Diagnostic Value of Computed Tomography and Magnetic Resonance in Detecting Peripheral and Central Vertigo

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Abstract

This literature review will assess the value of magnetic resonance imaging (MRI) and computed tomography (CT) in detecting pathologies associated with vertigo. The two most common types of vertigo, peripheral and central, are defined. Previous studies suggest that both MRI and CT are good options for detecting semicircular dehiscence syndrome related peripheral vertigo. Although the accuracy rates of MRI and CT are comparable in detecting acute intracranial hemorrhage, MRI has an overall higher diagnostic yield for stroke and multiple sclerosis related central vertigos. However, in clinical practice, hospitals take costs into consideration when making patients’ care plans. Having every patient go through imaging examinations can be time consuming and expensive. Peripheral vertigo can often be diagnosed by physical examination, whereas central vertigo requires confirmation from an effective diagnostic imaging modality due to its potential life-threatening nature. Therefore, carefully selecting patients presenting with central vertigo symptoms for MRI may be cost-effective in terms of providing quality patient care.

Introduction

Dizziness is one of the most common complaints patients bring to their physicians. The most prevailing type of dizziness is vertigo, the associated symptoms of which include an abnormal sensation of movement or rotation, imbalance, or difficulty maintaining an upright posture (Robinson, 2014). Vertigo accounts for 54% reports of dizziness in primary care. Peripheral vertigo due to inner ear problems consists of 93% of vertigo cases. A problem originating in the central nervous system, which is also known as central vertigo, is less common, but can be life-threatening (Labuguen, 2006).

The common causes of the inner ear problems that lead to peripheral vertigo are semicircular dehiscence syndrome (SCDS), benign paroxysmal positional vertigo (BPPV), and Meniere’s disease (Robinson, 2014). SCDS symptoms are caused by a partial or complete absence of the temporal bone overlying the superior semicircular canal of the vestibular system. BPPV is usually caused by floating crystals in the fluid of the inner ear. The movement of the
crystals and the fluid causes dizziness. Other traumas, such as an ear injury, can also lead to BPPV. Meniere’s disease is a disorder of the inner ear that is associated with occasional hearing loss and dizziness (Labuguen, 2006). Stress, high salt consumption, and drinking caffeine and alcohol may be the causes of Meniere’s disease. Signs and symptoms of peripheral vertigo include nausea, vomiting, sweating, and abrupt onset (Labuguen, 2006).

Central vertigo is caused by disease or injury to the central nervous system. Common causes include brain tumors, strokes, and multiple sclerosis (MS). Brain tumors found in the cerebellopontine angle typically result in vertigo-related symptoms. Types of tumors frequently found in this region are vestibular schwannoma (acoustic neuroma), infratentorial ependymoma, brainstem glioma, medulloblastoma, and neurofibromatosis. Cerebrovascular diseases, such as strokes, can also lead to vertigo (Bruzzone et al, 2004). This type of vertigo is generally caused by arterial occlusion to the vertebrobasilar system. Factors such as patients’ age, history of hypertension, atrial fibrillation, and prior cerebrovascular accident are often considered when assessing the possibility that a central vertigo is associated with a cerebrovascular disease (Labuguen, 2006). MS causes damage to the myelin sheath in the central nervous system. The multiple sclerosis plaques are considered the cause of vertigo related symptoms (Agamanolis, 2015). Signs and symptoms of central vertigo often involve gradual onset, and tend to be less intense than the symptoms associated with peripheral vertigo (Labuguen, 2006).

Other types of vertigo include cervical vertigo, drug-induced vertigo, and psychogenic vertigo. Cervical vertigo is triggered by somatosensory input from head and neck movements. Drug-induced vertigo is caused by an adverse reaction to medications. Psychogenic vertigo is associated with mood, anxiety, somatization, personality, or alcohol abuse disorders. These types of vertigo are rare, and are often diagnosed by laboratory evaluation and neuropsychological testing (Labuguen, 2006).

Head CT is often the first-choice imaging modality for patients with vertiginous symptoms. In terms of speed, CT typically is faster than MRI (Lawhn-Heath et al., 2013). However, MRI is known for its better contrast resolution. Vertigo related pathologies often involve particles, bony deficit, and blood occlusions which are found within small structures
Based on these facts, it is logical to say that MRI would be better than CT in detecting pathologies that cause vertigo. This literature review will compare the diagnostic value of MRI and CT in detecting peripheral and central vertigo.

