Step 1. Patient History and Behavior

Patient complains neck pain and dizziness/vertigo

- ✓ Review medical history (particularly cardiovascular profile) and red flags
- ✓ Medication review
- ✓ Characteristics of dizziness (time course, circumstances, severity, irritability, temporal relationship)

List potential differential diagnosis (*Appendix 2, 3*)

Step 2. Triage/Differential Diagnosis

Appropriate for clinical examination?

- ❑ **Canadian C-spine Rule**
  (Sn=99%, Sp=45%, LR+=1.81, LR-=0.01)
- ❑ **Sharp Purser Test**
  (Sn=69%, Sp=96%, LR+=15.6, LR-=0.33)
- ❑ **Alar Ligament Test**
  (Sn=69-72%, Sp=96-100%)
- ❑ **Transverse Ligament Test**

→ *Refer for imaging*

- ❑ **Cervical Spine ROM**
- ❑ Positional Provocative Testing
  (Sn=0-57%, Sp=87-100%, LR+=0.22-83.3, LR-=0.44-1.4)

→ *Refer to physician*

Oculomotor Examinations	Neurological Screen/Examinations
❑ Spontaneous nystagmus	❑ UMN signs
❑ Smooth pursuit	❑ CN signs
❑ Saccadic eye movements	❑ DTR
❑ Vergence	❑ Myotomes/Dermatomes

Vestibular / Positional Tests

- ❑ VOR
- ❑ **Head Impulse Test** (Sn=71%, Sp=82%, LR+=4.16, LR-=0.3)
- ❑ Head-shaking nystagmus
- ❑ Dynamic Visual Acuity test
- ❑ **Dix-Hallpike test** (Sn=79.3%, Sp=75%, LR+=3.17, LR-=0.11)
- ❑ Roll test

Step 3. Pattern Recognition of Cervicogenic Dizziness

Vestibular pathology suspected?
Treat and/or refer to physician/vestibular therapist

Cervical Spine Examinations	Head and Neck Differentiation
❑ **Forward head posture?**	❑ **Rob's Head and Neck Differentiation**
❑ **Segmental assessment**	❑ **Cervical Relocation Test**
❑ End feel	Any direction (Sn=92%, Sp=54%, LR+=2, LR-=0.15)
❑ Hypomobility segmental level	Mean (Sn=72%, Sp=75%, LR+=2.9, LR-=0.37)
❑ **Cervical Flexion Rotation Test**	❑ **Cervical Neck Torsion Test**
(Sn=90%, Sp=91%)	(Sn=72%, Sp=92%, LR+=2.9, LR-=0.37)
❑ **Craniocervical Flexion Test**	❑ Smooth Pursuit Neck Torsion Test
	(Sn=27-90%, Sp=55-88%, LR+=0.6-10, LR-=0.11-1.3)

Diagnosed as **Cervicogenic Dizziness**

Step 4. Development of Treatment Strategy

- ➢ Cervical spine impairment
- ➢ Altered cervical proprioception
- ➢ Disturbed postural stability
- ➢ Oculomotor disturbance

Appendix 1. Clinical Decision-Making Flowcharts

Jung et al. (2017)[3]

The First Step: Understanding History and Behavior

- Subjective review for red flags requiring medical urgency or referral to a specialist
- Medical history review for cardiovascular profile/illness, including vital signs
- Medication review
- Characteristics and temporal behavior of dizziness symptoms, including relationship to cervical dysfunction
- Identification of current or past history of WAD, cervical degeneration, and muscle spasm
- Subjective complaints associated with neck pain, stiffness, and movement restrictions
- Episodic nature associated with cervical movement or motion sensitivity

↓

The Second Step: Comparing and Contrasting Clinical Features for Differential Diagnoses

- An exclusion-based diagnostic process was utilized to differentiate similar diagnoses (**TABLE 2**)
- Screening with contraindication and precaution to related examination to minimize red flags for related medical conditions
- Reproduction of dizziness with cervical movements
- Absence of both central and peripheral vestibular disorders
- Absence of BPPV presenting with similar movement behaviors to those of CGD (sensitivity with neck and head stimulation)

↓

The Third Step: Pattern Recognition of CGD

- Relevant subjective history of cervical region and temporal relationship
- Presence of postural imbalance with forward head posture and relevant musculoskeletal impairments in cervical dysfunction, especially with upper cervical hypomobility
- Relieving factor associated with cervical movement testing (ie, cervical distraction and retraction)
- Positive CFRT, CCFT, and SPNT
- Altered sensorimotor disturbance

