VIDEO OCULOGRAPHY
Clinical Applications

DR.SATHIYA MURALI
ENT Surgeon
Madras ENT Research Foundation

Equilibrium is defined as the capacity of the body to maintain spatial orientation at rest and during motion

PHYSIOLOGY OF BALANCE

The normal erect posture of man is maintained by a complex interplay of

- *Visual*
- *Vestibular*
- *Proprioceptive inputs*

which are integrated and modulated by activity from other neurological centers

contd…..

The motor response generated in th CNS is directed to 2 Group of muscles viz.,

1. muscles of limbs, neck and trunk

   Vestibular-spinal reflex system

2. extra-ocular muscles of the two eyes

   Vestibular-ocular reflex system- VOG

INVESTIGATIONS

Vestibular function tests

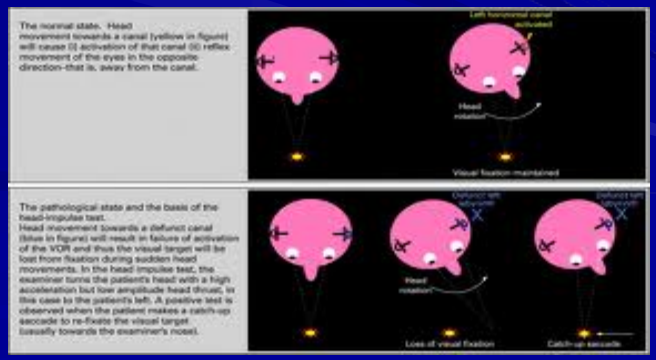
- Electro/Video oculography
- Rotation tests
- Computerized Dynamic Posturography
- Craniocorpography

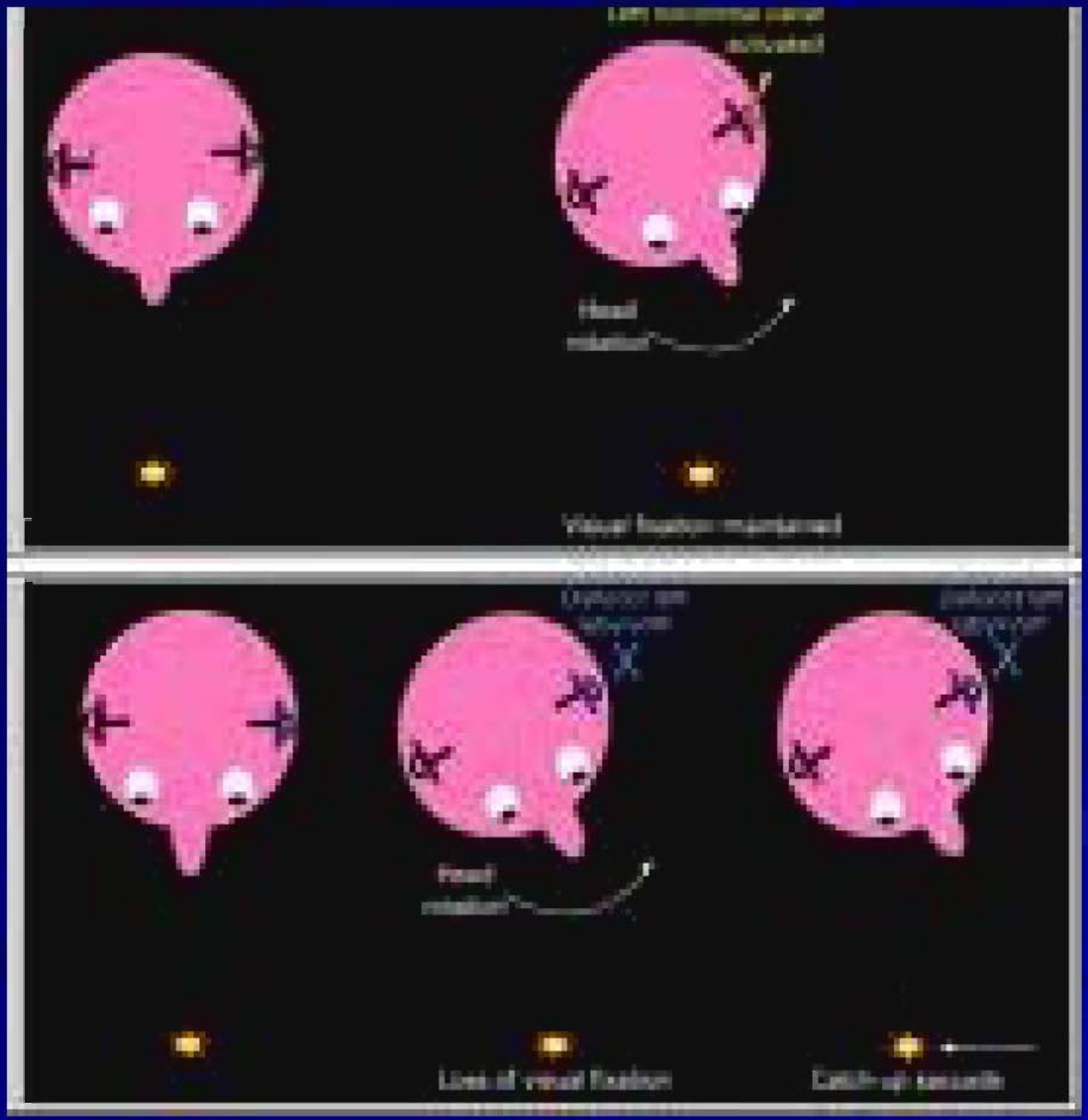
Monitoring electrical activity of brain when the brain is processing vestibular input

- Vestibular Evoked Myogenic Potentials (VEMP)
- Brain Electrical Activity Mapping (BEAM)

VESTIBULAR OCULAR REFLEX

- Defined as reflexive eye movement in response to head movement
- Occurs as a direct result of changes in labyrinthine electrical potentials
- Role of VOR is to allow stable gaze ie. , focused clear vision while the head is moving
- Prevents “RETINAL SLIP”

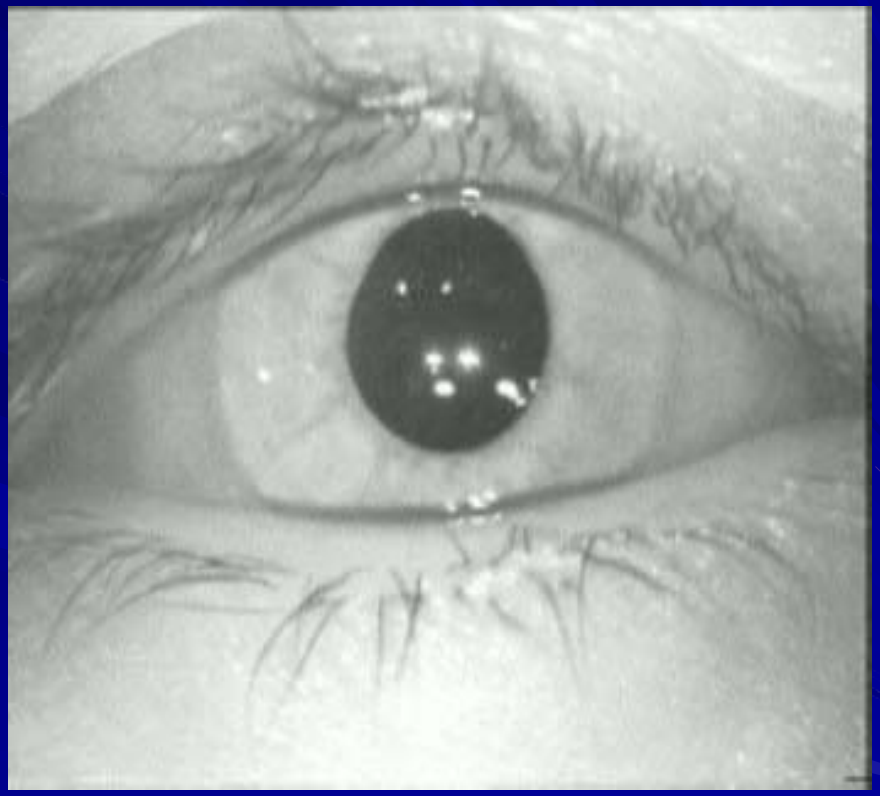




Nystagmus

- Important clinical sign in neurotology

- Nystagmus is an involuntary rhythmic shaking or wobbling of the eyes.



VNG/VOG

VOG is a test for assessing the integrity of vestibulo-ocular and allied reflex systems like the smooth pursuit system, the optokinetic system and the saccadic systems

VO25 Workstation setup

VNG / VOG

- Infrared vng/vog uses the conventional black and white camera
- Eyes illuminated with infrared light
- Eyes not reactive to IR light,eyes can be viewed while eyes are in total darkness,thus no fixation
- the eye movements are recorded by an infrared video camera and converted into a digital format through a software that documents the eye movements

VNG/VOG contd…

Horizontal and vertical tracings of eye movements are produced by the camera tracking the pupil of the eye.