**Comparison between MRI and CT in identifying peripheral vertigo**

Semicircular canal dehiscence syndrome (SCDS) is one of the few peripheral vertigo types that can be well visualized on imaging studies (Krombach et al, 2004). Therefore, this literature review will discuss the diagnostic value of MRI and CT in detecting SCDS.

**Semicircular canal dehiscence syndrome (SCDS)**

Patients’ history and physical examination are adequate for a working diagnosis of peripheral vertigo. However, CT and MRI are used to identify pathologies and to confirm the diagnosis (Krombach et al, 2004).

In 2004, Krombach and his colleagues conducted a study to assess the value of MRI (T2-weighted) and CT for detecting lesions in the semicircular canal in patients who were diagnosed with peripheral vertigo. Specifically, they reviewed the images of 185 vertigo patients who underwent both imaging modalities for indications of semicircular canal dehiscence. SCDS is diagnosed by measurement of the threshold for click-evoked vestibular activation and CT. Because the typical signs of SCDS are not always readily obvious in these two tests, sometimes an MRI of the inner ear may be performed (Krombach et al, 2004).

In Krombach and his colleagues’ study, bony defects related to SCDS were observed on MRI in 30 patients. In 27 of these patients, the CT results also confirmed the same bony defects as identified on MRI. In the other three patients, bony defects related to SCDS were visible on CT, but not observed on MRI. The detectable range of the bony defects is 1.32 - 4.2mm on MRI and 2 - 4mm on CT. In terms of spatial resolution, the MRI used in this study is better able to detect smaller bony defects than CT. However, due to the low signal from the connection of the semicircular canal to the subarachnoid space, a bony defect can be difficult to identify on MRI if
the subarachnoid space is narrow. Due to the higher contrast on CT, bony defects may be easily identified in this type of situation. Figure 1 shows the advantages of CT in demonstrating the bony defect over MRI (Krombach et al, 2004).

There have also been studies suggesting that the diagnosis of SCDC should not be made on the basis of CT findings alone. It is recommended to consider both characteristic symptoms and findings on clinical examinations (i.e. physical examinations and diagnostic imaging tests) when confirming peripheral vertigo (Minor and Carey, 2008).

**Figure 1.**

A Axial MRI. Difficult to identify the bony defect over the anterior branch of the superior semicircular canal.

B Axial CT. Visualization of the bony defect more obvious.

**Comparison between MRI and CT in identifying central vertigo**

Among the numerous causes of central vertigo, acute stroke and multiple sclerosis are the most frequent causes (Amar, 2012). The following sections will compare MRI to CT for these two causes.

*MRI and CT in Identifying Acute Stroke*

When a clinician suspects a central lesion, imaging studies with a focus in the posterior fossa are mandatory. When sudden changes in brain tumor size disrupt blood flow to the cerebellopontine angle and cause lesions in the surrounding area, it usually results in
unsteadiness which manifests vertiginous symptoms. Early detection of such a cerebrovascular accident (CVA) can help physicians to plan treatment early. In both hemorrhage and ischemia in the cerebellopontine angle, perilesional edema will heighten within the posterior fossa, which is known as the space-occupying effect. This effect is used as an indication of CVA in the cerebellopontine angle (Amar, 2012).

Due to its better resolution, MRI is preferred to CT in identifying ischemia, hemorrhage, tumor, and MS. Because of the limitations of CT, lesions in a small area such as the posterior fossa can be obscured by bony artifacts (Amar, 2012). Figure 2 shows the advantage of MRI in demonstrating hemorrhage in the right lobe of the cerebellum without bony artifact. In addition, CT findings may be normal in the early hours following an acute stroke (ischemia or hemorrhage). This is due to similar densities between the lesion and the surrounding tissue. (Marill, 2015).

In 2007, Chalela and his colleagues compared the accuracies of MRI and CT in detecting stroke. In their study, 217 of 356 patients had a final clinical diagnosis of acute stroke. 27 of these patients were diagnosed with acute intracranial hemorrhage. MRI detected this condition in
23 patients compared with CT in 25 patients. 190 of the patients were diagnosed with acute ischemia. MRI correctly identified 164 patients compared with 35 in CT. Table 1 summarizes the statistics of these data (Chalela et al., 2007).

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<td>Blinded imaging diagnosis compared to final clinical diagnosis</td>
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<td>Acute stroke</td>
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<td>Acute ischemic stroke</td>
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<td>Acute intracranial haemorrhage</td>
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Data are number (% of total sample, 95% CI).

