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# Yield of CT Angiography and Contrast-Enhanced MR Imaging in Patients with Dizziness

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## ABSTRACT

**BACKGROUND AND PURPOSE:** Dizziness is a common symptom in emergency and outpatient settings. The purpose of our study was to compare the diagnostic and therapeutic efficacy of CTA of the head and neck, contrast-enhanced MR imaging of the brain (CE-MR), and contrast-enhanced MR imaging of the internal auditory canals and temporal bones in patients with isolated dizziness, to determine which of these modalities should be preferred in the evaluation of dizziness.

**MATERIALS AND METHODS:** We retrospectively identified patients presenting with dizziness from January 2011 to June 2012 who underwent a CTA, CE-MR, or MRIAC. We excluded patients with signs or symptoms suggestive of other neurologic pathology or a history of an abnormality known to cause dizziness. We calculated the proportion of patients with abnormal findings on a study, tabulated the nature of the abnormality, and reviewed the medical records to determine whether imaging changed management.

**RESULTS:** Two hundred twenty-eight CTAs, 304 CE-MRs, and 266 MRIACs were included. Five patients (2.2%) with CTAs, 4 (1.3%) with CE-MRs, and 4 (1.5%) with MRIACs demonstrated significant findings that related to the history of dizziness or were incidental but judged to be clinically significant. Of these, 3 CTA (1.3%), 2 CE-MR (0.7%), and 3 MRIAC (1.1%) examinations resulted in a change in clinical management.

**CONCLUSIONS:** Imaging evaluation of the patient with uncomplicated dizziness is unlikely to identify clinically significant imaging findings and is very unlikely to result in a change in clinical management, with an overall TE of 1.0%. Thus, the routine use of imaging in the evaluation of the patient with dizziness cannot be recommended.

**ABBREVIATIONS:** CE-MR = contrast-enhanced MR imaging examination of the brain; DE = diagnostic efficacy; MRIAC = contrast-enhanced MR imaging examination of the internal auditory canals and temporal bones; TE = therapeutic efficacy

An estimated 7.5 million patients with dizziness are seen each year in the United States, making dizziness one of the most common principal neurologic complaints in both the emergency and outpatient settings.[1,2] The differential diagnosis for dizziness can be grouped into etiologies related to the peripheral nervous or the central nervous system or cerebrovascular causes.[3-6] When patients present with dizziness, clinicians want to be confident that CNS and cerebrovascular causes are excluded.[7,8] Although CNS causes of dizziness that are life-threatening or require urgent intervention are not common,[9-11] the potential severe consequences of misdiagnosis lower the threshold for brain imaging.[12]

A contrast-enhanced MR imaging examination is well-suited to detect many structural causes of both peripheral and central dizziness, including acute brain stem stroke, while contrast-enhanced MR imaging examination of the internal auditory canals and temporal bones is well-suited for the detailed evaluation of abnormalities of the seventh and eight cranial nerves, as well as the membranous labyrinth. Alternatively, CTA is sensitive for identifying vertebrobasilar insufficiency as an etiology of dizziness.

The imaging approach to the patient with dizziness varies widely in clinical practice. Locoregional preferences strongly influence the decision to use CTA, MRIAC, or CE-MR, and an evidence-based approach to imaging dizziness is lacking in current clinical practice. This may adversely impact the clinical value of these studies because the value of a diagnostic test is largely dependent on the prevalence (or the clinician's estimate of the pretest probability) of the target disorder, and the abnormalities detectable by CTA, MRIAC, or CE-MR are statistically unlikely etiologies in a general sample of patients with dizziness.[13] Defining the value of diagnostic tests in clinical care is a goal of health-

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care reform effort because test use contributes to both the cost and quality of care. We conducted the present study to determine the incidence and nature of abnormalities on CTA, CE-MR and MRIAC examinations performed in the work-up of patients with isolated dizziness and to assess which imaging technique contributed most effectively to the clinical management of patients with dizziness.

## MATERIALS AND METHODS

### Patient Selection and Image Acquisition

Our institutional review board approved this study, with a waiver of informed consent. All CTA, CE-MR, and MRIAC examinations included in this study were performed as part of patients' routine clinical care, and the results were retrospectively reviewed.

We searched our enterprise-wide electronic medical record, encompassing 20 academic and community hospitals, including a free-standing pediatric hospital, in an effort to identify patients with CTA, CE-MR, or MRIAC studies performed for the evaluation of dizziness. Radiology reports from January 1, 2011, to June 13, 2012, were searched by using the key words "dizziness," "dizzy," "giddiness," and "vertigo." CTA, CE-MR, and MRIAC studies were excluded if performed on patients with focal neurologic symptoms (ie, vomiting, focal weakness, aphasia, vision loss) in addition to dizziness or on patients with a known history of the following abnormalities that may result in dizziness: posterior fossa mass, severe vertebrobasilar vascular disease, vascular dissection, known posterior fossa ischemia/infarct, or multiple sclerosis. Demographic data collected included age and sex. Clinical data collected, from a retrospective review of the electronic medical record and radiology report, included presenting symptoms, presentation to the emergency department versus outpatient clinic, specialty of ordering clinician, imaging results, and postimaging clinical management.

