American College of Radiology
ACR Appropriateness Criteria®
Tinnitus

Variant 1: **Subjective or objective pulsatile tinnitus (no myoclonus or Eustachean tube dysfunction).**

Procedure	Appropriateness Category	Relative Radiation Level
CTA head with IV contrast	Usually Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Appropriate	☢☢☢
CT venography head with IV contrast	Usually Appropriate	☢☢☢
MRA head without and with IV contrast	Usually Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Appropriate	O
MRA head without IV contrast	May Be Appropriate	O
MR venography head without and with IV contrast	May Be Appropriate	O
Arteriography cervicocerebral	May Be Appropriate	☢☢☢
MR venography head without IV contrast	May Be Appropriate	O
MRI head and internal auditory canal without IV contrast	May Be Appropriate	O
US duplex Doppler carotid	May Be Appropriate	O
CT temporal bone with IV contrast	May Be Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢

Variant 2: **Asymmetric or unilateral, subjective, nonpulsatile tinnitus (no otoscopic finding; no asymmetric hearing loss, neurologic deficit, or trauma).**

Procedure	Appropriateness Category	Relative Radiation Level
MRI head and internal auditory canal without and with IV contrast	Usually Appropriate	O
MRI head and internal auditory canal without IV contrast	May Be Appropriate	O
CT temporal bone without IV contrast	May Be Appropriate	☢☢☢
CT temporal bone with IV contrast	May Be Appropriate	☢☢☢
CTA head with IV contrast	May Be Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT venography head with IV contrast	Usually Not Appropriate	☢☢☢
MRA head without IV contrast	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MR venography head without IV contrast	Usually Not Appropriate	O
MR venography head without and with IV contrast	Usually Not Appropriate	O
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
US duplex Doppler carotid	Usually Not Appropriate	O
MRI functional (fMRI) head without IV contrast	Usually Not Appropriate	O
MEG	Usually Not Appropriate	O

Variant 3: **Symmetric or bilateral, subjective, nonpulsatile tinnitus (no hearing loss, neurologic deficit, or trauma).**

Procedure	Appropriateness Category	Relative Radiation Level
CT venography head with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without IV contrast	Usually Not Appropriate	☢☢☢
MRI head and internal auditory canal without IV contrast	Usually Not Appropriate	O
MRI head and internal auditory canal without and with IV contrast	Usually Not Appropriate	O
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
CTA head and neck with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone with IV contrast	Usually Not Appropriate	☢☢☢
CT temporal bone without and with IV contrast	Usually Not Appropriate	☢☢☢
MRA head without IV contrast	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MR venography head without IV contrast	Usually Not Appropriate	O
MR venography head without and with IV contrast	Usually Not Appropriate	O
US duplex Doppler carotid	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
MRI functional (fMRI) head without IV contrast	Usually Not Appropriate	O
MEG	Usually Not Appropriate	O

TINNITUS

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Summary of Literature Review

Introduction/Background

Tinnitus is the perception of sound when no external sound is present. It is common, occurring in approximately 10% of the U.S. adult population [1]. Tinnitus is not a disease; rather, it is a symptom that can result from a number of underlying causes. Tinnitus may be categorized as pulsatile or nonpulsatile, primary (idiopathic) or secondary to another condition, and subjective or objective.

"Pulsatile" tinnitus is a repetitive sound coinciding with the patient's heartbeat, whereas "nonpulsatile" tinnitus is a continuous or constant nonsynchronous sound. Nonpulsatile tinnitus is almost always "subjective" (heard only by the patient), and is the most common variant, often associated with presbycusis, medication toxicities, exposures to environmental noises, or additional etiologies. Subjective tinnitus is perceived only by the patient, and may be caused by a variety of otologic, neurologic, and metabolic disorders [2], most often in the setting of sensorineural hearing loss. "Objective" tinnitus is audible to the examining health care provider and should prompt evaluation for an underlying vascular abnormality [3].

