Evolent Clinical Guideline ~~001~~2012 for Brain Magnetic Resonance Imaging (MRI) With or Without Internal Auditory Canal (IAC) Views

Guideline ~~or Policy~~ Number:	Applicable Codes	
Evolent_CG_~~001~~2012		
"Evolent" refers to Evolent Health LLC and Evolent Specialty Services, Inc. ***© 1997 - ~~2025~~2026 All rights Reserved***		
Original Date:	**Last Revised Date:**	**Implementation Date:**
September 1997	~~June 2024~~July 2025	January ~~2025~~2026

TABLE OF CONTENTS

STATEMENT

General Information

- *It is an expectation that all patients receive care/services from a licensed clinician. ~~All~~ All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. ~~If~~ 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 ~~MR/~~Magnetic Resonance Imaging (MRI) and Magnetic Resonance Angiography (MRA) are not ~~approvable~~ 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 ~~be~~show one or more of the following:

- Inconclusive or show a need for additional or follow up imaging evaluation ~~**OR**~~
- The office notes should clearly document an indication why overlapping imaging is needed and how it will change management for the patient.
- ~~(*Unless approvable in the **combination section** as noted in the guidelines)~~

(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

- ~~Chronic headache with a change in character/pattern (e.g., more frequent, increased severity, or duration)~~ [3]
- ~~Cluster headaches or other trigeminal-autonomic cephalgias, i.e., paroxysmal hemicrania, hemicrania continua, short-lasting unilateral neuralgiform headache attacks (SUNCT/SUNA) imaging is indicated once to eliminate secondary causes~~ [3,4]
- Acute ~~headache~~, sudden onset~~:~~ headache (< 4 weeks), with any ONE of the following:
  - ~~With~~ A personal or family history (brother, sister, parent, or child) of brain aneurysm or AVM (arteriovenous malformation) ~~**OR**~~
  - < 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 ~~[3,5,6]~~:~~:~~
  - 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~~). (See **background**)~~)
  - 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 > 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]
- ~~Fever~~
- ~~Subacute head trauma~~
- Pregnancy or ~~puerperium [7,8]~~postpartum [7]
- ~~Age > 50 [3,9,10]~~
- ~~Severe unilateral headache with radiation to or from the neck, associated with suspicion of carotid or vertebral artery dissection~~
- ~~Related to activity or event (sexual activity, exertion, Valsalva, position), new or progressively worsening [3,10,11,12]~~
- ~~Persistent or progressively worsening during a course of physician-directed treatment [3,13]~~

~~**Note**: Neuroimaging warranted for Migraine with atypical/complex migraine aura, but (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)~~

- ~~NOTE: Imaging is not indicated for a typical migraine aura [3] (see **background**)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.~~

- ~~Special Considerations~~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 ~~with~~ *(<18) When None of the Above Apply

- Persistent headache ~~[14,15,16]~~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
- ~~Symptoms indicative of~~Documented absence of family history of headache~~migraine~~
- Concern for increased intracranial pressure~~,~~ with symptoms such as recurring headaches after waking ~~with or without associated nausea/vomiting~~

- ~~Documented absence of family history of headache~~
- ~~Severe headache in a child with an underlying disease that predisposes to intracranial pathology (e.g., Immune deficiency, sickle cell disease, neurofibromatosis, History of neoplasm, coagulopathy, hypertension, congenital heart disease)~~

Neurological Symptoms or Deficits ~~(17,18,19,20,21,22)~~(11–15)

- Acute, new, ~~or~~ 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 ~~(see **background**)~~**Background)**

Stroke and Vascular Disease

Evaluation of Known or Suspected Stroke ~~(23,24,25)~~*(16,17)*

- ~~Known or~~ 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 ~~(see **background**)~~**Background)**
- History of stroke and ONE of the following:
  - No prior imaging
  - New neurologic signs or symptoms
- Suspected stroke with:
  - A ~~a~~ personal or first-degree family history (brother, sister, parent, or child) of aneurysm OR~~or~~
  - K~~k~~nown 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)
- ~~Screening~~ See **Imaging in Known Genetic Conditions** section for ~~silent cerebral infarcts in early school age children and adults with~~additional indications (including for HbSS sickle cell disease or HbSβ0 thalassemia ~~(26)~~)

- ~~Evaluation of neurological signs or symptoms in sickle cell disease (26,27)~~
- ~~High stroke risk in sickle cell patients (2 - 16 years of age) with a transcranial doppler velocity >200 (26,28)~~

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 ~~– see **background** (29,30)~~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.
- ~~Follow-up for known hemorrhage, hematoma, or vascular abnormalities~~ Click or tap here to enter text.
- ~~**Note**: MRI is the study of choice for detecting~~Suspected cerebral cavernous malformations (CCM) and other low flow vascular malformations (~~see **background**). Follow-up imaging of known CCM should be done only to guide treatment decisions or to investigate new symptoms.~~ 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 ~~(31,32,33)~~(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 ~~*(34,35,36)*~~*(21–23)*

~~For evaluation of known or suspected trauma~~

- 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 ~~persistently~~ < 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 ~~and~~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) ~~Brain Tumor, Mass, or Metastasis~~

- ~~Evaluation of~~
- 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 ~~Tumor/Mass/Cyst (3,37)~~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 ~~(see background)~~Background)

- Lesion ~~with atypical features for further evaluation~~(including bone tumor/abnormality or ~~follow up.~~
- ~~Suspected Pituitary Tumors~~ [38,39,40,41,42,43]
- ~~Neurologic findings~~soft tissue mass) ~~(e.g., visual field deficit suggesting compression of the optic chiasm, diplopia, gaze palsy)~~
  - ~~Suspected hypofunctioning pituitary gland based~~ on ~~hormonal testing.~~
    - ~~Hypopituitarism~~
    - ~~Growth hormone deficiency~~
    - ~~Hypogonadotropic hypogonadism [low sex hormones and gonadotropins (FSH/LH)]~~ [44]
      - ~~Total testosterone persistently < 150 with low or normal LH/FSH i.e., severe secondary hypogonadism **OR**~~
      - ~~Total testosterone levels persistently borderline around the lower limits of normal range (200-400 ng/dL) with low or normal LH/FSH; **AND**~~
        - ~~Neurological signs or symptoms; **OR**~~
        - ~~Other pituitary hormonal abnormalities; **OR**~~
        - ~~Low free testosterone and consideration and addressment of reversible functional causes of gonadotropin suppression (e.g., obesity, opioid use, diabetes, steroid use, or comorbid illness)~~
  - ~~Suspected hyperfunctioning pituitary gland based on hormonal testing.~~
    - ~~Central hyperthyroidism (high TSH)~~
    - ~~Cushing syndrome suspected (high ACTH (>5) with cortisol suppression on low or high dose dexamethasone suppression test)~~ [45,46,47]
    - ~~Acromegaly/gigantism (high GH/IGF-1)~~
    - ~~Elevated prolactin~~ [48,49]
      - ~~≥ 250 ng/mL **OR**~~
      - ~~After evaluation for another cause (e.g., pregnancy, hypothyroidism, renal insufficiency, medication- see **background**)~~
        - ~~≥ 100 ng/mL **OR**~~
        - ~~Persistently elevated **OR**~~
        - ~~Neuroendocrine signs or symptoms (i.e., headache, galactorrhea, abnormal menses, infertility, or bitemporal hemianopsia) **OR**~~
        - ~~Abnormal pituitary hormones (low testosterone/estrogen/ progesterone **AND** low or normal LH/FSH)~~
  - ~~Central Diabetes Insipidus (low ADH)~~

