Limited usefulness of routine head and neck CT angiogram in the imaging assessment of dizziness in the emergency department

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Abstract

Objective: To assess the usefulness of head and neck computed tomography angiogram for the investigation of isolated dizziness in the emergency department in detecting significant acute findings leading to a change in management in comparison to non-contrast computed tomography scan of the head.

Methods: Patients presenting with isolated dizziness in the emergency department investigated with non-contrast computed tomography and computed tomography angiogram over the span of 36 months were included. Findings on non-contrast computed tomography were classified as related to the emergency department presentation versus unrelated/no significant abnormality. Similarly, computed tomography angiogram scans were classified as positive or negative posterior circulation findings.

Results: One hundred and fifty-three patients were imaged as a result of emergency department presentation with isolated dizziness. Fourteen cases were diagnosed clinically as of central aetiology. Non-contrast computed tomography was positive in three patients, all with central causes with sensitivity 21.4%, specificity 100%, positive predictive value 100%, negative predictive value 92.6% and accuracy 92.8%. Computed tomography angiogram was positive for angiographic posterior circulation abnormalities in five cases, and only two of them had a central cause of dizziness, with sensitivity 14.3%, specificity 97.7%, positive predictive value 40%, negative predictive value 91.46% and accuracy 92.1%.

Conclusion: Both non-contrast computed tomography and computed tomography angiogram of the head and neck have low diagnostic yield for the detection of central causes of dizziness. However, non-contrast computed tomography has higher sensitivity and positive predictive value than computed tomography angiogram, implying a lack of diagnostic advantage from the routine use of computed tomography angiogram in the emergency department for the investigation of isolated dizziness. Further studies are required to determine the role of computed tomography angiogram in the work-up of isolated dizziness in the emergency department.

Keywords

Dizziness, vertigo, computed tomography, cerebral angiogram

Introduction

Dizziness and vertigo are common reasons for presentation to the emergency department (ED), representing 4–5% of ED presentations.1,2 The term dizziness is broadly used to describe multiple sensations including: (a) vertigo which corresponds to an illusory sensation of movement either of the person or the visual surround; (b) disequilibrium consistent with a sense of imbalance, unsteadiness or postural instability; (c) presyncope or near faint; and (d) psychophysiological dizziness associated with anxiety and panic.3,4

In acute vestibular syndrome (AVS), defined as a sudden onset of acute, ‘continuous’ vertigo associated with nausea, vomiting and head motion intolerance, the critical differential is often between central causes (i.e. stroke) and the more common peripheral causes (i.e. vestibular neuritis).5 The battery of head impulse, nystagmus and test of the skew (HINTS) is the diagnostic test of choice in patients with AVS and...
nystagmus, with 100% of sensitivity and 96% of specificity for stroke. However, 50% of patients with stroke and dizziness cannot be diagnosed appropriately due to a lack of other neurological symptoms or signs. Moreover, the HINTS battery is underutilised in the ED in patients with dizziness, with only 7% performed at the bedside, mostly explained by low awareness and a lack of adequate training in technique and interpretation of the exam by ED physicians. Approximately 4% of patients with AVS will have acute stroke, with the number increasing to up to one fourth of elderly patients with isolated dizziness. However, there are no well established guidelines for the appropriate role of neuroimaging in the assessment of patients with dizziness in the ED. While pathologies of the central nervous system are a statistically unlikely cause of dizziness, the lack of specialist assessment in the emergency setting means clinical findings are often equivocal or uncertain. As there is a fear of missed strokes and the potential consequences of misdiagnosis, there is pressure to image (with computed tomography (CT), computed tomography angiogram (CTA) or brain magnetic resonance imaging (MRI)) and a resultant increase in neuroimaging studies, healthcare expenditure, patient wait times, exposure to radiation and exposure to adverse events such as contrast reactions.