Combi mask

ADVANTAGES OF VOG

- The advantages claimed are:
  - Accuracy of 0.1 to 0.5 degrees
  - Contact free recording of eye movements
  - Ease of handling
  - Detects rotatory eye movements as in BPPV

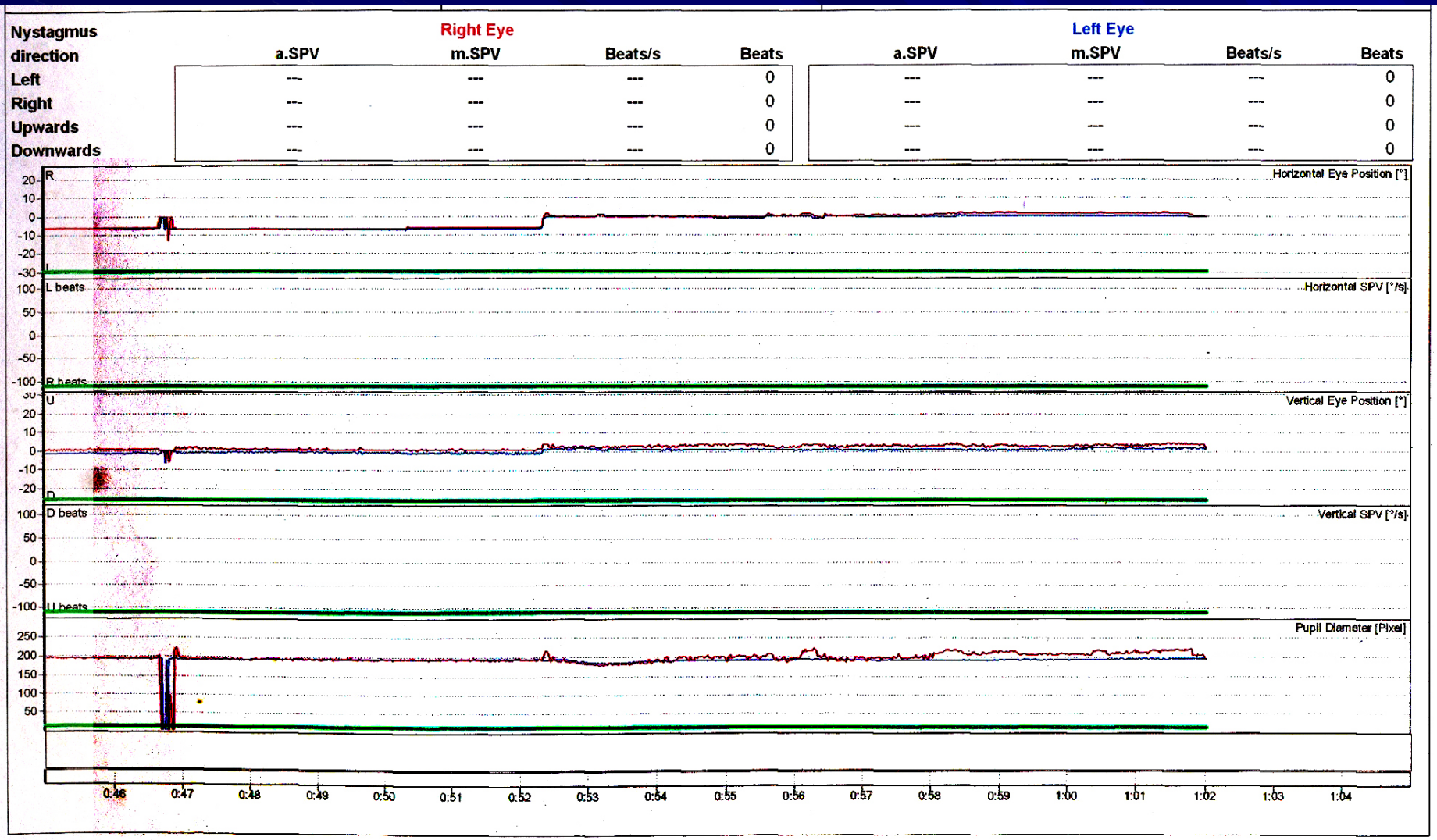
TESTS DONE

- Spontaneous nystagmus
- Gaze Test
- Smooth Pursuit test
- Saccades
- Optokinetic Test
- Positional Test
- Dix-Hallpike maneuver
- Caloric test

SPONTANEOUS NYSTAGMUS

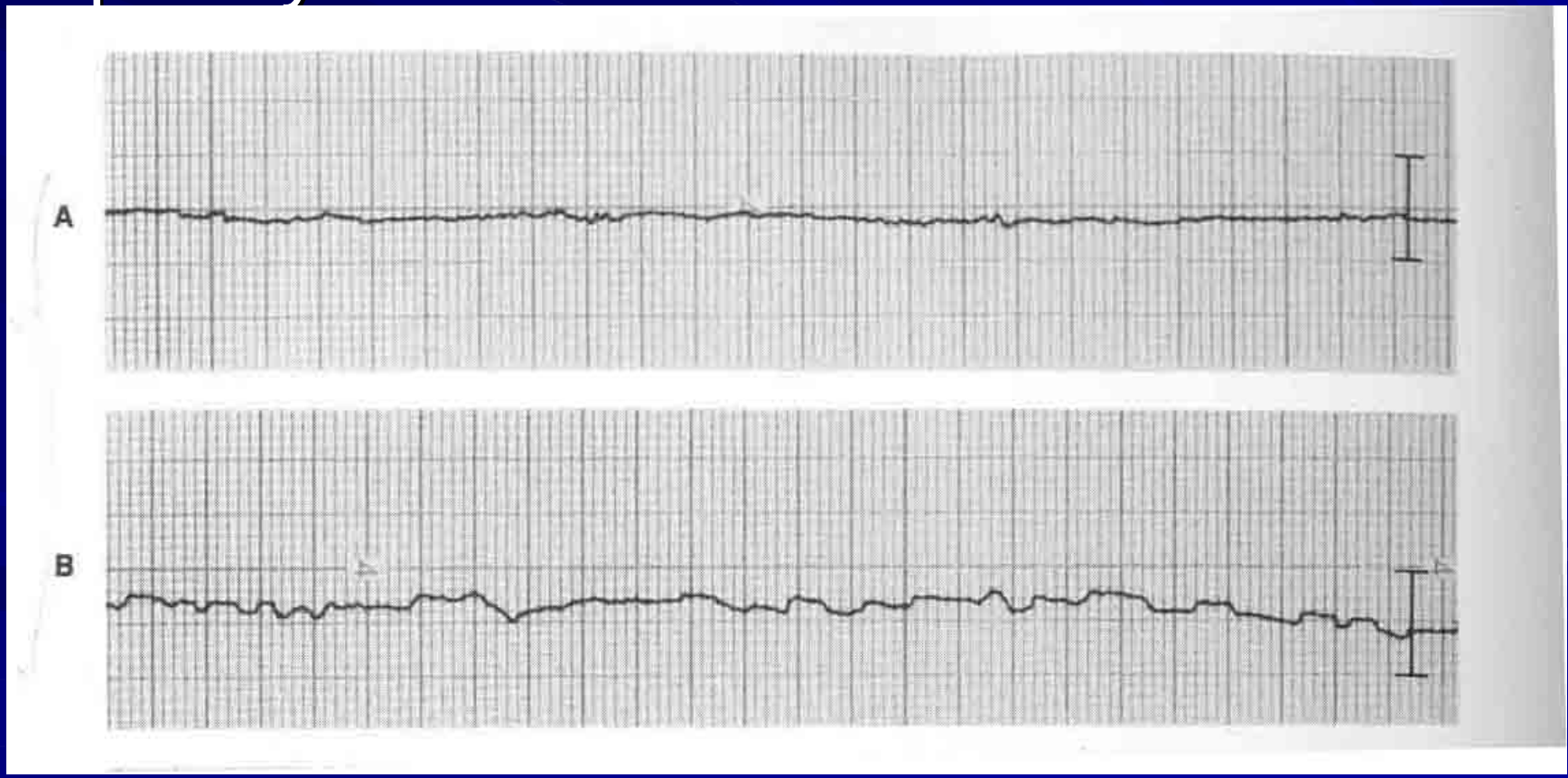
This is suitable for recording non evoked eye movements.To avoid fixation the light occluding mode should be used

