Evolent Clinical Guideline 2012 for Brain Magnetic Resonance Imaging (MRI) With or Without Internal Auditory Canal (IAC) Views

Guideline Number: Evolent_CG_2012	**Applicable Codes**	
"Evolent" refers to Evolent Health LLC and Evolent Specialty Services, Inc. 		
Original Date: September 1997	**Last Revised Date:** July 2025	**Implementation Date:** January 2026

TABLE OF CONTENTS

STATEMENT

General Information

- *It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. If applicable: All prior relevant imaging results and the reason that alternative imaging cannot be performed must be included in the documentation submitted.*
- *Where a specific clinical indication is not directly addressed in this guideline, medical necessity determination will be made based on widely accepted standard of care criteria. These criteria are supported by evidence-based or peer-reviewed sources such as medical literature, societal guidelines and state/national recommendations.*
- *The guideline criteria in the following sections were developed utilizing evidence-based and peer-reviewed resources from medical publications and societal organization guidelines as well as from widely accepted standard of care, best practice recommendations.*

Special Note

Brain Magnetic Resonance Imaging (MRI) and Magnetic Resonance Angiography (MRA) are not simultaneously approvable unless they meet the criteria described below in the Indications for **Brain MRI/Brain MRA** combination studies section. If there is a combination request for an overlapping body part, either requested at the same time or sequentially (within the past 3 months) the results of the prior study should show one or more of the following:

- Inconclusive or show a need for additional or follow up imaging evaluation
- The office notes should clearly document an indication why overlapping imaging is needed and how it will change management for the patient.

(See **Combination Studies** section for indicated combinations below)

Purpose

Brain (head) MRI is the procedure of choice for most brain disorders. It provides clear images of the brainstem and posterior brain, which are difficult to view on a CT scan. It is also useful for the diagnosis of demyelinating disorders (such as multiple sclerosis (MS) that cause destruction of the myelin sheath of the nerve). The evaluation of blood flow and the flow of cerebrospinal fluid (CSF) is possible with this non-invasive procedure.

INDICATIONS

Headache [1,2]

Evaluation of Headache

- Acute, sudden onset headache (< 4 weeks), with any ONE of the following:
  - A personal or family history (brother, sister, parent, or child) of brain aneurysm or AVM (arteriovenous malformation)
  - < 48 hours of "worst headache in my life" or "thunderclap" headache (Sudden onset new headache reaching maximum intensity within 2-3 minutes, lasting more than 5 minutes)
  - Prior history of stroke or intracranial bleed
  - Known coagulopathy or on anticoagulation
- New onset of headache (< 3 months with no prior history of headache) with any ONE of the following:
  - Fever
  - Subacute head trauma
  - Acute, new, or fluctuating neurologic deficits, such as sensory deficits, limb weakness, abnormal reflexes (pathological, asymmetric, hyperreflexia), speech difficulties, visual loss, lack of coordination, or mental status changes or with signs of increased intracranial pressure (papilledema)
  - Migraine with atypical/complex aura (such as motor, brainstem or retinal auras which may be characterized by motor weakness, balance issues, vertigo, slurred speech, visional loss and/or double vision) [3]
    - NOTE: Imaging is not indicated for typical migraine symptoms characterized by visual and/or sensory and/or speech/language symptoms AND the absence of motor, brainstem or retinal symptoms. Typical migraines develop gradually, last one hour or less and are completely reversible
  - Severe unilateral headache with radiation to or from the neck, associated with suspicion of carotid or vertebral artery dissection
  - History of cancer or significantly immunocompromised
  - Age $\geq$ 50 [4,5]
  - Related to activity or event (sexual activity, exertion, Valsalva, position), new or progressively worsening [6]
  - Persistent or progressively worsening during a course of physician-directed treatment [1]
  - Pregnancy or postpartum [7]
- Chronic headache (> 3 months) and a change in character/pattern (e.g., more frequent,

increased severity, or duration)

- Cluster headaches or other trigeminal-autonomic cephalalgias (paroxysmal hemicrania, hemicrania continua, short-lasting unilateral neuralgiform headache attacks (SUNCT/SUNA)) once to eliminate secondary causes

Additional Indications in the Pediatric Population (<18) When None of the Above Apply

- Persistent headache and any ONE of the following [8–10]:
  - Immune deficiency
  - History of neoplasm
  - History of congenital heart disease
  - See **Imaging in Known Genetic Conditions** for additional indications
  - Coagulopathy
  - Occipital location
  - Age < 6 years
  - Documented absence of family history of headache
  - Concern for increased intracranial pressure with symptoms such as recurring headaches after waking

Neurological Symptoms or Deficits [11–15]

- Acute, new, fluctuating, or persistent neurologic symptoms or deficits such as, sensory deficits, limb weakness, abnormal reflexes (pathological, asymmetric, hyperreflexia), speech difficulties, visual loss, lack of coordination, or mental status changes

Stroke and Vascular Disease

Evaluation of Known or Suspected Stroke [16,17]

- Suspected stroke with any acute, new, or fluctuating symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes
- History of stroke and ONE of the following:
  - No prior imaging
  - New neurologic signs or symptoms
- Suspected stroke with:
  - A personal or first-degree family history (brother, sister, parent, or child) of aneurysm OR
  - Known coagulopathy or on anticoagulation

- Symptoms of transient ischemic attack (TIA) (episodic neurologic symptoms such as sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes)
- See **Imaging in Known Genetic Conditions** section for additional indications (including for HbSS sickle cell disease or HbSβ0 thalassemia)

Evaluation of Known or Suspected Vascular Disease [18]

- Evaluation of suspected acute subarachnoid hemorrhage (SAH)
- Follow-up for known hemorrhage, hematoma, or vascular abnormalities [16]
- Suspected central venous thrombosis and ANY ONE of the following [16]:
  - Patient has a hypercoagulable state such as pregnancy, post-partum, prothrombotic conditions (acquired or genetic), malignancy, oral contraceptive use, recent infection, recent trauma or covid-19
  - Documentation of concern for central venous thrombosis is specified
  - Papilledema or signs/symptoms of increased intracranial pressure
- Known Moyamoya disease or reversible cerebral vasoconstriction with any new or changing neurological signs or symptoms.
- Suspected cerebral cavernous malformations (CCM) and other low flow vascular malformations (such as dural venous anomalies (DVA) and capillary telangiectasias)
  - NOTE: High flow vascular malformations (such as AVM and dural AV fistulas) are imaged with angiography rather than MRI
- First-degree relatives of patients with more than one family member with a CCM should have a screening MRI as well as genetic counseling [19,20]
- Follow-up imaging of known CCM only to guide treatment decisions or to investigate new symptoms

Head Trauma

Evaluation of Known or Suspected Trauma [21–23]

- Known or suspected trauma or injury to the head with documentation of one or more of the following acute, new, or fluctuating:
  - Focal neurologic findings
  - Motor changes
  - Mental status changes
  - Amnesia
  - Vomiting

- Seizures
- Headache
- Signs of increased intracranial pressure

- Known coagulopathy or on anticoagulation
- Known or suspected skull fracture by physical exam and/or prior imaging
- Post concussive syndrome if persistent or disabling symptoms and MRI has not been performed
- Subacute or chronic traumatic brain injury with new cognitive and/or neurologic deficit

Pituitary Disorders

Suspected Pituitary Disorders *(24–30)*

- Neurologic deficit on exam suggestive of pituitary lesion (e.g., visual field deficit suggesting compression of the optic chiasm, diplopia, gaze palsy)
- Abnormal laboratory evaluations suggestive of a pituitary lesion with ONE or more of the following:
  - Panhypopituitarism: all pituitary hormones levels are low (GH, TSH, LH, FSH, ACTH, prolactin)
  - Growth hormone deficiency: low GH/IGF-1 (i.e. peak GL < 8 on stimulation)
    - NOTE: Imaging is not indicated for growth hormone supplementation for familial or idiopathic short stature in the absence of laboratory confirmed GH deficiency
  - Central hyperthyroidism: High/normal TSH AND high FT4
  - Central hypothyroidism: Low/normal TSH AND low FT4 AND normal prolactin
  - Cushing's Disease:
    - High cortisol and ACTH >20 OR
    - High cortisol and indeterminate ACTH (ACTH 5-20) with ACTH >5 on dexamethasone suppression test
  - Acromegaly: with high IGF-1 OR normal IGF1 but GH >1 on 2 hour oral glucose tolerance test
  - Central Diabetes Insipidus (arginine vasopressin deficiency): low ADH with testing indicating a central cause and not a peripheral cause, i.e., plasma copeptin, water restriction + desmopressin (25)
  - Central precocious puberty in a child (male ≤ 9; female ≤ 8), with high or normal LH/FSH and high mineralocorticoids, androgens and/or estrogens (25)
  - Hypogonadotropic hypogonadism [low sex hormones and gonadotropins (FSH/LH)] based on ONE of the following:
    - Persistently low total testosterone < 150 in the setting of low or normal LH/FSH

(i.e., severe secondary hypogonadism)

- Borderline low total testosterone levels (150-400 ng/dL) AND low or normal LH/FSH AND one of the following:
  - Neurological signs or symptoms
  - Other pituitary hormonal abnormalities
  - Low free testosterone and no clear clinical explanation (such as steroid use, obesity, eating disorder, excessive stress, etc.) is provided

- Prolonged amenorrhea (> 3 months if previously normal menses; > 6 months if previous irregular menses) AND persistently low estradiol (< 200 pmol/L) AND low/normal LH/FSH and no clear clinical explanation (such as steroid use, obesity, eating disorder, excessive stress, etc.) is provided [31–33]
- Prolactin < 250 ng/mL and ALL of the following [31,32]:
  - Normal thyroid function tests
  - Normal renal function
  - Pregnancy is excluded (if applicable)
  - Not attributable to medication side effect
  - One of the following is present:
    - Prolactin ≥ 100 ng/mL
    - Persistently elevated prolactin (men > 20 ng/mL, non-pregnant females > 25 ng/mL)
    - Co-existent low testosterone/estrogen/progesterone AND low/normal LH/FSH
    - Neuroendocrine signs or symptoms (i.e., headache, galactorrhea, abnormal menses, infertility, or bitemporal hemianopsia)

    NOTE: Galactorrhea without elevated prolactin (normoprolactinemic) is usually due to breast pathology and evaluated with breast imaging

Pituitary Adenoma (Known)

- New neuroendocrine signs or symptoms (such as headache, galactorrhea, abnormal menses, infertility, or bitemporal hemianopsia)
- < 10 mm non-functional asymptomatic adenoma (microadenoma)
  - 12 months after initial diagnosis then every 2 years
- ≥ 10 mm non-functional asymptomatic adenoma (macroadenoma) with ONE of the following:
  - Unresected: every 6 months
  - Resected: annually
- Functional adenoma with ONE of the following:

- To assess response to treatment
- Rising hormonal level
- 12 months after initiation of drug holiday
- Resected: 3-6 months post-operatively

Cystic Lesions

- Pineal cyst and ONE of the following:
  - Symptoms suggestive of change (e.g., headaches, gaze paresis, ataxia, papilledema, nausea/vomiting) [34]
  - Atypical features (multiloculated, enhancing, solid component):
    - Follow-up at 1, 3 and 5 years after diagnosis
  - Asymptomatic and age < 18:
    - Once 1-2 years after diagnosis (if stable, no further imaging)
- Rathke cleft cyst and ONE of the following [35]:
  - Symptoms suggestive of change (e.g., headaches, gaze paresis, ataxia, papilledema, nausea/vomiting)
  - Atypical imaging features (off midline, fluid-fluid septations)
  - Asymptomatic:
    - Unresected: At years 1, 3 and 5 (if stable, no further imaging)
    - Resected: Annually for 5 years (if stable, no further imaging)
- Arachnoid cyst and ONE of the following [36,37]:
  - Surgical planning
  - Age < 4 years old
  - New symptoms suggestive of change (headaches, altered mental status, nausea/vomiting, seizures, visual/endocrine dysfunction)
- Midline dermoid cysts/sinuses with concern for intracranial extension [38,39]

Suspected Malignancy [40,41]

- Suspected brain tumor with any acute, new, or fluctuating neurologic symptoms or deficits such as sensory deficits, limb weakness, abnormal reflexes (pathological, asymmetric, hyperreflexia), speech difficulties, visual loss, lack of coordination, or mental status changes
- Lesion (including bone tumor/abnormality or soft tissue mass) on prior imaging [42]

Known Malignancy

Initial Staging and Recurrence

Indicated during the **initial diagnostic workup** for the following cancer types as routine imaging (regardless of symptoms):

