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Usefulness of Neuroimaging Studies in the Evaluation of Vertigo: A Population-Based Study

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Abstract

Purpose: Vertigo is a common complaint in primary care medicine, otolaryngology, and neurology. We reviewed our use of neuroimaging examinations for all patients diagnosed with Benign Paroxysmal Positional Vertigo (BPPV) and determined the diagnostic value of such examinations.

Methods: This study was a retrospective review of the digital medical records of all patients aged ≥18 years treated in the Dan Petah Tikwa District of the Clalit Health Services and who were diagnosed as having the ICD-9 diagnosis code for vertigo, dizziness, or imbalance from January 1, 2010 through December 31, 2013. Physical examination findings indicating whether the subjects met the clinical criteria for BPPV, demographic variables and type, timing, and results of any neuroimaging performed were extracted from these charts.

Results: Of the 2,418 patients diagnosed as having BPPV during the study period, 2,305 (95.3%) had undergone ≥1 cranial Computed Tomography (CT), examination and 607 (24.8%) had undergone ≥1 cranial Magnetic Resonance Imaging (MRI). The yields of clinically significant findings were 3 (0.1%) for CT and 2 (0.3%) for MRI. All positive pathological findings were observed in contrast-enhanced examinations; this trend was statistically significant at a $p < 0.0001$ (95% CI, 0.002-0.463). However, none of the findings led to any therapeutic changes, which was true regardless of treatment type or timing of neuroimaging in relation to treatment.

Conclusions: Consistent with the literature, this study showed a low diagnostic yield of clinically significant neuroimaging findings in BPPV, with an even lower yield for follow-up studies, regardless of the diagnostic modality employed.

Keywords: Benign Paroxysmal Positional Vertigo (BPPV); CT; MRI; Neuroimaging; Vertigo

Introduction

Vertigo is among the most frequently encountered symptoms in the medical field, and 2.4% of people (3.2% women, 1.6% men) will experience vertigo at some time during their lives [1]. The incidence of vertigo increases at age >65 years, with an incidence of 8.3% per year [2]. Benign Paroxysmal Positional Vertigo (BPPV) is the most commonly diagnosed variety of vertigo and is caused by the presence of cupulolithiasis or canalithiasis in semicircular canals. Accurate diagnosis of BPPV is done primarily by obtaining a medical history, followed by a general physical and neurological examination. In some cases, minimal laboratory testing (complete blood count, blood glucose, thyroid function test, electrolytes concentrations, liver tests, and renal function test) is also performed. The specific diagnosis is confirmed by

simple tests, among which the gold standard is the induction of a spinning sensation induced by a head-position change with respect to gravity. In addition, Diagnostic Positional Maneuvers (DPM), in which a torsional-vertical nystagmus is provoked by a specific ear-down position with a latency, are useful for diagnosis. These maneuvers include the Dix-Hallpike diagnostic maneuver, the Nylen-Barany test, the Supine Roll test, the Pagnini-McClure's test, the head-roll-test or "Bow-and Lean"-test [3].

Neuroimaging investigations rarely demonstrate abnormal findings in BPPV cases [4] and should only be performed to rule out rare pathologies that could mimic BPPV symptoms. Such entities include vestibular neuritis, labyrinthitis, superior canal dehiscence syndrome [5], Meniere's disease [6], perilymphatic fistula [7], local trauma [8], vertebra basilar insufficiency, cervicogenic vertigo [9], migraine-associated dizziness [10], central nervous system lesions [11], demyelinating diseases, and postural hypotension post-traumatic vertigo [12]. Neuroimaging is needed if the clinical examination is not able to distinguish benign causes of symptoms from illnesses requiring immediate attention. Reliable information on health services utilization and neuroimaging examination use of patients with vertigo in the community setting is scarce. Therefore, we sought to determine the extent to which neuroimaging imaging was performed/repeated and its value after the final diagnosis of BPPV was established. We hypnotized they are overused.

Materials and Methods

Data Sources

The digital medical records of the Dan Petah Tikva District of Clalit Health Services were queried for all subjects aged ≥18 years with an ICD-9 diagnostic code for vertigo, dizziness, or imbalance of any variety over a 4-year period from January 1, 2010 until December 31, 2013. Clalit is Israel's largest health fund, with a current population coverage rate of 60%. The Dan Petah Tikva District is an urban area with approximately 450,000 members. This study was approved by the Health Funds Ethics Committee in accordance with the Declaration of Helsinki (1964).

Study Population

From these records, a study population of all patients that met the criteria for BPPV was extracted. The inclusion criteria were (1) a complaint of rotational or spinning sensation with head-position change relative to gravity, (2) episodes provoked by everyday activities as rolling over in bed or tilting the head to look upward or bending forward, and (3) a positive nystagmus response to DPM. Patients were excluded if they had any other diagnosis for their vertigo or abnormal auditory electronystagmography or video nystagmography.

