

Diagnostic Approaches to Vertigo in Children

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Abstract

Vertigo and dizziness are uncommon symptoms in children. The prevalence of vertigo is 14%. However, vertigo and dizziness in children could cause late postural control, reduction in coordinating function, the emergence of paroxysmal head tilts, and repeated falling events. Vertigo in children is usually benign and mostly periphery vertigo, such as BPPV in children and otitis media. It might be caused by central vertigo. One factor of it could be fossa posterior tumors. Therefore, an accurate diagnosis is urgently required.

On the other hand, vertigo in children is hardly diagnosed. Children cannot draw correctly about their vestibular grievance, temporary vertigo quality, vague clinical symptoms, confusion with behavioral symptoms, and other conditions. On top of that, results from clinical and neurophysiological vestibular examinations on children are not similar. It is because children's vestibular organs are not mature. Therefore, vertigo in children will cause anxiety in parents and practitioners. Furthermore, it may cause ineffective clinical and supporting examination.

Vertigo diagnosis in children is the most complex challenge. Therefore, the diagnosis approach by using vertigo classification can simplify the process. Therefore practitioners can get a more accurate one. This article will discuss prevalence, etiology, pathophysiology, clinical manifestation, and vertigo management in children to ease daily practice.

Keywords: *Vertigo in children, dizziness in children, diagnostic approach, BPPV in children, vertigo in children classification.*

1. Introduction

Vertigo is a vestibular pathology symptom that is happening with labyrinth abnormality.¹ It is also understood as other neurological pathology, symptoms (such as seizures, tumors in *Cerebellopontine Angle*, migraine).(Bisdorff et al., 2015) Vertigo is defined by movement sensation (head or body) when there is no movement or abnormal head movement.¹(S. Swain et al., 2020)(Mack, n.d.) Furthermore, vertigo is a symptom of another disease. Therefore, anamnesis, physical examination, and supporting examination are essential to define the type of vertigo and its causation.¹

Vertigo in children rarely happens rather than in the adult.(S. Swain et al., 2020) The first case was documented in 1962.(S. Swain et al., 2020) Vertigo, vestibular deficit, and dizziness in children can cause late postural control, reduced coordination function, the appearance of proximal head tilts, and repeated falling event.(Klaus Jahn et al., 2015) It is uncommon to meet vertigo in children.(Klaus Jahn et al., 2015) The prevalence of vertigo in children is between 0,45%-14%.(Klaus Jahn et al., 2015) This range is happening because of inclusive and exclusive criteria, study design and data collection method, and difficulties in diagnosing vertigo in children.(Casani et al., 2015) The most common vertigo is peripheral.(S. Swain et al., 2020)(Casani et al., 2015) It is caused by vestibular neuritis, *benign paroxysmal vertigo* (BPV), migraines, and vertigo related to otitis media and head trauma.(S. Swain et al., 2020) (Casani et al., 2015) Central vertigo in children, caused by a tumor, rarely happens.(S. Swain et al., 2020)(Casani et al., 2015) However, it should be considered. Therefore, vertigo in children can be effectively diagnosed.(S. Swain et al., 2020)(Casani et al., 2015)

The most critical sign of vertigo can be addressed from the relevant and accurate clinical sign and symptom.(S. Swain et al., 2020)(Batson, 2004) However, it is not easy to detect vertigo in children because lack of

communication abilities, such as limited vocabulary and easy to be distracted. (S. Swain et al., 2020)(Batson, 2004) Therefore, children cannot draw their vestibular grievance correctly, how long the duration, the trigger, and the symptoms. (S. Swain et al., 2020)(Batson, 2004) Besides that, vertigo in children is usually benign, short duration, and has a vast diversity in vestibular and neurophysiology examination results. (S. Swain et al., 2020)(Batson, 2004) It is because children still immature in their vestibular organs. (S. Swain et al., 2020)(Batson, 2004) Therefore, the practitioner needs to make diagnostic approaches to define what is the cause through vertigo type classification. These will help practitioners and comprehensive capacity development in understanding vertigo in children to minimize misdiagnosis.

