intracerebral hemorrhage (7% vs. 9%). There were also no differences at 3 months in mortality (16% vs. 9%) or the modified Rankin scale score 0-2 (55% vs. 54%, respectively for all). The NIHSS score was the only independent determinant of a favorable functional outcome at 3 months (Rankin score of 0-2; odds ratio [OR]: of 0.89) in patients treated using CT perfusion mismatch criteria beyond 3 hours. This study is limited by the lack of a control group of patients without CT perfusion. The authors also note that results of this study cannot be generalized to patients with symptoms in the posterior circulation, an area where CT perfusion is known to underperform.

Rai et al. evaluated rates of recanalization and functional outcomes in a cohort of 99 patients selected by CT perfusion for treatment with endovascular stroke therapy and compared results with historical controls from the MERCI [Mechanical Embolus Removal in Cerebral Ischemia], Multi-MERCI, and Penumbra device trials that treated all comers. (15) Patients were included if they had anterior circulation symptoms at presentation with a baseline NIHSS score of 8 or greater and intracerebral vascular occlusion on admission CT angiography correlating with the neurologic deficit. There was no cut-off time for treatment. The type of endovascular therapy involved intra-arterial thrombolytics in 33.3% of patients, mechanical device in 24.2%, and both thrombolytics and mechanical thrombectomy in 42.4%. Successful recanalization was achieved in 55.6%, with a good outcome in 41.4% of patients. The recanalization rate in this study was not significantly different from the 46% for MERCI and 68% for Multi-MERCI but was significantly lower than the 82% recanalization rate in the Penumbra trial. In patients who were successfully recanalized, good outcomes were obtained in 67% of patients in this study in comparison with 46% in MERCI, 49% in Multi-MERCI, and 29% in Penumbra. The rate of futile recanalization (defined as a poor outcome despite successful recanalization) was 33% compared with 54% in MERCI, 51% in Multi-MERCI, and 71% for Penumbra. A small cerebral blood volume abnormality and large mean transit time-cerebral blood volume mismatch were strong predictors of a good outcome. This study is limited by the comparison of a retrospective cohort with results from prospective device trials and by the reliance on recanalization rates as the primary outcome rather than clinical measures.

A large number of case series have been published that have retrospectively assessed how CT perfusion at admission might facilitate clinical decision making and predict outcomes in patients with suspected acute ischemic stroke. Prospective trials are needed to evaluate the impact of this technology on health outcomes.

Conclusions: Four recent cohort studies describe how CT perfusion can be used in clinical care to select patients for endovascular therapy. However, these trials lack concurrent control groups and, therefore do not provide relevant evidence on the comparative efficacy of this approach compared to alternative strategies. Randomized trials are needed to establish with greater
Subarachnoid Hemorrhage and Cerebral Vasospasm

A 2010 meta-analysis on the diagnostic accuracy of CTA and CT perfusion for cerebral vasospasm identified 3 studies (64 patients) that met the inclusion criteria and contained the appropriate data for statistical analysis. (16) In these studies, "vasospasm" was defined on CT perfusion as a perfusion deficit demonstrating prolonged mean transit time and decreased cerebral blood flow. However, there were no standardized thresholds of mean transit time and cerebral blood flow to determine vasospasm, contributing to the heterogeneity among these studies. For this meta-analysis, “angiographic vasospasm” was defined as evidence of arterial narrowing compared with the parent vessel or with a baseline examination, with both symptomatic and asymptomatic patients included. In comparison with digital subtraction angiography, CT perfusion pooled estimates had 74% sensitivity and 93% specificity. Given the small sample size and the heterogeneity in the CT perfusion data, these results are considered preliminary.