MRI is the modality of choice for the detection of posterior fossa stroke, with a sensitivity of approximately 83% on diffusion-weighted imaging (DWI) images. Nevertheless, in many hospitals brain MRI is not an easily accessible modality, and CT is performed as a substitute to rule out serious pathology although its sensitivity for the detection of posterior fossa ischaemic stroke is only about 42%. CT is a good modality for the detection of haemorrhage, although haemorrhage accounts for only 4% of patients with a central cause of dizziness. As CTA is recommended for patients with symptoms highly suggestive of acute stroke (e.g. acute motor/speech disturbance or other typical vascular syndrome), obtaining CTA in acute dizziness appears justified when stroke is a concern. However, while CTA is sensitive in cases of vertebrobasilar insufficiency (VBI) or basilar occlusion that can present as isolated dizziness, this is a rare pathology accounting for only 1% of all strokes. In addition, there are few data describing the diagnostic yield of CTA in isolated acute dizziness. The purpose of this study was to assess the usefulness of head and neck CTA for the investigation of isolated dizziness in the ED in detecting significant acute findings leading to a change in management in comparison to non-contrast computed tomography scan of the head (NCCT).

Materials and methods

Our institutional research ethics board approved this study (REB# 20170509). We conducted a retrospective review of patients presenting to the ED with a complaint of isolated dizziness without any documentation of other focal neurological symptoms or signs in the imaging requisition or clinical notes. The review was conducted in our institutional picture archiving and communication system (PACS) between 1 January 2015 and 31 December 2017. Patients with isolated dizziness who underwent NCCT followed by a CTA of the head and neck ordered from the ED with clinical indication to rule out central causes of dizziness were included.

Clinical data were collected using our institutional electronic medical records system, including the patient’s age, gender, time of exam and diagnosis noted by the emergency physician at the time of presentation. If there was a referral to neurology or otorlaryngology, the final diagnosis made by the specialist was recorded. The clinical assessment documents were reviewed to classify the patients based on the clinical presentation into those consistent with a central versus a peripheral cause of dizziness. A staff neurologist experienced in neuro-otology (DL) reviewed the clinical documents of patients with an unclear diagnosis and assigned a final diagnosis of central versus peripheral dizziness.

The findings on NCCT were classified as acute/related to the ED presentation (acute/subacute posterior fossa ischaemia, acute posterior fossa haemorrhage, acute haemorrhage or ischaemia not in the posterior fossa, neoplasm), versus non-acute/unrelated (parenchymal volume loss, microangiopathic/microvascular disease, old infarct, encephalomalacia) or no significant abnormality. The findings on the subsequent CTA were classified based on the presence or absence of posterior circulation findings on the study report including significant luminal stenosis, occlusion or findings suggestive of dissection. Dedicated neuroradiologists read all the studies.

The statistical analysis included descriptive analysis as well as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of NCCT and CTA. A t-test was used to assess the difference in mean age between the patients with central and peripheral dizziness. All data were analysed by using MedCalc (version 12; MedCalc Software, Ostend, Belgium).

Results

From 1 January 2015 to 31 December 2017, a total of 159 cases of isolated dizziness had CT and CTA performed. Six cases were excluded due to incomplete coverage of the neck vessels on the CTA (n = 2) and lack of clinical documentation (n = 4). A total of 153 patients with isolated dizziness were included (102 women, 51 men, mean age 63.2 years).

Of these 153 patients, 14 were classified clinically as having a central cause of dizziness (nine women, five men, mean age 69.7 years). The mean age of the rest of the patients was 61.9 years (P = 0.072). Of the patients...
with central vertigo, only three patients (two women, one man, mean age 77.3 years) showed positive non-contrast CT findings including medullary haemorrhage, right temporal glioblastoma and acute infarct in the right cerebellar hemisphere. Of these 14 patients, two patients (one man, one woman, mean age 79 years) showed positive findings on CTA: complete occlusion of the mid-basilar artery that showed acute infarct in the right cerebellar hemisphere on the non-contrast CT and atherosclerotic narrowing of the V4 segment of the right vertebrobasilar artery (VA) which on the non-contrast CT showed medullary haemorrhage.

NCCT was positive in three patients with acute cerebellar infarct, medullary haemorrhage and glioblastoma. All had a clinical diagnosis of central cause of dizziness with sensitivity 21.4%, specificity 100%, PPV 100%, NPV 92.6%, with negative likelihood ratio (LR−) of 0.79 and accuracy of 92.8%.