Spontaneous nystagmus



SPONTANEOUS NYSTAGMUS

- Normal with steady eye position eyes open/eyes closed

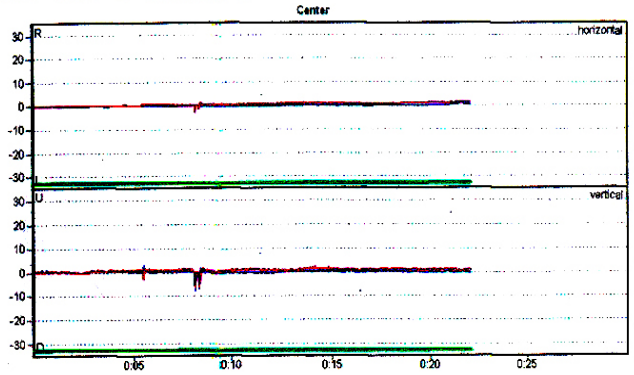


Gaze Test

- The eye movements are measured while the patient is fixating on a target
- Gaze test analyzes the nystagmus “beating” during the fixation period
- Presence or absence of spontaneous nystagmus (no task or center gaze)

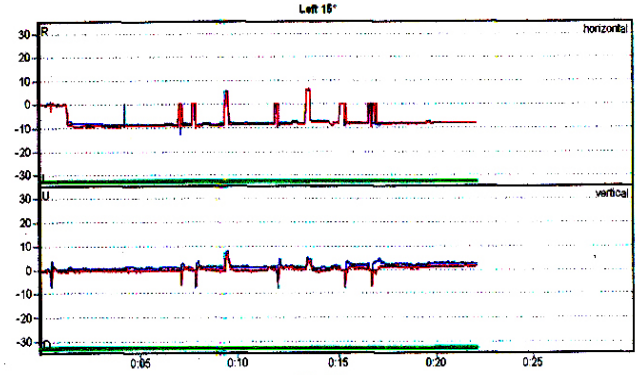

Gaze Test

Gaze evoked nystagmus



	Right	Left
← a.SPV	0.0	0.0
← Beats/s	0.0	0.0
→ a.SPV	0.0	0.0
→ Beats/s	0.0	0.0

	Right	Left
↑ a.SPV	0.0	0.0
↑ Beats/s	0.0	0.0
↓ a.SPV	0.0	0.0
↓ Beats/s	0.0	0.0



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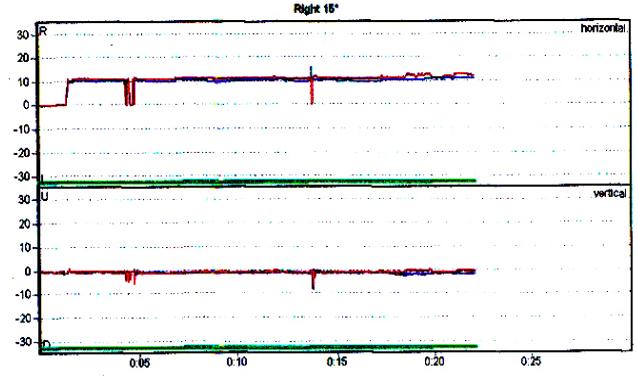

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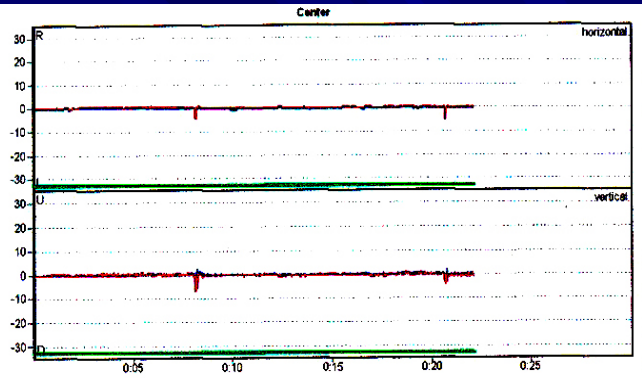

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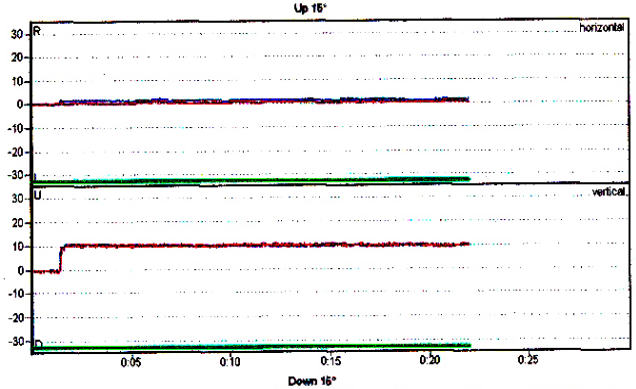

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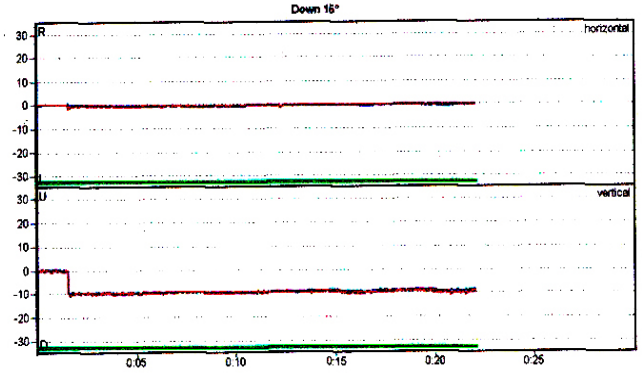

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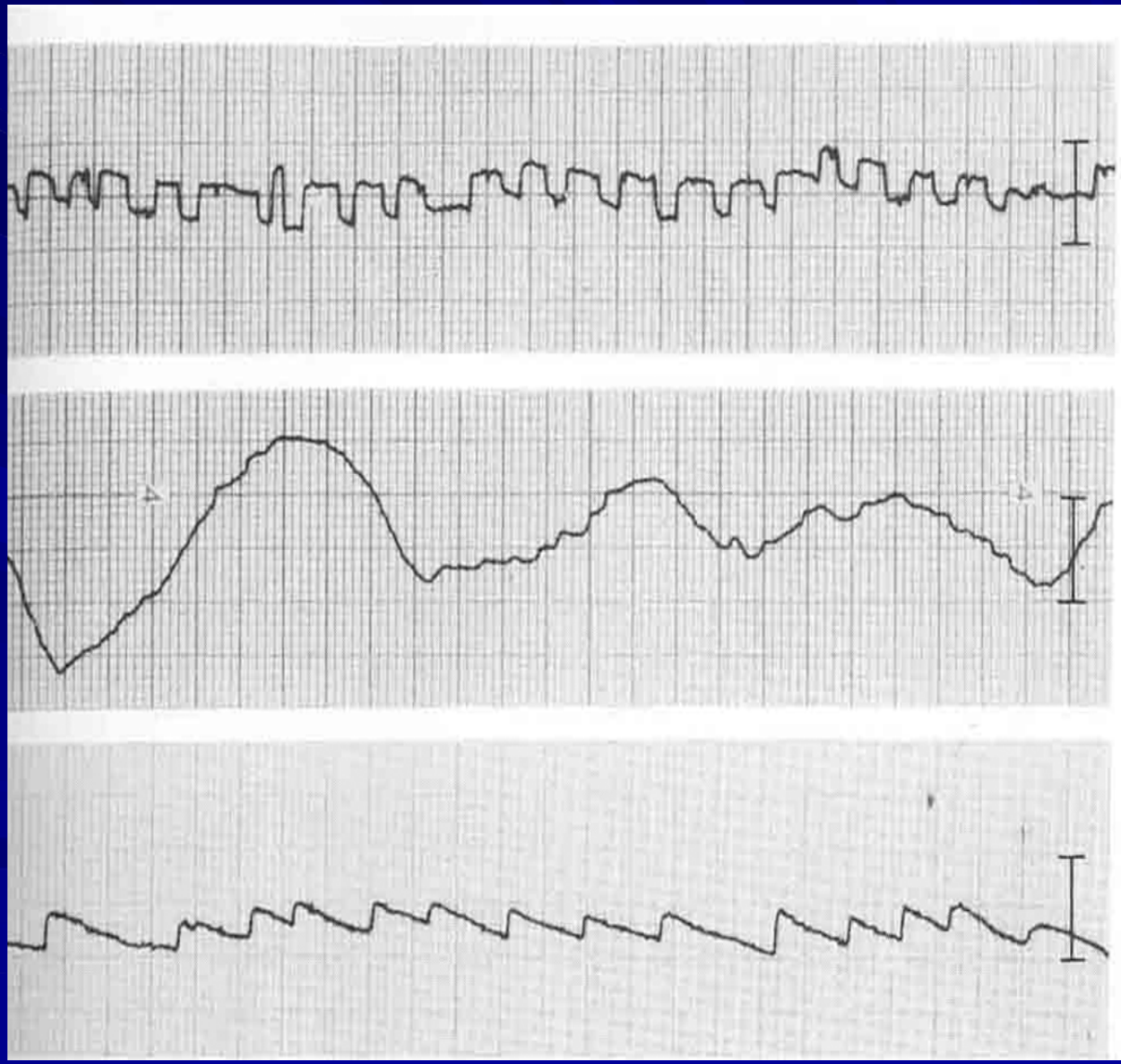
↓ Beats/s	0.0	0.0