In comparison with the final clinical diagnosis, MRI had a higher sensitivity of 83% and a specificity of 97% for the diagnosis of acute stroke, compared with 26% and 98% respectively for CT. For acute intracranial hemorrhage, MRI had a sensitivity of 81% and a specificity of 100%, compared with 89% and 100% respectively for CT. For acute ischemia, MRI had a sensitivity of 83% and a specificity of 96%, compared with 16% and 98% respectively for CT (Chalela et al., 2007).

Chalela’s findings are consistent with previous literatures. Viirre and Nelson (2009) also found that CT and MRI have comparable sensitivity for detecting hemorrhage. In addition, they also found that MRI has a superior sensitivity of 83% compared to 26% for CT when detecting ischemia.
MR and CT in Identifying Multiple Sclerosis

The characteristic sign of MS is multifocal lesions, also known as the multiple sclerosis plaques (Agamanolis, 2015). The diagnosis of MS requires various diagnostic tests. In addition to medical imaging, neurological examinations and laboratory tests are also required (Jones, 2008).

Although CT is still an imaging option, MRI has been reported more sensitive in visualizing MS plaques. Coin and Hucks-Folliss (1984) reported a case describing possible CT visualization of MS in a patient’s spinal cord. However, this finding was proven unreliable and unreproducible by Maravilla and his colleagues. According to Bachiller and Lieberman’s research, MS plaques may be depicted as low attenuation areas on CT, however, they are often not detected. Although MRI is capable of demonstrating plaques due to demyelination, there is not enough evidence to support whether it is able to differentiate the acute from the chronic. Nonetheless, a neurologist can make a diagnosis by correlating the lesions from an MRI with their present signs and symptoms. For detection of MS plaques, MRI has been proven to be more sensitive than CT (Maravilla et al., 1984).

Discussion

Clinically, CT is the first-choice imaging modality (Lawhn-Heath et al., 2013). However, it has been found to have a lower diagnostic yield for vertigo. CT may be useful in detecting certain pathologies of peripheral vertigo due to its high contrast. However, many subtypes of peripheral vertigo do not require confirmation from the imaging study before providing treatment. For representative vertigo types, MRI has been proven to have consistently higher sensitivity.

Although evidence-based guidelines for imaging study in vertigo patients have not been established, careful attention to physical findings of the neurologic, head and neck, and cardiovascular systems is important (Labugen, 2006). Vertical nystagmus is 80% sensitive to detect lesions in the vestibular nuclei and cerebellar vermis. The Dix-Hallpike maneuver is 83% sensitive to predict lesions related to BPPV. Vertiginous symptoms caused by pushing on the
tragus and external auditory meatus is an indication of a perilymphatic fistula. Dizziness caused by the Valsalva maneuver can indicate a perilymphatic fistulae or SDSC. Sudden changes in blood pressure and pulse in vertiginous patients upon standing may indicate dehydration or autonomic dysfunction (Jones, 2008). Knowing the meaning of these findings can be helpful to distinguish central vertigo from peripheral vertigo, which is helpful with selecting the appropriate imaging modality for the patient.

Cost-effectiveness is also a concern for health authorities in Canada. In British Columbia, a routine MRI exam costs $900, a non-contrast CT costs $600, and a contrast CT study costs $1,100. Vertigo accounts for an average of 4 million visits in ambulatory care settings annually (Fee Schedule, n.d.). This suggests potential costs of 10 billion per year if imaging modalities were unreasonably selected. To avoid an unnecessary burden to the health care system, it may not be practical to have every patient go through imaging examinations. Based on the currently available evidence, indications for imaging include signs of neurologic deficit, such as an inability to walk without support, direction-changing nystagmus, risk factors for CVA, and progressive unilateral hearing loss. These neurologic signs may indicate possible life-threatening central causes (Lawhn-Heath et al., 2013). Prioritizing these patients for an MRI scan may be more cost-effective in terms of providing quality patient care.
References


Appendices: Glossary

Nystagmus

Involuntary, rapid, and repetitive movement of the eye.

Dix-Hallpike maneuver

The physician turns the patient’s head 30 to 45 degrees to the affected. The patient keeps the eyes open. Rapidly lay the patient supine allowing the neck to hyperextend slightly and hang off the edge of the examining table. The onset of torsional upbeat or horizontal nystagmus denotes a positive test for benign paroxysmal positional vertigo.

Valsalva maneuver

Forced exhalation with nose plugged and mouth closed to increase pressure in the inner ear.

Ischemia

A restriction in blood supply to an organ or part of the body.

Hemorrhage

An artery in the brain ruptures and causes localized bleeding in the surrounding tissues.