# 뇌졸중에서의 안구운동장애

**이 승 한**
전남의대 신경과학교실, 전남대병원 신경과

# Eye movements in stroke

**Seung-Han Lee, MD, PhD**
Department of Neurology, Chonnam National University Medical School, Chonnam National University Hospital

## Stroke causing eye movement disorders

- Brainstem stroke
  - Medullary stroke:
    Lateral medullary syndrome / Medial medullary syndrome
  - Pontine stroke:
    Paramedian pontine stroke / Lateral pontine stroke
  - Midbrain stroke
    Ocular motor palsy (Oculomotor and trochlear palsy)
    Pretectal syndrome / Top of the basilar artery syndrome
- Cerebellar stroke
  - PICA/AICA/SCA stroke

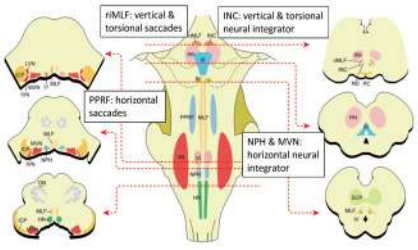
- Thalamic stroke
- Hemispheric stroke
  - MCA/ACA/PCA stroke

## Eye movements classification and eye movement disorders caused by stroke

- Saccades
- Smooth pursuit and visual fixation
- Vestibulo-ocular reflex (VOR)
- Vergence

- Nystagmus/saccadic intrusion
- Ophthalmoplegia and ocular misalignment
- Eye lid/pupil

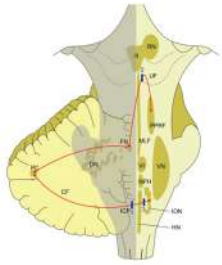
## Structures responsible for ocular motor control in the brainstem




## Neuro-ophthalmological findings in LMS

- **Horner's syndrome**
- **Spontaneous nystagmus (vestibular nucleus)**
  : contralesional mixed horizontal-torsional N (rostral lesion)
  : ipsilesional mixed horizontal-torsional N (caudal lesion)
  : vertical component – usually upbeat
  : pure torsional nystagmus
- **Horizontal gaze-evoked nystagmus**
  : medial vestibular nucleus (MVN)
- **Ocular ipsipulsion**
- **Ipsilesional OTR**
- **Ipsilesional head-shaking nystagmus**

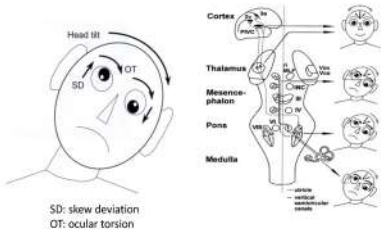
## Schematic representation of the involved pathways in ocular lateropulsion



The Purkinje cells (PC) of the dorsal ocular motor vermis inhibit the ipsilateral caudal fastigial nucleus (FN), which generates contralateral saccades when stimulated. The fibers from the caudal FN cross the midline, exit the cerebellum in the uncinate fasciculus, and project to the contralateral PPRF. Ocular ipsipulsion commonly occurs in LMS because of damage to the olivocerebellar fibers after decussation (1), while ocular contrapulsion occurs in the superior cerebellar infarction (2) or in the MMS (3) by damaging the fibers from the FN to the PPRF or the olivocerebellar fibers before decussation.

Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

## Ocular tilt reaction (OTR)




SD: skew deviation
OT: ocular torsion

## Neuro-ophthalmological findings in MMS

- **Spontaneous nystagmus**
  - : ipsilesional mixed horizontal-torsional nystagmus (NPH)
  - : upbeat nystagmus (dysruption of bilateral AC pathways or nucleus intercalatus/Roller)
- **Gaze-evoked nystagmus**
  - : horizontal GEN (ipsi-gaze >> contra-gaze) (NPH)
  - : vertical GEN (NPH, MVN)
- **Ocular contrapulsion**
- **Contralesional OTR**