Normal variables

Square waves in highly aroused individual

Sinusoidal oscillation of normal but drowsy individual

Rt beating nystagmus in a normal individual



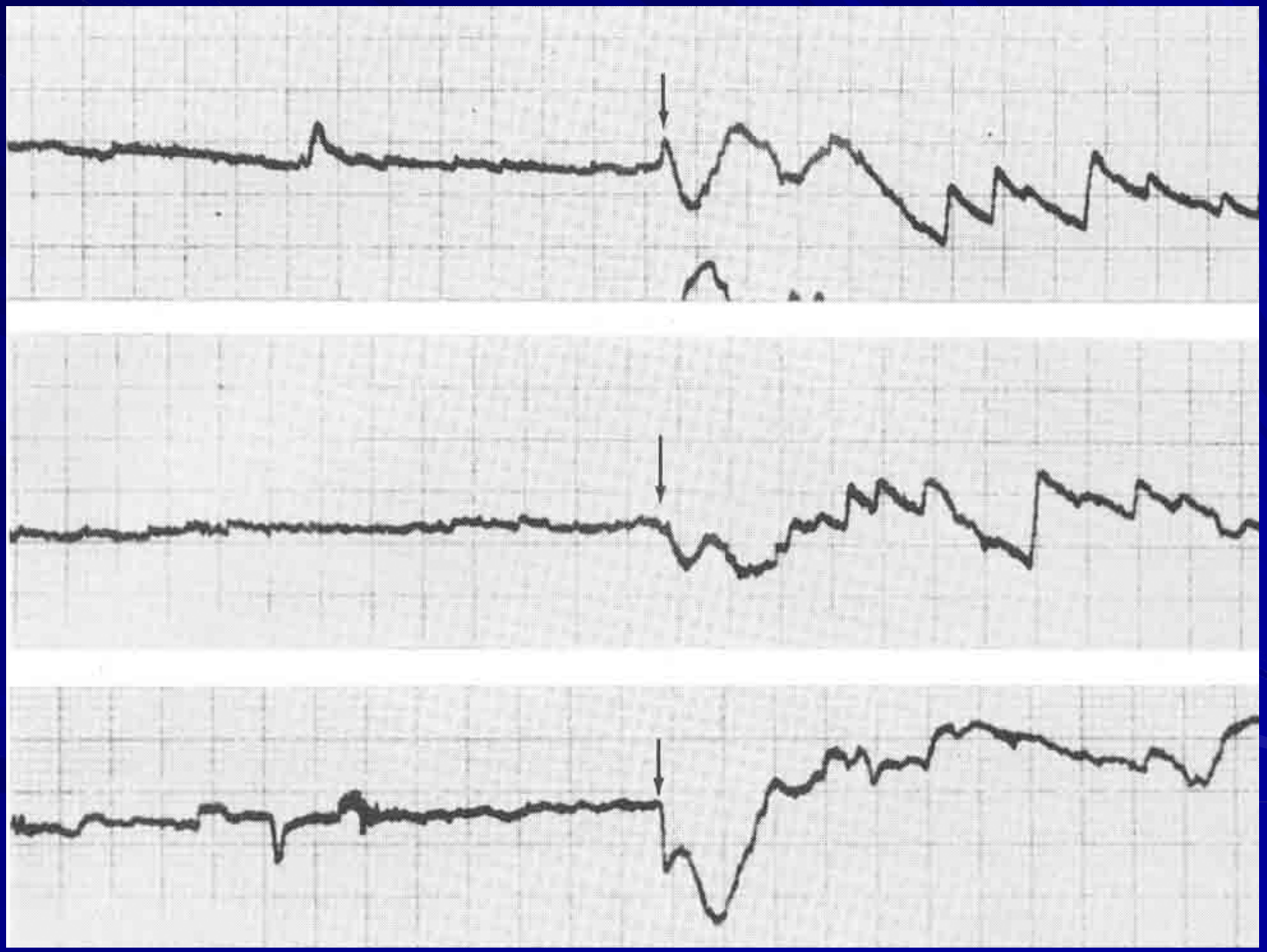
Lt vestibular neuronitis - Alexander law

eyes open *eyes closed*

Rt gaze

Center gaze

Lt gaze



Smooth Pursuit Tracking

- The smooth pursuit are eye movements used to maintain stable gaze on objects that are moving within the visual field
- Accurate pursuit requires a target and matches the target velocity
- Evaluated for symmetry (diff between Rt and Ltward scores) and Gain (eye velocity Vs target velocity)
- Tracking test results should resemble a smooth sinusoid. Breakup of movement may indicate CNS pathology

VOG

- The total excursion of the target should be 30 degree visual angle

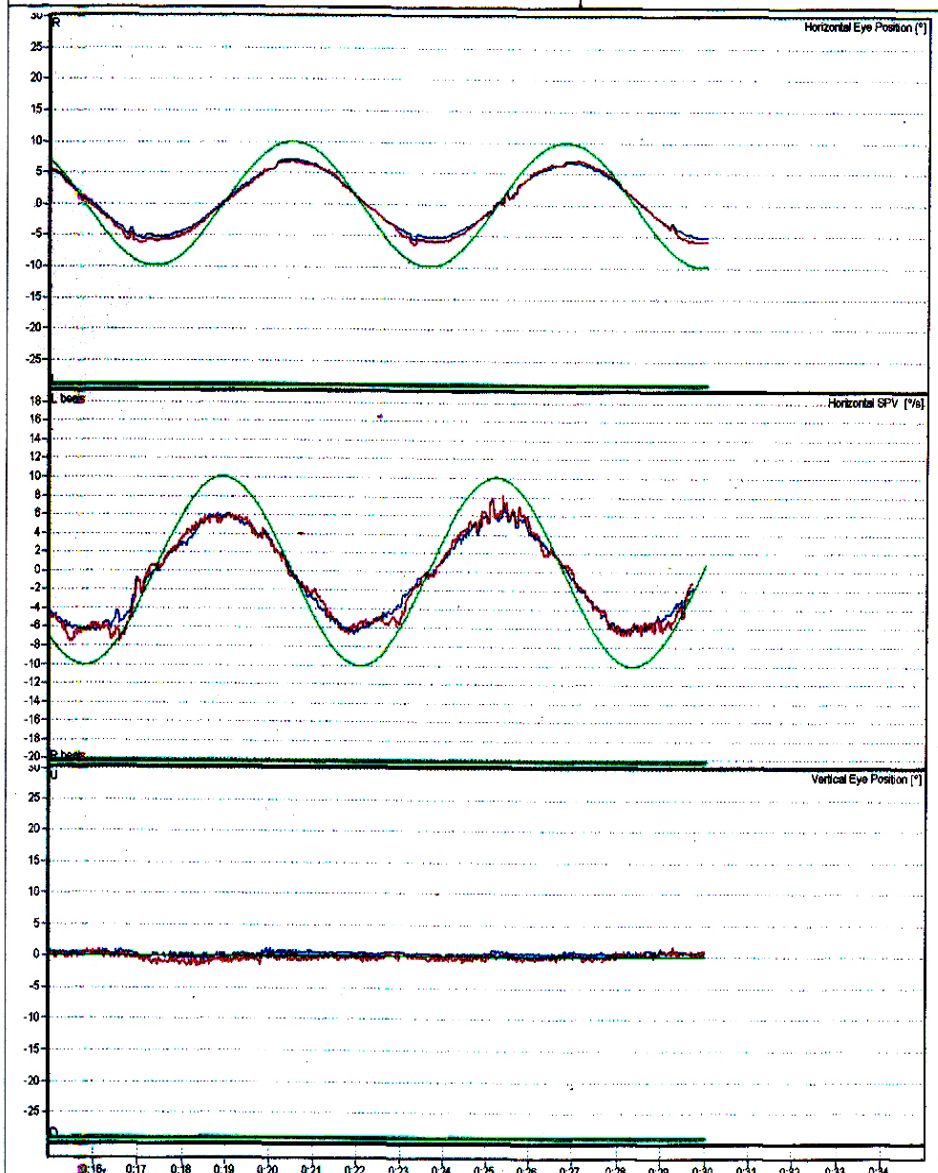
- The maximum target speed should be less than 40 to 50 degree/sec