- Adult and pediatric CNS tumors [40]
- Primary CNS lymphoma [40]
- Lung cancer (NSCLC and SCLC) [43,44]
- Melanoma
  - Primary mucosal tumor of the head and neck – any stage [45]
  - Stage III or IV for any primary site [46]
- Poorly differentiated neuroendocrine cancer [27]
- Gestational trophoblastic neoplasia with pulmonary metastases [47]
- Leukemia with suspicion of CNS involvement [48–50]
- Breast cancer stage IV [51]
- Small cell neuroendocrine carcinoma of the cervix (NECC) [52]
- Histiocytic neoplasms (Langerhans cell histiocytosis, Rosai-Dorfman, Erdheim-Chester) [53]
- Any malignancy with signs or symptoms of brain metastases (e.g., headache, sensory deficits, memory problems), at any stage in treatment (initial, restaging, surveillance). There does not need to be a neurologic deficit on exam or other workup done first for a patient with known malignancy

Restaging

Indicated every 2-3 cycles of chemotherapy **during active treatment** for the following diseases:

- Adult and pediatric CNS tumors [40]
- Primary CNS lymphoma [40]
- Breast cancer, stage IV or any stage if suspected development of brain metastases [51]
- Cutaneous melanoma, stage III or IV or any stage if suspected development of brain metastases [46]
- Non-small cell lung cancer [43]
  - Stage IV – every 2-3 cycles of treatment
  - All stages – end of treatment or with symptoms concern
- Small cell lung cancer [44]

- Poorly differentiated neuroendocrine cancer [27]
- Small cell neuroendocrine carcinoma of the cervix (NECC) [52]
- Histiocytic neoplasms (Langerhans cell histiocytosis, Rosai-Dorfman, Erdheim-Chester) [53]
- Any malignancy with signs or symptoms of brain metastases (e.g., headache, sensory deficits, memory problems), at any stage in treatment (initial, restaging, surveillance). There does not need to be a neurologic deficit on exam or other workup done first for a patient with known malignancy.
- Any malignancy with known CNS involvement

Surveillance

Routine, asymptomatic Brain MRI is appropriate during **surveillance** in the following diseases:

- Breast cancer stage IV [51]
  - As clinically indicated
- Cutaneous melanoma stage III/IV [46]
  - Every 3 months for 2 years, then every 6-12 months indefinitely
- Non-small cell lung cancer [43]
  - Every 3-6 months for 3 years, then every 6 months for 2 years, then annually
  - If suspected development of brain metastases
- Small cell lung cancer [44]
  - Every 3-4 months during year 1, every 6 months during year 2, and as clinically indicated thereafter
- Neuroendocrine carcinoma of the cervix (interval at discretion of treating provider) [52]
- Adult and pediatric CNS tumors [40]
  - For histologies not specifically detailed below, every 3-6 months for 3-5 years then at least annually.
    - High grade glioma/Glioblastoma – 2-8 weeks after radiation therapy, then every 2-4 months for 3 years, then every 3-6 months indefinitely
    - Ependymoma – every 3-4 months for 1 year, every 4-6 months for 1 year, every 6-12 months for 5-10 years, then as clinically indicated
    - Medulloblastoma – every 3 months for 1 year, every 6-12 months for 5-10 years, then as clinically indicated.
    - Meningioma – every 2-4 months for 3 years then every 3-6 months indefinitely
- Primary CNS lymphoma every 3 months for 2 years, every 6 months for 3 years, then annually [40]

- Histiocytic neoplasms (Langerhans cell histiocytosis, Rosai-Dorfman, Erdheim-Chester) every 3-6 months for 2 years then no more than annually [53]

Seizure Disorders

Evaluation of Known or Suspected Seizure Disorder [54–60]

- New onset of an unprovoked seizure
- Newly identified change in seizure activity/pattern
- Known seizure disorder without previous imaging
- Medically refractory epilepsy
- New onset afebrile seizures in children except for benign epilepsy syndromes
- Complex febrile seizures in children accompanied by ANY of the following [54,56]:
  - Abnormal neurologic exam
  - Autism, cerebral palsy or developmental delay (**see Background**)
  - Focal onset
  - Post-ictal Todd's paralysis (when a seizure is followed by a brief period of temporary paralysis)
  - Recurrent in 24 hours
  - Duration > 15 minutes
  - Abnormal EEG

Note: Advanced imaging is not indicated for simple pediatric febrile seizures

Note: Advanced imaging is not indicated for pediatric benign epilepsy syndromes/idiopathic focal or generalized epilepsy with typical features such as: Childhood absence epilepsy (JAE), Benign epilepsy with centrotemporal spikes (BECTS) also known as Benign Rolandic Epilepsy (BRE), Juvenile absence epilepsy (JAE), Juvenile myoclonic epilepsy (JME), benign epilepsy childhood with centrotemporal spikes (BECCT)

Multiple Sclerosis

Evaluation of Suspected Multiple Sclerosis [61,62]

- For evaluation of a patient with neurologic symptoms or deficits suspicious for MS with
  - A clinically isolated syndrome (optic neuritis, transverse myelitis, or brain stem syndrome); **OR**
  - Recurrent episodes of variable neurological signs or symptoms not attributable to another cause
- To demonstrate dissemination in time for diagnosis (every 6-12 months)

Evaluation of Known Multiple Sclerosis [62,63]

- To establish a new baseline (no recent imaging, postpartum))
- Prior to starting or switching disease-modifying therapy
- 3-6 months after starting/changing treatment
- Every 6-12 months until stable on disease-modifying treatment
- Once stable on disease-modifying treatment, every 1-2 years to assess for subclinical disease activity, less frequently when stable for 2-3 years
- 6-month repeat scan in patients with disease activity on MRI that is not associated with new clinical symptoms on a routine follow-up scan (i.e., Radiographically isolated syndrome)
- New signs or symptoms suggested of an exacerbation or unexpected clinical worsening
- In the pediatric population, increase frequency of imaging in children with highly active disease or in situations where imaging will change management
- Progressive Multifocal Leukoencephalopathy (PML) surveillance for MS patients on natalizumab (Tysabri) [64]
    - 12 months after the start of treatment in all patients
    - Further surveillance MRI scanning timing is based on risk of PML occurrence
        - Annually, if low risk (anti-JCV antibody negative)
        - Every 3-4 months, if high risk with ANY of the following:
            - seropositive for JC virus and have been treated with natalizumab for ≥18 months
            - high anti-JC virus antibody index values (>0.9)
            - previously treated with immunosuppressive therapies
    - Brain MRI every 3–4 months for up to 12 months, in high-risk patients who switch from natalizumab to other therapeutics

Infection and Inflammation

Evaluation of Known or Suspected Infection or Inflammatory Disease

- Suspected intracranial abscess or brain infection with acute altered mental status or with positive lab findings (such as elevated WBCs) **OR** follow-up assessment during or after treatment completed
- Meningitis with positive signs and symptoms (such as fever, headache, mental status changes, stiff neck) **OR** with positive lab findings (such as elevated white blood cells or abnormal lumbar puncture fluid exam) [65,66]
- Suspected encephalitis with headache and altered mental status or follow-up as clinically warranted

- Endocarditis with suspected septic emboli [67]
- Suspected Giant Cell (temporal arteritis) in a patient ≥ 50 with temporal headache, abrupt visual changes, jaw claudication, temporal artery tenderness, constitutional symptoms or elevated ESR [68–71]; **AND**
    - Negative initial work-up (color Doppler ultrasonography or biopsy); **OR**
    - Atypical features, failure to respond to treatment or concern for intracranial involvement

  Note: Protocol should include high-resolution contrast-enhanced imaging the temporal artery
- Vasculitis
    - Central Nervous System (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease with abnormal inflammatory markers or autoimmune antibodies
    - Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up [18,72,73]

  Note: Vessel wall MRI (ordered as Brain MRI) can also be performed in the evaluation of vasculitides [74]
- Immunocompromised patient (e.g., transplant recipients, HIV with CD4<200, primary immunodeficiency syndromes, hematologic malignancies) with focal neurologic symptoms, headaches, behavioral, cognitive or personality changes
- Progressive Multifocal Leukoencephalopathy (PML) [75,76]
    - Suspected in an immunocompromised patient with one of the following:
        - Neurologic symptoms
        - Positive JC virus
    - Known PML follow up as clinically indicated
- Neurosarcoidosis [77,78]
    - Initial Evaluation:
        - Suspected based on neurological sign/symptoms and lab work (ACE, CSF analysis) **OR**
        - Known history of sarcoidosis with neurological signs or symptoms
    - Follow-up of known neurosarcoidosis:
        - To assess treatment response
        - Worsening signs or symptoms

Cognitive Impairment and Dementia

Evaluation of Cognitive Impairment [79–81]

- Evaluation for mild cognitive impairment or dementia with all of the following:
  - Objective measures demonstrate impairment (MMSE/MoCA < 26 or other mental status instruments (see **Background**) or mild cognitive impairment on neuropsychological testing)
  - Full lab evaluation (thyroid function tests, CBC, CMP, and B12) has been completed and if abnormal, has been treated and the cognitive difficulty persists

Treatment of Alzheimer's Disease [82,83]

- Baseline and surveillance imaging for anti-amyloid-β monoclonal antibody treatment as per FDA labeling

Movement Disorders [15,84–86]

Evaluation of Movement Disorders

- For evaluation of acute onset of a movement disorder with concern for stroke or hemorrhage
- For evaluation of suspected Parkinson's with atypical features or unresponsive to levodopa

Note: Atypical parkinsonian syndromes include progressive supranuclear palsy (PSP), multiple system atrophy (MSA), corticobasal degeneration (CBD), and dementia with Lewy bodies.

- For evaluation of new non-Parkinson neurological symptoms in known Parkinson's disease complicating the evaluation of the current condition
- For the evaluation of other movement disorders to exclude a structural lesion (i.e., suspected Huntington disease, chorea, hemiballismus, atypical dystonia)

Note: MRI not indicated in essential tremor, Tourette' syndrome, or isolated focal dystonia (e.g., blepharospasm, cervical dystonia, laryngeal dystonia, oromandibular dystonia, writer's dystonia) [86,87]

Cranial Nerve and Vision Abnormalities

Vision Abnormalities

For evaluation of cranial nerve and visual abnormalities

- Suspected Optic neuritis [13]
- Abnormal eye findings on physical or neurologic examination that suggest CNS pathology (such as papilledema, pathologic nystagmus, optic atrophy, ocular nerve palsies, new onset anisocoria, visual field deficits)

NOTE: Advanced imaging is indicated for transient visual loss with a history consistent with transient ischemic attack (TIA) even if there is a normal exam at time of examination

- Binocular diplopia with concern for CNS pathology after comprehensive eye evaluation [88]

NOTE: Subjective symptoms such as blurred vision or double vision with no clear correlation on neurological examination requires a comprehensive eye evaluation to exclude more common causes, such as cataracts, refractive errors, retinopathy, glaucoma, or macular degeneration.

- Strabismus with neurological symptoms or signs, development delay, and/or an abnormal fundoscopic exam to rule out intracranial abnormalities [89]
- Horner's syndrome with signs/symptoms localizing the lesion to the brain (vertigo, altered facial sensation, contralateral CN IV palsy, crossed motor/sensory signs) [90,91]

Other Cranial Nerve Disorders [92]

- Advanced imaging for anosmia (CN I) (complete loss of smell), hyposmia (reduced sense of smell) or dysosmia (abnormal sense of smell) is indicated with ALL of the following [93]:
    - Persistent symptoms (generally considered to be 4 weeks or more)
    - Unknown origin (if related to rhinosinusitis, the indication for advanced imaging should meet the specific rhinosinusitis criteria)
    - Nasal endoscopy completed with indeterminate or abnormal findings OR nasal endoscopy documented as unavailable

    NOTE: Advanced imaging for suspected olfactory disorders requires imaging the entire olfactory system. This can be accomplished with either an MRI of the Face or an MRI of the Brain depending on the institutional-specific MRI protocol.
- Trigeminal (CN V) neuralgia or neuropathy [1]
- Occipital Neuralgia with atypical features (such as burning versus stabbing pain, referred pain to the face/ear, tinnitus, visual disturbances) to exclude a structural lesion [94]
- Facial Nerve Paresis / Bell's Palsy (CN VII) with atypical features (such as bilateral involvement, multiple episodes, slow resolution beyond three weeks, incomplete/no improvement at three months, or facial twitching/spasms prior to onset) [92,95–97]
- Hemifacial spasm (CN VII)
- Clinical evidence of cranial nerve (CN IX, X, XI, and/or XII) deficits or dysfunction (such as dysphagia, shoulder/neck movement abnormalities, tongue movement abnormalities, vocal fold movement or sensation abnormalities) [92]
- Bulbar symptoms, (such as difficulty in chewing, dysarthria, dysphagia, and dysphonia) and/or bulbar signs (such as atrophy and fasciculations of the tongue, weakness of the facial muscles, palatal weakness, absent gag reflex) [92]
- Pseudobulbar symptoms (such as dysphagia, dysarthria, sudden stereotyped emotional

outbursts that are not reflective of mood) and/or pseudobulbar signs (such as spastic tongue, facial weakness, exaggerated gag/jaw jerk) [92]

Congenital Abnormalities

Evaluation of Known or Suspected Congenital Abnormalities

- Known or suspected congenital abnormality with any acute, new, or fluctuating neurologic, motor, or mental status changes
- Evaluation of macrocephaly in an infant/child <18 with previously abnormal US, abnormal neurodevelopmental examination, signs of increased ICP or closed anterior fontanelle [98]
- Evaluation of microcephaly in an infant/child < 18 [99]
- Evaluation of craniosynostosis and other skull deformities. CT is preferred imaging to assess bony structures; MRI imaging is preferred to assess intracranial soft tissue [100]
- Cerebral palsy and ONE of the following:
  - Etiology has not been established in the neonatal period
  - There is change in the expected clinical or developmental profile or concern for progressive neurological disorder (see **Background**) [101]
- Prior treatment **OR** treatment planned for congenital abnormality

Note: For evaluation of known or suspected hydrocephalus please see section on CSF abnormalities, below.