↓

The Fourth Step: The Decision of Treatment Strategy

- Trial treatment driven to cervical region brings significant treatment impact on both cervical dysfunction and dizziness (patients 3 and 5)
- Treatment on cervical region also simultaneously improves overall dizziness where there was presence of abnormal altered sensorimotor items (patient 4)
- Altered proprioceptive input can also disturb other sensory systems, requiring additional treatment for sensorimotor retraining (patients 1, 2, 6, and 7)

FIGURE. The flow of the clinical decision-making approach. Abbreviations: BPPV, benign paroxysmal positional vertigo; CCFT, craniocervical flexion test; CFRT, cervical flexion rotation test; CGD, cervicogenic dizziness; SPNT, smooth pursuit neck torsional test; WAD, whiplash-associated disorder.

Reiley et al. (2017)[7]

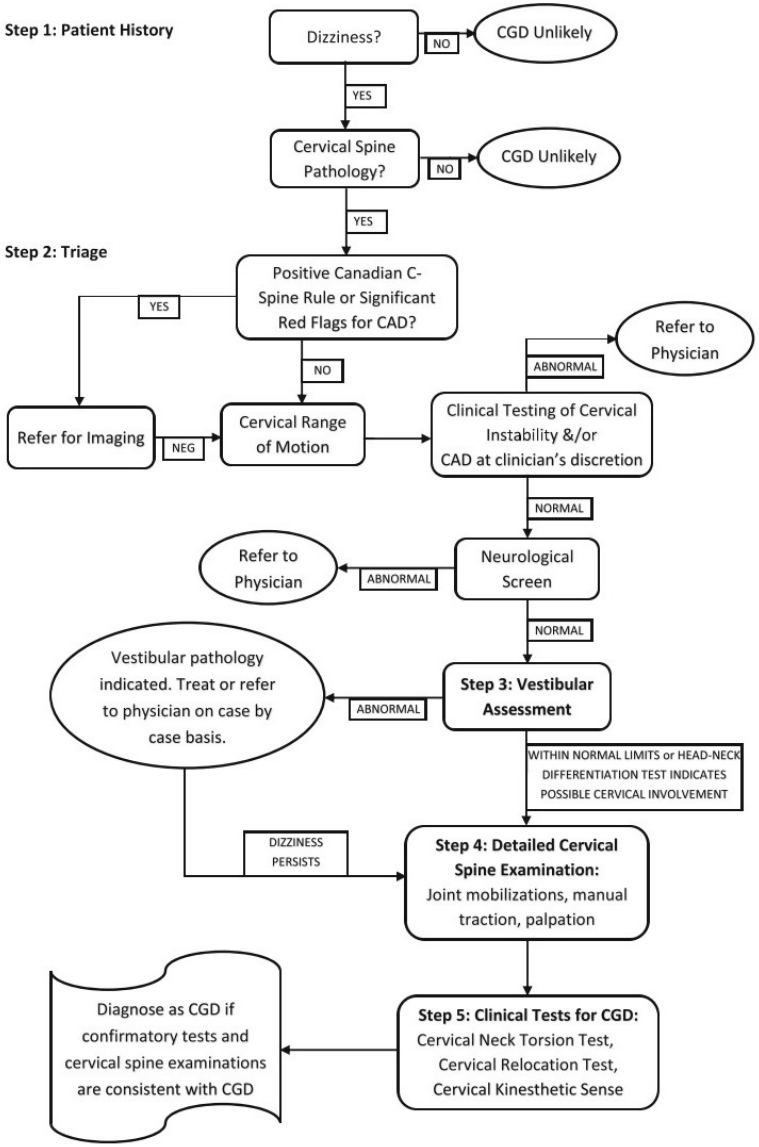

Fig. 1 Stepwise algorithm for diagnosing cervicogenic dizziness

Appendix 2. Potential Differential Diagnosis of Dizziness and Vertigo

- ❑ **Infection/Inflammation**
  - ❑ Vestibular Neuritis
  - ❑ Acute/Chronic Otitis Media
  - ❑ Labyrinthitis
  - ❑ Late-Stage Syphilis
- ❑ **Trauma**
  - ❑ BPPV
  - ❑ Perilymphatic Fistula
  - ❑ Post-Traumatic Endolymphatic Hydrops
- ❑ **Congenital Abnormality of Inner Ear**
- ❑ **Tumors**
  - ❑ Acoustic Neuroma
  - ❑ Cerebeller Lesions
- ❑ **Iatrogenic**
  - ❑ Medication
  - ❑ Ear Surgery
  - ❑ Ototoxicity
- ❑ **Degenerative**
  - ❑ Age-related
  - ❑ Cerebeller Atrophy
- ❑ **Metabolic/Hormonal**
  - ❑ Hypoglycemia
  - ❑ Hypothyroidism
  - ❑ Diabetes
  - ❑ Vestibular Migraine
- ❑ **Immune System Disease**
  - ❑ Autoimmune Inner Ear Disease
  - ❑ Multiple Sclerosis (MS)
- ❑ **Cardiovascular Disease**
  - ❑ Arrhythmias
  - ❑ Cerebellar Infarction (Stroke)
  - ❑ Transient Ischemic Disease (TIA)
  - ❑ Vertebral Artery Dissection/Insufficiency
  - ❑ Postural Hypotension
- ❑ **Psychophysiologic Dizziness**
  - ❑ Hyperventilation
  - ❑ Panic Disorder/Anxiety Attack
- ❑ **Motion Sickness**