- Precocious puberty in a child (male < 9; female < 8), with hormonal studies suggesting a central cause [50]
- Pituitary apoplexy with sudden onset of neurological and hormonal symptoms

- Histiocytic Neoplasms for screening and/or with neurological signs or symptoms [51,52]
  - Erdheim-Chester Disease
  - Langerhans Cell Histiocytosis
  - Rosai-Dorfman Disease

Evaluation of Known Brain Lesion/Cyst

- Follow-up of known pituitary adenoma
  - New neuroendocrine signs or symptoms
  - Functioning adenoma - prior To assess response to treatment and 1-year follow-up after drug holiday [38,39,40,53]
  - Asymptomatic Macroadenoma (≥ 10mm) follow-up every 6-18 months, post-surgical follow-up every 1-2 years after surgery [54]
  - Asymptomatic, non-functioning Microadenoma < 10mm repeat in one year; if stable, repeat every 2-3 years [54]
- Follow-up of known pineal cyst (≥ 5mm) if there are atypical features or symptoms (e.g., headaches, gaze paresis, ataxia, papilledema, nausea/vomiting) [55]
- Follow-up of known Rathke cleft cyst [56]
  - If no symptoms, MRI at 1/3/5 years to stability
- With new neurological symptoms or atypical imaging features[42]

Post treatment, yearly for 5 years.

  -

- Follow-up of known arachnoid cyst [57,58]
  - In patients < 4 years old, serial imaging is warranted.
  - In patients > 4 years old, repeat imaging only if newly symptomatic, i.e., headaches, increased intracranial pressure, hydrocephalus, local mass effect, seizures, visual/endocrine dysfunction.
- Midline dermoid cysts/sinuses with concern for intracranial extension [59,60,61]
- Histiocytic Neoplasms to assess treatment response and surveillance of known brain lesions [51,52]
  - Erdheim-Chester Disease

- ~~Langerhans Cell Histiocytosis~~
- ~~Rosai-Dorfman Disease~~

~~Brain MRI for~~ Known ~~Cancer~~Malignancy

~~Brain MRI is appropriate for **any malignancy when there are signs or symptoms of brain metastases** (e.g., headache, sensory deficits, memory problems). There does not need to be a neuro deficit on exam or other workup done first for a patient with cancer.~~

Initial Staging and Recurrence

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

- ~~Kidney cancer~~ ~~(62)~~
- Adult and pediatric CNS tumors (40)
- Primary CNS lymphoma (40)
- Lung cancer (NSCLC and SCLC) ~~(63,64)~~(43,44)
- Melanoma
  - Primary mucosal tumor of the head and neck – any stage ~~(65)~~(45)
  - Stage III or IV for any primary site ~~(66)~~(46)
- Poorly differentiated neuroendocrine cancer ~~(67)~~(27)
- Gestational trophoblastic neoplasia with pulmonary metastases ~~(68)~~(47)
- Leukemia with suspicion of CNS involvement ~~(69,70,71)~~(48–50)
- Breast cancer stage IV ~~(72)~~(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

~~Brain MRI is appropriate~~Indicated every 2-3 cycles of chemotherapy **during active treatment** for the following diseases:

- ~~B-Cell lymphomas (if CNS lymphoma present or concern for CNS lymphoma)~~ ~~(73)~~
- Adult and pediatric CNS tumors (40)
- Primary CNS lymphoma (40)

- Breast cancer, stage IV or any stage if suspected development of brain metastases ~~(72)~~(51)
- Cutaneous melanoma, stage III or IV or any stage if suspected development of brain metastases ~~(66)~~(46)
- Non-small cell lung cancer ~~(63)~~(43)
  - ~~All stages – initial staging and end of treatment~~
  - Stage IV – every 2-3 cycles of treatment
  - All stages – end of treatment or with symptoms concern
- Small cell lung cancer ~~(64)~~(44)
- Poorly differentiated neuroendocrine cancer (27)
- Small cell neuroendocrine carcinoma of the cervix (~~74)~~NECC) (52)
  - ~~All stages – initial staging~~
  - ~~Stage IV – every 2-3 cycles of treatment~~
- ~~Adult and pediatric CNS tumors (75)~~
- 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:

- ~~B-Cell lymphomas (if history of CNS lymphoma or concern for CNS lymphoma) every 6 months for 2 years then as clinically indicated (73)~~
- Breast cancer ~~(72)~~
  - stage IV ~~every 3-6 months~~(51)
    - ~~All other stages if suspected development of brain metastases~~
    - As clinically indicated
- Cutaneous melanoma ~~(66)~~
  - stage III~~,~~ /IV (46)
    - Every 3 months for 2 years, then every 6-12 months indefinitely
    - ~~All other stages if suspected development of brain metastases~~

- Non-small cell lung cancer ~~(63)~~(43)
  - ~~Stage IV~~ Every 3-6 months for 3 years, then every 6 months for 2 years, then annually
  - ~~All other stages~~ If suspected development of brain metastases
- Small cell lung cancer ~~(64)~~(44)
  - ~~Limited stage every 2-6 months for 1-2 years then every 6-12 months indefinitely~~
  - ~~Extensive stage every 2 months for 1 year,~~ Every 3-4 months ~~for years 2 and 3, every 6 months~~ during ~~years 4 and 5, then annually~~year 1, every 6 months during year 2, and as clinically indicated thereafter
- Neuroendocrine carcinoma of the cervix (~~74)~~interval at discretion of treating provider) (52)
  - ~~If suspected development of brain metastases~~
- Adult and pediatric CNS tumors ~~(75)~~(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

~~*Combination Studies for Initial Staging, Active Monitoring, or Evaluation of Suspected Metastases (37)*~~