2. Epidemiology

Vertigo is rare in children and teenagers. (S. K. Swain et al., 2020)(PERDOSSI, 2017) Its prevalence is between 8 to 15%. (S. K. Swain et al., 2020)(PERDOSSI, 2017) In clinical otolaryngology, vertigo prevalence is roughly 0,7%. (S. K. Swain et al., 2020)(PERDOSSI, 2017) A study in Scotland in 2165 children aged between 5 to 15 years shows the prevalence of one episode of rotator vertigo is 18%. (S. K. Swain et al., 2020) It is declining to 5% in a minimum of three episodes of vertigo. (S. K. Swain et al., 2020) Another study in 1050 children aged 1 to 15 in Finland shows that the prevalence of vertigo for the whole life is 8% and disturbance of body balance is 2%. (S. K. Swain et al., 2020) Episodes of vertigo and dizziness are uncommon in children rather than adult. (S. K. Swain et al., 2020) Prevalence of vertigo in children has only been between 0,4% to 15%. (S. K. Swain et al., 2020)(PERDOSSI, 2017) This range may not catch the reality because some factors, such as children, cannot address vestibular distraction, lack of complaint expression in children, and different causes of vestibular complaint in adults and children. (S. K. Swain et al., 2020)(PERDOSSI, 2017)

The most common cause of vertigo in children is peripher. (PERDOSSI, 2017) The most known cause of vertigo in children is vestibular migraine, benign paroxysmal vertigo, neuritis vestibular, and somatoform vertigo. (Casani et al., 2015) Vestibular migraine and somatoform vertigo are more frequent in girls. (Casani et al., 2015) Other research says that BPV in children and vestibular migraine are the two most factors of vertigo in children in preschool, school age, and teenage. (Lee et al., 2017) It is typical for an infratentorial tumor in the fossa posterior as a cause of central vertigo. (PERDOSSI, 2017)(Gruber et al., 2012) However, it is quite common in children. (Gruber et al., 2012)

3. Etiology and Pathophysiology

Vertigo may be caused by abnormalities of the vestibular system, either visual or proprioceptive. (PERDOSSI, 2017)(Macgregor, 2002) The labyrinth is the balancing organ. (PERDOSSI, 2017)(Macgregor, 2002) It contains three semicircular canals stimulated by angular acceleration. (PERDOSSI, 2017)(Macgregor, 2002) It is also utricle and saccule, stimulated by gravitation and vertical acceleration. (PERDOSSI, 2017)(Macgregor, 2002) An impulse from the labyrinth will be streamed to the nucleus vestibular, located in the brainstem, and then goes upward to longitudinal fasciculus medialis, moves to nervus cranialis, inverting eye ball's movement, and goes downward to vestibulospinal tractus. (PERDOSSI, 2017)(Macgregor, 2002) It gives its stimulation to extensor muscles in the head, limbs, and body to maintain body posture. Cerebellum accepts afferent impulses and becomes a center. (PERDOSSI, 2017)(Macgregor, 2002) Its task is to integrate oculovestibular and postural responses. (PERDOSSI, 2017)(Macgregor, 2002) It also represents the vestibular cortex on the temporal and posterior gyrus levels. (PERDOSSI, 2017)(Macgregor, 2002) Vestibular function is measured by vestibulocochlear reflect and nystagmus intensity. (PERDOSSI, 2017)(Macgregor, 2002) It is a result of labyrinth stimulated examination. (PERDOSSI, 2017)(Macgregor, 2002) Oculovestibular reflection causes eyes fixation on stationary items when the head and body moves. (PERDOSSI, 2017)(Macgregor, 2002)

4. Classification, Diagnostic Approach, and Common Interference

Vertigo in children is multifactor. (PERDOSSI, 2017) In general terms, vertigo in children is classified as spontaneous acute non-recurrent vertigo, recurrent vertigo, non-vertiginous vertigo, disequilibrium, and ataxia. (PERDOSSI, 2017) Another diagnostic approach divides vertigo into two cautions: central and peripher. (PERDOSSI, 2017) On periphery vertigo, lesions happen in the last organ (semicircular canals, utricle, or peripheral nerves). (PERDOSSI, 2017) On the other hand, in central vertigo, lesions happen from the vestibular nerves

nucleus until the central nerves system. (PERDOSSI, 2017) We can see the difference in clinical manifestation between central and peripheral vertigo in table 1. (Macgregor, 2002)