Data Analysis

Clinical information was summarized using descriptive statistics using χ^2 test for fixed variables and logistic regression for random variables and combinations. For imaging studies, only clinically significant findings related to BPPV were counted as pathological findings. Incidental unrelated findings were ignored. Confidence intervals were calculated for pertinent imaging finding rates by using a continuity correction. A p value of < 0.05 was considered statistically significant [13]. In cases of repeat neuroimaging examinations, all studies were included, but only the results of the pathological diagnostic neuroimaging findings, if present, were counted.

Diagnostic and Therapeutic Efficacy

To determine the value of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) examinations of the head in the work-up of BPPV, we used the 2 categories of efficacy defined by the American College of Radiology Committee on Efficacy. These were

- Diagnostic efficacy (the number of studies with a new or progressive major finding divided by the total number of studies) as an indicator of the value of the study in assisting a diagnosis.
- Therapeutic efficacy (the number of studies resulting in a change in clinical management divided by the total number of studies) as an indicator of the influence on the patient's clinical management [14].

Results

Within this 4-year period, 2,418 patients had an established diagnosis of BPPV (54% female, 46% male; $p = 0.833$). Of these patients, 2,305 (95.3%) had undergone ≥1 cranial CT; of those, 607 (25.1%) had, in addition, ≥1 brain MRI. Among those with neuroimaging examinations, 54.5% studies were conducted in a hospital setting and 45.5% in an outpatient facility ($p = 0.737$). Neither sex nor location of neuroimaging was associated with statistically significant differences in findings.

Among all patients with BPPV who had undergone CT neuroimaging, 1264 (54.8%) had undergone CT at initial diagnosis (initial CT; initial neuroimaging), and 1041 (45.1%) had undergone a second CT performed near or after the end of treatment (repeat CT; repeat neuroimaging). Overall, in the study population, 0.52 CTs per patient were performed in the initial neuroimaging period, and 0.82 CTs per patient were performed as a repeat neuroimaging ($p < 0.001$; 95% CI, 0.007-0.063; Table 1).

Number of patients	Total CT scans	Initial CT scans	Percentage of CT scans performed on initial neuroimaging	75 CT scans performed as repeat neuroimaging*	Percentage of repeat CT scans performed	CT scans per patient	Clinically significant pathological findings among all CTs	Percentage of significant pathological findings among all CT scans	
BPPV - vertigo Total group	2418	2305	1264	54.80%	1041	45.10%	0.95	3	0.10%
BPPV treated with canalith repositioning procedures[c]	1829	1443	804	55.70%	639	44.20%	0.8	1	0.06%
BPPV treated by other modalities[d]	587	850	454	76.90%	396	46.60%	1.5	1	0.10%
BPPV treated by surgery[e]	2	12	6	50%	6	50%	6	1	8.30%

[a]CT- Computed Tomography
[b]BPPV- Benign Paroxysmal Positional Vertigo
[c]Canalith repositioning procedure - Epley's or Semont or Yacovino or the 360° Baloh's maneuver, Vannucchi's forced prolonged position, or Asprella-Gufoni as well as with various nonstandard maneuvers for canalith repositioning; VRI - vestibular rehabilitation therapy and Brandt–Daroff exercise.
[d]Other treatment modalities - Watchful waiting, vestibulo-suppressant medication, herbal remedies, homeopathic remedies, natural diet for vertigo
[e]Surgery - Labyrinthectomy, posterior canal occlusion, singular neurectomy, vestibular nerve section, and trans-tympanic aminoglycoside application, and selective posterior canal

Table 1: [a]CT Neuroimaging Yields in Patients with Benign Paroxysmal Positional Vertigo [b](BPPV).

Most patients (1829, 75.7%) were treated by Canalith Repositioning (CRP), and the rest (587, 24.3%) were treated by Other Treatment Modalities (OTM). Patients who were treated by OTM had undergone cranial CT neuroimaging examinations significantly more frequently than those treated by CRP (1.5 vs. 0.8 per patient, respectively ($p < 0.001$; 95% CI, 0.032-0.097; Tables 1,2). In the group with patients who had undergone CT, only 3 patients showed pathological findings: 1 found on initial neuroimaging and the other 2 on repeat neuroimaging. All these findings were found on CT-angiography, with a diagnostic efficacy of 0.08% when performed as initial neuroimaging and of 0.2% when performed as repeat neuroimaging, ($p < 0.001$; 95% CI, 0.002-0.083). The number of CTs that would need to be performed to detect 1 pathological finding was 768 (Figure 1).