~~≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine~~

- 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 ~~(76,77,78,79,80,81,82)~~(54–60)

- New onset of an unprovoked seizure

- Newly identified change in seizure activity/pattern
- Known seizure disorder without previous imaging.
- Medically refractory epilepsy

- ~~***Special considerations in the pediatric population*** ***(76,82,83,84)***~~
- ~~Imaging is indicated in~~ 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~~ simple pediatric febrile seizures ~~that have none of the above characteristics.~~

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~~),(BECTS)).~~ 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 ~~***(85,86)***~~*(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 ~~***(86,87)***~~*(62,63)*

- To establish a new baseline (no recent imaging, postpartum~~, or 3-6 months after switching disease modifying therapy))~~)

- 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 ~~disease activity~~ that is not associated with new clinical symptoms on a routine follow-up scan (i.e., Radiographically isolated syndrome) ~~(88)~~
- ~~Every 1-2 years while on disease-modifying therapy to assess for subclinical disease activity, less frequently when stable for 2-3 years.~~
- 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) ~~(89)~~(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 ~~PML occurrence~~the following:
      - seropositive for JC virus and have been treated with natalizumab for ≥18 months ~~**OR**~~
      - high anti-JC virus antibody index values (>0.9) ~~**OR**~~
      - 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~~.~~

~~**Note:** In the pediatric population, use a similar scan frequency for disease and therapeutic monitoring. Increase frequency of imaging (e.g., every 6 months) in children with highly active disease or in situations where imaging will change management.~~

~~Infectious or Inflammatory Disease~~

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) ~~(90,91)~~(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 ~~;~~ ~~(92,93,94,95)~~ (68–71)~~.~~ , **AND**
  - Negative initial work-up (color Doppler ultrasonography or biopsy); **OR**
  - Atypical features, failure to respond~~se~~ 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 ~~(29,96,97)~~(18,72,73)

  Note: Vessel wall MRI (ordered as Brain MRI) can also be performed in the evaluation of vasculitides~~.~~ ~~(98)~~ (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) ~~(99,100,101)~~(75,76)
  - ~~Suspected based on clinical symptoms and/or JC virus status~~ in an immunocompromised patient~~.~~
  - ~~Follow up based~~ with one of the following:
    - Neurologic symptoms
    - Positive JC virus
  - Known PML follow up as clinically indicated~~.~~
- Neurosarcoidosis ~~(102,103)~~(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 ~~*(104,105,106,107)*~~*(79–81)*

- ~~Mental status score~~Evaluation for mild cognitive impairment or dementia with all of ~~either~~ the following:
  - Objective measures demonstrate ~~objective~~ impairment (MMSE ~~or~~ /MoCA ~~of less than~~< 26 or other ~~similar~~ mental status instruments~~*/formal~~ (see **Background**) or mild cognitive impairment on neuropsychological testing ~~showing at least mild cognitive impairment **AND** a completed basic metabolic workup (such as~~)
  - Full lab evaluation (thyroid function ~~testing, liver function testing, complete blood count, electrolytes, and B12)~~tests, CBC, CMP, ~~including LFTs~~ and B12) has been completed and if abnormal, has been treated and the cognitive difficulty persists
- ~~*Other examples include Mini-Cog, Memory Impairment Screen, Saint Louis University Mental Status Examination (SLUMS), Brief Alzheimer's Screen (BAS), Blessed Dementia Scale (BDS), Clinical Dementia Rating (CDR)~~ ~~(108,109)~~

Treatment of Alzheimer's Disease ~~with anti-amyloid-β monoclonal antibodies~~ ~~*(110,111)*~~*(82,83)*

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

Movement Disorders ~~(21,112,113,114,115)~~(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) ~~(114,116)~~(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 (s~~S~~uch as papilledema, pathologic nystagmus, optic atrophy, ocular nerve palsies, new onset anisocoria, visual field ~~deficit, etc.)~~ ~~**Note**: See **background**~~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 ~~intracranial~~CNS pathology after comprehensive eye evaluation ~~(117,118)~~(88)

~~Childhood strabismus with~~ **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 ~~(119)~~(89)
- Horner's syndrome with signs/symptoms localizing the lesion to the ~~central nervous system~~ ~~(120)~~brain (vertigo, altered facial sensation, contralateral CN IV palsy, crossed motor/sensory signs) (90,91)

Other Cranial Ne~~rve Disorders~~~~uropathies~~ (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 [3,121,122,123](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 , notably in atypical cases [124](94)
- Facial Nerve Paresis / Bell's Palsy if (CN VII) with atypical signs, features (such as bilateral involvement, multiple episodes, slow resolution beyond three weeks, incomplete/no improvement at fourthree months, or facial twitching/spasms prior to onset ([125,126]) (92,95–97)
- Hemifacial spasm ([121,127]CN VII)
- Other objective cranial nerve palsy (CN IX-XII) [121,128]
- Clinical evidence of cranial nerve (CN IX, X, XI, and/or XII) deficits or dysfunction (Ssuch as dysphagia, shoulder/neck movement abnormalities, tongue movement abnormalities, vocal fold movement or sensation abnormalities) (92)
- Bulbar symptoms, i.e.,(Ssuch as difficulty in chewing, weakness of the facial muscles, dysarthria, palatal weakness, dysphagia, and dysphonia) and/or bulbar signs, i.e., (Ssuch as atrophy and fasciculations of the tongue and , weakness of the facial muscles, palatal weakness, absent gag reflex [121]) (92)
- Pseudobulbar symptoms, i.e., (Ssuch as dysphagia, dysarthria, facial weakness, sudden, stereotyped emotional outbursts that are not reflective of mood) and/or pseudobulbar signs, i.e., (Ssuch as spastic tongue and , facial weakness, exaggerated gag/jaw jerk [129]) (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 [130](98)
- Evaluation of microcephaly in an infant/child < 18 [131](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 [132,133](100)
- Evaluation of the corticomedullary junction in Achondroplasia [134]
- Cerebral palsy and ONE of the following:
  - if eEtiology has not been established in the neonatal period

- T, there is change in the expected clinical or developmental profile or concern for progressive neurological disorder ([135]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 [136] ‡(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 [137](103,104)
- Initial evaluation for a known Known or suspected syrinx or syringomyelia ‡
- Known or suspected normal pressure hydrocephalus (NPH) [138]
- With symptomsAND one or more of the following (105):
  - With symptoms of Ggait difficulty, cognitive disturbance, and/or urinary incontinence
- Follow-up shunt evaluation [139]
- Post operativity if indicated based on underlying disease or pre-operative radiographic findings and/or ONE of the following (102):
  - Baseline imaging following placement or revision
  - 6-12 months after placement and/or revision
  - With neurologic symptoms that suggest Clinical concern for shunt malfunction
- Evaluation of known or suspected cerebrospinal fluid (CSF) leakage [140](106)
- Note: Cisternography for intermittent and complex CSF rhinorrhea/otorrhea. CSF fluid should always be confirmed with laboratory testing (Beta-2 transferrin assay) [140,141](106,107)
- Suspected spontaneous intra-cranial hypotension with distinct postural headache (other symptoms include nausea, vomiting, dizziness, tinnitus, diplopia, neck pain or imbalance) [3,142](1,108)
- CSF flow study for evaluation and management of CSF flow disorders [143,144](109,110)

‡Often congenital, but can present later in life; or less commonly acquired secondary to tumor, stroke, trauma, infection, etc.