  - ❑ Mal de Debarquement
- ❑ **Idiopathic Disorders**
  - ❑ Meniere's Disease

Appendix 3. Differential Diagnosis Tables

Jung et al. (2017)[3]

TABLE 2 DIFFERENTIAL DIAGNOSIS OF DIZZINESS BASED ON SYMPTOM ORIGIN

Signs and Symptoms	CAD[10,11,41]	BPPV[8,33,76]	Cervical Instability[16,25]	Cervicogenic Headache/Mechanical Neck Pain[25,35]	Unilateral Vestibular Dysfunction[26,33,74,79]	Cervicogenic Dizziness[27,50,73,83,86]
Associated pain	Headache	NA	Presents with neck pain	Unilateral, nonthrobbing pain beginning in neck	NA	Presents with neck pain
History of trauma	Neck trauma present	May occur after head or neck trauma	May occur after head or neck trauma	Not typical	May occur after head or neck trauma	May occur after head or neck trauma
Definition of dizziness	Light-headedness, related to neck movement	True spinning	"Head is going to fall off"	Not typical	Spinning sensation, unsteadiness	Vague complaints of light-headedness and unsteadiness
Duration of dizziness	Minutes to hours	Seconds	Nonspecific	NA	A few days to weeks	Minutes to hours
Frequency of dizziness	Episodic	Episodic	Episodic	NA	Episodic	Episodic
Presence of nystagmus	Visual disturbance/ nystagmus	With changes in position; torsional and directional	NA	NA	Spontaneous nystagmus may be present in the dark; may present with blurred vision and oscillopsia	Not present
Balance deficits	Drop attacks	Present during active BPPV	May be present	May be present	Present with head movement	Disequilibrium with head movements
Other neurological signs	Positive cranial nerve signs, dysphasia, dysarthria, diplopia	NA	Varies depending on severity or nature	None	None	Varies depending on severity or nature
Cardiovascular signs or symptoms	Risk factors/history of stroke	NA	Not typical	None	None	None

Abbreviations: BPPV, benign paroxysmal positional vertigo; CAD, cervical arterial disorder; NA, not applicable.

Treleaven et al. (2017)[9]

TABLE Differential Diagnosis and Suggested Management of Sensorimotor Control Disturbances in Those With Traumatic Neck Pain