## Comparisons of ocular motor findings with lesions of the medulla

**TABLE 1.** Comparisons of ocular motor findings with lesions of the medulla

| Clinical Finding/Test | Vestibular Nucleus | NPH | ICP |
|---|---|---|---|
| Spontaneous nystagmus | Contralesional, strong | Ipsilesional, weak | Ipsilesional, weak |
| GEN | Contralesional, strong | Strong, ipsilesional | None |
| Ocular tilt reaction | Ipsiversive | Contraversive | Contraversive |
| Body lateropulsion | Ipsilesional | Contralesional | Ipsilesional |
| SVV tilt | Ipsiversive | Contraversive | Contraversive |
| Smooth pursuit | Impaired, bilateral | Impaired, ipsilesional | Impaired, ipsilesional |
| Saccades | Normal | Normal | Normal |
| VOR | | | |
| HIT | Decreased gains, both HCs and PCs (↓ ipsilesional > ↓ contralesional) | Decrased gain, contralesional HC; increased gains, both ACs | Normal |
| Caloric | Ipsilesional paresis | Normal | Normal |

AC, anterior canal; GEN, gaze-evoked nystagmus; HC, horizontal canal; HIT, head impulse test; ICP, inferior cerebellar peduncle; NPH, nucleus prepositus hypoglossi; PC, posterior canal; SVV, subjective visual vertical; VOR, vestibulo-ocular reflex.

Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

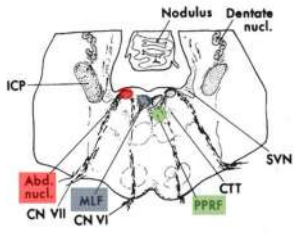
## Neuro-ophthalmological findings in pontine lesion

- INO (internuclear ophthalmoplegia): MLF
- Bilateral INO (WEBINO): MLF (bilateral)
- Conjugate gaze palsy: PPRF or 6th nucleus lesion
- One-and-a-half syndrome: PPRF or 6th nucleus lesion + MLF
- Abducens nerve palsy: 6th nerve fascicle

- Bruns nystagmus, pseudo-vestibular neuritis(AICA)
- Gaze-evoked nystagmus: PMT
- Jerky seesaw nystagmus in INO: MLF (VOR, vertical canal)

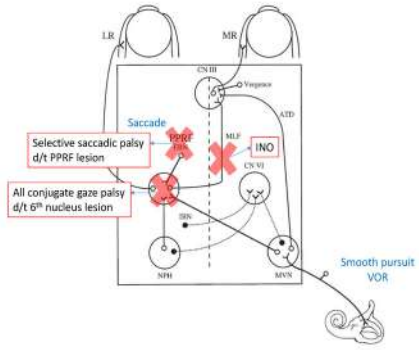
- Abnormal smooth pursuit: DLPN, NRTP
- Oculopalatal tremor: CTT
- Contralateral OTR in INO: MLF (otholithic pathway)
- Ocular bobbing

## Structures responsible for ocular motor control in the lower pons



## Clinical Features of INO

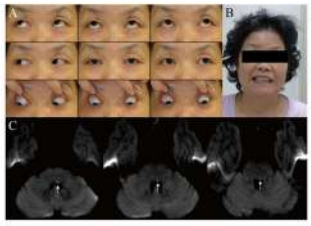
- Weakness of the ipsi. MR for conjugate eye movements—especially saccades, leading to "adduction lag"
- Adduction may be preserved during convergence
- Nystagmus or postsaccadic drift on abduction of the eye contralateral to the lesion—"dissociated nystagmus"
- Skew deviation—hypertropia on the side of the lesion
- Bilateral INO also causes gaze-evoked vertical nystagmus, impaired vertical pursuit, and decreased vertical vestibular responses
- Small-amplitude saccadic intrusions may interrupt fixation




## Comparison of clinical characteristics between the lesions of the abducens nucleus and PPRF

| | Abducens Nc | PPRF |
|---|---|---|
| Horizontal gaze | Loss of call conjugate movements toward the lesion<br>In the intact hemifield of gaze, ipsilaterally directed saccades may be relatively preserved | Selective horizontal saccadic palsy toward the lesion |
| Primary position | Contralateral gaze deviation during the acute phase | Contralateral gaze deviation during the acute phase |
| GEN | Horizontal GEN on looking contralaterally | Horizontal GEN on looking contralaterally |
| Other characteristic | Ipsilateral facial palsy often associated | Bilateral lesions cause slowing of vertical saccades |