~~Procedural Evaluations~~

~~*Preoperative/Procedural Evaluation*~~

- ~~Pre-operative evaluation for a planned surgery or procedure~~

~~*Postoperative/Procedural Evaluation*~~

- ~~A follow-up study may be needed to help evaluate a patient's progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.~~

~~Prior Imaging~~

~~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)~~Other Indications

- Vertigo associated with any ONE of the following ~~(20,145,146)~~(14,111)
  - Signs or symptoms suggestive of a possible CNS lesion (~~S~~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 ~~with concern for stroke.~~(s~~S~~uch as hypertension, smoking, obesity, hypercholesterolemia)
  - ~~After full~~Concern for central vertigo (source within the CNS) based on findings on neurologic examination and/or vestibular testing ~~with concern for central vertigo (i.e.,~~(~~S~~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 ~~(147)~~(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 ~~(148)~~(113)
- Syncope with documented clinical concern for seizure or associated neurological signs or symptoms ~~(149,150)~~ (114)
- Cyclical vomiting syndrome or abdominal migraine with any localizing neurological symptoms ~~(151,152,153)~~(115,116)
- ~~Soft tissue mass of the head with nondiagnostic initial evaluation (ultrasound and/or radiograph)~~ ~~(154,155,156)~~
- Psychological changes with neurological deficits on exam or after completion of a full neurological assessment that suggests a possible neurologic cause ~~(157)~~(117)
- Child < 18 years with global developmental delay (see **Background**) **OR** a developmental delay with abnormal neurological examination ~~(158,159,160)~~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 ~~.~~ ~~252~~(119)

- Unexplained event (BRUE) formerly apparent life-threatening event (ALTE) in infants < 1 year with concern for neurological cause based on history and exam ~~(161)~~(120)

Note: Imaging is not indicated in low-risk patients

- Bone Marrow Transplant (BMT) ~~(162)~~(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 ~~(163,164,165,166,167)~~(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 ~~w/o~~without Brain imaging see Evolent Clinical Guideline ~~014~~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 ~~tinnitus~~
- ~~Pulsatile~~, unilateral or asymmetric tinnitus
- Suspected auditory neuropathy
- Suspected acoustic neuroma (Schwannoma) or cerebellar pontine angle tumor ~~with any of the following~~based on clinical signs and symptoms~~:~~ (~~S~~such as unilateral ~~hearing~~/asymmetric sensorineural loss ~~by audiometry, headache~~, 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 (~~S~~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 (~~S~~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 (~~S~~such as headache, tinnitus, vertigo, nystagmus)
- Known OR suspected cholesteatoma (abnormal growth of epithelial tissue within the middle ear) [131]
- Suspected glomus tumor
- ~~Asymmetric sensorineural hearing loss on audiogram~~
- ~~Congenital/childhood sensorineural hearing loss suspected to be due to a structural abnormality (CNVIII, the brain parenchyma, or the membranous labyrinth) [17,168,169]. CT is the preferred imaging modality for the osseous anatomy and malformations of the inner ear.~~
- ~~CSF otorrhea (MRI/Nuclear Cisternography for intermittent leaks, CT for active leaks) [141]; there should be a high~~ 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 ~~or confirmatory CSF fluid laboratory testing (~~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)
  - ~~Clinical suspicion of acute mastoiditis as a complication of acute otitis media with intracranial complications (i.e., meningeal signs, cranial nerve deficits, focal neurological findings, altered mental status) [170]~~
  - Prior imaging (such as CT, nuclear medicine imaging) suggesting bony defect/lesion contributing to suspected/known CSF leak
- Facial Nerve Paresis / Bell's Palsy ~~for evaluation of the extracranial nerve course -if~~ (CN VII) with atypical ~~signs~~features (~~S~~such as bilateral involvement, multiple episodes, slow resolution beyond three weeks, incomplete/no improvement at ~~four~~three months, or facial twitching/spasms prior to onset~~ [121]~~) [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)

~~GENETICS AND RARE DISEASES~~

~~MEN1 (~~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~~) - pituitary or sella MRI~~ (MEN1) [27,144]:
  - Every 3~~-~~ years starting at age 5~~ years, starting at the age of 8-15 years [171] [40]~~
- ~~Von Hippel Lindau (VHL) - imaging of the brain and spinal cord for hemangioblastomas every 2 years starting at age 14 [40,62,172]~~
- ~~Li Fraumeni syndrome- annually [173,174]~~
- ~~NF-1- as clinically indicated with neurologic signs and symptoms and for follow-up of known intracranial tumors (no asymptomatic screening)~~
- ~~Known optic pathway gliomas should be imaged every 3 months for 1 year, then every 6 months for 2 years, the annually for 3-5 years, then less frequently as per clinical judgment until age 18 [175]~~
- ~~NF-2- Brain IAC- annually starting at the age of 10 years [176]~~
- Neurofibromatosis 1 (NF1) [145,146]:
  - New subjective or objective neurologic or cognitive concerns (including vision changes, growth changes, TIA or headaches)
- NF2-Related Schwannomatosis ~~- Brain and spine MRI every two to three years~~ [147]:
  - Annually beginning at age ~~12 years.~~10
- ~~Note: diagnosis is met with both genetic testing AND clinical features due to incomplete penetrance~~
- Capillary Malformation-Arteriovenous Malformation Syndrome (e.g., Sturge Weber Syndrome~~- once, after age 1 to rule out intracranial involvement; in patients <1 year, only if symptomatic [177])~~ [148]:
  - ~~Turcot Syndrome - low threshold for MRI for any neurological sign or symptoms of medulloblastoma [178]~~
  - ~~Tuberous Sclerosis – Every 1-3 years, until the age of 25 years [179]~~
  - ~~Those with asymptomatic subependymal giant cell astrocytoma (SEGA) in childhood should continue to be imaged periodically in adulthood.~~
  - ~~With large or growing SEGA or SEGA causing ventricular enlargement, more frequent brain MRIs as deemed clinically appropriate.~~
  - 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~~- Brain MRI at diagnosis and monthly age 0-6 months if whole body MRI not done; Q2-3 months age 7-18months, Q3months age 19 months-5 years [180])~~ [143,151].
  - ~~Constitutional mismatch repair deficiency syndrome (CMMRD) - Brain MRI every 6 months after diagnosis~~
  - ~~Fabrys disease- annual neurologic assessment with brain MRI/MRA every two to three years beginning at age 18 years [181]~~
  - 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 ~~[182]~~[154]:
  - ~~Baseline MRI between 12 and 18 months old~~
  - ~~Second MRI 1 year after baseline~~
  - ~~MRI every 6 months between 3 and 12 years old~~
  - ~~Annual MRI after 12 years old~~
  - ~~Heritable retinoblastoma (Pineoblastoma surveillance)~~
    - ~~Brain MRI at the time of retinoblastoma diagnosis; some centers recommend a brain MRI~~ Every 6 months until ~~5 years old [183,184]~~age 12
  - Annually after age 12
- For other genetic syndromes ~~and rare diseases~~ 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 ~~FOR~~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~~)~~

