Editorial

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The missing pressure: why middle ear physiology deserves a central role in AI-driven vertigo research

Abstract

Artificial intelligence (AI) is increasingly being explored as a tool in the diagnosis and management of vertigo, though its clinical integration remains in the early stages. While these developments hold promise, they also risk overshadowing foundational physiological mechanisms. One of the most underrecognized yet clinically significant contributors to dizziness is middle ear pressure (MEP) asymmetry, particularly in the context of Eustachian tube dysfunction (ETD). This editorial argues for the reintegration of middle ear physiology into both clinical frameworks and the design of AI-based diagnostic tools for vestibular disorders, drawing on a recent case of ground-level alternobaric vertigo (GLAV) and historical clinical evidence. Recognizing and addressing this diagnostic gap is essential for the development of truly patient-centered vertigo care.

Keywords: artificial intelligence, dizziness, Eustachian tube dysfunction, middle ear pressure, ground-level alternobaric vertigo, digital diagnostics, ChatGTP-assisted diagnosis, vestibular rehabilitation

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Abbreviations

MEP, middle ear pressure; ETD, Eustachian tube dysfunction; GLAV, ground-level alternobaric vertigo; BPPV, benign paroxysmal positional vertigo; PPPD, persistent postural-perceptual dizziness; AI, artificial intelligence; CNS, central nervous system; DTx, digital therapeutics; VR, virtual reality; vHIT, video head impulse test; VNG, videonystagmography; HINTS, head impulse, nystagmus, test of skew; ETC, Eustachian tube catheterization; JOENTR, Journal of Otolaryngology–ENT Research

Introduction

Artificial intelligence (AI) is revolutionizing the clinical evaluation of dizziness. Tools such as eye-tracking software, wearable sensors, and machine learning algorithms now assist clinicians in rapidly and accurately distinguishing between central and peripheral causes of vertigo.[1-5] These innovations promise greater objectivity, efficiency, and diagnostic consistency in a domain long challenged by subjective symptomatology and clinical ambiguity.

Yet amid this technological progress, foundational anatomical and physiological factors risk being overlooked—particularly middle ear pressure (MEP), a dynamic and measurable variable that remains largely absent from digital diagnostics. As AI increasingly informs clinical decision-making, omitting key parameters like MEP threatens to perpetuate misdiagnoses and ineffective treatments, particularly in patients with Eustachian tube dysfunction (ETD) or barometric imbalance.

What the Algorithms Miss

Most AI-based models for vertigo are trained on datasets that emphasize:

i. Vestibulo-ocular metrics (e.g., vHIT, VNG)
ii. Postural sway recordings
iii. Neuroimaging features [1-5]

Several reviews have highlighted these developments, including the role of wearable sensors, video-based diagnostics, and real-time data analysis. However, clinically measurable variables such as MEP are rarely included as diagnostic inputs or modeling parameters. The importance of tympanometry in diagnosing pressure-mediated dizziness has been well established in recent otolaryngology literature.[6]

This omission is not a limitation of the algorithms themselves, but a reflection of current clinical priorities and dataset design. Despite growing efforts to standardize biosignals and train AI models for vertigo, critical physiological factors like MEP continue to be excluded.

By relying solely on conventional inputs—eye movements, vestibular signals, and symptom narratives—AI frameworks risk reinforcing existing diagnostic blind spots rather than correcting them. Disorders such as ground-level alternobaric vertigo (GLAV), which result from MEP asymmetry and ETD, remain undetectable—not due to algorithmic inadequacy, but because the requisite data and pathophysiological concepts are entirely absent from their training pipelines.

This oversight is not unique to vestibular medicine. A recent 2025 scoping review of AI-based ophthalmic devices revealed that among 131 studies supporting regulatory approval, only 8% were interventional, and 19% of approved devices lacked any published performance evidence. Key demographic variables—such as age, sex, and ethnicity—were often missing or inconsistently reported.[7] Although centered on ophthalmology, the review underscores a broader pattern: AI adoption is advancing faster than the clinical quality and diversity of the data on which it relies.

Vertigo-specific AI thus faces a parallel dilemma. Without the deliberate reintegration of underrepresented physiological inputs such as MEP, even the most advanced vertigo-focused AI models will remain constrained by a diagnostic ceiling. These omissions risk systematic misclassification of pressure-mediated vestibular disorders, undermining the promise of personalized and physiologically grounded care.

The case that redefined relevance

A 2023 case report authored by the present writer described a patient with persistent dizziness that remained unexplained despite conventional vestibular and neurological evaluation, and was ultimately resolved following identification of MEP asymmetry and treatment with Eustachian tube catheterization (ETC).[8] Notably, the differential diagnosis and interpretive framework were clarified with the assistance of ChatGPT—an instance in which AI supported the clinical recognition of a condition that conventional pathways had overlooked.