	Cervical	Vertebral Artery	BPPV	Perilymph Fistula	Peripheral Vestibular	Central Vestibular	Psychological
Description	• Unsteadiness • Light-headedness	• Fainting • Vertigo dizziness	• Vertigo	• Vertigo • Dysequilibrium • Motion intolerance	• Vertigo • Unsteadiness • Motion intolerance	• Dysequilibrium • Motion intolerance	• Floating • Rocking • Fullness in head
Frequency	• Episodic	• Episodic	• Discrete attacks	• Episodic/constant	• Episodic vertigo • Constant unsteadiness	• Varies	• Varies
Duration	• Minutes to hours	• Several seconds	• Seconds	• Constant	• Seconds to minutes	• Varies	• Varies
Exacerbated	• Increasing neck pain • Neck movement	• Sustained neck extension and/or rotation	• Rolling in bed • Looking up • Lying down	• Visual challenges • Increased intracranial or atmospheric pressure (eg, blowing nose) • Loud noises	• Head positions or movement	• Spontaneous or provoked	• Stress • Anxiety • Hyperventilation
Relieved	• Decreasing neck pain	• Neck back to neutral	• Subsides if staying in provoking position	• Avoiding above activities, rest	• Head/body still	• Varies	• Relaxation
Associated symptoms	• Blurred vision • Nausea • Neck pain	• Dysarthria • Hemiparesis • Dysesthesia • Diplopia • Dysphagia • Drop attacks • Nystagmus • Nausea • Numbness	• Nausea • Vomiting	• Unilateral tinnitus • Aural pressure • Hearing loss	• Nausea • Vomiting • Hearing loss • Tinnitus • Ear fullness	• Nausea • Imbalance • CNS signs	• Lump throat • Heart palpitations • Tight chest
Suggested cause	• Abnormal cervical afferent input	• VA dissection/ insufficiency	• Debris in endolymph	• Leak of perilymph fluid into middle ear	• Vascular injuries • Fractures	• Brain stem • Cerebellum	• Anxiety • Stress
Primary objective findings	• Cervical musculoskeletal impairments • JPE, >4.5° • Increased sway • Balanced neck torsion • Positive SPNT • Positive cervical torsion test • Positive trunk-head coordination test • Absence of other findings	• Possible positive VBI tests • VAD: unilateral severe headache • Transient neurological disturbances relating to VA function	• Positive Dix-Hallpike or head roll	• Positive pressure test • Positive Valsalva test	• Head impulse • Head-shake DVA	• Spontaneous or gaze-evoked nystagmus • Oculomotor deficits* • Ataxia	• None
Suggested treatment	• Cervical musculoskeletal and tailored sensorimotor	• Referral to neurologist	• Epley or BBQ roll maneuver	• Referral to ENT • Surgery	• Tailored vestibular rehabilitation, central adaptation, habituation • Cervical musculoskeletal and tailored sensorimotor as required	• Tailored rehabilitation, oculomotor, vestibular, balance, and gait • Cervical musculoskeletal and tailored sensorimotor as required	• Meditation • Mindfulness • Stress management • Cervical musculoskeletal and tailored sensorimotor as required

Abbreviations: BBQ, barbeque; BPPV, benign paroxysmal positional vertigo; CNS, central nervous system; DVA, dynamic visual acuity; ENT, ear-nose-throat specialist; JPE, joint position error; SPNT, smooth-pursuit neck torsion; VA, vertebral artery; VAD, vertebral artery dissection; VBI, vertebral basilar insufficiency.
**Oculomotor includes skew deviation, vergence, smooth pursuit, and saccades.*

Jung et al. (2017)[3]