~~**Note:** MRA and CTA are generally comparable noninvasive imaging alternatives each with their own advantages and disadvantages. Accordingly, Brain MRI can alternatively be combined with Brain CTA/Neck CTA with appropriate medical reasoning.~~

~~**Exception:** 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 (185)~~

Brain MRI~~/~~ and Brain MRA

- Recent ischemic stroke or transient ischemic attack (TIA) ~~(186,187)~~(16,155)
- Thunderclap headache with continued concern for underlying vascular abnormality (i.e., aneurysm or reversible cerebral vasoconstriction syndrome) after initial negative brain imaging ~~(188,189,190,191)~~(1,2,8,156)
  - **Note:** Negative brain CT < 6 hours after headache onset excludes subarachnoid hemorrhage in neurologically intact patients~~(190)~~. (156) MRI lacks sensitivity in excluding subarachnoid hemorrhage less than 24 hours after headache onset. ~~(188,192)~~(2,157)
- Acute, sudden onset of headache with personal history of a vascular abnormality or first-degree family history of aneurysm ~~(191,193)~~(1,18)
- Headache associated with exercise, exertion, ~~Valsalva~~ or sexual activity ~~(4,11,12)~~(2)

- Suspected central venous thrombosis ~~(dural sinus~~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~~)~~ [187] ~~– Brain MRV see **background** is specified~~
  - ~~Neurological~~ Papilledema or signs/symptoms ~~or symptoms in sickle cell patients~~ [194]
  - ~~High stroke risk in sickle cell patients (2 - 16 years~~ of ~~age) with a transcranial doppler velocity > 200~~ [26]increased intracranial pressure
- See **Imaging in Known Genetic Conditions** for additional indications
- Known Moyamoya disease ~~(195,196)~~(17,158) or reversible cerebral vasoconstriction with any new or changing neurological signs or symptoms ~~(191,197)~~(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 ~~(193)~~(18)
- Suspected primary CNS vasculitis based on neurological signs and symptoms with completed infectious/inflammatory lab work-up ~~(193,198,199)~~(18,73,160)
- Giant cell arteritis with suspected intracranial involvement ~~(93)~~(68,70)
- ~~Fabrys disease annual neurologic assessment with~~ Brain MRI~~/MRA every two to three years beginning at age 18 years~~ [181]

~~Brain MRI/~~ and Brain ~~MRA~~/Neck MRA (16,17)

- Recent ischemic stroke or transient ischemic attack (TIA) ~~(186,187)~~(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 ~~(200,201)~~ ~~(~~(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)
- ~~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~~ [185]

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 ~~MRI~~/Cervical Spine MRI

- Horner's syndrome with symptoms localizing the lesion to the ~~central nervous system~~ ~~(202)~~brain and cervical spine (vertigo, altered facial sensation, contralateral CN IV palsy, crossed motor/sensory signs, radicular signs) (91,163)

Brain ~~MRI~~/Cervical Spine ~~MRI~~/Thoracic Spine MRI ~~(any combination)~~

- 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) ~~(203)~~(13)
  - For known MS, prior to the initiation or change of disease modification treatments and assess disease burden (to establish a new baseline) ~~(204,205)~~(62,164)
  - Follow-up scans, including brain and spine imaging, if patients have known spine disease (62):
    - ~~6-12 months~~3-6 months after starting/changing treatment~~.~~
    - Every ~~1-2~~6-12 months~~years~~ ~~while~~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 ~~MRI~~/Cervical Spine ~~MRI~~/ /Thoracic Spine ~~MRI~~/Lumbar Spine MRI ~~(any combination)~~

- 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 ~~(143,206,207)~~(103,109,165,166)
- Oncological Applications (e.g., primary nervous system, metastatic) ~~(208)~~(40)
  - Drop metastasis from brain or spine ~~(209)~~
  - Suspected leptomeningeal carcinomatosis ~~(210)~~(167)
  - Known t~~T~~umor 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) (CT myelogram)) [168]

- For evaluation of known Arnold-Chiari Malformation
- Tumor evaluation and monitoring in cancer predisposition syndromes
  - Von Hippel Lindau (VHL) - imaging of the brain and spinal cord for hemangioblastomas every 2 years starting at age 14 ([40,62,172]
  - Rhabdoid Tumor Predisposition Syndrome- Brain and Spine MRI at diagnosis and monthly age 0-6 months if whole body MRI not done; Q2-3 months age 7-18months, Q3months age 19 months-5 years.
  - NF-2- Brain IAC annually starting at the age of 10 years and spinal imaging at baseline and every 2 to 3 years with more frequent imaging, if warranted, based on sites of tumor involvement ([176]
  - Schwannomatosis - Brain and spine MRI every two to three years beginning at age 12 years [211]

Note: diagnosis is met with both genetic testing AND clinical features due to incomplete penetrance

/Cervical/Thoracic/Lumbar/Abdomen

Von Hippel Lindau (VHL) every 2 years starting at age 15.