CTA was performed with 16- or 64-section multidetector row CT scanners (LightSpeed VCT; GE Healthcare, Milwaukee, Wisconsin). CTA acquisitions were performed according to standard protocols by scanning from the aortic arch to the calvarial vertex by using an axial technique, 0.5 pitch, 1.25-mm collimation, 350 maximal mA, 120 kV (peak), 22-cm FOV, and 75–100 mL of iodinated contrast material administered by a power injector at 4–5 mL per second into an antecubital vein with automated contrast bolus tracking, triggering scanning once opacification in the aortic arch reached 50 HU.

Contrast-enhanced MR imaging examinations were performed on Signa HDxt Optima 1.5T and Discovery MR750 3T systems (GE Healthcare) by using a standard head coil. Sequences included sagittal and axial T1-weighted images (TR, 600 ms; TE, minimum; section thickness, 5 mm; number of acquisitions, 1) and spin-echo or fast spin-echo axial proton-attenuation- (TR, 2000–2500 ms; TE, minimum; section thickness, 5 mm; number of acquisitions, 1) and T2-weighted images (TR, 2000–2500 ms; TE, 84–102 ms; section thickness, 5 mm; number of acquisitions, 1). Contrast-enhanced T1-weighted images were obtained with 0.1-mmol/kg gadobenate dimeglumine (MultiHance; Bracco, Milan, Italy) by using typical T1-weighted parameters as described above. At our institution, postcontrast imaging of the brain is performed immediately (<1 minute) after contrast administration. FLAIR images (TR, 9000–10,000 ms; TE, 149 ms; TI, 2200 ms) and diffusion-weighted imaging (single-shot echo-planar; TR, 10,000 ms; TE, minimum; section thickness, 5 mm; matrix, 128) sequences were also performed. All patients had images obtained in at least 2 orthogonal directions. FOV ranged from 200 to 220 mm, depending on patient size.

MR imaging examinations of the internal auditory canal were performed on Signa HDxt Optima 1.5T and Discovery MR750 3T systems (GE Healthcare) by using a standard head coil. Acquisitions involved the use of axial FLAIR and sagittal T1-weighted spin-echo sequences of the entire brain and an axial T1-weighted spin-echo sequence centered on the internal auditory canals before contrast administration (TR/TE, 440/12 ms; 3-mm section thickness; 256 × 256 matrix; 180 × 180 FOV), a fast imaging employing steady-state acquisition sequence centered on the internal auditory canal (TR/TE, 8.00/2.40 ms; 384 × 156 matrix; 180 × 180 FOV; 0.8-mm section thickness), and axial and coronal T1-weighted spin-echo sequences centered on the internal auditory canal, using fat saturation, after the administration of a gadolinium-based contrast agent (same parameters as those of the precontrast T1-weighted spin-echo sequence).

### Diagnostic and Therapeutic Efficacy

To determine the value of CTA and CE-MR examinations in the work-up of dizziness, we used the 2 categories of efficacy defined by the American College of Radiology Committee on Efficacy.[14] Diagnostic efficacy (the number of studies with a new or progressive major finding divided by the total number of studies) is an indicator of the value of the study in assisting in a diagnosis. Therapeutic efficacy (the number of studies resulting in a change in clinical management divided by the total number of studies) is an indicator of the influence on the patient's clinical management.

### Data Analysis

Percentages and confidence intervals were calculated for pertinent imaging finding rates by using a continuity correction.[15]

## RESULTS

### Patient Selection and Image Acquisition

Two hundred thirty-nine CTA, 320 CE-MR, and 268 MRIAC studies performed for dizziness were initially evaluated. Among patients with CTA examinations, 2 were excluded for focal neurologic deficits (aphasia, bilateral upper extremity weakness) and 9 were excluded for a known history of an abnormality that may result in dizziness (known vertebrobasilar insufficiency, posterior fossa arteriovenous malformation). Among patients with CE-MR examinations, 4 were excluded because of a known multiple sclerosis diagnosis, 6 were excluded because of focal neurologic deficits (aphasia, right leg weakness, vision loss), and 6 were excluded because of a known history of an abnormality that may result in dizziness (prior posterior fossa infarction, posterior fossa metastasis, vertebrobasilar insufficiency). Among patients with MRIAC examinations, 2 were excluded because of a known history of an abnormality that may result in dizziness (vestibular schwannoma). No studies were excluded because of inadequate diagnostic quality of the images. The remaining 228 CTA, 304 CE-MR,