CTA was abnormal according to our criteria in five patients. The abnormal findings were as follows: acute dissection of the left VA V1 segment, severe atherosclerotic narrowing of the left VA origin, age indeterminate occlusion of the left VA, atherosclerotic narrowing of the right VA V4 segment and complete occlusion of the mid-basilar artery up to the origin of the superior cerebellar artery. The mean age of patients with positive CTA was 79 years. Atherosclerotic disease of the carotids and VAs and a history of amyloid angiopathy were risk factors found in two of the patients with positive CTA. Only two of the five positive CTA cases were judged to have had a central cause of dizziness, with sensitivity 14.3%, specificity 97.7%, PPV 40%, NPV 91.46%, with LR− of 0.88 and accuracy of 92.1% (Table 1). The final diagnoses in the rest of the abnormal CTA cases were benign paroxysmal vertigo and medication side effect in two patients.

**Discussion**

Our results show that while both NCCT and CTA of the head and neck have a low diagnostic yield for the detection of central causes of dizziness. The addition of CTA had lower sensitivity, lower PPV and LR− closer to unity when compared with NCCT (sensitivity 14.3% vs. 21.4%; PPV 40% vs. 100%, LR− 0.79 vs. 0.88, respectively) implying a lack of diagnostic advantage from its regular use along with NCCT in the ED of our institution. In particular, the LR− points towards the limited usefulness of CTA in this clinical setting as a normal scan is not helpful in reducing the likelihood of having a central aetiology for dizziness. Moreover, given that the two cases of central dizziness with abnormal CTA also had positive findings on non-contrast CT, in this population no cases of central causes of dizziness would have been missed if CTA were performed only in patients with positive NCCT.

Analysing the abnormal CTA cases in more detail is also instructive. In one case of central dizziness and abnormal CTA, atherosclerotic narrowing of the right V4 segment was associated with acute medullary haemorrhage seen on the plain CT. It is unlikely that the atherosclerosis was directly related to the haemorrhage, implying that this CTA abnormality was incidental. In the second case with occlusion of the mid-basilar artery, a right cerebellar infarct was evident on the plain CT. In addition, this patient was an 84-year-old woman with hypertension and dyslipidaemia who presented with AVS (gait ataxia, nausea, vomiting) without nystagmus. This clinical presentation does not allow application of the HINTS exam which requires the presence of nystagmus definitively to diagnose a peripheral cause. As such, this case may have been judged high risk for a central cause, especially given the patient’s advanced age and vascular risk factors. Finally, in the case of acute dissection of the VA, these CTA findings were determined to be artificial on follow-up with MRI showing no acute ischaemic change and magnetic resonance angiography (MRA) with dissection protocol showing no acute dissection. In retrospect, a persistent trigeminal artery was identified that led to errors in interpreting the initial CTA, and the final diagnosis was of peripheral vertigo.

To the best of our knowledge the comparison between CT and CTA in the diagnosis of isolated dizziness has not previously been described. One study reported the role of MRI versus NCCT in the evaluation of patients with dizziness, finding the sensitivity of CT to be 50.58% for the detection of central causes of dizziness compared with 83% on MRI. In addition Navi et al. reported the yield of CT for detecting a relevant abnormality in dizzy patients of 6% compared to 9% for MRI. The value of CT in the diagnosis of dizziness has previously been reported by Lawh-Heath et al. who described a sensitivity of 40% of NCCT in the diagnosis of acute dizziness aetiology. Our results are in agreement with those of Mitsunaga and Yoon and Navi et al., who found a low diagnostic yield of NCCT for dizziness in the emergency setting of 7.1% and 6%, respectively. This could be explained by the known very low CT sensitivity (42%) in the diagnosis of posterior fossa strokes. 11 Inference, intracranial haemorrhage and neoplasms were the typical findings described on CT in patients with dizziness in the ED. Other findings included hydrocephalus and skull base fracture.