Brain MRI Brain/ MRI and Face/Sinus MRI

- Granulomatosis with polyangiitis (Wegener's granulomatosis) disease [212][169]
- Trigeminal neuralgia or neuropathy with an atypical presentation (for evaluation of the extracranial nerve course) [121] See **background**[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 [185][170]

Brain/ MRI and 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 [19,213][13,171]
- Bilateral optic disk swelling (papilledema) with visual loss [19,214,215,216][13]
- Optic neuritis [214,215,217]
  - 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 ~~(203)~~(13)
- Suspected retinoblastoma ~~(218,219)~~(13)
- ~~Chest CT (or MRI)~~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/~~ and~~ Brain~~/Abdomen/Pelvis~~ MRI ~~Combination Studies~~

- ~~Multiple Endocrine Neoplasia Syndrome Type 1 (MEN-1)~~
- ~~Chest/Abdomen/Pelvis annually~~
- ~~Brain/Chest/Abdomen/Pelvis every 3 years~~
- 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~~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

~~Coding~~

~~CPT~~ Codes

70551, 70552, 70553, +0698T~~ – Brain MRI~~

Applicable Lines of Business

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

BACKGROUND

~~Contraindications~~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 ~~and~~ 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.

~~Headache and Migraine~~

~~MRI for Headache –~~ 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. Neurologic imaging is warranted in patients with headache disorders along with abnormal neurologic examination results or predisposing factors for brain pathology. Contrast-enhanced MRI is performed for evaluation of inflammatory, infectious, neoplastic, and demyelinating conditions~~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

~~**Headache timeframes and other characteristics** – Headaches can be classified as acute, subacute or chronic. Acute headaches are present from hours to days, subacute from days to weeks and chronic headaches for more than 3 months. Acute severe headaches are more likely to be pathological (e.g., SAH, cerebral venous thrombosis) than non-acute (e.g., migraine, tension-type). Headaches can also be categorized as new onset or chronic/recurrent. Non-acute new onset headaches do not require imaging unless there is a red flag as delineated above. Incidental findings lead to additional medical procedures and expense that do not improve patient well-being. Primary headache syndromes, such as migraine and tension headaches, are often episodic with persistent or progressive headache not responding to treatment requiring further investigation (e.g., new daily persistent headache). Imaging is indicated in chronic headaches if there is a change in the headache frequency (number of headaches episodes/month), duration of each episode, severity of the headaches or new characteristics, such as changing aura or associated symptoms.~~ ~~(1,2,3,4,220,221,222,223,224)~~

~~**Migraine with aura** (4,5,225) – The headache phase of a migraine is preceded and/or accompanied by transient neurological symptoms referred to as aura in at least a third of migraine attacks. Migraine with typical aura consists of visual and/or sensory and/or speech/language symptoms, but no motor, brainstem or retinal symptoms and is characterized by gradual development, duration of each symptom no longer than one hour, a mix of positive and negative features and complete reversibility. Atypical or complex aura includes motor, brainstem, monocular visual disturbances, or ocular cranial nerve involvement (hemiplegic migraine, basilar migraine/brainstem aura, retinal migraine, ophthalmoplegic migraine) and secondary causes need to be excluded. Additional features of an aura that raise concern for an underlying vascular etiology include late age of onset, short duration, evolution of the focal symptoms, negative rather than positive visual phenomenon, and history of vascular risk factors.~~

~~Individuals presenting with a new migraine with aura (especially an atypical or complex aura) can mimic a transient ischemic attack or an acute stroke. If there is a new neurologic deficit, imaging should be guided by concern for cerebrovascular disease, not that the individual has a headache.~~ ~~(9,226)~~

~~Drop Metastases~~

~~**Drop Metastases** – Drop metastases are intradural extramedullary spinal metastases that arise from intracranial lesions. Common examples of intracranial neoplasms that result in drop metastases include pineal tumors, ependymomas, medulloblastomas, germinomas, primitive neuroectodermal tumors (PNET), glioblastomas multiform, anaplastic astrocytomas, oligodendrogliomas and less commonly choroid plexus neoplasms and teratomas.~~ ~~(209)~~

Pulsatile Tinnitus

Pulsatile tinnitus - has many etiologies, and the choice of study should be based on accompanying signs and symptoms. For general screening MRI brain with IAC/MRA brain and neck is approvable. If IIIH is suspected (typically with headache and vision changes in a younger woman with a high BMI), MRI/MRV brain is indicated. If there is concern for vascular etiology, CTA or MRA brain/neck is indicated. If there is associated hearing loss and neurological signs/symptoms, MRI brain with IAC is indicated. If the temporal bone is suspected to be involved and/or retrotympanic lesion seen on otoscopy, CT temporal bone/IAC is indicated. If there is concurrent concern for boney and a vascular issue, CTA of the head and neck can be used to evaluate both.

Leptomeningeal Carcinomatosis

Leptomeningeal Carcinomatosis [210,227,228,229] – Leptomeningeal metastasis is an uncommon and typically late complication of cancer with poor prognosis and limited treatment options. Diagnosis is often challenging with nonspecific presenting symptoms ranging from headache and confusion to focal neurologic deficits such as cranial nerve palsies. Standard diagnostic evaluation involves a neurologic examination, MRI of the brain and spine with gadolinium, and cytologic evaluation of the cerebral spinal fluid (CSF). Hematologic malignancies (leukemia and lymphoma), primary brain tumors as well as solid malignancies can spread to the leptomeninges. The most common solid tumors giving rise to LM are breast cancer (12 - 35 %), small and non-small cell lung cancer (10-26 %), melanoma (5 -25 %), gastrointestinal malignancies (4-14 %), and cancers of unknown primary (1-7 %).

Brain MRI/MRA

Combination MRI/MRA of the Brain – This is one of the most misused combination studies and other than what is indicated above these examinations should be ordered in sequence, not together. Vascular abnormalities can be visualized on the brain MRI.

Vertigo

MRI and Vertigo – The most common causes of vertigo seen are benign paroxysmal positional vertigo (BPPV), vestibular neuronitis (VN) and Meniere's disease. These peripheral causes of vertigo are benign, and treatment involves reassurance and management of symptoms. Central causes of vertigo, such as cerebrovascular accidents (CVAs), tumors and multiple sclerosis (MS), need to be considered if the individual presents with associated neurological symptoms, such as weakness, diplopia, sensory changes, ataxia, or confusion. Magnetic resonance imaging is appropriate in the evaluation of individuals with vertigo who have neurologic signs and symptoms, progressive unilateral hearing loss or risk factors for cerebrovascular disease. MRI is more appropriate than CT for diagnosing vertigo due to its superiority in visualizing the posterior portion of the brain, where most central nervous system disease that causes vertigo is found. A full neurologic and otologic evaluation including provocative maneuvers, vestibular function testing and audiogram can help evaluate vertigo of unclear etiology and differentiate between central and peripheral vertigo.