While seemingly anecdotal, this case underscores a broader concern: how many cases of "idiopathic" or "refractory" vertigo cases are, in fact, barometric in origin—misattributed to more familiar diagnoses such as Meniere's disease, benign paroxysmal positional vertigo (BPPV) or otolithiasis, vestibular neuritis, vestibular migraine, vertebrogenic dizziness, persistent postural-perceptual dizziness (PPPD), as well as central causes, and others—simply because middle ear barometric imbalance linked to ETD was never considered?[9]

Precedent from the Literature

Importantly, this phenomenon is not isolated. In 2012, Bluestone and colleagues reported a patient who exhibited a sustained MEP exceeding +200 mmH_2O and experienced GLAV due to a blocked tympanostomy tube.[10] This case, published in a high-impact otolaryngology journal, offers a compelling historical precedent for re-evaluating MEP in vertigo diagnostics. Remarkably, that case and the 2023 report by the present author share three core features:

i. No identifiable central or labyrinthine pathology

ii. MEP asymmetry identified via tympanometry

a. Bluestone et al.[10]: pronounced pressure elevation (>+200 mmH_2O) in the ear with the obstructed tympanostomy tube, with normal pressure in the contralateral ear

b. Kim[8]: subtler bilateral pressure differences, yet sufficient to provoke GLAV symptoms in the absence of other identifiable causes

iii. Rapid and sustained symptom resolution following normalization of MEP

Despite such precedents, tympanometry remains vastly underutilized in AI-enabled vertigo diagnostics. The recurrence of these findings—spanning not only recent decades but reaching back to the 19th-century clinical observations of James Yearsley and Peter Allen—should not be dismissed as coincidence. Rather, they should serve as sentinel warnings: when MEP is excluded from the clinical equation, we may misclassify, mistreat, and misunderstand a significant subset of dizzy patients.[11]

Why this matters for AI-based vertigo research

To truly advance beyond eye motion and sway pattern analysis, AI models must evolve into multimodal diagnostic systems—capable of integrating a wider range of clinically relevant data. Among the most underutilized yet impactful are:

i. Tympanometric readings

ii. Eustachian tube function history

iii. Swallowing disorders, particularly those associated with ETD

iv. Nasal airflow and barometric symptomatology

v. Reflux-related symptom patterns, particularly laryngopharyngeal reflux (LPR)

vi. Intervention outcomes, such as the efficacy of Eustachian tube catheterization (ETC)

Failure to incorporate these parameters risks persistent misclassification of ETD-related vertigo and undermines the potential utility of even the most technically sophisticated algorithms.

Recent innovations in vestibular rehabilitation**,** including virtual reality (VR)-based platforms and emerging digital therapeutics (DTx)**,** represent a promising intersection of technology and medicine. These immersive systems aim to promote gaze stabilization, balance retraining, and habituation through interactive exercises. However, such interventions inherently presume diagnostic accuracy. When conditions like GLAV or ETD are misdiagnosed—or not diagnosed at all—due to the exclusion of middle ear physiology from diagnostic frameworks, these advanced tools may be targeting the wrong disorder with misapplied precision.

Innovation without diagnostic integrity becomes technological misdirection.

Imagine a patient whose vertigo arises not from central vestibular dysfunction, but from MEP asymmetry due to ETD—a condition that could be resolved with simple ETC**.** Instead, that patient is directed toward VR-based DTx designed for an entirely different pathology. This is not merely a misstep; it is a diagnostic irony: technology applied with great sophistication, but in the wrong direction. (Figure 1)

Figure 1 A surreal depiction of ground-level alternobaric vertigo (GLAV).

This image was originally conceptualized by the author using AI-assisted tools and first appeared in an earlier chapter exploring GLAV through both clinical and philosophical lenses. As an illustrative analogy, the image portrays a state in which one half of the body appears anchored to Earth, while the other half feels attached to the Moon or a distant star—evoking the sensation that the body is split and pulled between celestial spheres. This metaphor conveys the profound cortical disorientation that may arise when each ear transmits conflicting pressure signals, disrupting the unified perception of gravity.

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Figure adapted from: Kim HY. Ground-Level Alternobaric Vertigo: A Contemporary Perspective on Eustachian Tube Dysfunction and Balance. IntechOpen; 2024.[9]

Let us review the old and learn the new

In an era captivated by novelty, we must also reclaim what has been overlooked. As Goethe wrote:

"In science it is a service of the highest merit to seek out those fragmentary truths attained by the ancients, and to develop them further."[12]

Peter Drucker defined innovation as "an activity that changes the value and satisfaction of consumers." In other words, innovation is not merely about creating something entirely new, but about increasing the value of what already exists—turning underutilized resources into greater benefit.[13]

In the field of vertigo care, this may mean restoring attention to something deceptively simple: middle ear pressure (MEP).

In the inaugural issue of *JOENTR*, I advocated for preserving traditional methods such as Eustachian tube catheterization (ETC)—not as medical artifacts, but as tools still capable of delivering patient value. That philosophy underpins this editorial as well.

Re-centering MEP in the diagnostic conversation calls not for uncritical adoption of new tools, nor the abandonment of physiological wisdom, but for integrity in how innovation is applied—ensuring that progress remains patient-centered and physiologically grounded.

Final reflections

The prospect that advanced AI may one day perform surgical procedures independently is no longer far-fetched. Yet before reaching that stage, AI must first be trained in foundational domains such as anatomy, physiology, pathophysiology, and clinically grounded reasoning. Diagnostic accuracy is not merely a function of pattern recognition; it requires the cognitive integration of mechanistic understanding, biological processes, and phenomenological insight.

Both clinicians and AI systems must be educated within a framework that reflects this integrative approach—one that extends beyond imaging and symptom checklists to encompass physiological variables such as MEP, Eustachian tube function, and barometric responsiveness. These factors are especially critical in the assessment of vertigo, where their omission can result in diagnostic misattribution and suboptimal care.

Most importantly, the limitations observed in AI-based diagnostic systems do not arise in isolation; they mirror longstanding epistemological gaps embedded in clinical training and practice. If middle ear pressure gradients and Eustachian mechanics are overlooked in training data, it is because they were first neglected in our clinical thinking. The real challenge, then, is not only to refine AI—but to elevate the diagnostic awareness from which such systems are derived.

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Conflicts of interest

The author declares no conflicts of interest.

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