Cerebrospinal Fluid (CSF) Abnormalities

Evaluation of Known or Suspected CSF Abnormalities

- Evaluation of suspected hydrocephalus with any acute, new, or fluctuating neurologic, motor, or mental status changes [102]
- Follow up of known hydrocephalus with new symptoms or to plan/monitor treatment [102]
- For initial evaluation of a suspected Arnold Chiari malformation [103]
- Follow-up imaging of a known type II or type III Arnold Chiari malformation. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms [103,104]
- Known syrinx or syringomyelia
- Known or suspected normal pressure hydrocephalus (NPH) [105]
  - With symptoms of gait difficulty, cognitive disturbance, and/or urinary incontinence
- Follow-up shunt evaluation and ONE of the following [102]:
  - Baseline imaging following placement or revision
  - 6-12 months after placement or revision

- Clinical concern for shunt malfunction

- Evaluation of known or suspected cerebrospinal fluid (CSF) leakage [106]
- Cisternography for intermittent and complex CSF rhinorrhea/otorrhea. CSF fluid should always be confirmed with laboratory testing (Beta-2 transferrin assay) [106,107]
- Suspected spontaneous intra-cranial hypotension with distinct postural headache (other symptoms include nausea, vomiting, dizziness, tinnitus, diplopia, neck pain or imbalance) [1,108]
- CSF flow study for evaluation and management of CSF flow disorders [109,110]

Other Indications

- Vertigo associated with any ONE of the following [14,111]
  - Signs or symptoms suggestive of a possible CNS lesion (such as a positive HINTS test, ataxia, dysarthria, visual loss, double vision, weakness, mental status change, hearing loss, tinnitus or a change in sensation)
  - Progressive unilateral/asymmetric hearing loss and/or tinnitus
  - Concern for stroke with known risk factors for cerebrovascular disease (such as hypertension, smoking, obesity, hypercholesterolemia)
  - Concern for central vertigo (source within the CNS) based on findings on neurologic examination and/or vestibular testing (such as skew deviation, vertical nystagmus, head thrust test, and/or videonystagmography (VNG) / electronystagmography (ENG) testing results suggesting a likely CNS etiology)

  NOTE: "Vertigo" is the sensation that a person or their surroundings are moving. There are many vague, nonspecific terms that are often used instead including "dizzy", "light-headed", "woozy", "groggy", or "giddy". The reviewer should examine the record to determine if the patient is experiencing vertigo or another condition (such as presyncope, ataxia, anxiety, arrhythmia). If it is not clear what condition is being described, clarification should be requested.
- Diagnosis of central sleep apnea on polysomnogram
  - Children > 1 year [112]
  - Adults in the absence of heart failure, chronic opioid use, high altitude, or treatment emergent central sleep apnea **AND** concern for a central neurological cause (Chiari malformation, tumor, infectious/inflammatory disease) **OR** with an abnormal neurological exam [113]
- Syncope with documented clinical concern for seizure or associated neurological signs or symptoms [114]
- Cyclical vomiting syndrome or abdominal migraine with any localizing neurological symptoms [115,116]
- Psychological changes with neurological deficits on exam or after completion of a full neurological assessment that suggests a possible neurologic cause [117]

- Child < 18 years with global developmental delay (see **Background**) **OR** a developmental delay with abnormal neurological examination or abnormal EEG [118]

Note: MRI is not recommended as a part of routine evaluation in children with autism spectrum disorder and no other neurologic findings [119]

- Unexplained event (BRUE) formerly apparent life-threatening event (ALTE) in infants < 1 year with concern for neurological cause based on history and exam [120]

Note: Imaging is not indicated in low-risk patients

- Bone Marrow Transplant (BMT) [121]
  - For initial workup of BMT (along with CT Chest, CT Sinus and CT Abdomen and Pelvis)
- Opsoclonus-myoclonus-ataxia syndrome [122]
  - At diagnosis
  - As clinically indicated

MR Perfusion Imaging [123–125]

- Neurovascular disease
  - Assessment of ischemic penumbra in acute stroke
  - Assessment of cerebrovascular reserve
  - Further evaluation of known vascular abnormality (stenosis, malformation, vasospasm, vasculitis, Moya-Moya)
- Mass lesions
  - Differentiating tumor from tumor mimic
  - Differentiating glioblastoma from brain metastasis
  - Discriminating low- from high-grade gliomas
  - Differentiating recurrent brain tumors from radiation/chemo necrosis
  - Surgical planning

MRI Brain with Internal Auditory Canal (IAC)

(If only images of the IACs is needed without Brain imaging see Evolent Clinical Guideline 2048 for Sinus, Face, Orbit, Neck and Internal Auditory Canal MRI)

- Asymmetric/Unilateral sensorineural hearing loss documented on audiogram [11]
- Congenital hearing loss (unilateral or bilateral, conductive or sensorineural)

NOTE: "Congenital" refers to a condition, trait, or exposure that is present at birth that is due to genetic factors, non-genetic factors, or a combination of both. However, hearing loss can be mild initially and progress over time after birth, so the diagnosis of congenital hearing loss is not necessarily limited to young children only

- Pulsatile tinnitus (unilateral or bilateral) [126]
- Non-pulsatile, unilateral or asymmetric tinnitus
- Suspected auditory neuropathy
- Suspected acoustic neuroma (Schwannoma) or cerebellar pontine angle tumor based on clinical signs and symptoms (such as unilateral/asymmetric sensorineural loss, vertigo, disturbed balance or gait, unilateral/asymmetric tinnitus, facial weakness, or altered sense of taste) [127]
- Advanced imaging is indicated for peripheral vertigo (source within the temporal bone) with ALL of the following:
    - Clinical evidence of a peripheral source of vertigo (such as head-Impulse with saccade, spontaneous unidirectional horizontal nystagmus, positive Dix-Hallpike maneuver, Electronystagmography (ENG) testing and/or rotary chair testing indicating peripheral vertigo)
    - Persistent symptoms after a trial of pharmacotherapy (such as meclizine, diazepam) AND four weeks or more of vestibular therapy (such as Epley's maneuvers, vestibular rehabilitation)
- Suspected necrotizing otitis externa (formally known as malignant otitis externa) particularly in high-risk populations (such as immunocompromised, poorly controlled diabetes, prior radiation therapy) [128]
- Clinical suspicion of a complication of acute otitis media including any ONE of the following [129,130]:
    - Systemic illness or toxic appearance
    - Signs/symptoms of possible intracranial complications (such as headache, tinnitus, vertigo, nystagmus)
- Known OR suspected cholesteatoma (abnormal growth of epithelial tissue within the middle ear) [131]
- Suspected glomus tumor
- MRI IAC imaging for possible CSF otorrhea (or secondary CSF rhinorrhea via the eustachian tube) is indicated with any ONE of the following [107,132]:
    - High index of suspicion of CSF leak based on clinical evidence (such as persistent leaking, worse leaking with provocative maneuvers (Valsalva), positive Beta-2 transferrin assay of the leakage)
    - Prior imaging (such as CT, nuclear medicine imaging) suggesting bony defect/lesion contributing to suspected/known CSF leak
- Facial Nerve Paresis / Bell's Palsy (CN VII) with atypical features (such as bilateral involvement, multiple episodes, slow resolution beyond three weeks, incomplete/no improvement at three months, or facial twitching/spasms prior to onset) [95,96]

PREOPERATIVE OR POSTOPERATIVE ASSESSMENT

When not otherwise specified in the guideline:

Preoperative Evaluation:

- Imaging of the area requested is needed to develop a surgical plan

Postoperative Evaluation:

- Known or suspected complications
- A clinical reason is provided how imaging may change management

NOTE: This section applies only within the first few months following surgery

FURTHER EVALUATION OF INDETERMINATE FINDINGS ON PRIOR IMAGING

Unless follow up is otherwise specified within the guideline:

- For initial evaluation of an inconclusive finding on a prior imaging report that requires further clarification
- One follow-up exam of a prior indeterminate MR/CT finding to ensure no suspicious interval change has occurred. (No further surveillance unless specified as highly suspicious or change was found on last follow-up exam)

IMAGING IN KNOWN GENETIC CONDITIONS

- Achondroplasia [133]:
  - Once (to evaluate the corticomedullary junction; typically done in infancy)
- Beckwith-Wiedemann syndrome [134]:
  - At diagnosis if significant developmental delay is present
- Constitutional mismatch repair deficiency syndrome (CMMRD) [135]:
  - Every 6 months
- Fabrys Disease [136]:
  - Every 2 years (including at diagnosis) starting at age 18 OR
  - More frequently if symptomatic
- FAP (Familial Adenomatous Polyposis) [137]:
  - As clinically indicated
- Hemochromatosis [138]:

- As clinically indicated

- Heritable Retinoblastoma (RB1) [139,140]:
  - Every 6 months
- Li Fraumeni (TP53) [141,142]:
  - Annually
- LZTR1-related Schwannomatosis [143]:
  - Every 2 years starting at age 12
- Multiple Endocrine Neoplasia type 1 (MEN1) [27,144]:
  - Every 3 years starting at age 5
- Neurofibromatosis 1 (NF1) [145,146]:
  - New subjective or objective neurologic or cognitive concerns (including vision changes, growth changes, TIA or headaches)
- NF2-Related Schwannomatosis [147]:
  - Annually beginning at age 10
- Capillary Malformation-Arteriovenous Malformation Syndrome (e.g., Sturge Weber Syndrome) [148]:
  - Once at diagnosis
  - Repeat imaging only if symptomatic
- Sickle Cell Disease [149,150]:
  - When needed to screen for silent stroke
  - Abnormal Transcranial Doppler Velocity > 200 cm/s
  - New neurologic or cognitive concerns (including TIA, no formal testing required)
  - When cessation or changing frequency of transfusions is under consideration
- SMARCA4 and SMARCB1 (Includes SMARCB1-associated Schwannomatosis and Rhabdoid Tumor Predisposition Syndrome) [143,151]:
  - At diagnosis
  - Monthly from age 0-6 months
  - Every 2 months from age 7-18 months
  - Every 3 months from age 19 months – 5 years
  - Annually after age 5
- Tuberous Sclerosis [152]:
  - Annually
- Von Hippel-Lindau (VHL) [153]:

- At diagnosis (including IAC) then annually starting at age 11

- X-linked Adrenoleukodystrophy [154]:
  - Every 6 months until age 12
  - Annually after age 12

- For other genetic syndromes not otherwise addressed in the guideline, coverage is based on a case-by-case basis using societal guidance

Combination Studies for Imaging in Known Genetic Conditions

NOTE: When medical necessity is met for an individual study **AND** conscious sedation is required (such as for young pediatric patients or patients with significant developmental delay), the entire combination is indicated

Brain MRI and Brain MRA

- Fabrys Disease [136]:
  - Every 2 years (including at diagnosis) starting at age 18 OR
  - More frequently if symptomatic

- Sickle Cell Disease [149,150]:
  - When needed to screen for silent stroke
  - Abnormal Transcranial Doppler Velocity > 200 cm/s
  - New neurologic or cognitive concerns (including TIA, no formal testing required)
  - When cessation or changing frequency of transfusions is under consideration

Brain/Breast/Whole Body MRI

- Li-Fraumeni (TP53) [142]:
  - Annually
  - NOTE: Can include Abdomen MRI if meets family history requirement. Additional imaging may be needed based on patient-specific factors

Chest CT and Brain/Abdomen/Pelvis MRI

- Multiple Endocrine Neoplasia type 1 (MEN1) [27,144]:
  - Annually starting at age 8
  - NOTE: Every 3 years include Brain MRI

Brain/Cervical Spine/Thoracic Spine/Lumbar Spine MRI

- LZTR1-related Schwannomatosis [143]:

- Every 2 years starting at age 12

- Neurofibromatosis 1 (NF1) [145,146]:
  - Signs and symptoms concerning for brain or spinal tumor

Brain/Cervical Spine/Thoracic Spine/Lumbar Spine/Whole Body MRI

- SMARCA4 and SMARCB1 (Includes SMARCB1-associated Schwannomatosis and Rhabdoid Tumor Predisposition Syndrome) [143,151]:
  - At diagnosis
  - Monthly from age 0-6 months
  - Every 2 months from age 7-18 months
  - Every 3 months from age 19 months – 5 years
  - Annually after age 5

Brain/Cervical Spine/Thoracic Spine/Lumbar Spine/Abdomen MRI

- Von Hippel-Lindau (VHL) [153]:
  - Annually (including at diagnosis) starting at age 11

OTHER COMBINATION STUDIES WITH BRAIN MRI

These body regions might be evaluated separately or in combination as documented in the clinical notes by physical examination findings (e.g., localization to a particular segment of the neuroaxis), patient history, and other available information, including prior imaging.