Macrocephaly

MRI for Macrocephaly – Consider ultrasound in infants with macrocephaly and a normal neurological examination, no evidence of increased ICP and an open anterior fontanelle. If head US is normal, the infant should be monitored closely. [230] The anterior fontanelle generally closes between 10 and 24 months of age, with 3% closing between 5-9 months and 11% after 24 months. [231]

Anosmia

Anosmia – Nonstructural causes of anosmia include post-viral symptoms, medications (Amitriptyline, Enalapril, Nifedipine, Propranolol, Penicillamine, Sumatriptan, Cisplatin, Trifluoperazine, Propylthiouracil). These should be considered prior to advanced imaging to look for a structural cause.

Anosmia and dysgeusia have been reported as common early symptoms in individuals with COVID-19, occurring in greater than 80 percent of individuals. For isolated anosmia, imaging is typically not needed once the diagnosis of COVID has been made given the high association. As such, COVID testing should be done prior to imaging. [232,233,234]

MRI Orbits, Face, and Neck MRI rather than MRI Brain is the mainstay for directly imaging the olfactory apparatus and sinonasal or anterior cranial fossa tumors that may impair or directly involve the olfactory apparatus.

Temporal Arteritis

Giant cell arteritis (GCA) is an inflammatory disorder that should be considered in individuals over the age of 50 with the following signs or symptoms: new headaches, acute onset of visual disturbances (especially transient monocular visual loss), jaw claudication, constitutional symptoms, tenderness over the temporal artery, and elevated ESR and/or CRP. A diagnosis of polymyalgia rheumatica (PMR) is highly associated. Extra- and intracranial cerebral vasculitis can also be seen but is rarer, and strokes are related to vasculitis of extracranial cerebral arteries causing vertebral or internal carotid arteries stenosis. Gold standard for diagnosis of GCA is temporal artery biopsy. Color Doppler ultrasound (CDUS) can be used as a surrogate for temporal artery biopsy in some cases. High-resolution magnetic resonance imaging (MRI) can visualize the temporal arteries when used with contrast.

Galactorrhea and Hyperprolactinemia

Galactorrhea and MRI – Isolated galactorrhea without elevated prolactin (normoprolactinemic) is usually due to breast pathology, i.e., breast feeding, trauma, ill-fitting undergarments. Consider mammogram, breast ultrasound, and serial dilution of the individual's prolactin sample to correct for possible hook effect. [235,236]

Chart 1: Causes of Hyperprolactinemia [48]

Physiological	1. Coitus 2. Exercise 3. Lactation 4. Pregnancy

	5. Sleep 6. Stress
Pathological	• Hypothalamic-pituitary stalk damage o Granulomas o Infiltrations o Irradiation o Rathke's cyst o Trauma: pituitary stalk section, suprasellar surgery o Tumors: craniopharyngioma, germinoma, hypothalamic metastases, meningioma, suprasellar pituitary mass extension • Pituitary o Acromegaly o Idiopathic o Lymphocytic hypophysitis or parasellar mass o Macroadenoma (compressive) o Macroprolactinemia o Plurihormonal adenoma o Prolactinoma o Surgery o Trauma • Systematic Disorders o Chest – neurogenic chest wall trauma, surgery, herpes zoster o Chronic renal failure o Cirrhosis o Cranial radiation o Epileptic seizures o Polycystic ovarian disease o Pseudocyesis
Pharmacological	1. Anesthetics 2. Anticonvulsant 3. Antihistamines (H_2)

	4. Antihypertensives 5. Cholinergic agonist 6. Drug-induced hypersecretion 7. Catecholamine depletory 8. Dopamine receptor blockers 9. Dopamine synthesis inhibitor 10. Estrogens: oral contraceptives, oral contraceptive withdrawal 11. Neuroleptics/antipsychotics

Central Venous Thrombosis

A MR Venogram is indicated for the definite evaluation of a central venous thrombosis/dural sinus thrombosis. The most frequent presentations are isolated headache, intracranial hypertension syndrome (headache, nausea/vomiting, transient visual obscurations, pulsatile tinnitus, CN VI palsy, papilledema), [237] seizures, focal neurological deficits, and encephalopathy. Risk factors are hypercoagulable states inducing genetic prothrombotic conditions, antiphospholipid syndrome and other acquired prothrombotic diseases (such as cancer), oral contraceptives, pregnancy, puerperium (6-weeks postpartum), infections, and trauma. COVID-19 infection is associated with hypercoagulability, a thromboinflammatory response, and an increased incidence of venous thromboembolic events (VTE) [238,239]. Since venous thrombosis can cause SAH, infarctions, and hemorrhage, parenchymal imaging with MRI/CT is also appropriate [30,240,241].

Non-aneurysmal Vascular Malformations

Non-aneurysmal vascular malformations can be divided in low flow vascular malformations and high flow vascular malformations. Low flow vascular malformations include dural venous anomalies (DVA), cavernomas, and capillary telangiectasias. High flow vascular malformations include AVM and dural arteriovenous fistulas (dAVF). For low flow malformations, MRI is the study of choice. Limited medical literature is available to support vascular imagining (CTA or MRA). CTA plays a limited role in the assessment of cavernoma but may be used to demonstrate a DVA. MRA is not usually helpful in the assessment of cavernoma, capillary telangiectasia, and DVA. Vascular imaging is indicated in high flow vascular malformations [242].

There is no evidence to support screening of first-degree relatives for AVMs [243]. The risk of having an AVM may be higher than in the general population, but absolute risk is low.

Stroke/TIA

MRI and recent stroke or transient ischemic attack – When revascularization therapy is not indicated or available in patients with an ischemic stroke or TIA, the focus of the work-up is on secondary prevention. Both stroke and TIA should have an evaluation for high-risk modifiable factors such as carotid stenosis atrial fibrillation as the cause of ischemic symptoms [244]. Diagnostic recommendations include neuroimaging evaluation as soon as possible, preferably

~~with magnetic resonance imaging, including DWI; noninvasive imaging of the extracranial vessels should be performed, and noninvasive imaging of intracranial vessels is reasonable.~~ ~~(245)~~

~~Patients with a history of stroke and recent work-up with new signs or symptoms indicating progression or complications of the initial CVA should have repeat brain imaging as an initial study. Patients with remote or silent strokes discovered on imaging should be evaluated for high-risk modifiable risk factors based on the location and type of the presumed etiology of the brain injury.~~

- 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)

~~(246,247,248,249,250,251)~~

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	Medication review, consider brain

Gait	Characteristic	Work up/Imaging
	movements	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
~~Neurogenic~~Neuropathic	Steppage, dragging of toes	EMG, if there is foot drop, Lumbar spine MRI Pelvis MR appropriate evidence of 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~~) [247,249,250,251]~~.) [173–176]