In 2011, Sanelli et al. reported a prospective study with 97 patients that evaluated the accuracy of CT perfusion to diagnose delayed cerebral ischemia following aneurysmal subarachnoid hemorrhage. (17) CT perfusion was performed between days 6 and 8 in asymptomatic patients and on the day of clinical deterioration in symptomatic patients. Perfusion maps were qualitatively evaluated by 2 neuroradiologists who were blinded to clinical and imaging data and compared to the reference standard. Based on a multistage hierarchical reference standard that incorporated both imaging and clinical criteria, 40 patients (41%) were diagnosed with delayed cerebral ischemia. Overall diagnostic accuracy for CT perfusion, determined from receiver operating characteristic (ROC) curves, was 93% for cerebral blood flow, 88% for mean transit time, and 72% for cerebral blood volume. The study also sought to determine a quantitative threshold for delayed cerebral ischemia with CT perfusion, although it was noted that absolute thresholds may not be generalizable due to differences in scanner equipment and post-processing methods. Clinical outcomes of the delayed cerebral ischemia group included 19 patients (48%) with no permanent neurologic deficit, 16 (40%) with permanent neurologic deficit, and 5 (13%) who died during hospitalization.

Sanelli et al. also reported a retrospective study of the development of vasospasm in 75 patients with aneurysmal subarachnoid hemorrhage who had an earlier CT perfusion assessment (likely overlap in subjects with the study described above). (18) Based on a multistage reference standard, 28 patients (37%) were classified as vasospasm. CT perfusion values (cerebral blood flow and mean transit time) on days 0-3 were found to be significantly lower in the vasospasm group. Optimal thresholds were then determined for cerebral blood flow (50% sensitivity and 91% specificity), mean transit time (61% sensitivity and 70% specificity) and cerebral blood volume (36% sensitivity and 89% specificity). Clinical outcomes of the vasospasm group included 15 patients (54%) with no permanent neurologic deficit, 11 (39%) with permanent neurologic deficit, and 2 (7%) who died during hospitalization.

Conclusions: CT perfusion is being evaluated for the diagnosis of vasospasm and delayed cerebral ischemia following aneurysmal subarachnoid hemorrhage. A prospective trial showed a qualitative measure of cerebral blood flow to have 93% accuracy for the detection of delayed cerebral ischemia with lower accuracy for cerebral blood volume. Prospective trials are needed to evaluate whether CT perfusion in patients with aneurysmal subarachnoid hemorrhage leads
Brain Tumors

A 2011 review by Jain indicates that most of the literature on the utility of perfusion imaging for glioma grading is based on various MR perfusion techniques. (19) One study compared CT perfusion with conventional MRI in 19 patients. (20) With a cut-off point of greater than 1.92 normalized cerebral blood volume (nCBV), there was sensitivity of 85.7% and specificity of 100% to differentiate high-grade gliomas. There were no significant differences in nCBV between grade III or IV tumors. A subsequent study by Jain and colleagues correlated CT perfusion findings with histopathologic grade in 32 patients with astroglial tumors. (21) Eight additional patients with oligodendrogliomas were excluded from analysis because of the known higher blood volume compared with astroglial tumors. Of the 32 patients included in the study, 8 had low-grade gliomas and 24 had high-grade gliomas. In this selected set of patients, CT perfusion showed significant differences in the grade III and grade IV tumors. Prospective studies in an appropriate population of patients are needed to evaluate the sensitivity and specificity of CT perfusion glioma grading, with histopathologic assessment of tumors as the independent reference standard.