Classification of smooth pursuit by Benitez

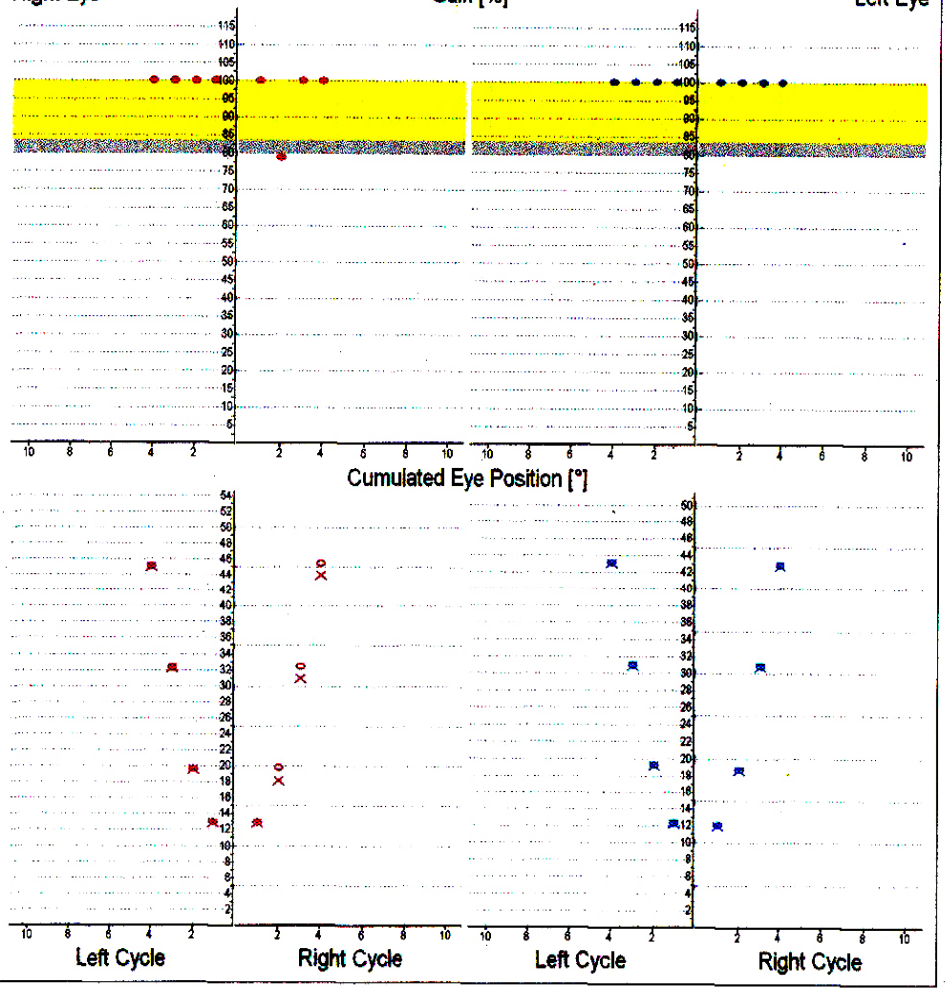
- PATTERN 1
- PATTERN 2
- PATTERN 3
- PATTERN 4

- **WAVE VERY SMOOTH**
- **IRREGULAR RECORD WITH PERIODIC BITES**
- **FEATURED BY SACCADIC SUBSTITUTION OF SP**
- **FEATURED BY DISORGANIZATION OF PURSUIT EYE MOVEMENTS**

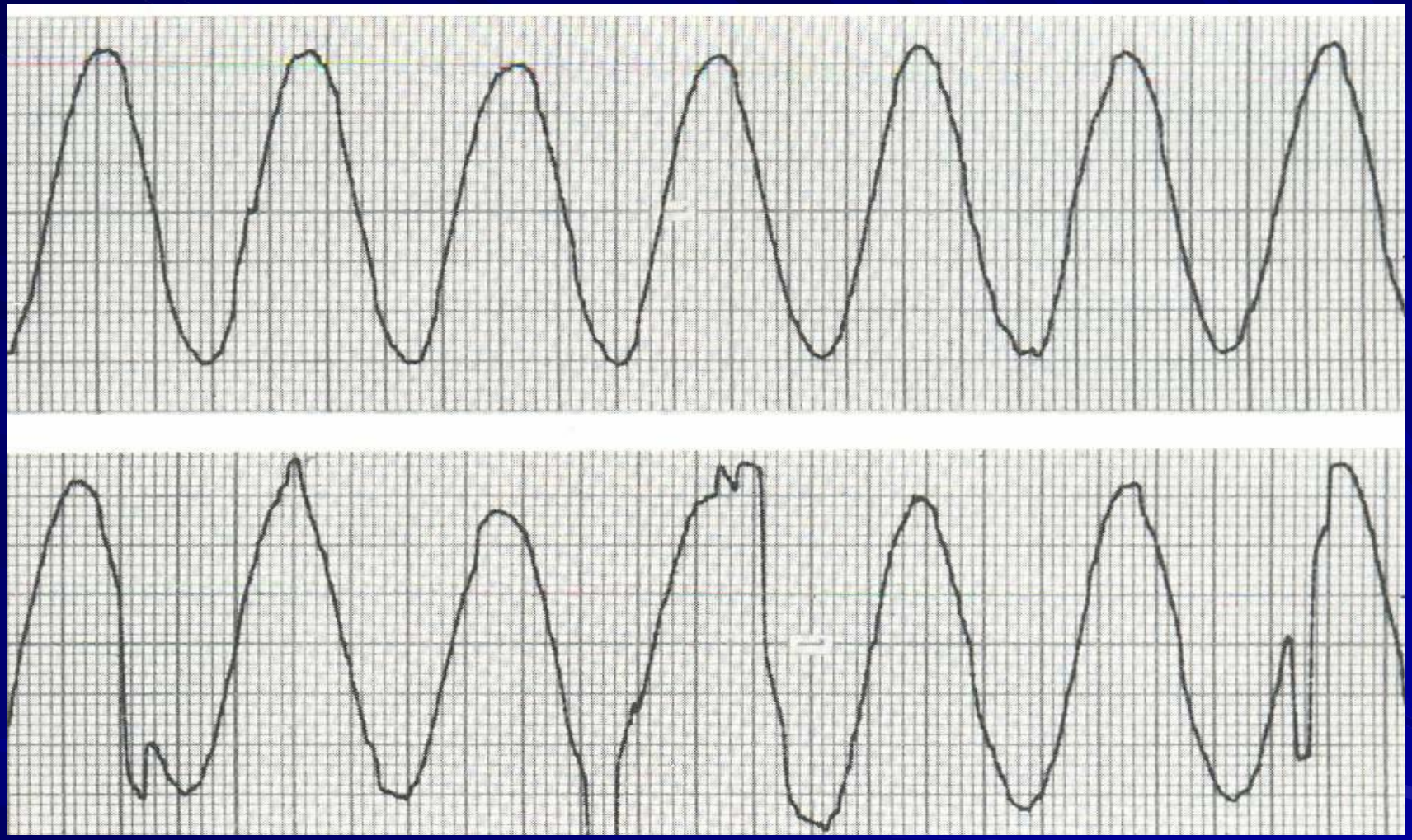
Smooth Pursuit



	Right Eye	Left Eye
Gain Left Cycle [%]	100	100
Gain Right Cycle [%]	94	100
Side Difference	-2	0
SPV Left Cycle [°/s]	6	6
SPV Right Cycle [°/s]	6	6