~~Neurological Deficits~~

~~Examples of abnormal reflexes related to upper motor neuron lesion/central pathology include hyperreflexia, clonus, Hoffman sign and Babinski, snout, palmar grasp, and rooting reflexes.~~

~~Visual loss has many possible etiologies, and MRI is only indicated in suspected neurological causes of visual loss based on history and exam. Visual field defects, such as bitemporal hemianopsia, homonymous hemianopsia, or quadranopsia, require imaging as well as does suspected optic nerve pathology. Subjective symptoms such as blurred vision or double vision with no clear correlate on neurological examination requires a comprehensive eye evaluation to exclude more common causes, such as cataracts, refractive errors, retinopathy, glaucoma, or macular degeneration. Transient visual loss with history consistent with TIA but normal exam at time of examination also should be imaged. Positive visual phenomena, such as photopsias or scintillations that march across the visual field, suggest migraine whereas negative phenomenon, such as shaded or blurred, is more characteristic of ischemia.~~

~~Definitions~~

~~MMSE – The Mini Mental State Examination (MMSE) is a tool that can be used to assess mental status systematically and thoroughly. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The MMSE has been the~~

~~most commonly used measure of cognitive function in dementia research, but researchers have recognized that it is relatively insensitive and variable in mildly impaired individuals. The maximum score is 30. A score of 23 or lower is indicative of cognitive impairment. The MMSE takes only 5-10 minutes to administer and is, therefore, practical to use repeatedly and routinely.~~

~~MoCA – The Montreal Cognitive Assessment (MoCA) was designed as a rapid screening instrument for mild cognitive dysfunction. It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. MoCA differs from the MMSE mainly by including tests of executive function and abstraction, and by putting less weight on orientation to time and place. Ten of the MMSE's 30 points are scored solely on the time-place orientation test, whereas the MoCA assigns it a maximum of six points. The MoCA also puts more weight on recall and attention-calculation performance, while de-emphasizing language skill. Time to administer the MoCA is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.~~

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.

~~**Trigeminal Neuralgia (TN)** – According to the International Headache Society, TN is defined as "a disorder characterized by recurrent unilateral brief electric shock-like pain, abrupt in onset~~

and termination, limited to the distribution of one or more divisions of the trigeminal nerve and triggered by innocuous stimuli." [4]. Atypical features include bilateral, hearing loss, dizziness/vertigo, visual changes, sensory loss, numbness, pain > 2min, pain outside trigeminal nerve distribution and progression [121].

Occipital Neuralgia – According to the International Headache Society, occipital neuralgia is defined "Unilateral or bilateral paroxysmal, shooting or stabbing pain in the posterior part of the scalp, in the distribution(s) of the greater, lesser and/or third occipital nerves, sometimes accompanied by diminished sensation or dysesthesia in the affected area and commonly associated with tenderness over the involved nerve(s). Pain is eased temporarily by local anesthetic block of the affected nerve(s). Occipital neuralgia must be distinguished from occipital referral of pain arising from the atlantoaxial or upper zygapophyseal joints or from tender trigger points in neck muscles or their insertions." [121]

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

~~Summary~~

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 o Clarified labs o Added amenorrhea section o Updated adenoma section • Updated IAC section o Clarified congenital hearing loss o Added peripheral vertigo o Added Necrotizing otitis externa Clarified: • Acute and chronic headache timeframes • Migraine aura • Central venous thrombosis

Date	Summary
	● 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	● Changes ○ Updated references ○ Updated background section ○ Updated combination section ● Added ○ Genetic syndromes and rare disease section- reorganized 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**

Date	Summary
	○ 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)) ● Clarified ○ Updated pediatric seizure section. ○ Treatment of Alzheimer's disease with anti-amyloid-β monoclonal antibodies - baseline and surveillance imaging as per FDA labeling ● Deleted ○ Aduhelm monitoring ○ MRI Brain with IAC/MRA Head/MRA Neck section
~~May 2023~~	~~1. Updated and reformatted references~~ ~~2. Updated background section~~ ~~3. Added:~~ ~~4. Indeterminate imaging section~~ ~~5. Follow up of known Rathke cleft cyst~~ ~~1. If no symptoms, MRI at 1/3/5 years to stability~~ ~~2. With new neurological symptoms or atypical imaging features~~ ~~3. Post treatment, yearly for 5 years~~ ~~6. General Information moved to beginning of guideline with added statement on clinical indications not addressed in this guideline~~ ~~7. Added statement regarding further evaluation of indeterminate findings on prior imaging~~ ~~8. Clarified:~~ ~~9. Abnormal reflexes (*pathological, asymmetric, hyperreflexia)*~~

Date	Summary
	10. New onset headache - Related to activity or event (sexual activity, *exertion, Valsalva*, position), new or progressively worsening 11. Post concussive syndrome if persistent or disabling symptoms and *MRI* has not been performed 12. *Screening* for silent cerebral infarcts in early school age children and adults with *HbSS sickle cell disease or HbSβ0 thalassemia* 13. Cushing syndrome *suspected (high ACTH (>5) with cortisol suppression on low or high dose dexamethasone suppression test)* 14. Elevated prolactin after evaluation for another cause - neuroendocrine signs or symptoms (i.e., headache, galactorrhea, abnormal menses, infertility, or bitemporal hemianopsia) and/or *abnormal pituitary hormones (low testosterone /estrogen/* 15. *progesterone AND low or normal LH/FSH)* 16. Total testosterone levels persistently borderline around the lower limits of normal range (200-400 ng/dL) with low or normal LH/FSH; AND Low free testosterone and *consideration and addressment* of reversible functional causes of gonadotropin suppression (e.g., obesity, opioid use, diabetes, steroid use, or comorbid illness) 17. Tumor surveillance *as per professional society recommendations* 18. Note: In the pediatric population, imaging is not indicated in simple febrile seizures *or in idiopathic focal or generalized epilepsy with typical features [BECTS, childhood absence epilepsy (CAE), juvenile absence epilepsy (JAE), and juvenile myoclonic epilepsy (JME)]* 19. 6-month repeat scan in patients with MRI disease activity that is not associated with *new clinical symptoms on a routine follow-up scan (i.e., Radiographically isolated syndrome)* 20. Indications for MR Perfusion Imaging section 21. Brain MRI/Brain MRA - Headache associated with exercise, *exertion*, *Valsalva* or sexual activity 22. Deleted: 1. Pediatric seizure indications and combined with adult 2. Anosmia (loss of smell) or dysosmia documented by objective testing that is persistent and of unknown origin (also in combo 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