Table 3 Presentation of cervicogenic dizziness and competing diagnoses

Diagnosis	Duration	Signs and symptoms
Acute Vestibular Loss	Single attack, several attacks, or persistent for several weeks.	Sudden vertigo or dizziness possibly accompanied by tinnitus, diplopia, nausea, vomiting [15].
Benign Paroxysmal Positional Vertigo	A few seconds to several minutes.	Vertigo. Occurs with changes in position relative to gravity [50].
Central Vestibular Disorders	Several days to weeks.	Constant vertigo, facial asymmetry, swallowing or speech problems, ptosis, ataxia, sensation changes, upper motor neuron signs, abnormal head thrust test, direction changing nystagmus, pure vertical nystagmus, pure torsional nystagmus, a skew deviation, and other neurological symptoms [23, 51].
Cervical Arterial Dysfunction	Several minutes.	Dizziness that is typically accompanied by diplopia, numbness around the lips, nystagmus, ataxia, bilateral neurological symptoms, dysphagia, dysarthria and headaches. Associated with nausea and vomiting [19].
Cervicogenic Dizziness	Several minutes to hours [3].	Dizziness and disequilibrium due to changes in cervical spine position [3].
Labyrinthine Concussion	Episodically over hours to days [26].	Cervical neck pain is common. Hearing loss, tinnitus, and dizziness [18].
Ménière's Disease	Minutes to hours, rarely longer than 24 h [12].	Presents with episodic, intense vertigo, accompanied by aural fullness, tinnitusand fluctuating hearing loss. Attacks are typically preceded by aura and followed by a period of exhaustion and generalized dizziness. As Ménière's disease progresses, the hearing loss and tinnitus intensify and become more persistent, and the acute attacks of vertigo may be replaced by more chronic problems with dizziness and imbalance [12, 13].
Vestibular Migraine	4–72 h.	Vestibular Migraine Diagnostic Criteria (International Headache Society) [17]. A. At least five episodes involving criteria C and D. B. A current or past history of *Migraine without aura* or *Migraine with aura.* C. Vestibular symptoms* of moderate or severe intensity, lasting between 5 min and 72 h. D. At least 50% of episodes are associated with at least one of the following three migrainous features: 1) headache with at least two of the following four characteristics: unilateral location, pulsating quality, moderate or severe intensity, aggravation by routine physical activity; 2) photophobia and phonophobia; 3) visual aura. E. Not better accounted for by another ICHD-3 diagnosis or by another vestibular disorder. *Barany Society's Classification of Vestibular Symptoms: a. spontaneous vertigo: i. internal vertigo (a false sensation of self-motion) ii. external vertigo (a false sensation of visual surroundings spinning or flowing) b. positional vertigo, triggered by a complex or large moving stimulus c. visually induced vertigo, triggered by a complex or large moving visual stimulus d. head motion-induced vertigo, occurring during head motion e. head motion-induced dizziness with nausea
Whiplash Associated Disorder	Variable. Days to weeks and in some cases months.	Cervical neck pain and hypersensitivity, decreased cervical range of motion, dizziness, tinnitus, and headache. Associated with psychological factors, such as low pain tolerance and fear avoidance [21].

Appendix 4. Summary of Diagnostic Accuracy of the Test[3]

Table 1 Diagnostic accuracy of tests

Test	Diagnosis	Sensitivity (%)	Specificity (%)	PV+ (%)	PV- (%)	LR+	LR-	Reference
Canadian C-Spine Rule	Cervical Spine Trauma	99	45	6.03	100	1.81	0.01	Stiell et al. [36]; Duane et al. [37]
Cervical Arterial Dysfunction (CAD) Test	CAD	0–57	87–100	0–100	26–96	0.22–83.3	0.44–1.4	Hutting et al. [22]; Petersen et al. [38]
Sharp Purser Test	Transverse Ligament Stability	69	96	85	90	15.6	0.33	Uitvlugt & Indenbaum [39]; Hutting et al. [40]
Alar Ligament Test	Alar Ligament Stability	Right: 69 Left: 72	Right: 100 Left: 96	Right: 100 Left: 93	Right: 80 Left: 81	–	–	Kaale et al. [41]
Dix-Hallpike	Posterior Canal BPPV	79.3	75	95.8	33.3	3.17	0.14	Halker et al. [42]
Head Thrust Test	Unilateral Vestibular Hypofunction	71 (88 for complete loss)	82	87	65	4.16	0.3	Schubert et al. [43]
Manual Spinal Examination	Cervical Facet Joint Dysfunction	92	71	–	–	3.17	0.11	Schneider et al. [30]
Palpation for Segmental Tenderness	Cervical Facet Joint Mediated Pain	94	73	–	–	3.48	0.08	Schneider et al. [30]
Cervical Neck Torsion Test	Cervicogenic Dizziness (versus BPPV)	72	92	–	–	9	0.3	L'Heureux-Leabeau et al. [14]
Cervical Relocation Test (with positive test defined by any of the 4 positions with JPE >4.5°)	Cervicogenic Dizziness (versus BPPV)	92	54	–	–	2	0.15	L'Heureux-Leabeau et al. [14]
Cervical Relocation Test (with positive test defined by mean JPE >4.5°)	Cervicogenic Dizziness (versus BPPV)	72	75	–	–	2.9	0.37	L'Heureux-Leabeau et al. [14]
Smooth Pursuit Neck Torsion (SPNT) Test	CGD in people with WAD and dizziness	90 27 56	91 55 88	92 – –	71 – –	10 0.6 –	0.11 1.3 –	L'Heureux-Leabeau et al. [14] Tjell & Rosenhall [34] Kongsted et al. [35]