Primary tinnitus is idiopathic, and may or may not have concomitant sensorineural hearing loss, and there is typically no cure. It may resolve spontaneously or symptoms can be mitigated with auditory, behavioral, or cognitive therapies. Secondary tinnitus is associated with an underlying source that may or may not require imaging to define. Etiologies range from cerumen impaction to middle ear or labyrinthine disorders, vascular abnormalities, vestibular schwannoma or intracranial hypertension.

The primary evaluation of tinnitus begins with a comprehensive otologic examination to determine if a vascular retrotympanic mass is present, audiometric examination, and review of medical history and medications (including over the counter), prior to imaging [3]. The appropriateness of imaging examinations or modalities depends both upon the characterization of tinnitus and any related symptoms. It is common that tinnitus co-exists with other symptoms, therefore this document includes references to the ACR Appropriateness Criteria® for "Hearing Loss and/or Vertigo" [4], "Head Trauma" [5], and "Cerebrovascular Disease" [6] to guide imaging in these settings. This is in accordance with the AAO-HNS clinical practice guideline for tinnitus [3], which also makes strong recommendations against imaging in patients with subjective, nonpulsatile tinnitus that does not localize to one ear and is not associated with a focal neurologic abnormality or asymmetric hearing loss. Those guidelines also focused on the impact of quality of life, noting that patients with tinnitus and severe anxiety or depression require prompt identification and intervention because suicide is reported in tinnitus patients with coexisting psychiatric illness [3].

Discussion of Procedures by Variant

Variant 1: Subjective or objective pulsatile tinnitus (no myoclonus or Eustachean tube dysfunction).

The main purpose for the imaging of patients with pulsatile tinnitus is to determine if an underlying anomaly or abnormality may be addressed with medical, endovascular, surgical, or radiation therapy [7]. Primary

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considerations include vascular masses [8,9], aberrant arterial or venous anatomy [10,11], vascular malformations [12,13], and intracranial hypertension [14-16]. Objective tinnitus is rare and has been attributed to turbulent flow in the setting of atherosclerotic carotid artery disease, jugular bulb abnormalities, abnormal condylar, and mastoid emissary veins, which may not be recognized as having a pulsatile component. Correlation with the physical examination prior to imaging is recommended, to appropriately distinguish patients with objective tinnitus related to muscle spasm/myoclonus [17-20] or Eustachean tube dysfunction from those where a vascular cause is suspected.

CT and CTA

Dedicated temporal bone computed tomography (CT) is recommended as a first-line study in the setting of a vascular retrotympanic mass or subjective pulsatile tinnitus [8,9,21,22] to determine if a paraganglioma or adenomatous middle ear tumor is the source of pulsatile tinnitus, or if there is variant vascular anatomy. Temporal bone CT is also sensitive for semicircular canal dehiscence [23]; however, a risk of overestimation of superior semicircular dehiscence may occur in the absence of oblique reformats (in the planes Stenver and Poschl) given the intrinsic sloping of the petrous temporal bone [24].

Given concerns for a possible underlying vascular process, contrast-enhanced CT angiography (CTA) of the head and neck is also supported as a first-line imaging modality [12,25-27]. Dedicated temporal bone CT reconstructions can be created from the high resolution source CTA images without additional radiation exposure to the patient [28], however, there is no evidence to support the practice of a combined CTA/CT temporal bone examination rather than one or the other alone or sequentially. Contrast bolus timing can be adapted to define arterial and venous anatomy [28], to identify vascular variants of the arteries [10], or persistent petro-squamosal sinus [11], and pathology such as dural arteriovenous fistula (AVF) [12,13], arterial dissection [29,30], or sigmoid sinus wall diverticulum or anomalies (commonly associated with intracranial hypertension/pseudotumor cerebri syndrome) [14-16]. An advantage of CTA is bone algorithms that enable assessment of osseous channels in the bone in dural AVF, or dehiscence of the sigmoid plate or jugular bulb [12,26,27].