Table 1. Clinical Presentation of Vertigo. (Macgregor, 2002)

	Peripheral Vertigo	Central Vertigo
Episode	Episodic, sudden onset	Constant
direction of nystagmus	Unidirectional	Varies
Axis nystagmus	Horizontal, rotator	Horizontal, rotary, oblique, vertical
Nystagmus type	Fast and slow phase	Irregular or <i>equal</i> phase
Hearing loss, tinnitus	Possible	There is no
Loss of consciousness	There is no	Possible
Other neurological signs/symptoms	There is no	Cerebellar sign (+), cranial nerve deficit, pyramidal sign (often)

Hearing loss can be approached by acute onset vertigo or paroxysmal episode vertigo (Shown in table 2). (Macgregor, 2002) If we meet continuous or constant vertigo and no improvement, the diagnostic approach can be based on an abnormal neurologic examination (Shown in table 3). (Macgregor, 2002) Younger children may find it difficult to complain, may not be able to verbalize complaints, or maybe too afraid to complain. (PERDOSSI, 2017) Therefore, parents should be aware of the clinical appearance of their child in the form of abnormal or tilted head posture, eyelid and/or pupil abnormalities, and hearing loss. (PERDOSSI, 2017)

Table 2. Approaches to the Diagnosis of Acute Paroxysmal Vertigo in Children. (Macgregor, 2002)

Acute Paroxysmal Vertigo	
Hearing Loss (+)	Hearing Loss (-)
- Labyrinthitis	- <i>Infants</i> –benign paroxysmal vertigo or tortilocholis
- Meniere's disease	- Juvenile vestibular neuronitis
- Perilymphatic fistula	- Labyrinth Concussion
- Vascular occlusion	- Positional paroxysmal vertigo
- Temporal bone fracture	- Migraine
	- Seizures
	- <i>Subclavian steal</i>

Table 3. Approach to the Diagnosis of Continuous Vertigo in Children. (Macgregor, 2002)

Continuous Vertigo	
Neurological Abnormalities (+)	Neurological Abnormalities (-)
- Acoustic Neuroma (Neurofibromatosis type 2)	- Hyperviscosity syndrome
- Posterior Fossa Tumor	- Cardiac dysrhythmia
- Drug-induced (aminoglycosides, furosemide, INH, ASA, quinine diphenylhydantoin)	- Sickle cell disease
- Muscle tension headaches	- Depression
- Cholesteatoma	- Polycythemia
- Stroke Infarction	- Severe anemia
- Demyelination disease (e.g., MS)	- Panic and anxiety disorders
- Vertebrobasilar insufficiency	- Metabolic disease (diabetes mellitus, Addison's disease, thyroid disease)

4.1. Labyrinthitis

Labyrinthitis diagnosis is shown by a history of virus infection before onset vertigo, accompanied by acute unilateral hearing interference.(Devaraja, 2018) It is signed by severe acute vertigo, nystagmus, queasiness, and retch.(Devaraja, 2018) Vertigo is severed by head movement. Patience chooses to lay off his/her ears on the upper side. (Devaraja, 2018) These episodic symptoms are usually relieved after several days. Vertigo and dizziness in childhood are often caused by otitis media (OM) and middle ear effusion (MEE), which represent two of the most common diseases in children. (Devaraja, 2018) Because most children with abnormal middle ear ventilation do not report a balance disturbance or vertigo, their parents usually report the symptoms, which describe clumsiness, awkwardness, and sometimes, frequent falling. (Devaraja, 2018) Different theories have been proposed about how middle ear pathologies can affect the vestibular labyrinth.(Devaraja, 2018) Golz et al. postulated that toxins present in middle ear fluid enter the inner ear fluid and cause serous labyrinthitis. (Devaraja, 2018) Other researchers have proposed that pressure changes in the middle ear cause displacements of the round and oval windows, leading to secondary movement of labyrinthine fluids. (Devaraja, 2018)

4.2. Meniere Disease

Endolymphatic hydrops cause Meniere disease.(Devaraja, 2018) It can happen spontaneously or slowly sequels. It is because of trauma and viral infection.(Devaraja, 2018) It is discovered by dizziness, unilateral hearing loss, and unilateral tinnitus.(Devaraja, 2018) It also could be bilateral Meniere disease, although it rarely happens.(Devaraja, 2018)