In 2011, Xyda et al. reported a prospective study of the feasibility and efficacy of volume perfusion CT (VPCT) for the preoperative assessment of cerebral gliomas in 46 consecutive patients with suspected cerebral gliomas. (22) (Whereas typical perfusion CT covers a relatively narrow range of brain tissue, the VPCT system with multispiral acquisition covers the entire tumor.) Two blinded readers independently evaluated VPCT by drawing volumes of interest (VOIs) around the tumor according to maximum intensity projection volumes. The VOIs were mapped onto the cerebral blood volume, flow, and permeability perfusion datasets, which correspond to histopathologic microvascular density. VPCT was followed by stereotactic biopsy or surgery to evaluate the histopathology of the tumor and classified into low-grade (I and II) and high-grade (III and IV). The diagnostic power of the perfusion parameters were analyzed by receiver operating characteristic (ROC) curve analysis. Permeability demonstrated the highest diagnostic accuracy (97% sensitivity, 100% specificity), positive predictive value (100%), and negative predictive value (94%) to identify or exclude high-grade tumors. Potential uses of VPCT are to guide biopsy and to monitor low-grade gliomas. This is the first report using VPCT to differentiate gliomas; therefore, replication of these findings in an independent sample of patients is needed.

Ongoing Clinical Trials

A search of online site ClinicalTrials.gov in August 2012 found the following trials:

- Dutch acute stroke trial (DUST): Prediction of outcome with computed tomography (CT) – perfusion and CT-angiography” to assess whether combined CT perfusion and CT angiography parameters can predict patient outcome in acute ischemic stroke (NCT00880113). The study will include patients with acute stroke symptoms who present in the hospital within 9 hours of onset of symptoms. Patients who awaken with stroke symptoms can only be included if they went to sleep without any stroke symptoms, and the time from going to sleep until imaging is less than 9 hours. Estimated enrollment is 1,500 patients with completion in December 2013.
Clinical Input Received through Physician Specialty Societies and Academic Medical Centers

While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

In response to requests, input was received from 4 physician specialty societies (8 reviewers) and 3 academic medical centers while this policy was under review in 2012. The majority input supported some uses of CT perfusion; however, there was little consensus on the specific indications that would be considered medically necessary. For use in late stroke, most reviewers agreed that CT perfusion can identify patients with late stroke who may benefit from thrombolysis, but there was no consensus on whether the benefits of using this strategy to select patients with late stroke for thrombolysis outweigh the risks. Some additional indications recommended by reviewers included differential diagnosis, e.g. excluding stroke mimics, determination of stroke subtype, determination of stroke extent, identification of patients at high early risk for debilitating stroke following transient ischemic attack, determining the need for blood pressure management, guiding disposition decisions such as the need for intensive care unit placement, and establishing prognosis. Evaluation of chronic cerebral ischemia and head trauma were also noted as potential indications. There was near consensus that CT perfusion is investigational for head trauma and for the staging and management of brain tumors. Additional references were provided, which were subsequently reviewed.

Summary

CT perfusion appears to hold promise for improving care of patients with various neurologic conditions. One of the potential areas of benefit is the potential for greater individualization of therapy for acute stroke by better defining ischemic areas at risk that may benefit from thrombolysis. However, the current evidence is insufficient to determine whether outcomes are improved with use of this technique. Randomized clinical trials are needed in which a strategy employing CT perfusion in the treatment of acute stroke is compared with traditional strategies. For other indications such as subarachnoid hemorrhage and brain tumors, the data on CT perfusion are limited. Because the impact of CT perfusion imaging on clinical outcomes is not known, this technique is considered investigational.

Practice Guidelines and Position Statements

American Heart Association (AHA) and American Stroke Association (ASA) 2012 guidelines for the management of aneurysmal subarachnoid hemorrhage recommend that perfusion imaging with CT or MR can be useful to identify regions of potential brain ischemia (Class IIa; Level of Evidence B). (23) The guidelines state that there are emerging data that perfusion imaging, demonstrating regions of hypoperfusion, may be more accurate for identification of delayed
cerebral ischemia than anatomic imaging of arterial narrowing or changes in blood flow velocity by transcranial Doppler. The guidelines concluded that CT perfusion is a promising technology, although repeat measurements are limited by the risks of dye load and radiation exposure.

AHA and ASA 2007 guidelines for the early management of adults with ischemic stroke recommended that multimodal CT and magnetic resonance imaging (MRI) may provide additional information that will improve diagnosis of ischemic stroke (Class I, Level of Evidence A). (24) At the time of this guideline, the role of CT perfusion and CT angiography in making acute treatment decisions had not yet been established.