NOTE: When medical necessity is met for an individual study **AND** conscious sedation is required (such as for young pediatric patients or patients with significant developmental delay), the entire combination is indicated

Brain MRI and Brain MRA

- Recent ischemic stroke or transient ischemic attack (TIA) [16,155]
- Thunderclap headache with continued concern for underlying vascular abnormality (i.e., aneurysm or reversible cerebral vasoconstriction syndrome) after initial negative brain imaging [1,2,8,156]
  - **Note:** Negative brain CT < 6 hours after headache onset excludes subarachnoid hemorrhage in neurologically intact patients. [156] MRI lacks sensitivity in excluding subarachnoid hemorrhage less than 24 hours after headache onset. [2,157]
- Acute, sudden onset of headache with personal history of a vascular abnormality or first-degree family history of aneurysm [1,18]
- Headache associated with exercise, exertion, or sexual activity [2]

- Suspected central venous thrombosis and ANY ONE of the following [16]:
  - Patient has a hypercoagulable state such as pregnancy, post-partum, prothrombotic conditions (acquired or genetic), malignancy, oral contraceptive use, recent infection, recent trauma or Covid-19
  - Documentation of concern for central venous thrombosis is specified
  - Papilledema or signs/symptoms of increased intracranial pressure
- See **Imaging in Known Genetic Conditions** for additional indications
- Known Moyamoya disease [17,158] or reversible cerebral vasoconstriction with any new or changing neurological signs or symptoms [1,159]
- Suspected secondary CNS vasculitis based on neurological signs or symptoms in the setting of an underlying systemic disease with abnormal inflammatory markers or autoimmune antibodies [18]
- Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up [18,73,160]
- Giant cell arteritis with suspected intracranial involvement [68,70]

Brain MRI and Brain/Neck MRA [16,17]

- Recent ischemic stroke or transient ischemic attack (TIA) [16,155]
- History of stroke and **ONE** of the following:
  - No prior workup
  - New neurologic signs or symptoms
- Suspected carotid or vertebral artery dissection with focal or lateralizing neurological deficits
- Pulsatile tinnitus with concern for a suspected arterial vascular and/or intracranial etiology [127,161,162]
  - **NOTE:** For the indication of pulsatile tinnitus the Brain MRI of the combination should include the Internal Auditory Canal (IAC)
- Giant cell arteritis with suspected intracranial and extracranial involvement [69]

Note: CTA and MRA are generally comparable noninvasive imaging alternatives, each with their own advantages and disadvantages. Brain MRI can be combined with Brain CTA/Neck CTA

Brain/Cervical Spine MRI

- Horner's syndrome with symptoms localizing the lesion to the brain and cervical spine (vertigo, altered facial sensation, contralateral CN IV palsy, crossed motor/sensory signs, radicular signs) [91,163]

Brain/Cervical Spine/Thoracic Spine MRI

- Combination studies for MS: These body regions might be evaluated separately or in combination as guided by physical examination findings (e.g., localization to a particular segment of the spinal cord), patient history (e.g., symptom(s), time course, and where in the CNS the likely localization(s) is/are), and other available information, including prior imaging.
    - For evaluation of neuromyelitis optica spectrum disorders (recurrent or bilateral optic neuritis; recurrent transverse myelitis) [13]
    - For known MS, prior to the initiation or change of disease modification treatments and assess disease burden (to establish a new baseline) [62,164]
    - Follow-up scans, including brain and spine imaging, if patients have known spine disease [62]:
        - 3-6 months after starting/changing treatment
        - Every 6-12 months until stable on disease modifying therapy
        - Once stable on disease modifying treatment, every 1-2 years to assess for subclinical disease activity, less frequently when stable for 2-3 years.

Brain/Cervical Spine/Thoracic Spine/Lumbar Spine MRI

- For initial evaluation of a suspected Arnold Chiari malformation
- Follow-up imaging of a known type II or type III Arnold Chiari malformation. For Arnold Chiari type I, follow-up imaging only if new or changing signs/symptoms [103,109,165,166]
- Oncological Applications (e.g., primary nervous system, metastatic) [40]
    - Drop metastasis from brain or spine
    - Suspected leptomeningeal carcinomatosis [167]
    - Known tumor evaluation and monitoring in neurocutaneous syndromes
- CSF leak highly suspected and supported by patient history and/or physical exam findings (e.g., known or suspected spontaneous (idiopathic) intracranial hypotension (SIH), post lumbar puncture headache, post spinal surgery headache, orthostatic headache, rhinorrhea or otorrhea, or cerebrospinal-venous fistula) [168]
- Tumor evaluation and monitoring in cancer predisposition syndromes

Brain/Face/Sinus MRI

- Granulomatosis with polyangiitis (Wegener's granulomatosis) disease [169]
- Trigeminal neuralgia or neuropathy with an atypical presentation (for evaluation of the extracranial nerve course) [92]
- For approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent

intracranial pathology [170]

Brain/Orbit MRI

- Optic neuropathy or unilateral optic disk swelling of unclear etiology to distinguish between a compressive lesion of the optic nerve, optic neuritis, ischemic optic neuropathy (arteritic or non-arteritic), central retinal vein occlusion or optic nerve infiltrative disorders [13,171]
- Bilateral optic disk swelling (papilledema) with visual loss [13]
- Optic neuritis
    - If atypical presentation (bilateral, absence of pain, optic nerve hemorrhages, severe visual impairment, lack of response to steroids, poor recovery or recurrence) [13,172]
    - If needed to confirm optic neuritis and rule out compressive lesions
- Known or suspected neuromyelitis optica spectrum disorder with severe, recurrent, or bilateral optic neuritis [13]
- Suspected retinoblastoma [13]
- For approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology [170]

Neck/Brain MRI

- Objective cranial nerve palsy (CN IX-XII) (for evaluation of the extracranial nerve course) [92]
- Bell's Palsy/hemifacial spasm that meets the above criteria [92]
- For approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology [170]

Sinus/Chest/Abdomen and Pelvis CT and Brain MRI

- Prior to Bone Marrow Transplantation

Combination Studies for Malignancy for Initial Staging or Restaging

Unless otherwise specified in this guideline, indication for combination studies for malignancy for initial staging or restaging:

- Concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Abdomen, Brain, Chest, Neck, Pelvis, Cervical Spine, Thoracic Spine or Lumbar Spine.

CODING AND STANDARDS

Codes

70551, 70552, 70553, +0698T

Applicable Lines of Business

☒	CHIP (Children's Health Insurance Program)
☒	Commercial
☒	Exchange/Marketplace
☒	Medicaid
☒	Medicare Advantage

BACKGROUND

Contraindications and Preferred Studies

- Contraindications and reasons why a CT/CTA cannot be performed may include: impaired renal function, significant allergy to IV contrast, pregnancy (depending on trimester).
- Contraindications and reasons why an MRI/MRA cannot be performed may include: impaired renal function, claustrophobia, non-MRI compatible devices (such as non-compatible defibrillator or pacemaker), metallic fragments in a high-risk location, patient exceeds weight limit/dimensions of MRI machine.

Computed Tomography (CT) versus Magnetic Resonance Imaging (MRI)

Generally, magnetic resonance imaging is the preferred imaging technique for evaluating the brain parenchyma, and CT is preferable for evaluating subarachnoid hemorrhage. CT is faster and more readily available than MRI and is often used in urgent clinical situations.

Memory Status Instruments

Cut off values for cognitive impairment

Mini-Cog < 3

Memory Impairment Screen < 5

Saint Louis University Mental Status Examination (SLUMS)

- High school education <27
- Less than high school education <25

Brief Alzheimer's Screen (BAS) <24

Blessed Dementia Scale (BDS) >3

Clinical Dementia Rating

- Sum of boxes score > or equal to 4.5 or
- Global score greater than or equal to 1

Montreal Cognitive Assessment (MoCA) < 26

Mini-Mental Status Exam (MMSE) < 26

Table 1: Gait and Brain Imaging [173–176]

Gait	Characteristic	Work up/Imaging
Hemiparetic	Spastic unilateral, circumduction	Brain and/or, Cervical spine imaging based on associated symptoms
Diplegic	Spastic bilateral, circumduction	Brain, Cervical and Thoracic Spine imaging
Myelopathic	Wide based, stiff, unsteady	Cervical and/or Thoracic spine MRI based on associated symptoms
Ataxic	Broad based, clumsy, staggering, lack of coordination, usually also with limb ataxia	Brain imaging
Apraxic	Magnetic, shuffling, difficulty initiating	Brain imaging
Parkinsonian	Stooped, small steps, rigid, turning en bloc, decreased arm swing	Brain Imaging
Choreiform	Irregular, jerky, involuntary movements	Medication review, consider brain imaging as per movement disorder Brain MR guidelines
Sensory ataxic	Cautious, stomping, worsening without visual input (i.e., + Romberg)	EMG, blood work, consider spinal (cervical or thoracic cord imaging) imaging based on EMG
Neuropathic	Steppage, dragging of toes	EMG, if there is foot drop, Lumbar spine MRI Pelvis MR appropriate evidence of

Gait	Characteristic	Work up/Imaging
		plexopathy
Vestibular	Insecure, veer to one side, worse when eyes closed, vertigo	Consider Brain/IAC MRI as per GL

Non-neurological causes of gait dysfunction include pain (antalgic), side effects of drugs (analgesic, antihistamines, benzos, psych meds, antihypertensives), visual loss, hearing impairment, orthopedic disorders, rheumatologic disorders, psychogenic, and cardiorespiratory problems (orthostasis). [173–176]

MRI and developmental delay

Significant developmental delay is defined as significant delay (more than two standard deviations below the mean) in one or more developmental domains: gross/fine motor, speech/language, cognition, social/personal, and activities of daily living. Isolated delay in social/language development is characteristic of autism spectrum disorders or hearing loss. Isolated delay in motor development is characteristic of cerebral palsy (a static encephalopathy) or myopathy. Global developmental delay (GDD) is a subset of developmental delay defined as significant delay (by at least 2 SD's) in two or more developmental categories. Note that the term "GDD" is usually reserved for children <5 years old, whereas in older children >5 years, disability is quantifiable with IQ testing.

Low risk brief resolved unexplained event (BRUE) formerly apparent life-threatening event (ALTE) requires all the following:

- Age > 60 days
- Gestational age ≥ 32 weeks or older and corrected gestational age ≥ 45 weeks
- First brief event
- Event lasting < 1 minute
- No CPR required by the trained medical provider
- No concerning historical features or physical examination findings

SUMMARY OF EVIDENCE

ACR Appropriateness Criteria® Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage [18]

Study Design: The study design involves a detailed literature review and expert panel recommendations to establish imaging guidelines for various cerebrovascular conditions. The criteria are based on the latest evidence and expert consensus to ensure appropriate imaging procedures are selected for different clinical scenarios.