Pattern 1(**wave very smooth)**



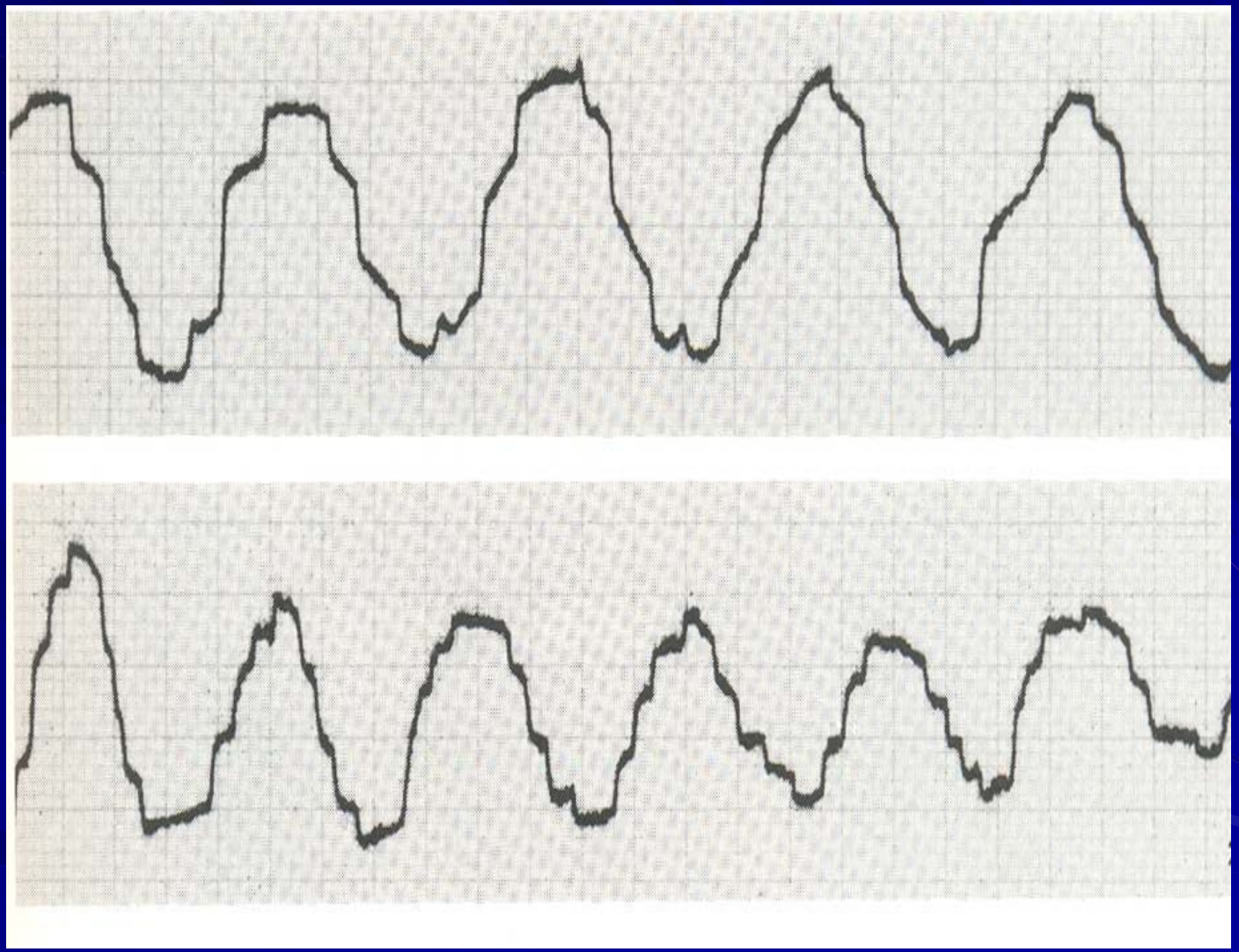
Pattern 2 (irregular record with periodic bites)

Pattern 3

Saccadic substitution of smooth pursuit

Medullo Blastoma

Progressive Supranuclear palsy

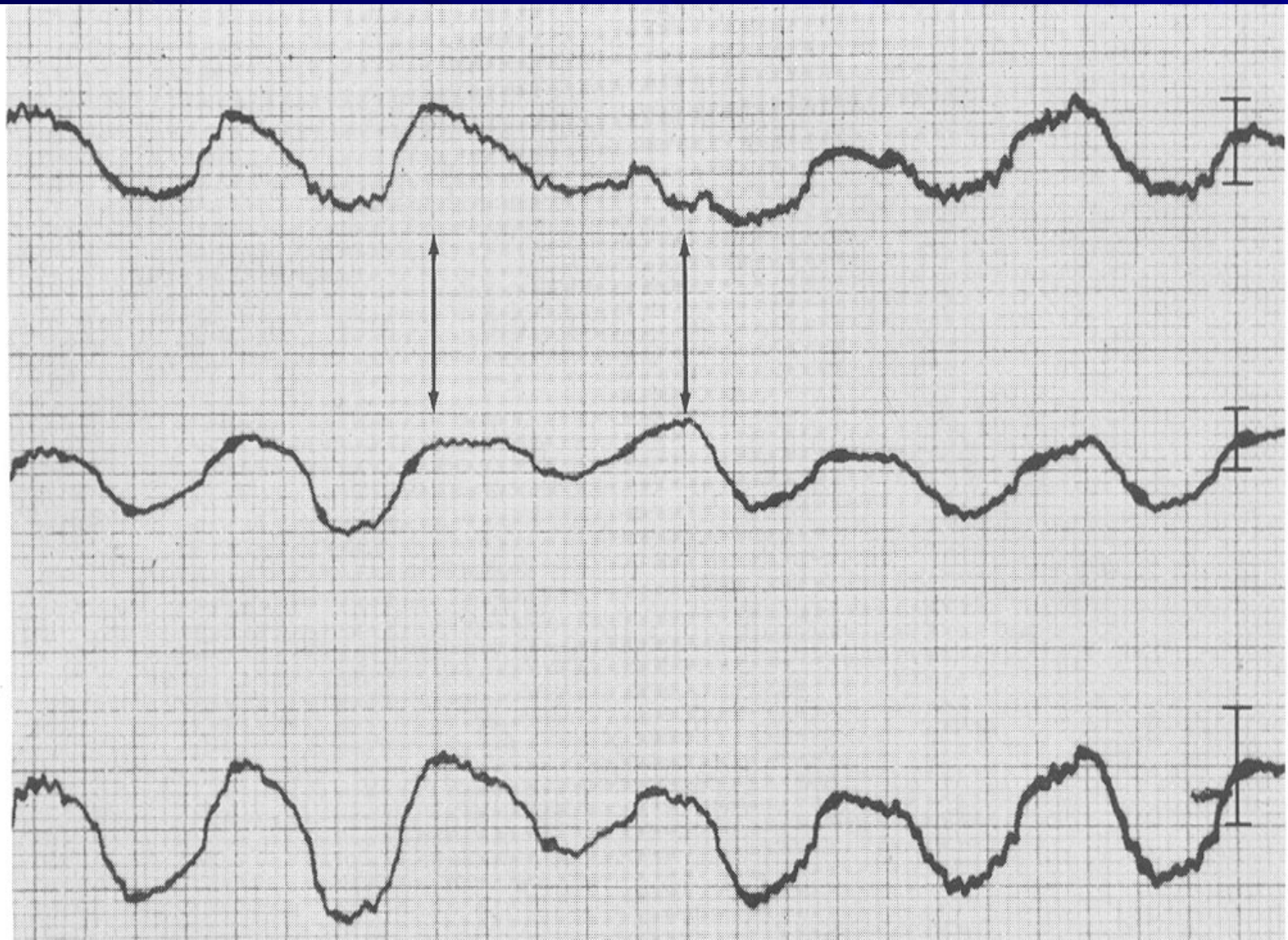


Pattern 4

Disorganization Of Pursuit Eye Movements

Wandering
Slowed
inaccurate
tracking

Brain
stem
lesion



SACCADES

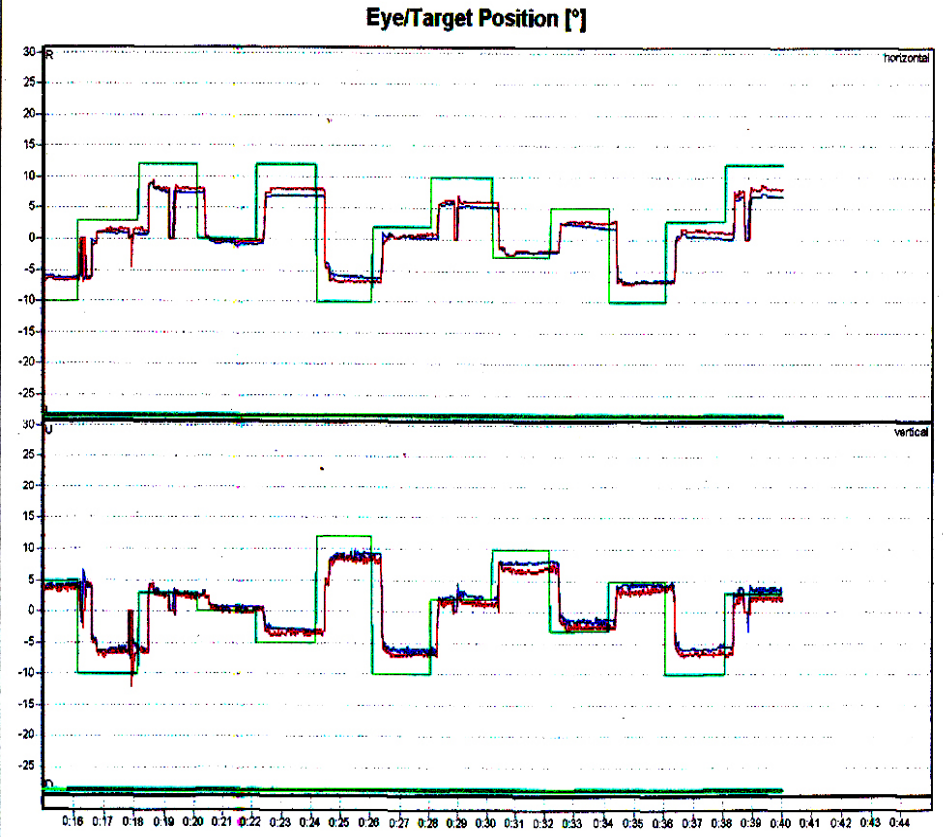
The saccade test, also called the calibration test, evaluates the saccadic eye movement system. This system is responsible for rapid eye movements to bring an object of interest into the center of line of light (foveal vision)