4.3. BPV on Children

Prevalence of BPV in children is assumed around 3% for children under 18.(van de Berg et al., 2020) Its symptoms are recurrent vertigo with puke, paleness, fright, posture imbalance, ataxia, or nystagmus. (van de Berg et al., 2020) This condition starts before age four and spontaneously improves in 8 until ten years. (van de Berg et al., 2020) The caution is the floating debris on semicircular canals or particles from otoconia, apart from utriculus, moving to cupula. (van de Berg et al., 2020) This type of vertigo is related to head trauma and neuronitis vestibular. (van de Berg et al., 2020) However, in some patients, it is hard to find the cause. (van de Berg et al., 2020)

4.4. Vestibular Migraine

Migraine commonly becomes a cause of recurrent vertigo in adults or children. (Devaraja, 2018)(Gioacchini et al., 2014) Perez-Plasencia *et al.* hypothesize that vertigo may relate to temporary vasospasm and cause ischemic in the labyrinth or central vestibular in patience with migraine.(Gioacchini et al., 2014) Vertigo migraine has a characteristic that is episodic attack.(Gioacchini et al., 2014) The duration is from minutes to hours, accompanied by headache and sensitivity to light and sound.(Gioacchini et al., 2014) Same as in adults, vertigo in children are detected by vestibular symptoms, followed or preceded or accompanied by headache. (Gioacchini et al., 2014)

4.5. Trauma

There are two causes of trauma that lead to vertigo in children: labyrinth concussion and lesion on the central nerve system. (Devaraja, 2018)(Gioacchini et al., 2014) Lesions on the central nervous system could be caused by brain stem or cerebellum contusion and temporal bone fracture. (Devaraja, 2018) Those contusions and fractures could be happened because of head trauma caused by a blunt object or whiplash.(Devaraja, 2018) In temporal bone fracture, a concussion that hits labyrinth or vestibular nerves, children can experience vertigo with nystagmus and nausea. (Gioacchini et al., 2014) It is reported that head penetration injury can cause secondary vertigo by the happening of fistula perimlife. (Devaraja, 2018)(Gioacchini et al., 2014)

4.6. Central Nerve System Interference

Some central nervous system interference causes dizziness or vertigo, disequilibrium, imbalance, and ataxia. (Devaraja, 2018) In children, the interference that can cause vertigo is cerebellum abnormality such as hypoplasia

vermin cerebellar, posterior fossa tumor, Arnold Chiari malformation. (Devaraja, 2018)(Ranalli, 2019) Fossa posterior tumor infrequently causes vertigo or imbalance in children. (Devaraja, 2018)(Ranalli, 2019) A tumor will cause persistent and progressive symptoms such as ataxia, dysarthria, diplopia, hearing loss, and cranial nerves dysfunction. (Devaraja, 2018)(Ranalli, 2019) We need an MRI scan to indicate this case.

4.7. Type II Familial Ataxia

Familial ataxia is an uncommon syndrome and genetic abnormality with the inherited dominant, autosomal pattern. (PERDOSSI, 2017) This abnormality is detected by disequilibrium episodic dizziness for some hours. (PERDOSSI, 2017) Besides that, we can find abnormalities in eyeball movement and other neurologic deficit. (Ranalli, 2019)

4.8. Seizure

Two types of seizures are related to vertigo: vestibular and vestibulogenic. (PERDOSSI, 2017) A vestibular seizure is a seizure that causes vertigo. (PERDOSSI, 2017) The symptoms of a seizure are vertigo itself. (PERDOSSI, 2017) On the other hand, vestibulogenic seizure is a reflect seizure caused by stimulating semicircular canalize with sudden rotation or calorie test. (PERDOSSI, 2017)

4.9. Drug-related Dizziness

Many drugs, such as Aminoglycoside, can cause non-vertigo dizziness. Another drug is phenytoin for epilepsy. (PERDOSSI, 2017) Intoxication is a sign of dizziness and nystagmus from using this drug. (PERDOSSI, 2017)