MRI and MRA

Magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA) have been shown to be of comparable accuracy to catheter angiography in small series [31,32] and may be considered as a noninvasive alternative to screen for a suspected intracranial vascular malformation. Noncontrast MRI and MRA techniques are available for evaluating for vascular anomalies, malformations or dissection in patients with allergies or contraindications to iodinated contrast or gadolinium contrast [27]. MRI of the internal auditory canals and MRA techniques can characterize the relationship between nerves and blood vessels. There remains ongoing debate regarding the significance of vascular contact/impingement of the cisternal eighth cranial nerve [10,33-35] and given the prevalence of normal, asymptomatic vascular loops, this finding should not obviate a search for another explanation for tinnitus.

Angiography

Craniocervical angiography is typically reserved for patients with objective pulsatile tinnitus, subjective pulsatile tinnitus with inconclusive noninvasive imaging findings [27,29], or for further characterization of an intracranial dural AVF identified on noninvasive imaging; it can also be used to better differentiate between a paraganglioma or lesion that may mimic a paraganglioma such as middle ear adenomatous tumors [9].

US

Carotid duplex or Doppler ultrasound (US) is helpful to delineate extracranial carotid stenosis when suspected as the prime cause of pulsatile tinnitus [27]. Elevated extracranial carotid resistive indices and end diastolic velocity may be seen in the setting of intracranial vascular abnormalities [36], and should be addressed with intracranial modalities discussed above.

Variant 2: Asymmetric or unilateral, subjective, nonpulsatile tinnitus (no otoscopic finding; no asymmetric hearing loss, neurologic deficit, or trauma).

Nonpulsatile tinnitus may be described as ringing, buzzing, or clicking sensations. In this variant, a preceding clinical exam is important because otoscopy may identify a cause such as cerumen impaction, a middle ear infection, or mass [3]. Any imaging decisions should be guided on those examination findings, rather than the symptom of tinnitus. If there is concomitant asymmetric hearing loss, neurologic deficit, or head trauma, imaging should be guided by the ACR Appropriateness Criteria® for "Hearing Loss and/or Vertigo" [4], "Cerebrovascular Disease" [6], or "Head Trauma" [5], respectively.

MRI and MRA
In the setting of subjective nonpulsatile unilateral tinnitus without clinically evident cause or other associated symptoms, retrocochlear lesions, such as a vestibular schwannoma or other cerebellopontine angle cistern lesion [37-40], or auditory pathway masses are of concern [35,50]. These are best evaluated with MRI of the internal auditory canals without and with contrast.

Unilateral tinnitus has also been associated with temporomandibular joint disorders, which may be evaluated with dedicated temporomandibular joint MRI protocols, although the mechanism is not clear [41-44].

Delayed MRI after intravenous or intratympanic contrast has been proposed for the detection of endolymphatic hydrops in the setting of Meniere disease, however this has not been validated or shown to be correlative with tinnitus symptoms [45,46].

CT and CTA
If the patient is unable to undergo MR imaging, CT may be helpful to evaluate for underlying vascular or osseous processes; however, CT has limited sensitivity in detecting small masses along the cranial nerves, cisterns, brain or brainstem. Dedicated temporal bone CT reconstructions can be created from high resolution source CTA images without additional radiation exposure to the patient [28], but there is no evidence to support the practice of a combined CTA/CT temporal bone examination rather than one or the other alone or sequentially.

Angiography
Arteriography is not routinely used in the evaluation of patients with nonpulsatile tinnitus.

US
US is not routinely used in the evaluation of patients with nonpulsatile tinnitus.

MEG and fMRI
Magnetoencephalography (MEG) and functional MRI (fMRI) have been used to better define brain activity [47,48] and neural connections [49,50] in patients with tinnitus, however these techniques remain in the research realm.