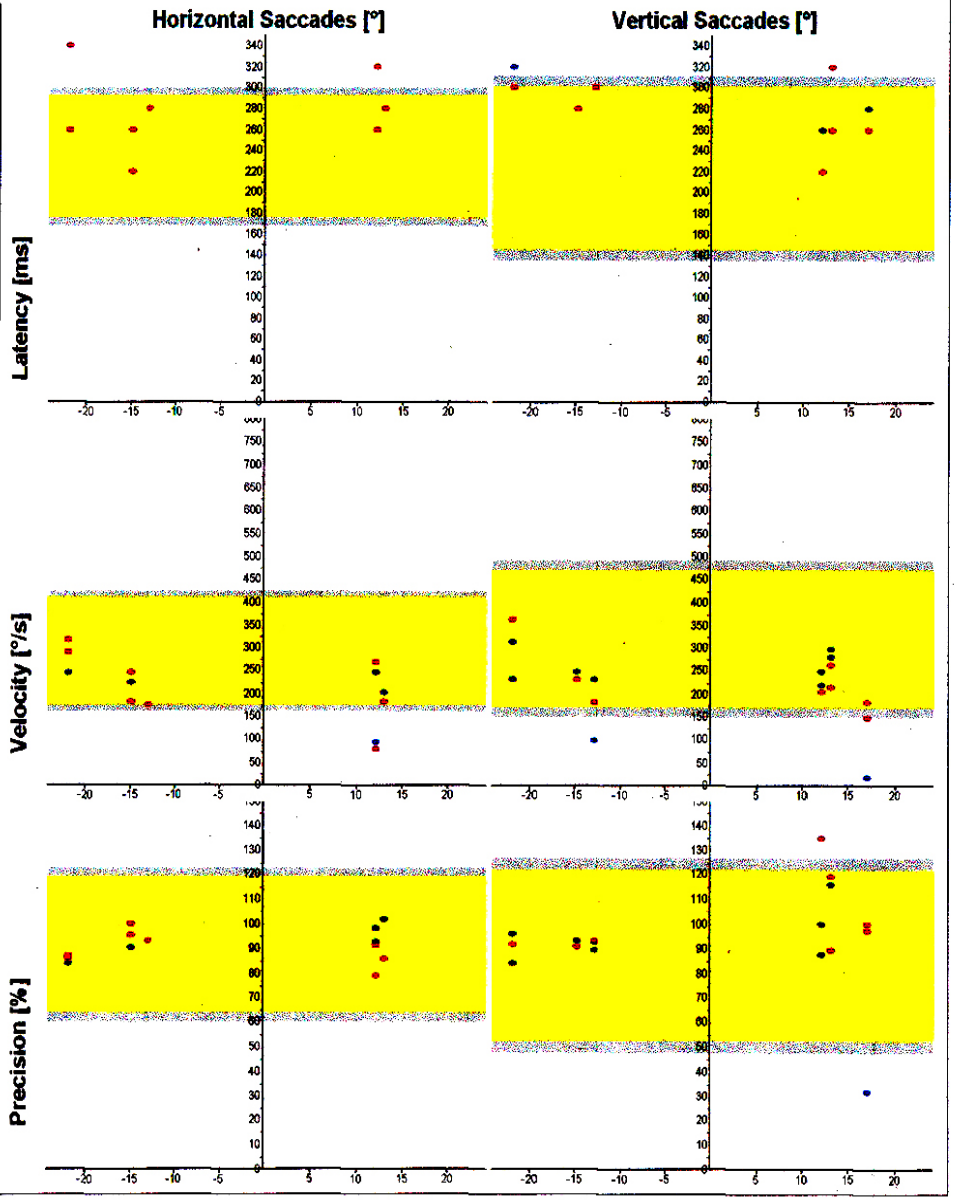
VOG

- Target appears for 1 to 4 secs before changing position
- Target can appear anywhere within a range of 30 ^{0} from center
- The angle subtended between two target positions is 20 ^{0}

Saccades

	Left	Right	Down	Up
Target Movements	7	6	6	6
Left Eye				
Accepted Saccades	2	3	5	6
Latency [ms]	240	287	300	287
Velocity [°/s]	235	181	224	202
Precision [%]	87	98	91	87
Right Eye				
Accepted Saccades	5	3	3	5
Latency [ms]	272	287	293	284
Velocity [°/s]	242	176	259	203
Precision [%]	92	85	92	108





Contd…

Tested for

1.LATENCY

2.ACCURACY

3.VELOCITY

Latency contd…

- Latency is the difference in time between the presentation of a new target & the initiation of eye movement
- For unpredictable target – latency - 150 to 250 milli secs
- Predictable target – latency – 76 milli secs
- Abnormal if delay is beyond – 260 to270 ms or longer

contd…

Asymmetrical latencies seen in occipital or parietal cortex lesions. For these patients, saccades in one direction may be normal with a prolongation of saccades in the opposite direction.

Accuracy

- Ability to fixate the target both quickly and accurately on a new object
- Eye movement should be equal in amplitude to the distance between the former object and the new one
- 10 to 15%under shoot is permissible in normal subjects

Velocity

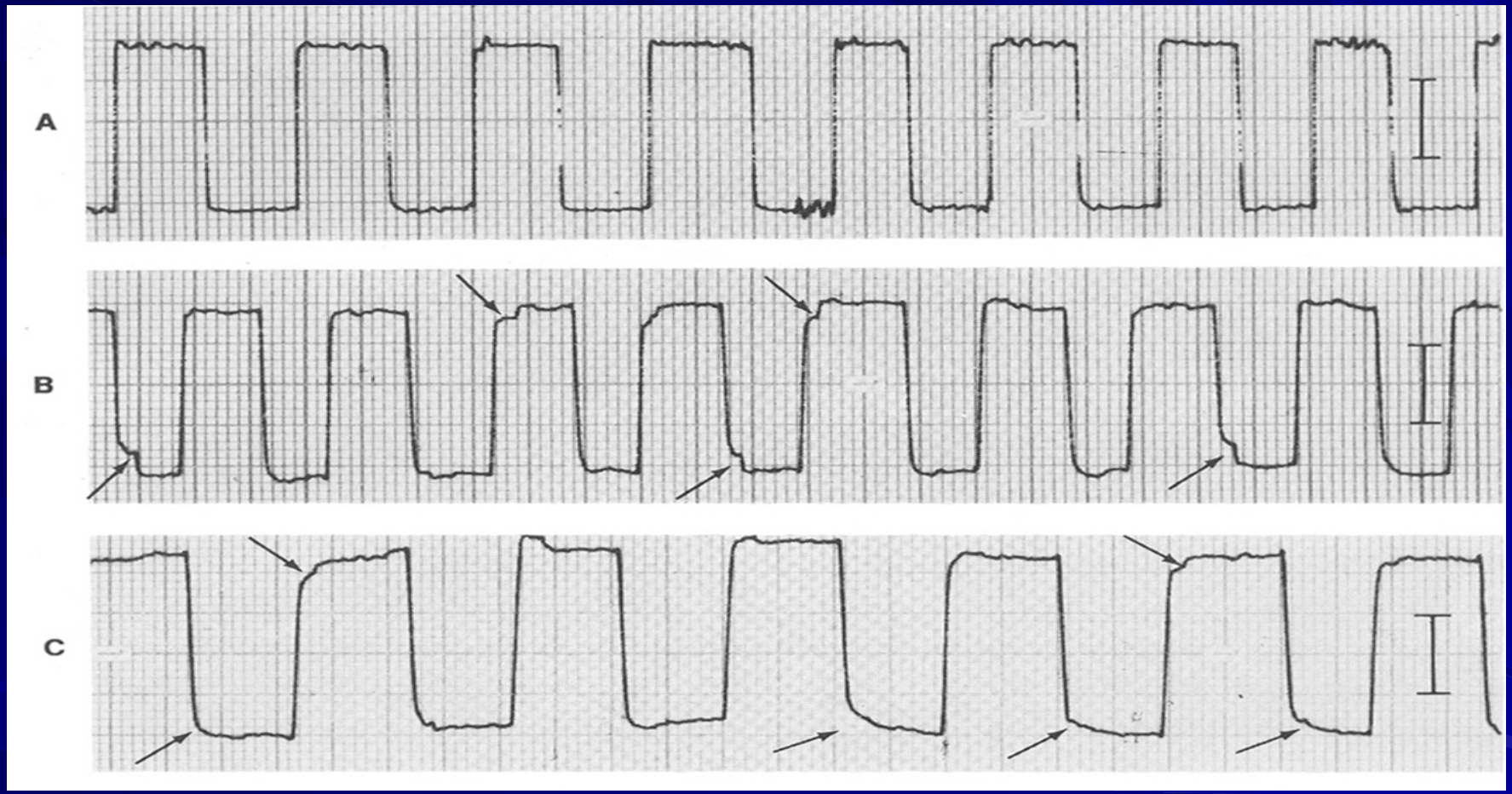
- Saccadic velocity is measured as the peak speed of eye movement when refixating gaze
- Usually velocity is 700 degrees/sec