4.10. Nonneurotologic Interference (Psychogenic)

The interference of non-neurotologic is psychiatric dizziness. (PERDOSSI, 2017) It is ubiquitous at a young age. (PERDOSSI, 2017) It can be accompanied by depression, teenage adaptation reactions, or behavioral problems. (PERDOSSI, 2017) We will get a typical result if we do clinical treatment of vestibular, auditory, electroencephalograph, and imaging. (PERDOSSI, 2017)

5. DIAGNOSTIC EVALUATION

5.1. Anamnesis

We have to anamnesis with the following inquiry: duration and other symptoms such as nystagmus, hearing grievance, and loss of consciousness. (O'Reilly et al., 2011) We also have to delve deeper by asking about the history of past illness, especially in neonatal and perinatal times, such as sepsis and infection. (O'Reilly et al., 2011)(Valente, 2011) We also have to look after the probability of ototoxic treatment. (O'Reilly et al., 2011)(Valente, 2011) A deeper inquiry in table 4 will guide the clinician to make a differential diagnosis of children's patience with vertigo. (O'Reilly et al., 2011)

Table 4. Clinical information based on history can be extracted from the patient/parent with several focused question series. (O'Reilly et al., 2011)

Question	Clinical Information
What does it taste feel?	Are the symptoms of vestibular vertigo or something else (presyncope, syncope, seizures)
Are there any other associated symptoms?	- Hearing loss after head trauma - Tinnitus, hearing loss (Meniere's) - Dysarthria, diplopia, paresthesias (vertebrobasilar lesions) - Cranial nerve deficits (skull fractures, intracranial lesions) - Headache, torticollis (migraine) - Sweating, palpitations, shortness of breath (orthostasis, panic attacks)

How long did the symptoms last, and how many times did they appear?	- Seconds to minutes (BPPV) - Hours (TIA, migraine, Meniere's) - Days to weeks (labyrinthitis, vestibular neuritis)
What made the symptoms better or worse?	- Worsens with movement (almost all generalized vestibular vertigo) - Worsens with rotation and pressure (BPPV) - Worsening with Valsalva (perilymph fistula)
What is the history of the disease?	- Otologic disease (perilymph fistula, labyrinthitis, BPPV) - <i>Sensorineural hearing loss</i> (ototoxic medication, congenital or acquired vestibular hypofunction) - Neuropathy (peripheral neuropathy) - Vascular disease (von Whipple Lindau with intracranial lesions) - Family history of neoplasms (acoustic neuroma, neurofibromatosis, medulloblastoma) - Anxiety/Depression (panic attacks) - Intolerance to the movement (migraine) - Family history of balance disorders (periodic ataxia, hereditary vestibulopathy, migraine) - Autoimmune disease - History of seizures (temporal lobe epilepsy) - Ophthalmological diseases (amblyopia)

5.2. Physical Examination

We must do the physical examinations: standard Ear Nose Throat (ENT) examination and neurological examination, such as cranial nerves examination, eyes Range of Movement (ROM) , divergence, smooth pursuit, visibility, Romberg, muscle strength, internal tendon reflexes, and cerebellar function. We could add eyesight examination and dynamic eyesight examination. We also must look over the evidence of static and dynamic imbalance of vestibule function. ¹⁷(K. Jahn et al., 2011)

5.3. Supporting Examination

We have to consider the treatment to remove differential diagnosis from vertigo causation, such as ; (K. Jahn et al., 2011)(Bhandari & Goswami, 2019)

EEG

Computerized dynamic posturography

VEMP (vestibular evoked myogenic potential)

Laboratory Examination (Complete blood test, electrolyte, calcium, magnesium, disturbed glucose tolerance test, thyroid function)

Neuroimaging

5.4. Management

Mostly, vertigo in children is benign and has a good prognosis.^{8,18} Most cases can be solved effectively by physical therapy and medication.^{8,18} Vestibular rehabilitation therapy could be considered a treatment for BPPV, Meniere's disease, labyrinthitis, neuritis vestibular, and post-traumatic vertigo patience if the symptoms appear for more than one week.^{8,18} Vertigo management in children is usually described from the causation.^{8,18} Therefore, diagnosis is essential in choosing appropriate therapy.^{8,18}

Acknowledgement

I acknowledge nothing.

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