Target Population: The target population includes patients with cerebrovascular diseases such as aneurysms, vascular malformations, and SAH. Specific variants address different clinical

presentations, including known acute SAH, suspected cerebral vasospasm, untreated cerebral aneurysms, previously treated cerebral aneurysms, high-risk cerebral aneurysm screening, known high-flow vascular malformations, and suspected CNS vasculitis.

Key Factors:

Imaging Recommendations: The document outlines the appropriateness of various imaging modalities, including arteriography, CTA, MRA, MRI, and ultrasound, for different clinical scenarios. Each variant provides specific recommendations based on the clinical presentation and the relative radiation level associated with each imaging procedure.

Clinical Presentations: The criteria cover a wide range of clinical presentations, from acute SAH to surveillance monitoring of untreated and treated aneurysms, as well as screening for high-risk populations and evaluation of suspected CNS vasculitis.

Expert Panel: The recommendations are developed by an expert panel on neurological imaging, including specialists from various institutions and organizations. The panel's collaboration ensures a comprehensive and well-rounded approach to imaging guidelines.

Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition [(2)]

Study Design: The ICHD-3 is a systematic classification of headache disorders based on extensive research and clinical studies. The classification is hierarchical, allowing for detailed diagnosis from the first-digit level to the fifth. The criteria for each headache type are based on clinical features, diagnostic criteria, and evidence from field-testing studies.

Target Population: The target population includes individuals experiencing various types of headaches, ranging from primary headaches like migraines and tension-type headaches to secondary headaches attributed to other disorders. The classification is intended for use by healthcare professionals, including neurologists, general practitioners, and researchers, to diagnose and manage headache disorders.

Key Factors:

Primary Headaches: The document classifies primary headaches into categories such as migraines, tension-type headaches, and trigeminal autonomic cephalalgias. Each category includes specific diagnostic criteria, clinical features, and comments on pathophysiology and treatment.

Secondary Headaches: These are headaches attributed to other disorders, such as trauma, vascular disorders, infections, and psychiatric disorders. The classification provides criteria for diagnosing secondary headaches based on the temporal relationship between the headache and the underlying disorder.

Diagnostic Criteria: The criteria for each headache type include the number of attacks, duration, pain characteristics, associated symptoms, and exclusion of other diagnoses. For example, migraine without aura requires at least five attacks lasting 4-72 hours with specific pain characteristics and associated symptoms like nausea and photophobia.

Field Testing: The classification includes results from field-testing studies that validate the diagnostic criteria. These studies involve large populations and use advanced diagnostic methods like neuroimaging and genetic testing.

Clinical and Research Applications: The ICHD-3 is designed for both clinical practice and research. It helps clinicians diagnose and manage headache disorders and provides a standardized framework for researchers to study headache epidemiology, pathophysiology, and treatment.

ACR Appropriateness Criteria® Cerebrovascular Diseases-Stroke and Stroke-Related Conditions [16]

Study Design: The document is a guideline developed by the American College of Radiology (ACR) Appropriateness Criteria Expert Panel on Neurological Imaging. It is based on a systematic analysis of medical literature from peer-reviewed journals and follows established methodology principles such as the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) and the RAND/UCLA Appropriateness Method.

Target Population: The guidelines are intended for use by radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment for patients with cerebrovascular diseases, including stroke and stroke-related conditions.

Key Factors:

Conditions Covered: The guidelines encompass a wide range of cerebrovascular diseases, including carotid stenosis, carotid dissection, intracranial large vessel occlusion, and cerebral venous sinus thrombosis. They also address complications such as intraparenchymal hemorrhage and completed ischemic strokes.

Imaging Recommendations: The document provides evidence-based guidelines for appropriate imaging examinations for diagnosis and treatment of specified medical conditions. It includes recommendations for various imaging modalities such as CT, MRI, MRA, and ultrasound.

Clinical Scenarios: The guidelines cover different clinical scenarios, including transient ischemic attack (TIA), acute ischemic stroke, recent ischemic infarct, and known intraparenchymal hemorrhage, among others.

Methodology: The guideline development and revision process involves a multidisciplinary expert panel and supports the systematic analysis of medical literature. In instances where peer-reviewed literature is lacking or equivocal, expert opinions are used to formulate recommendations.

ANALYSIS OF EVIDENCE

Shared Conclusions [2,16,18]**:**

1. **Diagnostic Imaging**: All three articles emphasize the importance of diagnostic imaging in identifying and managing cerebrovascular conditions. They discuss various imaging

modalities such as CT, MRI, MRA, and CTA, highlighting their roles in diagnosing conditions like stroke, aneurysms, and vascular malformations.

2. **Clinical Guidelines**: The articles provide clinical guidelines for the management of cerebrovascular diseases. They stress the need for evidence-based approaches and the use of standardized criteria to ensure accurate diagnosis and effective treatment.
3. **Risk Factors**: Each article discusses the risk factors associated with cerebrovascular diseases, including hypertension, smoking, and genetic predispositions. They highlight the importance of identifying these risk factors to prevent and manage conditions effectively.

POLICY HISTORY

Date	Summary
July 2025	• Edited the policy history for June 2025 to better reflect the changes that were presented at committee. No clinical changes

June 2025	• Guideline name changed from Brain MRI to Brain Magnetic Resonance Imaging (MRI) With or Without Internal Auditory Canal (IAC) Views
	• Guideline number changed from 001 to 2012
	• Added new bullet-point to the General Statement section
	• Updated Imaging in Known Genetic Conditions section
	• Checked the Medicare Advantage box in the Applicable Lines of Business table
	• Added a Summary of Evidence and Analysis of Evidence
	• Updated refences
	• Updated background
	• Updated combination section
	• Updated cancer section
	• Reorganized pediatric headache section
	• Reorganized pituitary section
	  ○ Clarified labs
	  ○ Added amenorrhea section
	  ○ Updated adenoma section
	• Updated IAC section

Date	Summary
	○ Clarified congenital hearing loss ○ Added peripheral vertigo ○ Added Necrotizing otitis externa Clarified: ● Acute and chronic headache timeframes ● Migraine aura ● Central venous thrombosis ● Low and high flow vascular malformations ● Pediatric seizures ● Clarified follow up scan follow up time frames ● Clarified JC virus status and progressive multifocal leukoencephalopathy (PML) ● Cognitive impairment labs ● Horner's syndrome ● Visual symptoms ● Cranial neuropathies ● Follow up of known hydrocephalus ● Follow-up shunt evaluation ● Vertigo Added: ● History of stroke ● Genetic section ● Cystic lesion section (clarified timeframes) ● Added anosmia back in with conditions
June 2024	● <u>Changes</u> ○ Updated references ○ Updated background section ○ Updated combination section ● <u>Added</u> ○ Genetic syndromes and rare disease section- reorganized

Date	Summary
	indications ○ Note: Vessel wall MRI (ordered as Brain MRI) can also be performed in the evaluation of vasculitides ○ PML suspected or known to the infectious or inflammatory disease section. ○ And updated Brain MRI for Known Cancer sections (initial staging, restaging and surveillance) ○ Vertigo with progressive unilateral hearing loss or **tinnitus** ○ Horner's syndrome with symptoms localizing the lesion to the central nervous system (Brain/Cervical MRI Combo) ○ Known Moyamoya disease or eversible cerebral vasoconstriction with any new or changing neurological signs or symptoms (also to (Brain MRA /MRI combo) ○ Suspected secondary CNS vasculitis based on neurological signs or symptoms in the setting of an underlying systemic disease with abnormal inflammatory markers or autoimmune antibodies (Brain MRA /MRI combo) ○ Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up ((Brain MRA /MRI combo)) ○ Giant cell arteritis with suspected intracranial and extracranial involvement (Brain MRA /Neck/ Brain MRI combo)) ● <u>Clarified</u> ○ Updated pediatric seizure section. ○ Treatment of Alzheimer's disease with anti-amyloid-β monoclonal antibodies - baseline and surveillance imaging as per FDA labeling ● <u>Deleted</u> ○ Aduhelm monitoring ○ MRI Brain with IAC/MRA Head/MRA Neck section

LEGAL AND COMPLIANCE

Guideline Approval

Committee

Reviewed / Approved by Evolent Specialty Services Clinical Guideline Review Committee

Disclaimer

Evolent Clinical Guidelines do not constitute medical advice. Treating health care professionals are solely responsible for diagnosis, treatment, and medical advice. Evolent uses Clinical Guidelines in accordance with its contractual obligations to provide utilization management. Coverage for services varies for individual members according to the terms of their health care coverage or government program. Individual members' health care coverage may not utilize some Evolent Clinical Guidelines. Evolent clinical guidelines contain guidance that requires prior authorization and service limitations. A list of procedure codes, services or drugs may not be all inclusive and does not imply that a service or drug is a covered or non-covered service or drug. Evolent reserves the right to review and update this Clinical Guideline in its sole discretion. Notice of any changes shall be provided as required by applicable provider agreements and laws or regulations. Members should contact their Plan customer service representative for specific coverage information.

Evolent Clinical Guidelines are comprehensive and inclusive of various procedural applications for each service type. Our guidelines may be used to supplement Medicare criteria when such criteria is not fully established. When Medicare criteria is determined to not be fully established, we only reference the relevant portion of the corresponding Evolent Clinical Guideline that is applicable to the specific service or item requested in order to determine medical necessity.

REFERENCES

1. Utukuri PS, Shih RY, Ajam AA, et al. ACR Appropriateness Criteria® Headache: 2022 Update. *Journal of the American College of Radiology*. 2023;20(5):S70-S93. doi:10.1016/j.jacr.2023.02.018
2. International Headache Society. Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. *Cephalalgia*. 2018;38(1):1-211. doi:10.1177/0333102417738202
3. Evans RW, Burch RC, Frishberg BM, et al. Neuroimaging for Migraine: The American Headache Society Systematic Review and Evidence-Based Guideline. *Headache: The Journal of Head and Face Pain*. 2020;60(2):318-336. doi:10.1111/head.13720
4. Nahas SJ. New Guidelines on Headache Imaging. New England Journal of Medicine Journal Watch. January 8, 2020. https://www.jwatch.org/na50541/2020/01/08/new-guidelines-headache-imaging
5. Togha M, Karimitafti MJ, Ghorbani Z, et al. Characteristics and comorbidities of headache in patients over 50 years of age: a cross-sectional study. *BMC Geriatr*. 2022;22(1):313. doi:10.1186/s12877-022-03027-1
6. González-Quintanilla V, Madera J, Pascual J. Update on headaches associated with physical exertion. *Cephalalgia*. 2023;43(3):3331024221146989. doi:10.1177/03331024221146989
7. Hamilton KT. Secondary Headaches During Pregnancy and the Postpartum Period. *Pract Neurol*. Published online May 2020:62-66. https://practicalneurology.com/diseases-diagnoses/headache-pain/secondary-headaches-during-pregnancy-and-the-postpartum-period/31660/
8. Hayes LL, Palasis S, Bartel TB, et al. ACR Appropriateness Criteria® Headache–Child. *Journal of the American College of Radiology*. 2018;15(5):S78-S90. doi:10.1016/j.jacr.2018.03.017
9. Trofimova A, Vey BL, Mullins ME, Wolf DS, Kadom N. Imaging of Children With Nontraumatic Headaches. *American Journal of Roentgenology*. 2018;210(1):8-17. doi:10.2214/AJR.17.18561
10. Gofshteyn JS, Stephenson DJ. Diagnosis and Management of Childhood Headache. *Curr Probl Pediatr Adolesc Health Care*. 2016;46(2):36-51. doi:10.1016/j.cppeds.2015.11.003
11. Sharma A, Kirsch CFE, Aulino JM, et al. ACR Appropriateness Criteria® Hearing Loss and/or Vertigo. *Journal of the American College of Radiology*. 2018;15(11):S321-S331. doi:10.1016/j.jacr.2018.09.020
12. Soares BP, Shih RY, Utukuri PS, et al. ACR Appropriateness Criteria® Altered Mental Status, Coma, Delirium, and Psychosis: 2024 Update. *Journal of the American College of Radiology*. 2024;21(11):S372-S383. doi:10.1016/j.jacr.2024.08.018
13. Kennedy TA, Corey AS, Policeni B, et al. ACR Appropriateness Criteria® Orbits Vision and Visual Loss. *Journal of the American College of Radiology*. 2018;15(5):S116-S131. doi:10.1016/j.jacr.2018.03.023