## Clinical findings of the 6th nucleus lesion



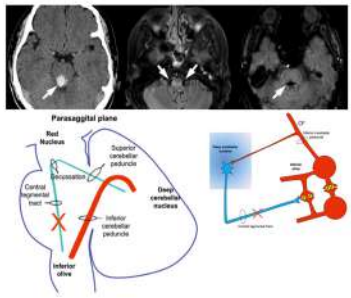

- Loss of all conjugate movements towards the lesion – "ipsilateral, horizontal gaze palsy"
- Contralateral gaze deviation, in acute phase
- Horizontal gaze-evoked nystagmus on looking contralaterally
- Ipsilateral facial palsy often associated

Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

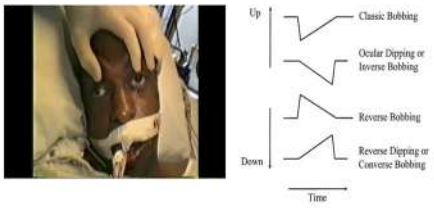
## Clinical Features of "One-And-A-Half" syndrome

- Ipsilateral horizontal gaze palsy and INO
- Only surviving horizontal conjugate movement is abduction of the contralateral eye
- Paralytic pontine exotropia on looking straight ahead (one eye is deviated laterally)
- Vergence and vertical movements may be spared

## Guillain-Mollaret Triangle (Dentate nucleus, Red nucleus, Inferior Olive) – Oculopalatal tremor



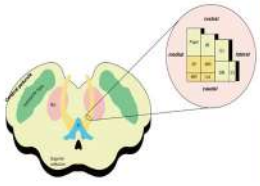
## Ocular bobbing after pontine hemorrhage




## Neuro-ophthalmological findings in midbrain stroke

- Ocular motor palsy (3rd or 4th) : nuclear or fascicular
- Vertical gaze palsy
- Horizontal gaze palsy
- Pretectal syndrome
  - : Defective vertical gaze, esp. upward
  - : Light-near dissociation of the pupils
  - : Lid retraction (Collier's sign)
  - : Convergence-retraction nystagmus
  - : Convergence spasm
- Contralesional OTR

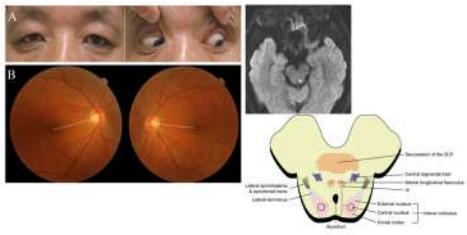
## Fascicular lesion of the oculomotor nerve : 3rd nerve palsy with other long tract sign



| Syndrome | Associated sign | Lesion |
|---|---|---|
| Weber | Contralateral hemiplegia | Cerebral peduncle |
| Benedict | Contralateral hemiplegia, involuntary movements or tremor | Cerebral peduncle, substantia nigra, red nucleus |
| Claude | Contralateral ataxia | Superior cerebellar peduncle, red nucleus |
| Nothnagel | Ipsilateral ataxia | Superior cerebellar peduncle |

Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

## Isolated trochlear palsy due to midbrain stroke




Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

## Topodiagnosis of lesions involving INC and riMLF

| | INC | riMLF |
|---|---|---|
| Unilateral inactivation | | |
| OTR | Contraversive | Contraversive |
| Torsional nystagmus | Ipsiversive | Contraversive |
| GEN | Vertical and torsional GEN | No |
| VOR | | |
| Torsional | Little effects on VOR gain and phase | Loss of ipsitorsional nystagmus |
| Vertical | Little effects on VOR gain and phase | |
| Saccades | | |
| Torsional | Reduced or abolished contralesional fast phases | All ipsitorsional components are lost |
| Vertical | Reduced amplitudes and normal velocity | Slowed |
| Bilateral inactivation | | |
| GEN | Vertical and torsional GEN | No |
| VOR | | |
| Torsional and vertical | Severely reduced gain and phase lead | Preserved |
| Saccades | | |
| Torsional | | Loss of all vertical and torsional saccades |
| Vertical | Reduced amplitudes and normal velocity | |
| Unilateral stimulation | | |
| OTR | Ipsiversive | |
| Torsional nystagmus | Contraversive | |

Adapted from (119).
GEN, gaze-evoked nystagmus; INC, interstitial nucleus of Cajal; OTR, ocular tilt reaction; riMLF, rostral interstitial nucleus of the medial longitudinal fasciculus; VOR, vestibulo-ocular reflex.