Appendix 5. Examination Description and Interpretation

Examination (Diagnosis)	Description	Interpretation
Step 2 Triage/Differential Diagnosis		
Canadian C-Spine Rule[7,8] (Cervical Spine Trauma)	1) Any high-risk factor present: Age ≥ 65 years OR *Dangerous MOI** OR Paresthesias in extremities. If YES to any, radiography should be performed. If NO to all, continue to 2). (*Fall from elevation ≥0.9 m (3 ft)/five stairs, axial load to head, motor vehicle collision at high speed (>100 km/h), rollover, ejection, motorized recreational vehicles, bicycle struck, or bicycle collision) 2) Any *low risk factor** that allows safe assessment of ROM? If NO to all, radiography should be performed; if YES to any, continue to 3). (*Simple rear-end motor vehicle collision OR Sitting position in ED OR Ambulatory at any time OR Delayed (not immediate) onset of neck pain OR Absence of midline cervical spine tenderness) 3) Able to actively rotate neck 45° left and right? If unable, radiography should be performed.	➢ The determination of risk factor guides the use of cervical radiography. ➢ Sensitivity=99%, Specificity=45%, PV+=6.03%, PV-=100%, LR+=1.81, LR-=0.01 ➢ Canadian C-Spine Rule is not applicable in non-trauma cases, to patients who are not alert (GCS<14), for patients with age < 16 years, during pregnancy, or for patients with unstable vital signs, acute paralysis, known vertebral disease, or previous history of cervical spine surgery.
Sharp-Purser Test[5,6,7] (Transverse Ligament Instability)	1) The patient is in a sitting position with their head slightly flexed. The clinician assesses the patient's resting symptoms. 2) The clinician places one hand over the patient's forehead, while the thumb of the other hand is placed over the C2 (axis) spinous process for stabilization. 3) The clinician applies a posteriorly directed force on the forehead.	➢ A positive test is defined by symptom reproduction during forward flexion, decrease in symptoms during posterior translation, or excessive displacement (>4 mm) during posterior translation ("clunk"). ➢ Sensitivity=69%, Specificity=96%, PV+=85%, PV-=90%, LR+=15.6~17.25, LR-=0.32~0.33
Transverse Ligament Test[6] (Transverse Ligament Instability)	1) The patient is in supine with the head supported by a pillow in the neutral position. The clinician supports the occiput in the palms of the hands and the third, fourth, and fifth fingers while the 2 index fingers are placed in the space between the occiput and the C2 spinous process, thus overlying the neural arch of the atlas. 2) The head and C1 are then lifted (sheared) anteriorly together, while the head is maintained in its neutral position and gravity fixes the rest of the neck. The patient is instructed to report any symptoms other than local pain and soreness.	➢ A positive test is defined by the sensation of a lump in the throat or the presence of cardinal signs or symptoms.
Alar Ligament Test[6,7] (Alar Ligament Instability)	1) The patient is in either sitting or supine position with head slightly flexed to engage the Alar ligament. The clinician assesses the patient's resting symptoms. 2) The clinician firmly stabilizes the spinous process of C2 (axis) using a pincer grasp. 3) While either lateral flexion or rotation is passively performed by the clinician, the movement of C2 (axis) is assessed.	➢ A positive test is defined by lack of palpable movement of the C2 spinous process during lateral flexion or rotation. ➢ (R/L) Sensitivity=69/72%, Specificity=100/96%, PV+=100/93%, PV-=80/81%