Total patients in group (%)	MRI (%)	Initial	Clinically significant findings on initial MRI(%)	Repeat MRI (%)	Clinically significant findings on second MRI (%)	p	RR
BPPV - vertigo Total group	2418 (37.6%)	411(17%)	0	196(8.1%)	2(1.02%)	<0.0001	0.009-0.043

BPPV treated with Epley's maneuver for canalith repositioning	1,829 (51.3%)	352(19.2%)	0	149(8.2%)	2(1.3%)	<0.0001	
BPPV treated by other modalities*	587(48.7%)	59(10%)	0	47(8%)	0(0)	0	
BPPV treated by surgery	2	0	0	0	0	0	

*Other modalities- watchful waiting, vestibule suppressant medication, VRI - Vestibular Rehabilitation Therapy, Brandt-Daroff exercises and surgery
[a]BPPV -Benign Paroxysmal Positional Vertigo
[b]MRI -Magnetic Resonance Imaging

Table 2: BPPV[a]- MRI[b] Initial and Repeat Neuroimaging Yields.

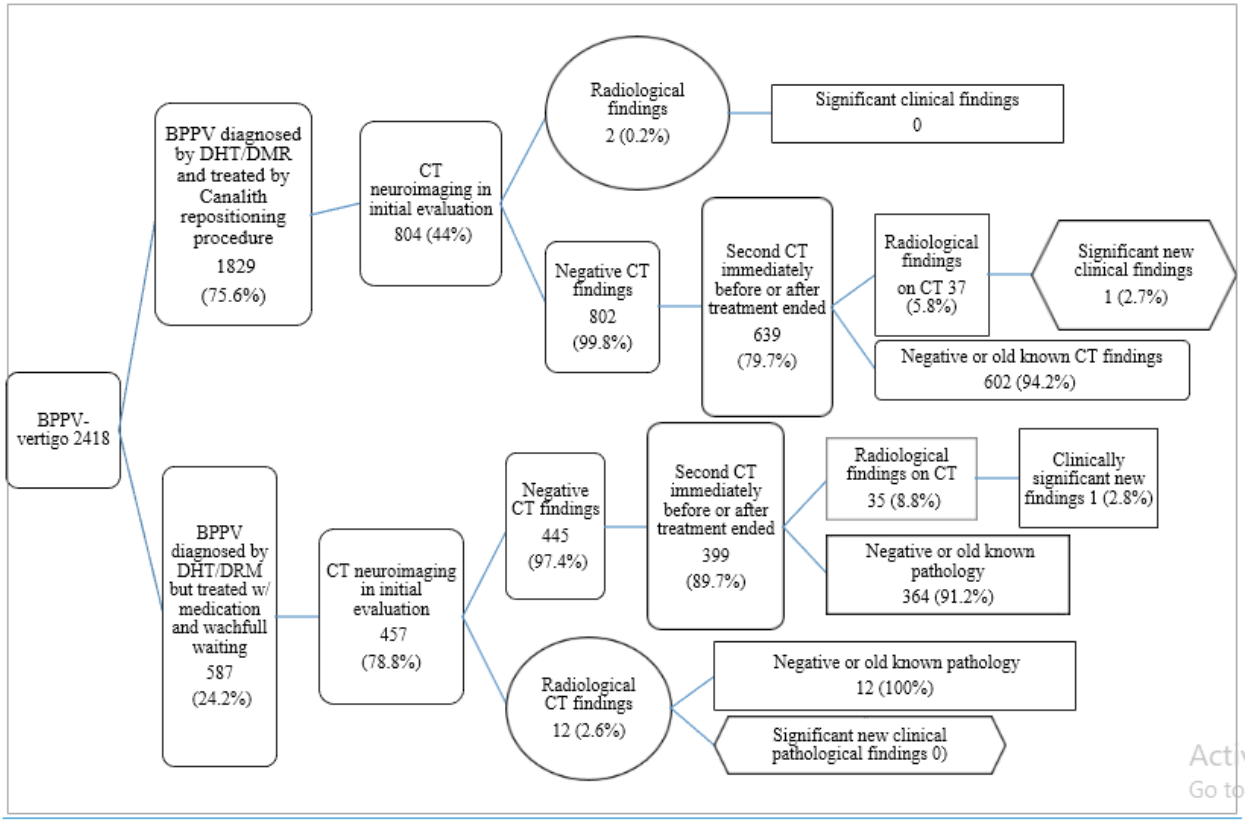

Figure 1: Flow chart of computed tomographic (CT) neuroimaging examinations in patients with Benign Paroxysmal Positional Vertigo (BPPV). [BPPV: Benign Paroxysmal Positional Vertigo; DHT: Dix-Hallpike Test; DRM: Diagnostic Positional Maneuvers CT: Computed Tomography].