**Table 1. Sensitivity, specificity, PPV and NPV of NCCT and CTA for central causes of dizziness.**

|          | Sensitivity | Specificity | PPV | NPV |
|----------|-------------|-------------|-----|-----|
| NCCT     | 21.4%       | 100%        | 100%| 92.6%|
| CTA      | 14.3%       | 97.7%       | 40% | 91.46%|

Other unrelated CTA findings included: severe narrowing of the right ICA (n = 1), intracranial aneurysms (n = 12), meningioma (n = 6).

CTA: computed tomography angiogram; ICA: internal carotid artery; NCCT: non-contrast computed tomography; NPV: negative predictive value; PPV: positive predictive value.
Moubayed and Saliba\textsuperscript{14} found a high diagnostic yield of MRA in patients with dizziness and with at least three risk factors for stroke, with a sensitivity of 85.7\% and a PPV of 6.1\% in the identification of abnormalities of the VA. One study suggested that routine MRI in patients with dizziness is not useful because the abnormalities are very similar in symptomatic and asymptomatic people.\textsuperscript{15} In general, the incidence of acute intracranial lesions in patients with dizziness and without significant neurological abnormality is very low,\textsuperscript{16} suggesting that the routine use of imaging is not cost-effective in the management of these patients.

Although MRI is the modality of choice in the assessment of posterior fossa stroke in patients with dizziness, CTA is often used as a surrogate in centres where MRI is not feasible in the emergency setting. In addition to the detailed assessment of the vertebrobasilar circulation, CTA carries the advantage of allowing accurate evaluation of the carotids and anterior intracranial circulation arteries for incidental asymptomatic findings (e.g. carotid stenosis and intracranial aneurysms) as well as allowing a post-contrast acquisition of the head for assessment of pathological enhancement. Regarding the use of CTA in patients with acute dizziness, Fakhran et al.\textsuperscript{19} described a diagnostic efficacy of CTA of 2.2\% with a therapeutic efficacy of 1.3\%. On the other hand, Chen et al.\textsuperscript{20} found that the presence of calcifications on CTA is a factor that could predict an ischaemic stroke but does not improve the sensitivity. Moreover, one study performed in patients presenting to the ED with subjective dizziness found that vascular risk factors and positive focal exam are able to identify patients with posterior circulation ischaemia, and the addition of CTA does not significantly increase the ability to identify patients at highest risk correctly.\textsuperscript{21} Previous studies have described the clinical features associated with impending stroke including: first episode of transient ischaemic attack, language disturbance, duration of symptoms more than 10 minutes, gait disturbance, ataxic gait, elevated platelets or glucose, unilateral weakness, history of carotid stenosis and elevated diastolic pressure.\textsuperscript{22} Therefore, stroke risk factors and findings on clinical exam are the most important elements that may predict that an isolated dizziness presentation is due to an acute ischaemic stroke. In agreement with this report, one of our cases positive for a central cause of dizziness demonstrated carotid atherosclerotic disease.

The American College of Radiology (ACR) considers that the use of CTA in patients with dizziness may be appropriate when the cause of dizziness cannot be categorised as peripheral, with a goal of ruling out VBI given that approximately 15–25\% of the patients with VBI will complain of dizziness as the initial symptom.\textsuperscript{23–25} However, it should be noted that these recommendations are not specific to acute presentations and pertain to cases with and without neurological findings. As mentioned above, CTA efficacy has been shown to be only 2.2\% in acute dizziness.\textsuperscript{19} In addition, the diagnostic efficacy of CTA, contrast-enhanced MRI and MRI of the internal auditory canal in patients with isolated dizziness has been reported as low, with less than 3\% of abnormalities detected on the three modalities.\textsuperscript{19} As discussed above, this is likely to be due to most cases of dizziness in the ED being related to peripheral vestibular disorders such as vestibular neuritis/labyrinthitis, benign paroxysmal positional vertigo, or to metabolic or cardiovascular diseases.\textsuperscript{1} Our results are also in agreement with these reports, with only two cases positive for the central cause of dizziness due to VBI. Moreover, the LR– values of both NCCT and CTA suggest the low diagnostic performance of both modalities in the detection of central cause of dizziness.