**Table 1: Patient demographics and clinical characteristics**

| | CT Angiography | Contrast-Enhanced MR Imaging, Brain | Contrast-Enhanced MR Imaging, IAC | Total |
|---|---|---|---|---|
| No. of patients | 228 | 304 | 266 | 798 |
| No. of males (%) | 106 (47) | 115 (38) | 98 (37) | 319 (40) |
| Age (yr) (mean) (range) | 56 (19–90) | 55 (15–90) | 54 (6–93) | 55 (6–93) |
| Emergency setting (%) | 191 (84) | 63 (21) | 3 (1) | 257 (32) |
| Diagnostic efficacy | 5 (2.2%) | 4 (1.3%) | 4 (1.5%) | 13 (1.6%) |
| Therapeutic efficacy | 3 (1.3%) | 2 (0.7%) | 3 (1.1%) | 8 (1.0%) |

**Note:**—IAC indicates internal auditory canal.

**Table 2: Ordering clinicians by specialty**

| | CT Angiography (%) | Contrast-Enhanced MR Imaging, Brain (%) | Contrast-Enhanced MR Imaging, IAC (%) | Total (%) |
|---|---|---|---|---|
| Otolaryngology | 0 (0%) | 35 (12%) | 158 (59%) | 193 (24%) |
| Neurology | 23 (10%) | 41 (13%) | 31 (12%) | 95 (12%) |
| Internal medicine/primary care specialties | 13 (6%) | 137 (45%) | 68 (26%) | 218 (27%) |
| Emergency department | 191 (84%) | 63 (21%) | 3 (1%) | 257 (32%) |
| Neurosurgery | 1 (0.4%) | 8 (3%) | 3 (1%) | 12 (2%) |
| Other[a] | 0 (0%) | 20 (7%) | 3 (1%) | 23 (3%) |

**Note:**—IAC indicates internal auditory canal.

[a] Each ordering 3 or fewer studies: Cardiology, Cardiothoracic Surgery, Endocrinology, General Surgery, Hematology/Oncology, Obstetrics and Gynecology, Ophthalmology, Pediatrics, Physical Medicine and Rehabilitation, Pulmonology, Rheumatology, Radiation Oncology, and Urology.

and 266 MRIAC studies were included in our study. Demographics and clinical characteristics are summarized in Table 1.

An overwhelming majority of the CTA studies were ordered by emergency department physicians, while most MRIAC examinations were requested by otolaryngologists. Ordering clinicians of CE-MR examinations spanned a more diverse array of specialties, but a plurality was ordered by primary care physicians. The specialties of ordering physicians are shown in Table 2.

### *Diagnostic and Therapeutic Efficacy*

Of all CTA studies, 5 of 228 (2.2%; 95% CI, 0.08%–5.32%) demonstrated previously unknown major findings in the evaluation of dizziness. One revealed multifocal basilar artery stenosis with severe narrowing of the mid-basilar artery, 1 showed >70% bilateral internal carotid artery stenosis, 1 had an occluded right internal carotid artery, and 2 were suspected of showing mild fibromuscular dysplasia. Of all CTA studies, only 3 were documented to have changed management (1.3%; 95% CI, 0.03%–4.12%): the study with basilar stenosis, the study with >70% internal carotid stenosis, and the study with an occluded right internal carotid artery. No clinical action was taken for the findings of possible mild fibromuscular dysplasia.

Of all CE-MR studies, 4 of 304 (1.3%, 95% CI, 0.04–3.57%) demonstrated previously unknown major findings in the setting of a dizziness work-up. Two demonstrated remote cerebellar infarcts that were not previously known, 1 revealed an aggressive-appearing right temporal lobe intraparenchymal mass, and a third showed a new metastasis to the right orbit in a patient with thyroid cancer. Of all CE-MR studies, only the studies demonstrating the right temporal lobe mass and the new orbital metastasis (which was thought to be unrelated to the patient's dizziness) were documented to have changed clinical management (0.7%; 95% CI, 0.01%–2.62%). Dizziness in 1 patient with a remote cerebellar infarct was thought to be related to alcohol withdrawal, while dizziness in the second patient with cerebellar infarct was thought to be related to dehydration.

Of all MRIAC studies, 4 of 266 (1.5%; 95% CI, 0.05%–4.06%) demonstrated previously unknown major findings in the setting of a dizziness work-up. One demonstrated a large mastoid effusion and findings of otomastoiditis. Two demonstrated vestibular schwannomas, and 1 study demonstrated enhancement in a middle cerebral peduncle, thought to be related to a previously unknown diagnosis of demyelinating disease. The patient with a mastoid effusion and findings of otomastoiditis had an infection in that region already suspected clinically. Only the remaining 3 findings (1.1%; 95% CI, 0.03%–3.54%) resulted in a change in management.