Positional Provocative Testing[7] (Cervical Arterial Dysfunction)	All positions should be held for a minimum of 10s, unless symptoms are provoked sooner. After each sustained position, the patient should return to neutral cervical spine position for at least 10s to allow for any latent response to emerge. 1) While seated, the patient performs end range active cervical rotation in both directions. 2) While seated, the patient performs active end range combined cervical extension and rotation in both directions. 3) With patient supine, the clinician brings the patient into passive end range cervical rotation in both directions. 4) With patient supine, the clinician brings the patient into passive end range combined cervical extension and rotation in both directions.	➢ CAD testing is believed to cause decreased blood flow in the vertebrobasilar arteries with rotation alone and internal carotid arteries with combined extension and rotation. ➢ Positive signs and symptoms include dizziness, nystagmus, diplopia, loss of consciousness, diaphoresis, dysphagia, dysarthria, nausea, numbness around the lips, or other neurological symptoms. ➢ Sensitivity=0~57%, Specificity=87~100%, PV+=0~100%, PV-=26~96%, LR+=0.22~83.3, LR-=0.44~1.4
Spontaneous Nystagmus[2] (Acute unilateral vestibular loss or Central Vestibular Dysfunction)	Holding the patient's head with one hand (placed on top of the patient's head or under the patient's chin), have the patient look straight ahead and observe for nystagmus	➢ If spontaneous nystagmus present, acute unilateral vestibular loss or brainstem/cerebellum abnormalities is suspected.
Smooth Pursuit[2,3] (Central Vestibular Dysfunction)	Holding the patient's head with one hand. Following the eye movement range assessment, have the patient follow your slowly moving finger horizontally (from center to 30 degrees right and then 30 degrees left), and then come back to center and test for vertical smooth pursuit (center to 30 degrees up to 30 degrees down).	➢ Abnormal findings include corrective catch-up saccades, nystagmus, or asymmetry pursuit eye and indicate brainstem/cerebellum abnormalities. ➢ The peak velocity of smooth pursuit eye movement decreases, and pursuit becomes more saccadic in the elderly. ➢ Vertical eye pursuit is often interrupted by a saccade even in younger individuals. ➢ A small jump in the eye movement as the eyes cross at the midline is OK.
Saccadic Eye Movements[2] (Central Vestibular Dysfunction)	Holding the patient's head with one hand. Hold your finger tip about 15 degrees to one side of your nose. Ask the patient to look at your nose, then at your finger, repeating several times. Do this from the center to right to center, center to left to center, center to up to center, and center to down to center.	➢ For saccades to eccentric targets, the amplitude should not be hypermetric or hypomentric.
Vergence[2]	Hold the patient's forefinger in your hand about 2 feet away from the patient's face. Ask him/her to focus on the finger while you move it toward the bridge of the patient's nose. Ask the patient to tell you when the target becomes double.	➢ The eyes should converge and the pupils should constrict. ➢ Normal near point of convergence id any distance <10cm (4 inches).

Head Impulse Test[2,7] (Peripheral Vestibular Dysfunction)	1) Grasp the patient's head firmly with both hands and pitch their head forward 30° to align the horizontal semicircular canals. Instruct the patient to look at your nose. 2) Gently move the patient's head back and forth with intermittent high velocity, randomly timed thrusts. 3) While performing head thrusts, observe the patient's eyes to determine whether they are able to maintain ocular fixation on your nose or not.	➢ A failure to maintain fixation on the visual target (nose) indicates hypofunction on the side that the thrust was directed toward. ➢ Sensitivity=71%, Specificity=82%, PV+=87%, PV-=65%, LR+=4.16, LR-=0.3
Dix-Hallpike test[1,2,7] (Posterior SCC PBBV)	1) The patient is initially sitting upright with legs extended. The clinician passively rotates the patient's head 45° toward the side being tested. 2) The clinician helps the patient to rapidly lie down on the table while keeping the head slightly extended. The clinician observes the patient's eyes for nystagmus for at least 60 s; there can be a latency period of up to 15 s before the onset of nystagmus.	➢ The direction of the nystagmus beats will be on the same side as the involved canal. ➢ Patients with posterior canal BPPV will have a positive Dix-Hallpike test and concomitant vertigo. ➢ Sensitivity=79.3%, Specificity=75%, PV+=95.8%, PV-=33.3%, LR+=3.17, LR-=0.14
Roll test[1,2,7] (Horizontal SCC BPPV)	1) The patient is initially positioned in supine with their neck flexed 20°. 2) The clinician quickly rotates the patient's head 90° to either side and observes for nystagmus for at least 60 s. 3) The clinician slowly returns the patient's head to midline, maintaining neck flexion, then repeats the procedure on other side.	➢ Two potential horizontal nystagmus findings may occur with this maneuver, reflecting 2 types of horizontal semicircular canal BPPV: geotropic type and apogeotropic type. ➢ Identifying the affected side is necessary to effectively treat BPPV.
Head-shaking Nystagmus[2,7] (Peripheral Vestibular Dysfunction)	1) Grasp the patient's head firmly with both hands and pitch their head forward 30° to align the horizontal semicircular canals. Instruct the patient to close their eyes. 2) Passively oscillate the patient's head side to side 20 times at 1–2 Hz. Instruct them to open their eyes just prior to completing the 20 side to side movements. 3) Observe for post-headshake nystagmus.	➢ The side of vestibular hypofunction is on the side contralateral to the direction of the fast phase.