Our results showed that patients classified with central causes of dizziness were older compared to the peripheral group. This is in agreement with previous reports describing a higher risk of stroke, especially cerebellar infarction, in patients with advanced age and other vascular risk factors.\textsuperscript{26}

Regarding the financial impact of neuroimaging in the diagnosis of patients with dizziness in the ED, it has been estimated that in 2011 the total national cost in the United States of patients presenting to the ED with dizziness was approximately $3.9 billion per year, with the overuse of CT head as one of the factors related to high costs.\textsuperscript{27} Furthermore, one study performed in Ontario\textsuperscript{28} showed that the costs of dizziness-related visits to the ED and as an inpatient in a tertiary care centre represent about $31 million per year, with higher costs in cases that required admission, overnight stay and prolonged care. The use of imaging in this clinical setting is often fruitless, with one study showing that in 94\% of the dizziness visits with CT imaging, a central nervous system diagnosis was not found. Furthermore, the visits with CT scan were associated with increased ED length of stay compared to visits without CT scan.\textsuperscript{29} Similar results have been described regarding the ED length of stay and the use of health resources, which appear to be similar in patients with acute dizziness compared to patients presenting in the ED with chest pain.\textsuperscript{30}

In the evaluation of the patient with dizziness in the emergency setting, careful attention should be paid to the clinical examination and risk factors, with a focused physical examination (HINTS) having demonstrated a better sensitivity than early MRI in the distinction between vestibular neuritis and posterior circulation stroke.\textsuperscript{6,7,31} As a result, imaging tests, including CT/CTA and MRI/MRA should not be considered in cases in which the clinical history and examination are suggestive of a peripheral cause of dizziness. An appropriate approach will also reduce the wait time in the ED and the associated health costs. In these studies, trained neurologists performed the clinical assessment, and in practice imaging is often
used when the clinical assessment is considered equivocal. However, even in cases in which a non-worrisome diagnosis was made, such as peripheral vestibular dysfunction, orthostatic hypotension or migraines, one study found that approximately 37% of patients underwent neuroimaging and a quarter of the patients were admitted to the hospital. This may be explained by the high level of concern for ruling out serious diseases, although this probably represents an overuse of imaging and inpatient resources. This suggests that special training in the performance and interpretation of clinical tests used in acute dizziness may be helpful to reduce physicians’ reliance on ineffective imaging.

Our study has some limitations. It is a retrospective study of patients from a single institution. It reflects the experience in our institution in cases in which NCCT head and CTA of the head and neck were performed together in patients with dizziness in the ED. Detailed clinical data are not available and when the diagnosis was not clear the final diagnosis was based on the ED notes. In addition, clinical factors that could prove the appropriateness of the radiological imaging may have been missed. Some of the findings on CTA (e.g. atherosclerotic VA stenosis) are of indeterminate age and it remains difficult to determine the degree of contribution of these findings to the patient’s ED presentation. Finally, the small number of positive cases on NCCT and on CTA in our study population constitutes an additional limitation to our assessment. Future studies should confirm the low sensitivity and specificity of CTA in the imaging of acute dizziness in multiple centres. Furthermore, determining the optimal approach to the work-up of patients with isolated dizziness in the ED should be done prospectively, likely using clinical factors to determine which patients to image and which modality to use. In addition, such studies should ideally focus on which imaging studies influence management decisions.

Conclusion

Both NCCT and CTA of the head and neck have low diagnostic yield for the detection of central causes of dizziness in the ED. However, NCCT has higher sensitivity and PPV than CTA, implying a lack of diagnostic advantage from the routine addition of CTA to NCCT in the ED for the investigation of isolated dizziness. CTA should not be used as a substitute for MRI, which is the imaging modality of choice in this clinical scenario. The evaluation of a patient with isolated dizziness should start and be guided by a detailed clinical examination. If this evaluation suggests that brain imaging is necessary, we recommend starting with plain CT scan of the head. CTA should be reserved for patients with positive findings on plain CT (i.e. stroke) and/or high-risk clinical factors (i.e. advanced age, vascular risk factors, etc.) that mandate further vascular imaging. This approach allows the better use of health resources, less wait time in the ED and lower radiation exposure. Future studies should prospectively clarify the optimal approach to imaging acute isolated dizziness.

Conflict of interest

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