As shown in (Table 2), 607 (25.1%) patients in this study had undergone an additional MRI neuroimaging examination, 411 (67.7%) had undergone it performed as part of the initial diagnostic work-up, and 196 (32.3%) as repeat neuroimaging near or after the end of treatment. Significantly more patients had undergone MRI as repeat neuroimaging rather than as initial neuroimaging ($p < 0.0001$; 95% CI, 0.009-0.043). Most of these patients (515, 84.8%) were treated with CRP and the rest with OTM. Patients treated with OTM had undergone head MRI neuroimaging examinations significantly more frequently. Among all MRIs, only 2 (0.3%) showed any pathological findings, for a clinical efficacy of 0.3%. All of these were found during repeat neuroimaging with contrast-enhanced MRI examination of the auditory canal and temporal bone. However, neither finding (cerebellar infarct in 1 case and enhancement of the middle cerebellar peduncle in the other) had any effect on therapeutic interventions. We calculated that 304 MRIs would be required for the detection of 1 significant finding.

Discussion

Vertigo is a common medical dilemma in outpatient practice [15,16]. According to the literature, the diagnosis of BPPV is generally be made clinically. However, the findings of our study show that this recommendation is often not followed in outpatient clinical practice because almost all patients in the study group had undergone ≥1 neuroimaging study. Furthermore, despite adequate clinical parameters for diagnosis, 43% had undergone a second CT and 25% had undergone an additional MRI. The low yields of pathological findings on neuroimaging examinations in our study are in agreement with the findings of Colledge, et al. who determined in a large study that the use of routine MRI is unlikely to reveal a specific cause for vertigo [17]. These findings are also consistent with the findings of a follow-up study by the same group, which concluded that neuroimaging was expensive and rarely helpful in people with dizziness/vertigo [18].

Differences between clinical practice and recommended guidelines are not unique to our study. For example, in a national survey of practice patterns concerning the evaluation of vertigo and syncope, the responses indicated overuse of neuroimaging examinations by 82%-85% (more testing than recommended by the guidelines of the American College of Cardiology/American Heart Association). Overuse of testing more frequently results from a physician's desire to reassure patients or themselves than an incorrect belief that it was clinically necessary [19].

There are several potential reasons why care for patients with vertigo in the community seems to differ from published guidelines:

- Lack of familiarity or awareness of the guidelines.
- Lack of agreement with the guidelines.
- Lack of competency in performing the necessary clinical diagnostic procedures.

A number of factors may contribute to these reasons. Primary care providers may not be aware of the guidelines because they were published in specialty journals. They may also not agree with the guidelines if the patients in the clinical trials, on which the guidelines are based, do not adequately represent BPPV patients in routine care. Patients in outpatient care may be more symptomatic than those in the clinical trials and thus less tolerant of the positions required to perform the diagnostic positional procedures or may have more restriction of movement and comorbidities. Competency may be decreased because providers have reported difficulty recalling the steps of the diagnostic procedures [20]. We acknowledge that a limitation of this study was that it was a retrospective analysis. Therefore, we might not have adequately appreciated the gravity of the symptomatic patients in the vertigo group after they received treatment, which might have decreased the physicians' confidence in the diagnosis and increased the rate of repeat neuroimaging.

Conclusions

This study found that there was neuroimaging examination overuse in the evaluation of patients with vertigo; furthermore, neuroimaging examinations provided no true medical diagnostic benefit. Improving care provider knowledge of standard guidelines may help decrease neuroimaging overuse. We believe that establishment of systematic training to improve otoneurological skills in primary care services that do not specialize in the treatment of dizziness, vertigo, or syncope patients would be worthwhile to minimize repeat neuroimaging imaging that is unlikely to produce useful findings in BPPV.

Author Statement

I certify that I have participated sufficiently in the conception and design of this work and the analysis and interpretation of the data as well as the writing of the manuscript. I also take public responsibility for the work. I further attest that no organization or entity or interest group, including my employer, was involved in supporting the study financially or otherwise. Furthermore, no organization/entity/interest group had any influence on the study results, statistical analysis, writing, editing, or decision for publication. Furthermore, all expenses (financial or other) were allocated by me from my personal fund or my own research savings fund, and no other funding was provided by anyone except me. I believe the manuscript represents valid work. I have reviewed the final version of the manuscript and approved it for publication. Neither this manuscript nor one with substantially similar content under our authorship has been published or is being consider for publication elsewhere, Furthermore, I am willing to produce the data on which the manuscript is based in the editors or their

assignees request for the same.

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