When we took all 3 types of imaging together, the overall diagnostic efficacy of imaging of patients with dizziness was 0.016 (95% CI, 0.009–0.029), while the overall therapeutic efficacy was 0.010 (95% CI, 0.005–0.020).

Of the studies with previously unknown major findings, 4 were ordered by otolaryngologists (DE, 0.021; 95% CI, 0.007–0.056), 2 were ordered by neurologists (DE, 0.021; 95% CI, 0.004–0.081), 2 were ordered by primary care physicians (DE, 0.009; 95% CI, 0.002–0.036), and 5 were ordered by emergency department physicians (DE, 0.020; 95% CI, 0.007–0.047). Of the studies that changed management, 3 were ordered by otolaryngologists (TE, 0.016; 95% CI, 0.004–0.048), 1 was ordered by a neurologist (TE, 0.011; 95% CI, 0.001–0.066), 1 was ordered by a primary care physician (TE, 0.005; 95% CI, 0.001–0.029), and 3 were ordered by emergency department physicians (TE, 0.011; 95% CI, 0.003–0.037).

## DISCUSSION

The purpose of this study was to compare the efficacy of CTA, CE-MR, and MRIAC in the evaluation of uncomplicated dizziness. Our results indicate that the diagnostic and therapeutic efficacy of imaging of dizziness with any of the 3 modalities is extremely low. Unsuspected abnormalities were found in <3% of

patients, and only slightly more than half of these induced a change in clinical management.

Imaging certainly plays a role in the evaluation of the patient with dizziness with accompanying focal neurologic symptoms and/or signs, known vascular abnormality, prior posterior fossa ischemic event, or posterior fossa mass, and may have a role in the evaluation of patients with dizziness with >3 thrombotic stroke risk factors.[16] On the basis of our findings, however, we cannot endorse the routine use of imaging—with CTA, CE-MR, or MRIAC—in the evaluation of the patient with dizziness without other symptoms or risk factors.

The diagnostic approach to the patient with dizziness is complex and often combines a detailed history and physical examination with various ancillary tests including the Dix-Hallpike maneuver, orthostatic blood pressure testing, auditory brain stem response testing, posturography, electronystagmography, and imaging, but there is not a unifying consensus on when imaging may or may not be appropriate or even on which specific imaging test should be obtained.[17-29] Some authors advocate early imaging to exclude a vascular or ischemic basis for vertigo, particularly in patients with thrombotic stroke risk factors,[16] while others argue against the routine use of imaging.[18-21] Even among those authors who favor early imaging, however, there is no consensus on the type of imaging to be performed.

Despite the significant variability in the type of imaging studies performed in the evaluation of patients with dizziness—some of which is undoubtedly due to local biases—an improvement in patient outcomes has yet to be established for any of the various imaging protocols.[30] Some authors have attempted to emphasize physical examination in lieu of reliance on imaging.[31]

Reliance on imaging in the emergency department may also be driven by a fear of missing a potentially treatable vertebral artery dissection with associated medullary infarction. Despite concern that this rare cause of dizziness may at times present with isolated vertigo,[32-34] multiple recent reports have confirmed the utility of bedside physical examination and a detailed history in identifying and appropriately triaging this important subset of often young patients presenting with vertigo.[35-37]

On the basis of our findings, we would caution against the use of routine imaging in the evaluation of the patient with uncomplicated dizziness. The importance of a careful and detailed history and physical examination cannot be overstated, however, because there is a major role for imaging in the evaluation of the patient with dizziness with focal neurologic symptoms or for patients with a known history of a posterior fossa mass, severe vertebrobasilar vascular disease, vascular dissection, known posterior fossa ischemia/infarct, and multiple sclerosis.

The principal limitation of our study is the relatively large number of exclusion criteria used. Given that a large number of patients presenting with vertigo are elderly and are therefore likely to have some of the comorbidities defined as exclusion criteria in our study, one may argue that our recommendations are applicable to only a subset of the general population presenting with dizziness. However, our exclusion rate of 4% does not suggest that this would affect our overall conclusion. Another potential limitation is that we did not attempt to differentiate between the various subtypes of dizziness, notably vertigo versus lightheadedness. It may prove interesting to investigate whether differentiating among subtypes of dizziness could uncover a subset of patients that has a greater proportion of clinically relevant abnormalities evident on imaging.

## CONCLUSIONS

Imaging evaluation of patients with uncomplicated dizziness is unlikely to identify a clinically significant imaging finding and is very unlikely to result in a change in clinical management, with an overall therapeutic efficacy of only 1.0%. Thus, the routine use of imaging in the evaluation of the patient with dizziness with no other symptom or sign cannot be recommended.

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