14. Wang LL, Thompson TA, Shih RY, et al. ACR Appropriateness Criteria® Dizziness and Ataxia: 2023 Update. *Journal of the American College of Radiology*. 2024;21(6):S100-S125. doi:10.1016/j.jacr.2024.02.018
15. Harvey HB, Watson LC, Subramaniam RM, et al. ACR Appropriateness Criteria® Movement Disorders and Neurodegenerative Diseases. *Journal of the American College of Radiology*. 2020;17(5):S175-S187. doi:10.1016/j.jacr.2020.01.042
16. Pannell JS, Corey AS, Shih RY, et al. ACR Appropriateness Criteria® Cerebrovascular Diseases-Stroke and Stroke-Related Conditions. *Journal of the American College of Radiology*. 2024;21(6):S21-S64. doi:10.1016/j.jacr.2024.02.015
17. Robertson RL, Palasis S, Rivkin MJ, et al. ACR Appropriateness Criteria® Cerebrovascular Disease-Child. *Journal of the American College of Radiology*. 2020;17(5):S36-S54. doi:10.1016/j.jacr.2020.01.036
18. Ledbetter LN, Burns J, Shih RY, et al. ACR Appropriateness Criteria® Cerebrovascular Diseases-Aneurysm, Vascular Malformation, and Subarachnoid Hemorrhage. *Journal of the American College of Radiology*. 2021;18(11):S283-S304. doi:10.1016/j.jacr.2021.08.012
19. Akers A, Al-Shahi Salman R, A. Awad I, et al. Synopsis of Guidelines for the Clinical Management of Cerebral Cavernous Malformations: Consensus Recommendations Based on Systematic Literature Review by the Angioma Alliance Scientific Advisory Board Clinical Experts Panel. *Neurosurgery*. 2017;80(5):665-680. doi:10.1093/neuros/nyx091
20. Velz J, Stienen MN, Neidert MC, Yang Y, Regli L, Bozinov O. Routinely Performed Serial Follow-Up Imaging in Asymptomatic Patients With Multiple Cerebral Cavernous Malformations Has No Influence on Surgical Decision Making. *Front Neurol*. 2018;9. doi:10.3389/fneur.2018.00848
21. Polinder S, Cnossen MC, Real RGL, et al. A Multidimensional Approach to Post-concussion Symptoms in Mild Traumatic Brain Injury. *Front Neurol*. 2018;9:1113. doi:10.3389/fneur.2018.01113
22. Shih RY, Burns J, Ajam AA, et al. ACR Appropriateness Criteria® Head Trauma: 2021 Update. *Journal of the American College of Radiology*. 2021;18(5):S13-S36. doi:10.1016/j.jacr.2021.01.006
23. Panwar J, Hsu CCT, Tator CH, Mikulis D. Magnetic Resonance Imaging Criteria for Post-Concussion Syndrome: A Study of 127 Post-Concussion Syndrome Patients. *J Neurotrauma*. 2020;37(10):1190-1196. doi:10.1089/neu.2019.6809
24. Petersenn S, Fleseriu M, Casanueva FF, et al. Diagnosis and management of prolactin-secreting pituitary adenomas: a Pituitary Society international Consensus Statement. *Nat Rev Endocrinol*. 2023;19(12):722-740. doi:10.1038/s41574-023-00886-5
25. Burns J, Policeni B, Bykowski J, et al. ACR Appropriateness Criteria® Neuroendocrine Imaging. *Journal of the American College of Radiology*. 2019;16(5):S161-S173. doi:10.1016/j.jacr.2019.02.017
26. Molitch ME. Diagnosis and Treatment of Pituitary Adenomas. *JAMA*. 2017;317(5):516-524. doi:10.1001/jama.2016.19699

27. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Neuroendocrine and Adrenal Tumors Version 2.2025 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
28. GH Research Society. Consensus Guidelines for the Diagnosis and Treatment of Growth Hormone (GH) Deficiency in Childhood and Adolescence: Summary Statement of the GH Research Society1. *J Clin Endocrinol Metab*. 2000;85(11):3990-3993. doi:10.1210/jcem.85.11.6984
29. Kannan S, Kennedy L. Diagnosis of acromegaly: state of the art. *Expert Opin Med Diagn*. 2013;7(5):443-453. doi:10.1517/17530059.2013.820181
30. Majumdar A, Mangal N. Hyperprolactinemia. *J Hum Reprod Sci*. 2013;6(3):168-175. doi:10.4103/0974-1208.121400
31. Melmed S, Casanueva FF, Hoffman AR, et al. Diagnosis and Treatment of Hyperprolactinemia: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab*. 2011;96(2):273-288. doi:10.1210/jc.2010-1692
32. Vilar L, Vilar CF, Lyra R, Freitas M da C. Pitfalls in the Diagnostic Evaluation of Hyperprolactinemia. *Neuroendocrinology*. 2019;109(1):7-19. doi:10.1159/000499694
33. American Society for Reproductive Medicine. Current evaluation of amenorrhea: a committee opinion. *Fertil Steril*. 2024;122(1):52-61. doi:10.1016/j.fertnstert.2024.02.001
34. Jenkinson MD, Mills S, Mallucci CL, Santarius T. Management of pineal and colloid cysts. *Pract Neurol*. 2021;21(4):292-299. doi:10.1136/practneurol-2020-002838
35. Petersson M, Berinder K, Eden Engström B, et al. Natural history and surgical outcome of Rathke's cleft cysts—A study from the Swedish Pituitary Registry. *Clin Endocrinol (Oxf)*. 2022;96(1):54-61. doi:10.1111/cen.14622
36. Jafrani R, Raskin J, Kaufman A, Lam S. Intracranial arachnoid cysts: Pediatric neurosurgery update. *Surg Neurol Int*. 2019;10(1):15. doi:10.4103/sni.sni_320_18
37. Mustansir F, Bashir S, Darbar A. Management of Arachnoid Cysts: A Comprehensive Review. *Cureus*. Published online April 10, 2018:e2458. doi:10.7759/cureus.2458
38. Buncke MJ, Lilly GL, Hamilton BE, MacArthur CJ. When is pre-operative imaging required for craniofacial dermoid cysts/sinuses? A review. *Int J Pediatr Otorhinolaryngol*. 2022;155:111090. doi:10.1016/j.ijporl.2022.111090
39. Choi JS, Bae YC, Lee JW, Kang G Bin. Dermoid cysts: Epidemiology and diagnostic approach based on clinical experiences. *Arch Plast Surg*. 2018;45(06):512-516. doi:10.5999/aps.2018.00017
40. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Central Nervous System Cancers Version 5.2024. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
41. American College of Radiology. *ACR Appropriateness Criteria® Brain Tumors*.; 2024.

42. American College of Radiology. *ACR Appropriateness Criteria® Suspected Primary Bone Tumors*.; 2024.
43. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Non-Small Cell Lung Cancer Version 3.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org. https://www.nccn.org/professionals/physician_gls/pdf/nscl.pdf
44. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Small Cell Lung Cancer Version 4.2025 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
45. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Head and Neck Cancers NCCN Evidence Blocks Version 2.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org. Accessed November 13, 2024. https://www.nccn.org/professionals/physician_gls/pdf/head-and-neck.pdf
46. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Melanoma: Cutaneous V.2.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
47. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Gestational Trophoblastic Neoplasia Version 2.2025 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
48. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Acute Myeloid Leukemia Version 2.2025 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
49. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Pediatric Acute Lymphoblastic Leukemia Version 2.2025 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
50. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Acute Lymphoblastic Leukemia Version 2.2024 © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.
51. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Breast Cancer Version 2.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.

52. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Cervical Cancer Version 3.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.

53. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Histiocytic Neoplasms Version 3.2024. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.

54. Hourani R, Nasreddine W, Dirani M, et al. When Should a Brain MRI Be Performed in Children with New-Onset Seizures? Results of a Large Prospective Trial. *American Journal of Neuroradiology*. 2021;42(9):1695-1701. doi:10.3174/ajnr.A7193

55. Lee RK, Burns J, Ajam AA, et al. ACR Appropriateness Criteria® Seizures and Epilepsy. *Journal of the American College of Radiology*. 2020;17(5):S293-S304. doi:10.1016/j.jacr.2020.01.037

56. Trofimova A, Milla SS, Ryan ME, et al. ACR Appropriateness Criteria® Seizures-Child. *Journal of the American College of Radiology*. 2021;18(5):S199-S211. doi:10.1016/j.jacr.2021.02.020

57. Ho K, Lawn N, Bynevelt M, Lee J, Dunne J. Neuroimaging of first-ever seizure. *Neurol Clin Pract*. 2013;3(5):398-403. doi:10.1212/CPJ.0b013e3182a78f25

58. Krumholz A, Wiebe S, Gronseth GS, et al. Evidence-based guideline: Management of an unprovoked first seizure in adults. *Neurology*. 2015;84(16):1705-1713. doi:10.1212/WNL.0000000000001487

59. Ramli N, Rahmat K, Lim KS, Tan CT. Neuroimaging in refractory epilepsy. Current practice and evolving trends. *Eur J Radiol*. 2015;84(9):1791-1800. doi:10.1016/j.ejrad.2015.03.024

60. Hirtz D, Ashwal S, Berg A, et al. Practice parameter: Evaluating a first nonfebrile seizure in children. *Neurology*. 2000;55(5):616-623. doi:10.1212/WNL.55.5.616

61. Thompson AJ, Banwell BL, Barkhof F, et al. Diagnosis of multiple sclerosis: 2017 revisions of the McDonald criteria. *Lancet Neurol*. 2018;17(2):162-173. doi:10.1016/S1474-4422(17)30470-2

62. Wattjes MP, Ciccarelli O, Reich DS, et al. 2021 MAGNIMS–CMSC–NAIMS consensus recommendations on the use of MRI in patients with multiple sclerosis. *Lancet Neurol*. 2021;20(8):653-670. doi:10.1016/S1474-4422(21)00095-8

63. Rae-Grant A, Day GS, Marrie RA, et al. Practice guideline recommendations summary: Disease-modifying therapies for adults with multiple sclerosis. *Neurology*. 2018;90(17):777-788. doi:10.1212/WNL.0000000000005347

64. McGuigan C, Craner M, Guadagno J, et al. Stratification and monitoring of natalizumab-associated progressive multifocal leukoencephalopathy risk: recommendations from an expert group. *J Neurol Neurosurg Psychiatry*. 2016;87(2):117-125. doi:10.1136/jnnp-2015-311100

65. Saberi A, Roudbary SA, Ghayeghran A, Kazemi S, Hosseininezhad M. Diagnosis of Meningitis Caused by Pathogenic Microorganisms Using Magnetic Resonance Imaging: A

Systematic Review. *Basic and Clinical Neuroscience Journal*. 2018;9(2):73-86. doi:10.29252/nirp.bcn.9.2.73

66. Oliveira CR, Morriss MC, Mistrot JG, Cantey JB, Doern CD, Sánchez PJ. Brain Magnetic Resonance Imaging of Infants with Bacterial Meningitis. *J Pediatr*. 2014;165(1):134-139. doi:10.1016/j.jpeds.2014.02.061
67. Ahn Y, Joo L, Suh CH, et al. Impact of Brain MRI on the Diagnosis of Infective Endocarditis and Treatment Decisions: Systematic Review and Meta-Analysis. *American Journal of Roentgenology*. 2022;218(6):958-968. doi:10.2214/AJR.21.26896
68. D'Souza NM, Morgan ML, Almarzouqi SJ, Lee AG. Magnetic resonance imaging findings in giant cell arteritis. *Eye*. 2016;30(5):758-762. doi:10.1038/eye.2016.19
69. Maz M, Chung SA, Abril A, et al. 2021 American College of Rheumatology/Vasculitis Foundation Guideline for the Management of Giant Cell Arteritis and Takayasu Arteritis. *Arthritis & Rheumatology*. 2021;73(8):1349-1365. doi:10.1002/art.41774
70. Yip A, Jernberg ET, Bardi M, et al. Magnetic resonance imaging compared to ultrasonography in giant cell arteritis: a cross-sectional study. *Arthritis Res Ther*. 2020;22(1):247. doi:10.1186/s13075-020-02335-4
71. Diamantopoulos AP, Haugeberg G, Hetland H, Soldal DM, Bie R, Myklebust G. Diagnostic Value of Color Doppler Ultrasonography of Temporal Arteries and Large Vessels in Giant Cell Arteritis: A Consecutive Case Series. *Arthritis Care Res (Hoboken)*. 2014;66(1):113-119. doi:10.1002/acr.22178
72. Agarwal S, Sebastian LJD, Gaikwad S, et al. The role of susceptibility-weighted imaging & contrast-enhanced MRI in the diagnosis of primary CNS vasculitis: a large case series. *Sci Rep*. 2024;14(1):4718. doi:10.1038/s41598-024-55222-2
73. Godasi R, Pang G, Chauhan S, Bollu PC. Primary Central Nervous System Vasculitis. *StatPearls*. Published online June 19, 2023. https://www.ncbi.nlm.nih.gov/books/NBK482476/
74. Edjlali M, Qiao Y, Boulouis G, et al. Vessel wall MR imaging for the detection of intracranial inflammatory vasculopathies. *Cardiovasc Diagn Ther*. 2020;10(4):1108-1119. doi:10.21037/cdt-20-324
75. Kartau M, Sipilä JO, Auvinen E, Palomäki M, Verkkoniemi-Ahola A. Progressive Multifocal Leukoencephalopathy: Current Insights . *Degener Neurol Neuromuscul Dis*. 2019;Volume 9:109-121. doi:10.2147/DNND.S203405
76. Pjanic M, Aleckovic-Halilovic M, Basic-Jukic N. JC Virus in Kidney Transplant Population: Are We Cautious Enough? *J Clin Med*. 2024;13(8):2217. doi:10.3390/jcm13082217
77. Voortman M, Drent M, Baughman RP. Management of neurosarcoidosis: a clinical challenge. *Curr Opin Neurol*. 2019;32(3):475-483. doi:10.1097/WCO.0000000000000684
78. Bradshaw MJ, Pawate S, Koth LL, Cho TA, Gelfand JM. Neurosarcoidosis. *Neurol Neuroimmunol Neuroinflamm*. 2021;8(6):e1084. doi:10.1212/NXI.0000000000001084
79. Health Quality Ontario. The appropriate use of neuroimaging in the diagnostic work-up of dementia: an evidence-based analysis. *Ont Health Technol Assess Ser*. 2014;14(1):1-64.