In 2009, the AHA issued a scientific statement on imaging of acute ischemic stroke. (10) The statement included the following recommendations regarding perfusion imaging:

**Perfusion-Derived Values**

Quantitative thresholds of tissue that is dead or destined to die versus tissue that is still living and may be salvageable are the goal of all perfusion techniques. Although the performance of such studies may be considered to identify and differentiate the ischemic penumbra and infarct core, their accuracy and usefulness have not been well established (Class IIb, Level of Evidence B).

**Clinical Role of Perfusion Imaging**

1. The admission volumes of infarct core and ischemic penumbra may be significant predictors of clinical outcome, possibly exceeding the prognostic value of admission NIHSS score [National Institutes of Health Stroke Score] (Class IIb, Level of Evidence B).

2. There is increasing but as yet indirect evidence that even relatively imprecise measures of core/penumbra mismatch may be used to select patients for treatment beyond a strict 3-hour time window for intravenous thrombolysis. Together with vascular imaging, these approaches may determine suitability for other therapies such as mechanical clot retrieval and intra-arterial thrombolysis, as well as provide a surrogate marker for treatment efficacy (Class IIb, Level of Evidence B).

American College of Radiology (ACR) Appropriateness Criteria® from 2011 provides the following ratings for CT head perfusion with contrast: (25)

- Rating of 2 (usually not appropriate) for asymptomatic individuals with structural lesion on physical examination (cervical bruit) and/or risk factors.
- Rating of 6 (may be appropriate) if directly employed in decision making and planning treatment for carotid territory or vertebrobasilar transient ischemic attack; initial screening survey.
- Rating of 6 (may be appropriate) for a new focal neurologic defect, fixed or worsening; less than 3 hours, if CT is used for planning treatment such as thrombectomy.
- Rating of 6 (may be appropriate) for a new focal neurologic defect, fixed or worsening; 3 to 24 hours, if CT is used for planning treatment such as thrombectomy within 8 hours of symptom onset.
• Rating of 5 (may be appropriate) for a new focal neurologic defect, fixed or worsening; longer than 24 hours, if used for decision making or planning treatment such as angioplasty and stenting.

• The ACR also notes that CT stroke protocols combining a brain non-contrast CT, CT angiography, and CT perfusion may produce a relative radiation level of 1-10 mSv, and repeated use of this protocol in an individual patient may result in high radiation exposure to the scalp and eyes.

ACR and American Society of Neuroradiology (ASNR) published a guideline for the performance of CT perfusion in 2007. (26) The guidelines listed the following indications:

1. Brain

Primary indications: acute neurological change suspicious for stroke, suspected vasospasm following subarachnoid hemorrhage, cerebral hemorrhage with secondary local ischemia, and intracranial tumors.

Secondary indications: follow-up of acute cerebral ischemia or infarction in the subacute or chronic phase of recovery; to assist in planning, and evaluating the effectiveness of, therapy for arterial occlusive disease; and in patients with contraindication to magnetic resonance imaging (MRI) or with devices or material in or close to the field of view that would result in nondiagnostic MRI scans. CT perfusion scanning may also be helpful in the setting of acute trauma.

2. Head and neck

Primary indications: evaluation of the vascular status of solid tumors where MRI is degraded due to susceptibility artifact from air-containing spaces or from surgical clips or dental work.

Secondary indications: Follow-up of tumor response to therapy.

The Agency for Healthcare Research and Quality (AHRQ) published a report on acute stroke in 2005. (27) This report addressed multiple issues regarding CT perfusion and also angiography in terms of how these modalities affect the use of thrombolytic therapy for acute ischemic stroke. This report indicated that studies with prospective use of CT perfusion and angiography techniques in patient selection for thrombolysis were not identified.

Medicare National Coverage

There is no national coverage decision.

References:


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