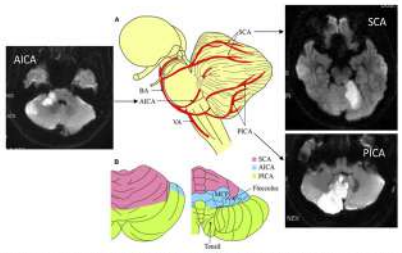
Lee SH, Kim JS, 2017 J Neuro-Ophthalmol

## Clinical characteristics of the dorsal midbrain syndrome

- **Nystagmus and other involuntary eye movements**
  - Upbeat, downbeat, convergence-retraction nystagmus, torsional, see-saw or hemi-see-saw nystagmus
  - Vertical GEN
  - Paroxysmal OTR
- **Ophthalmoplegia**
  - Vertical: upgaze, downgaze, both up- and down-gaze palsy, vertical 1 & 1/2 syndrome, monocular elevation palsy
  - Horizontal: pseudo-sixth nerve palsy, contralateral saccadic palsy, ipsilateral pursuit impairment
  - Vergence: convergence or divergence insufficiency, convergence spasm
- **Ocular misalignment**
  - Exotropia, esotropia
  - Skew deviation: contralateral, alternating, intermittent
  - Sustained upgaze or downgaze
- **Pupillary abnormalities**
  - Anisocoria
  - No or diminished light reflex
  - Light-near dissociation
- **Lid abnormalities**
  - Collier sign (lid retraction)
  - Ptosis

Leigh & Zee, 2015

## Cerebellar infarction




PICA, posterior inferior cerebellar artery; AICA, anterior inferior cerebellar artery); SCA, superior cerebellar artery

## Cerebellar infarction

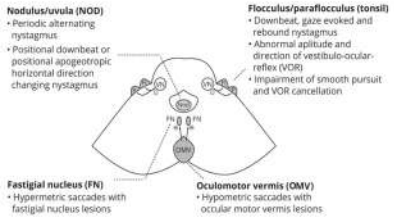
Table 1. Differentiating among common central and peripheral acute vestibular syndromes

| | PICA-Caudal cerebellum including nodulus, lateral medulla | AICA- pons/flocculus/labyrinth | Vestibular nucleus | Vestibular neuritis |
|---|---|---|---|---|
| Isolated vertigo | Possible, common | Possible, uncommon | Possible, uncommon | Almost always |
| Caloric canal paresis | None | Common | Abnormal, if medial subnucleus involved | Abnormal, if superior or complete vestibular nerve involved |
| Bedside head-impulse test | Normal | Abnormal | Abnormal, if medial subnucleus involved | Abnormal, if superior or complete vestibular nerve involved |
| Hearing loss | None | Common | None | None |
| Spontaneous nystagmus | Ipsilesional (cerebellum), ipsilesional or contralesional (lateral medullal | Contralesional Direction-changing (Bruns) | Ipsilesional or contralesional | Unidirectional* |
| Effect of gaze on nystagmus | Variable, typically* Direction-changing | Unidirectional | Variable | Unidirectional |
| Skew deviation | Variable, usual in lateral medullary | Variable | Variable | Occasionally |
| Side of truncal deviation | Ipsi-contralesional | Ipsilesional | Ipsilesional | Ipsilesional |
| Postural instability | Variable, usually severe (fall without assistance) | Variable | Variable | Mild to moderate |
| Common causes | Ischemic | Ischemic, demyelination | Ischemic | Viral, idiopathic |

*Direction-changed bidirectional gaze- evoked nystagmus that the intensity is maximal when gazes towards the lesion side; †Direction-fixed unidirectional gaze- evoked nystagmus beating toward the healthy side (from Lee [42], with permission).

Lee H, 2014 J Stroke

## Eye movement abnormalities that have localizing value with respect to the cerebellum




Kronenbuerger, Zee, 2018 Neurology
Leigh & Zee, 2015

## Clinical findings of diencephalic lesions

**Thalamic lesions**

- Conjugate gaze deviation away from the side of the lesion (wrong-way deviation)
- Sustained downward deviation of the eyes (due to compression of the dorsal midbrain), sometime with convergence – "thalamic esotropia"
- Vertical saccadic palsy (especially down) when caudal thalamic lesions extend into the riMLF
- Ipsilateral or contralateral tilt of subjective visual vertical

**Pulvinar lesions**

- Difficulties in shifting gaze into the contralateral hemifield
- Hemispatial neglect (especially with acute, right-sided lesions)

Leigh & Zee, 2015