80. Narayanan L, Murray AD. What can imaging tell us about cognitive impairment and dementia? *World J Radiol*. 2016;8(3):240-254. doi:10.4329/wjr.v8.i3.240

81. McCollum L, Karlawish J. Cognitive Impairment Evaluation and Management. *Medical Clinics of North America*. 2020;104(5):807-825. doi:10.1016/j.mcna.2020.06.007

82. Leqembi. Package insert. Eisai Inc. U.S. Food and Drug Administration. 2023. https://www.accessdata.fda.gov/drugsatfda_docs/label/2023/761269Orig1s001lbl.pdf

83. Wu W, Ji Y, Wang Z, et al. The FDA-approved anti-amyloid-β monoclonal antibodies for the treatment of Alzheimer's disease: a systematic review and meta-analysis of randomized controlled trials. *Eur J Med Res*. 2023;28(1):544. doi:10.1186/s40001-023-01512-w

84. McFarland NR. Diagnostic Approach to Atypical Parkinsonian Syndromes. *CONTINUUM: Lifelong Learning in Neurology*. 2016;22(4):1117-1142. doi:10.1212/CON.0000000000000348

85. Pyatigorskaya N, Gallea C, Garcia-Lorenzo D, Vidailhet M, Lehericy S. A review of the use of magnetic resonance imaging in Parkinson's disease. *Ther Adv Neurol Disord*. 2014;7(4):206-220. doi:10.1177/1756285613511507

86. Sharifi S, Nederveen AJ, Booij J, van Rootselaar AF. Neuroimaging essentials in essential tremor: A systematic review. *Neuroimage Clin*. 2014;5:217-231. doi:10.1016/j.nicl.2014.05.003

87. Comella CL. *Cervical Dystonia*.; 2019. https://rarediseases.org/rare-diseases/cervical-dystonia/

88. Iliescu DA, Timaru CM, Alexe N, et al. Management of diplopia. *Rom J Ophthalmol*. 2017;61(3):166-170. doi:10.22336/rjo.2017.31

89. Maciag EJ, Martín-Noguerol T, Ortiz-Pérez S, Torres C, Luna A. Understanding Visual Disorders through Correlation of Clinical and Radiologic Findings. *RadioGraphics*. 2024;44(2):e230081. doi:10.1148/rg.230081

90. Sadaka A, Schockman SL, Golnik KC. Evaluation of Horner Syndrome in the MRI Era. *Journal of Neuro-Ophthalmology*. 2017;37(3):268-272. doi:10.1097/WNO.0000000000000503

91. Maamouri R, Ferchichi M, Houmane Y, Gharbi Z, Cheour M. Neuro-Ophthalmological Manifestations of Horner's Syndrome: Current Perspectives. *Eye Brain*. 2023;Volume 15:91-100. doi:10.2147/EB.S389630

92. Rath TJ, Policeni B, Juliano AF, et al. ACR Appropriateness Criteria® Cranial Neuropathy: 2022 Update. *Journal of the American College of Radiology*. 2022;19(11):S266-S303. doi:10.1016/j.jacr.2022.09.021

93. Saltagi AK, Saltagi MZ, Nag AK, et al. Diagnosis of Anosmia and Hyposmia: A Systematic Review. *Allergy Rhinol (Providence)*. 2021;12:21526567211026570. doi:10.1177/21526567211026568

94. Choi I, Jeon SR. Neuralgias of the Head: Occipital Neuralgia. *J Korean Med Sci*. 2016;31(4):479-488. doi:10.3346/jkms.2016.31.4.479

95. Baugh RF, Basura GJ, Ishii LE, et al. Clinical practice guideline: Bell's palsy. *Otolaryngol Head Neck Surg*. 2013;149(3 Suppl):S1-27. doi:10.1177/0194599813505967

96. Yao L, Wang B, Lu F, He X, Lu G, Zhang S. Facial nerve in skullbase tumors: imaging and clinical relevance. *Eur J Med Res*. 2023;28(1):121. doi:10.1186/s40001-023-01078-7

97. Al-Noury K, Lotfy A. Normal and pathological findings for the facial nerve on magnetic resonance imaging. *Clin Radiol*. 2011;66(8):701-707. doi:10.1016/j.crad.2011.02.012

98. Tan AP, Mankad K, Gonçalves FG, Talenti G, Alexia E. Macrocephaly. *Topics in Magnetic Resonance Imaging*. 2018;27(4):197-217. doi:10.1097/RMR.0000000000000170

99. Hanzlik E, Gigante J. Microcephaly. *Children*. 2017;4(6):47. doi:10.3390/children4060047

100. Rossi A, Argyropoulou M, Zlatareva D, et al. European recommendations on practices in pediatric neuroradiology: consensus document from the European Society of Neuroradiology (ESNR), European Society of Paediatric Radiology (ESPR) and European Union of Medical Specialists Division of Neuroradiology (UEMS). *Pediatr Radiol*. 2023;53(1):159-168. doi:10.1007/s00247-022-05479-4

101. Novak I, Morgan C, Adde L, et al. Early, Accurate Diagnosis and Early Intervention in Cerebral Palsy. *JAMA Pediatr*. 2017;171(9):897-907. doi:10.1001/jamapediatrics.2017.1689

102. Khalatbari H, Parisi MT. Management of Hydrocephalus in Children: Anatomic Imaging Appearances of CSF Shunts and Their Complications. *American Journal of Roentgenology*. 2021;216(1):187-199. doi:10.2214/AJR.20.22888

103. Hatgaonkar AM, Mahajan SM, Hatgoankar KA, Bandre GR. MRI Imaging Insights in Chiari Malformation Type 1 and Variations With Hydrosyringomyelia. *Cureus*. 2024;16(3):e55676. doi:10.7759/cureus.55676

104. Whitson WJ, Lane JR, Bauer DF, Durham SR. A prospective natural history study of nonoperatively managed Chiari I malformation: does follow-up MRI surveillance alter surgical decision making? *J Neurosurg Pediatr*. 2015;16(2):159-166. doi:10.3171/2014.12.PEDS14301

105. Damasceno BP. Neuroimaging in normal pressure hydrocephalus. *Dement Neuropsychol*. 2015;9(4):350-355. doi:10.1590/1980-57642015DN94000350

106. Cheema S, Anderson J, Angus-Leppan H, et al. Multidisciplinary consensus guideline for the diagnosis and management of spontaneous intracranial hypotension. *J Neurol Neurosurg Psychiatry*. 2023;94(10):835-843. doi:10.1136/jnnp-2023-331166

107. Hiremath SB, Gautam AA, Sasindran V, Therakathu J, Benjamin G. Cerebrospinal fluid rhinorrhea and otorrhea: A multimodality imaging approach. *Diagn Interv Imaging*. 2019;100(1):3-15. doi:10.1016/j.diii.2018.05.003

108. Deline C. Spontaneous Intracranial Hypotension. National Organization for Rare Disorders. May 29, 2024. https://rarediseases.org/rare-diseases/spontaneous-intracranial-hypotension/

109. Mohammad SA, Osman NM, Ahmed KA. The value of CSF flow studies in the management of CSF disorders in children: a pictorial review. *Insights Imaging*. 2019;10(1):3. doi:10.1186/s13244-019-0686-x

110. Br G, Sharma PK, Polaka Y, S P, Natarajan P. The Role of Phase-Contrast MRI in Diagnosing Cerebrospinal Fluid Flow Abnormalities. *Cureus*. 2024;16(3):e57114. doi:10.7759/cureus.57114

111. Newman-Toker DE, Kerber KA, Hsieh Y, et al. <scp>HINTS</scp> Outperforms <scp>ABCD</scp> 2 to Screen for Stroke in Acute Continuous Vertigo and Dizziness. *Academic Emergency Medicine*. 2013;20(10):986-996. doi:10.1111/acem.12223

112. Selvadurai S, Al-Saleh S, Amin R, et al. Utility of brain MRI in children with sleep-disordered breathing. *Laryngoscope*. 2017;127(2):513-519. doi:10.1002/lary.26042

113. Regn DD, Davis AH, Smith WD, Blasser CJ, Ford CM. Central Sleep Apnea in Adults: Diagnosis and Treatment. *Federal Practitioner*. 2023;40(3):78-86. doi:10.12788/fp.0367

114. Brignole M, Moya A, de Lange FJ, et al. 2018 ESC Guidelines for the diagnosis and management of syncope. *Eur Heart J*. 2018;39(21):1883-1948. doi:10.1093/eurheartj/ehy037

115. Raucci U, Borrelli O, Di Nardo G, et al. Cyclic Vomiting Syndrome in Children. *Front Neurol*. 2020;11:583425. doi:10.3389/fneur.2020.583425

116. Venkatesan T, Levinthal DJ, Tarbell SE, et al. Guidelines on management of cyclic vomiting syndrome in adults by the American Neurogastroenterology and Motility Society and the Cyclic Vomiting Syndrome Association. *Neurogastroenterology & Motility*. 2019;31(S2):e13604. doi:10.1111/nmo.13604

117. Luttrull MD, Boulter DJ, Kirsch CFE, et al. ACR Appropriateness Criteria® Acute Mental Status Change, Delirium, and New Onset Psychosis. *Journal of the American College of Radiology*. 2019;16(5):S26-S37. doi:10.1016/j.jacr.2019.02.024

118. Randhawa HS, Bagale S, Umap R, Randhawa J. Brain Magnetic Resonance Imaging-Based Evaluation of Pediatric Patients With Developmental Delay: A Cross-Sectional Study. *Cureus*. Published online April 11, 2022:e24051. doi:10.7759/cureus.24051

119. Byrne D, Fisher A, Baker L, Twomey E, Gorman KM. Yield of brain MRI in children with autism spectrum disorder. *Eur J Pediatr*. 2023;182(8):3603-3609. doi:10.1007/s00431-023-05011-2

120. Tieder JS, Bonkowsky JL, Etzel RA, et al. Brief Resolved Unexplained Events (Formerly Apparent Life-Threatening Events) and Evaluation of Lower-Risk Infants: Executive Summary. *Pediatrics*. 2016;137(5):e20160591. doi:10.1542/peds.2016-0591

121. Gerull S, Medinger M, Heim D, Passweg J, Stern M. Evaluation of the Pretransplantation Workup before Allogeneic Transplantation. *Biology of Blood and Marrow Transplantation*. 2014;20(11):1852-1856. doi:10.1016/j.bbmt.2014.06.029

122. Rossor T, Yeh EA, Khakoo Y, et al. Diagnosis and Management of Opsoclonus-Myoclonus-Ataxia Syndrome in Children. *Neurol Neuroimmunol Neuroinflamm*. 2022;9(3). doi:10.1212/NXI.0000000000001153