Variant 3: Symmetric or bilateral, subjective, nonpulsatile tinnitus (no hearing loss, neurologic deficit, or trauma).

Imaging is not indicated in all cases of tinnitus symptoms, and is unrevealing in the setting of tinnitus related to medications, noise-induced hearing loss, presbycusis or chronic bilateral hearing loss. Whether CT or MRI is needed for evaluation of nonpulsatile tinnitus often depends on concomitant symptoms or examination findings such as hearing loss, neurologic deficit or head trauma, as tinnitus has been reported in the setting of hemorrhage [51,52], neurodegeneration [53], and spontaneous intracranial hypotension [54-56], among others. References to those ACR Appropriateness Criteria documents are provided below.

Tinnitus in the setting of a nontraumatic neurologic deficit should be primarily guided by the onset of symptoms, with reference to the ACR Appropriateness Criteria® "Cerebrovascular Disease" [6].

Please see the ACR Appropriateness Criteria® "Hearing Loss and/or Vertigo" [4] to guide imaging of tinnitus in the setting of asymmetric hearing loss or vertigo, which may be associated with disorders of the middle ear (otitis or cholesteatoma [57]), cochlea (labyrinthitis [58], otosclerosis [59], or intralabyrinthine hemorrhage [52,60]), or central/neural structures (vestibular schwannoma and cerebellopontine angle masses [37,38,40], brainstem or auditory pathway lesions [51,61]).

Tinnitus may also be a presenting or delayed symptom in the setting of a temporal bone fracture [5,62] or vascular injury. See the ACR Appropriateness Criteria® "Head Trauma" [5] for additional detail.

CTA and CTV
CTA/CT venography (CTV) is not routinely used in the evaluation of patients with symmetric or bilateral nonpulsatile tinnitus.

MRI
MRI is not routinely used in the evaluation of patients with symmetric or bilateral nonpulsatile tinnitus.

MRA and MRV
MRA/MR venography (MRV) is not routinely used in the evaluation of patients with symmetric or bilateral nonpulsatile tinnitus.

US
US is not routinely used in the evaluation of patients with symmetric or bilateral nonpulsatile tinnitus.

Arteriography
Arteriography is not routinely used in the evaluation of patients with symmetric or bilateral nonpulsatile tinnitus.

MEG and fMRI
MEG and fMRI have been used to better define brain activity [47,48] and neural connections [49,50] in patients with tinnitus; however, these techniques remain in the research realm.

Summary of Recommendations

- In patients with pulsatile tinnitus, temporal bone CT and CTA are appropriate to evaluate for a middle ear mass or vascular etiology. MRI may be considered as a noninvasive alternative to screen for a suspected intracranial vascular malformation.
- Given concern for retrocochlear process, MRI of the internal auditory canals is the most appropriate imaging test for subjective nonpulsatile unilateral tinnitus without a clinically evident cause or other associated symptoms.
- If there is concomitant asymmetric hearing loss, neurologic deficit, or head trauma, imaging should be guided by those respective ACR Appropriateness Criteria documents, rather than the presence of tinnitus.
- Imaging is not indicated in all cases of tinnitus symptoms, and is usually not appropriate for symmetric or bilateral, subjective, nonpulsatile tinnitus in the absence of other symptoms.

Summary of Evidence
Of the 63 references cited in the *ACR Appropriateness Criteria® Tinnitus* document, 5 are categorized as therapeutic references including 1 good-quality study, and 1 quality study that may have design limitations. Additionally, 57 references are categorized as diagnostic references including 2 good-quality studies, and 11 quality studies that may have design limitations. There are 40 references that may not be useful as primary evidence. There is 1 reference that is a meta-analysis study.

The 63 references cited in the *ACR Appropriateness Criteria® Tinnitus* document were published from 1990-2016.

Although there are references that report on studies with design limitations, 3 good-quality studies provide good evidence.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [63].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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