Step 3 Pattern Recognition of Cervicogenic Dizziness		
Cervical Flexion Rotation Test[3] (Upper Cervical Spine Dysfunction)	1) The patient is in a supine position. The clinician passively flexes the cervical spine maximally to end range and then passively rotates the head bilaterally. 2) The end ROM in rotation is determined either by patient report of onset of pain or firm resistance felt by the clinician. The clinician quantifies the ROM either by visual estimate or use of the CROM device.	➢ A positive test is defined by a restriction of rotation ROM with a cutoff of <32° of rotation or a 10° reduction. ➢ (To diagnose cervicogenic dizziness,) Sensitivity=90~95%, Specificity=90~97%, LR+=9.0~9.4, LR-=0.11~0.27
Craniocervical Flexion Test[3] (Deep Cervical Flexors Dysfunction)	1) The patient is in a supine position, with the neck resting in a neutral position. The uninflated pressure sensor is placed behind the neck so that it abuts the occiput and is inflated to a stable baseline pressure of 20 mmHg. 2) The patient performs the five stages of the test sequentially targeting 2-mmHg progressive pressure increases from the baseline of 20 mmHg to a maximum of 30 mmHg. 3) The patient may also maintain a isometric contraction at the progressive pressures as an endurance task.	•
Cervical Segmental Test[7] (Cervical Facet Joint Dysfunction)	Patient positioned in prone with neutral cervical spine. Clinician applies posterior to anterior directed force to the articular pillars of the cervical spine bilaterally, one joint at a time.	• A positive test is defined as patient report of ≥3/10 increase in concordant local or referred pain intensity when clinician rated resistance to motion as 'moderate' to 'marked'.
Cervical Joint Position Error/ Cervical Relocation test[3,4,7] (Cervicocephalic Proprioception and Neck Reposition Sense)	1) The patient begins seated, facing a wall 90 cm away, and wearing a head-mounted laser pointer that is centered on a target on the wall. 2) The patient keeps their eyes closed while moving their neck in a specified direction, then back to what they believe to be centered starting position. The patient verbally indicates when they believe they are back to center. 3) The patient repeats this process for right rotation, left rotation, flexion, and extension (in no particular order).	➢ The mean distance from the actual center to the subjective center is used to calculate the joint position error (JPE) for each movement. An error of 4.5° is the cutoff point suggesting a failure of head and neck relocalization precision. ➢ When a positive test is defined by any of the 4 positions with JPE >4.5°, the diagnostic accuracy is; Sensitivity=92%, Specificity=54%, LR+=2, LR-=0.15 ➢ When a positive test is defined by mean JPE >4.5°, the diagnostic accuracy is; Sensitivity=72%, Specificity=75%, LR+=2.9, LR-=0.37

Cervical Neck Torsion Test[7]	The patient begins seated on a swivel chair and turns their trunk 90° to the either the right or left, holding for 30 s, then returns their trunk to center. The patient then repeats the same process in the opposite direction. Each position, including the center positions, is maintained for 30 s. Throughout the test, the head is stabilized by the clinician and therefore motionless. The clinician also must continuously observe for nystagmus.	➢ A positive test is defined by nystagmus (excluding spontaneous nystagmus) of more than 2° per second in any of the four positions (left trunk rotation, neutral rotation, right trunk rotation, neutral rotation). ➢ Sensitivity=72%, Specificity=92%, LR+=9, LR-=0.3
Smooth Pursuit Neck Torsion Test (clinical modification)[3,7]	*There is a lack of consensus in the description of proper performance methodology of the SPNT. The utility of the SPNT as a diagnostic tool for differentiating CGD from WAD has not yet been studied in a clinical setting. Therefore, accurate method of SPNT is with use of surface electrodes and moving visual target. 1) The patient is in a sitting position on a moving stool. The patient's head is kept in a horizontal position, and the head rotation is introduced, to a maximum of 45°, by turning the patient's chair. 2) The therapist instructs the patient to trace a slowly moving target with the eyes in a right or left horizontal direction while keeping the head steady. This test is done in a neutral torso position, with the torso turned to the right and with the torso turned to the left side. The velocity of corrected saccades is compared in the 3 different positions.	➢ The larger the difference between smooth pursuit with neck torsion and smooth pursuit in neutral, the more likely the patient is suffering from a whiplash associated disorder. ➢ Sensitivity=27-90%, Specificity=55-91%, PV+=92%, PV-=71%,LR+=0.6-10, LR-=0.11-1.3

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