123. ACR-ASNR-SPR. *Practice Parameter for the Performance of Intracranial Magnetic Resonance Perfusion Imaging*.; 2023.

124. Wang L, Wei L, Wang J, et al. Evaluation of perfusion MRI value for tumor progression assessment after glioma radiotherapy. *Medicine*. 2020;99(52):e23766. doi:10.1097/MD.0000000000023766

125. Metaweh NAK, Azab AO, El Basmy AAEH, Mashhour KN, El Mahdy WM. Contrast-Enhanced Perfusion MR Imaging to Differentiate Between Recurrent/Residual Brain Neoplasms and Radiation Necrosis. *Asian Pacific Journal of Cancer Prevention*. 2018;19(4):941-948. doi:10.22034/APJCP.2018.19.4.941

126. Cao AC, Hwa TP, Cavarocchi C, et al. Diagnostic Yield and Utility of Radiographic Imaging in the Evaluation of Pulsatile Tinnitus: A Systematic Review. *Otology & Neurotology Open*. 2023;3(2):e030. doi:10.1097/ONO.0000000000000030

127. Jain V, Policeni B, Juliano AF, et al. ACR Appropriateness Criteria® Tinnitus: 2023 Update. *Journal of the American College of Radiology*. 2023;20(11):S574-S591. doi:10.1016/j.jacr.2023.08.017

128. Rosenfeld RM, Schwartz SR, Cannon CR, et al. Clinical practice guideline: acute otitis externa. *Otolaryngol Head Neck Surg*. 2014;150(1 Suppl):S1-S24. doi:10.1177/0194599813517083

129. Bertolaso C, Cammisa I, Orsini N, et al. Diagnosing acute mastoiditis in a pediatric emergency department: a retrospective review. *Acta Biomedica*. 2023;94(2). doi:10.23750/abm.v94i2.13839

130. Patel KM, Almutairi A, Mafee MF. Acute otomastoiditis and its complications: Role of imaging. *Oper Tech Otolayngol Head Neck Surg*. 2014;25(1):21-28. doi:10.1016/j.otot.2013.11.004

131. Xun M, Liu X, Sha Y, Zhang X, Liu JP. The diagnostic utility of diffusion-weighted magnetic resonance imaging and high-resolution computed tomography for cholesteatoma: A meta-analysis. *Laryngoscope Investig Otolaryngol*. 2023;8(3):627-635. doi:10.1002/lio2.1032

132. Vemuri N V., Karanam LSP, Manchikanti V, Dandamudi S, Puvvada SK, Vemuri VK. Imaging review of cerebrospinal fluid leaks. *Indian Journal of Radiology and Imaging*. 2017;27(4):441-446. doi:10.4103/ijri.IJRI_380_16

133. Legare JM. Achondroplasia. *GeneReviews®*. Published online May 11, 2023. https://www.ncbi.nlm.nih.gov/books/NBK1152/

134. Shuman C, Kalish JM, Weksberg R. Beckwith-Wiedemann Syndrome. *GeneReviews®*. Published online September 21, 2023. https://www.ncbi.nlm.nih.gov/books/NBK1394/

135. Idos G, Valle L. Lynch Syndrome. *GeneReviews®*. Published online February 4, 2021. https://www.ncbi.nlm.nih.gov/books/NBK1211/

136. Mehta A, Hughes DA. Fabry Disease. *GeneReviews®*. Published online April 11, 2024. https://www.ncbi.nlm.nih.gov/sites/books/NBK1292/

137. Yen T, Stanich PP, Axell L, Patel SG. APC-Associated Polyposis Conditions. *GeneReviews®*. Published online May 12, 2022. https://www.ncbi.nlm.nih.gov/books/NBK1345/

138. Piperno A, Bertola F, Bentivegna A. Juvenile Hemochromatosis. *GeneReviews*®. Published online January 9, 2020. https://www.ncbi.nlm.nih.gov/books/NBK1170/

139. Lohmann DR, Gallie BL. Retinoblastoma. *GeneReviews*®. Published online September 21, 2023. https://www.ncbi.nlm.nih.gov/books/NBK1452/

140. Kamihara J, Bourdeaut F, Foulkes WD, et al. Retinoblastoma and Neuroblastoma Predisposition and Surveillance. *Clinical Cancer Research*. 2017;23(13):e98-e106. doi:10.1158/1078-0432.CCR-17-0652

141. Schneider K, Zelley K, Nichols KE, Schwartz Levine A, Garber J. Li-Fraumeni Syndrome. *GeneReviews*®. Published online September 1, 2025. https://www.ncbi.nlm.nih.gov/books/NBK1311/

142. Referenced with permission from the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines®) for Genetic/Familial High-Risk Assessment: Breast, Ovarian, Pancreatic, and Prostate Version 3.2025. © National Comprehensive Cancer Network, Inc. 2025. All rights reserved. To view the most recent and complete version of the guideline, go online to NCCN.org.

143. Dhamija R, Plotkin S, Gomes A, Babovic-Vuksanovic D. LZTR1- and SMARCB1-Related Schwannomatosis. *GeneReviews*®. Published online April 25, 2024. https://www.ncbi.nlm.nih.gov/books/NBK487394/

144. Giusti F, Marini F, Brandi ML. Multiple Endocrine Neoplasia Type 1. *GeneReviews*®. Published online March 10, 2022. https://www.ncbi.nlm.nih.gov/books/NBK1538/

145. Friedman J. Neurofibromatosis 1. *GeneReviews*®. Published online April 3, 2025. https://www.ncbi.nlm.nih.gov/books/NBK1109/

146. Miller DT, Freedenberg D, Schorry E, et al. Health Supervision for Children With Neurofibromatosis Type 1. *Pediatrics*. 2019;143(5):e20190660. doi:10.1542/peds.2019-0660

147. Evans DG. NF2-Related Schwannomatosis. *GeneReviews*®. Published online April 20, 2023. https://www.ncbi.nlm.nih.gov/books/NBK1201/

148. Bayrak-Toydemir P, Stevenson DA. Capillary Malformation-Arteriovenous Malformation Syndrome. *GeneReviews*®. Published online September 12, 2019. https://www.ncbi.nlm.nih.gov/books/NBK52764/

149. Bender M, Carlberg K. Sickle Cell Disease. *GeneReviews*®. Published online February 13, 2025. https://www.ncbi.nlm.nih.gov/books/NBK1377/

150. DeBaun MR, Jordan LC, King AA, et al. American Society of Hematology 2020 guidelines for sickle cell disease: prevention, diagnosis, and treatment of cerebrovascular disease in children and adults. *Blood Adv*. 2020;4(8):1554-1588. doi:10.1182/bloodadvances.2019001142

151. Nemes K, Bens S, Bourdeaut F, et al. Rhabdoid Tumor Predisposition Syndrome. *GeneReviews*®. Published online May 12, 2022. https://www.ncbi.nlm.nih.gov/books/NBK469816/

152. Northrup H, Koenig MK, Pearson DA, Au KS. Tuberous Sclerosis Complex. *GeneReviews*®. Published online August 1, 2024. https://www.ncbi.nlm.nih.gov/books/NBK1220/

153. van Leeuwaarde RS van, Ahmad S, van Nesselrooij B, Zandee W, Giles RH. Von Hippel-Lindau Syndrome. *GeneReviews*®. Published online May 1, 2025. https://www.ncbi.nlm.nih.gov/books/NBK1463/

154. Raymond G V, Moser AB, Fatemi A. X-Linked Adrenoleukodystrophy. *GeneReviews*®. Published online April 6, 2023. https://www.ncbi.nlm.nih.gov/books/NBK1315/

155. Kleindorfer DO, Towfighi A, Chaturvedi S, et al. 2021 Guideline for the Prevention of Stroke in Patients With Stroke and Transient Ischemic Attack: A Guideline From the American Heart Association/American Stroke Association. *Stroke*. 2021;52(7):e364-e467. doi:10.1161/STR.0000000000000375

156. Chen CY, Fuh JL. Evaluating thunderclap headache. *Curr Opin Neurol*. 2021;34(3):356-362. doi:10.1097/WCO.0000000000000917

157. Marcolini E, Hine J. Approach to the Diagnosis and Management of Subarachnoid Hemorrhage. *Western Journal of Emergency Medicine*. 2019;20(2):203-211. doi:10.5811/westjem.2019.1.37352

158. Gonzalez NR, Amin-Hanjani S, Bang OY, et al. Adult Moyamoya Disease and Syndrome: Current Perspectives and Future Directions: A Scientific Statement From the American Heart Association/American Stroke Association. *Stroke*. 2023;54(10):e465-e479. doi:10.1161/STR.0000000000000443

159. Burton TM, Bushnell CD. Reversible Cerebral Vasoconstriction Syndrome. *Stroke*. 2019;50(8):2253-2258. doi:10.1161/STROKEAHA.119.024416

160. Zuccoli G, Pipitone N, Haldipur A, Brown RD, Hunder G, Salvarani C. Imaging findings in primary central nervous system vasculitis. *Clin Exp Rheumatol*. 2011;29(1 Suppl 64):S104-S109.

161. Hofmann E, Behr R, Neumann-Haefelin T, Schwager K. Pulsatile Tinnitus: imaging and differential diagnosis. *Dtsch Arztebl Int*. 2013;110(26):451-458. doi:10.3238/arztebl.2013.0451

162. Pegge SAH, Steens SCA, Kunst HPM, Meijer FJA. Pulsatile Tinnitus: Differential Diagnosis and Radiological Work-Up. *Curr Radiol Rep*. 2017;5(1):5. doi:10.1007/s40134-017-0199-7

163. Davagnanam I, Fraser CL, Miszkiel K, Daniel CS, Plant GT. Adult Horner's syndrome: a combined clinical, pharmacological, and imaging algorithm. *Eye*. 2013;27(3):291-298. doi:10.1038/eye.2012.281

164. Kaunzner UW, Gauthier SA. MRI in the assessment and monitoring of multiple sclerosis: an update on best practice. *Ther Adv Neurol Disord*. 2017;10(6):247-261. doi:10.1177/1756285617708911

165. Hidalgo JA, Tork CA, Varacallo MA. Arnold-Chiari Malformation. *StatPearls*. Published online September 4, 2023. https://www.ncbi.nlm.nih.gov/books/NBK431076/

166. Radic JAE, Cochrane DD. Choosing Wisely Canada: Pediatric Neurosurgery Recommendations. *Paediatr Child Health*. 2018;23(6):383-387. doi:10.1093/pch/pxy012

167. Wang N, Bertalan MS, Brastianos PK. Leptomeningeal metastasis from systemic cancer: Review and update on management. *Cancer*. 2018;124(1):21-35. doi:10.1002/cncr.30911

168. Patel DM, Weinberg BD, Hoch MJ. CT Myelography: Clinical Indications and Imaging Findings. *RadioGraphics*. 2020;40(2):470-484. doi:10.1148/rg.2020190135

169. Watanabe R, Hashimoto M. Eosinophilic Granulomatosis with Polyangiitis: Latest Findings and Updated Treatment Recommendations. *J Clin Med*. 2023;12(18). doi:10.3390/jcm12185996

170. Ruskin KJ, Ruskin AC, Nussmeier NA (Ed). Anesthesia for magnetic resonance imaging and computed tomography procedures. *UpToDate*. Published online December 3, 2024. https://www.uptodate.com/contents/anesthesia-for-magnetic-resonance-imaging-and-computed-tomography-procedures

171. Salvetat ML, Pellegrini F, Spadea L, Salati C, Zeppieri M. Non-Arteritic Anterior Ischemic Optic Neuropathy (NA-AION): A Comprehensive Overview. *Vision*. 2023;7(4):72. doi:10.3390/vision7040072

172. Spillers NJ, Luther PM, Talbot NC, et al. A Comparative Review of Typical and Atypical Optic Neuritis: Advancements in Treatments, Diagnostics, and Prognosis. *Cureus*. Published online March 13, 2024:e56094. doi:10.7759/cureus.56094

173. Pirker W, Katzenschlager R. Gait disorders in adults and the elderly. *Wien Klin Wochenschr*. 2017;129(3-4):81-95. doi:10.1007/s00508-016-1096-4

174. Marshall FJ. Approach to the elderly patient with gait disturbance. *Neurol Clin Pract*. 2012;2(2):103-111. doi:10.1212/CPJ.0b013e31825a7823

175. Stanford Medicine. Gait Abnormalities. The Stanford Medicine 25. https://stanfordmedicine25.stanford.edu/the25/gait.html

176. Tetreault LA, Karpova A, Fehlings MG. Predictors of outcome in patients with degenerative cervical spondylotic myelopathy undergoing surgical treatment: results of a systematic review. *European Spine Journal*. 2015;24(S2):236-251. doi:10.1007/s00586-013-2658-z