- Abnormal if slower than 430 degrees/secs for larger amplitudes and 200 degrees/sec for smaller amplitudes of saccades

VELOCITY

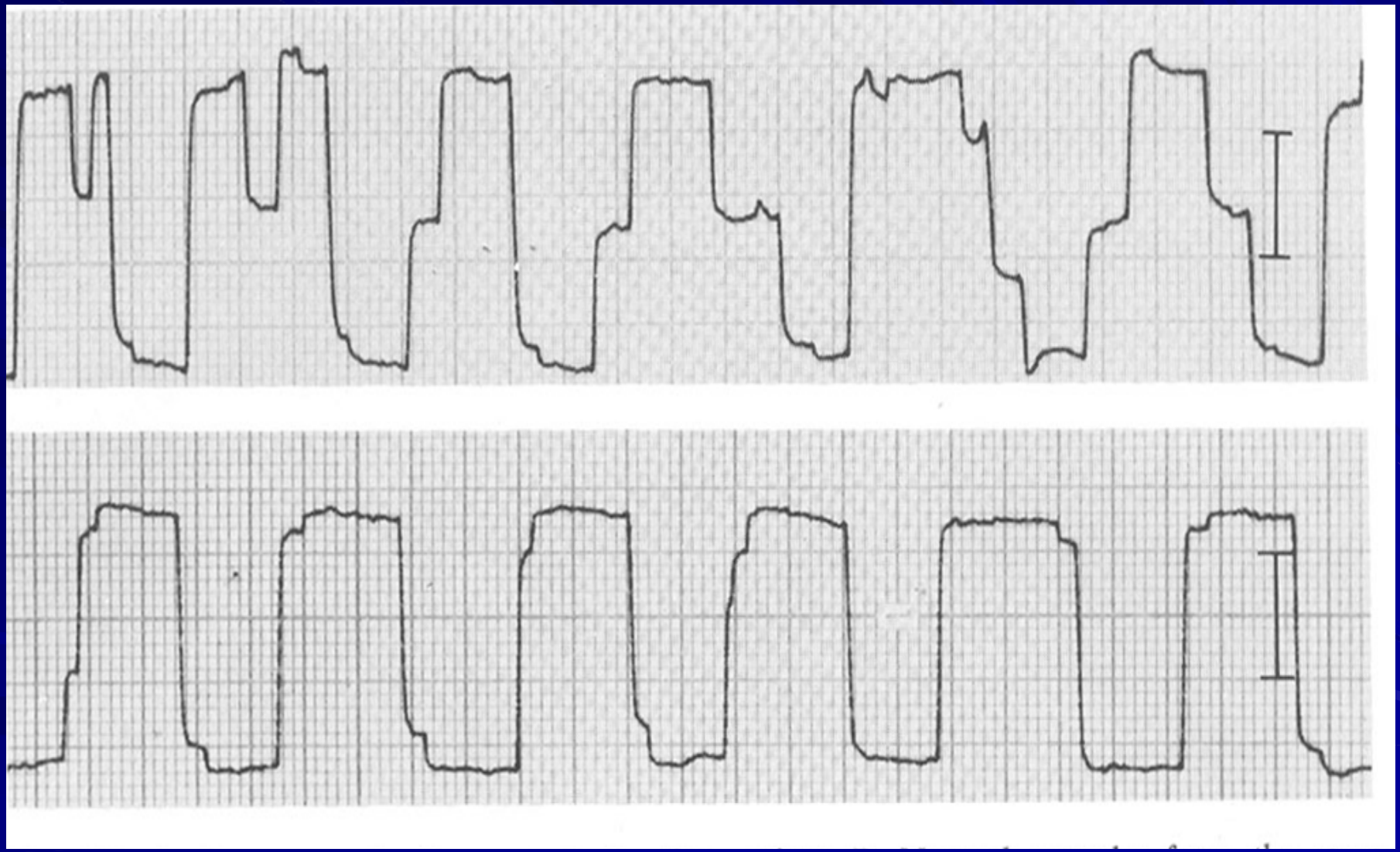
- Saccadic slowing
- Abnormally fast saccades
- Asymmetrical velocity

Normal Saccades

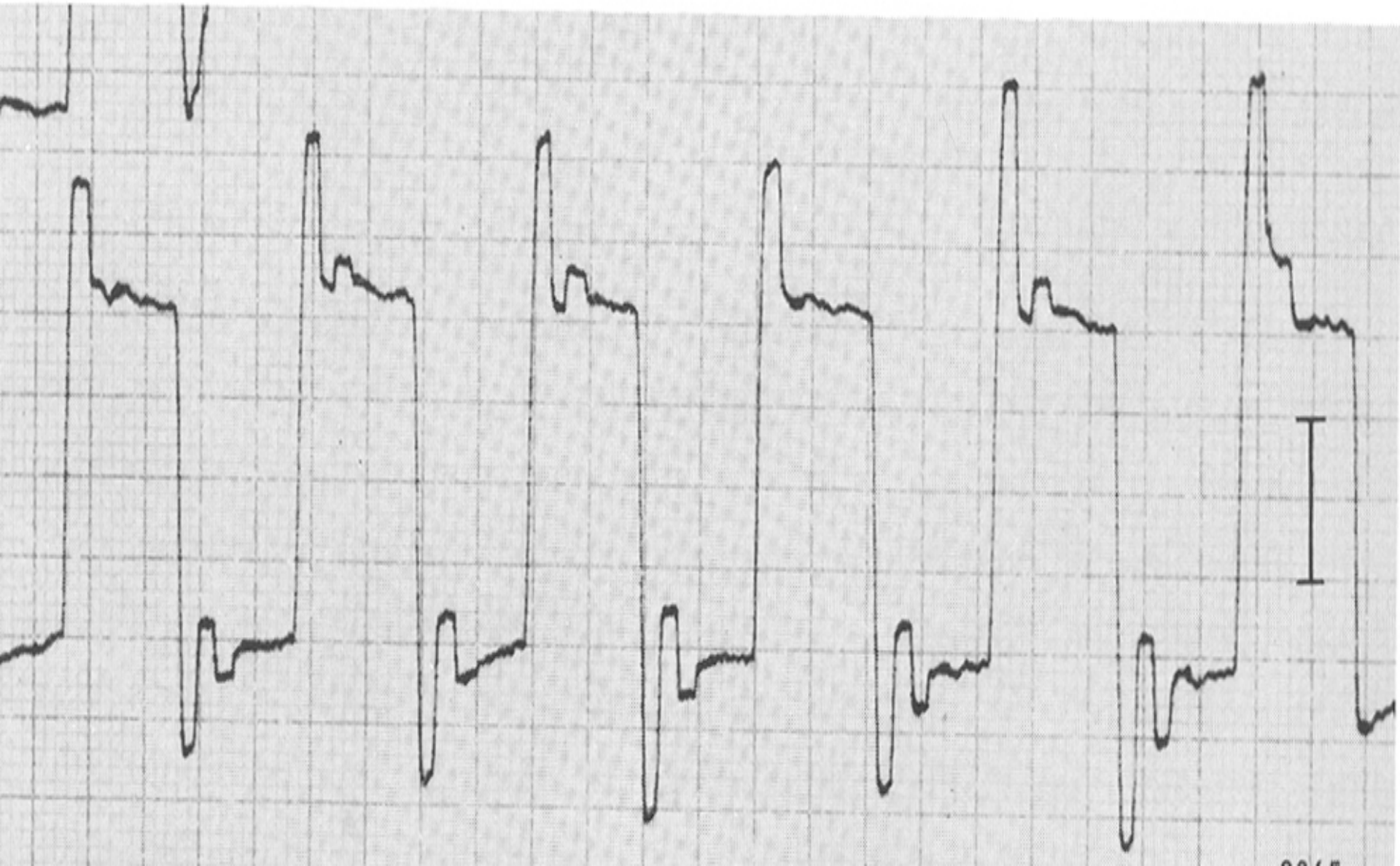


Saccades with glissades

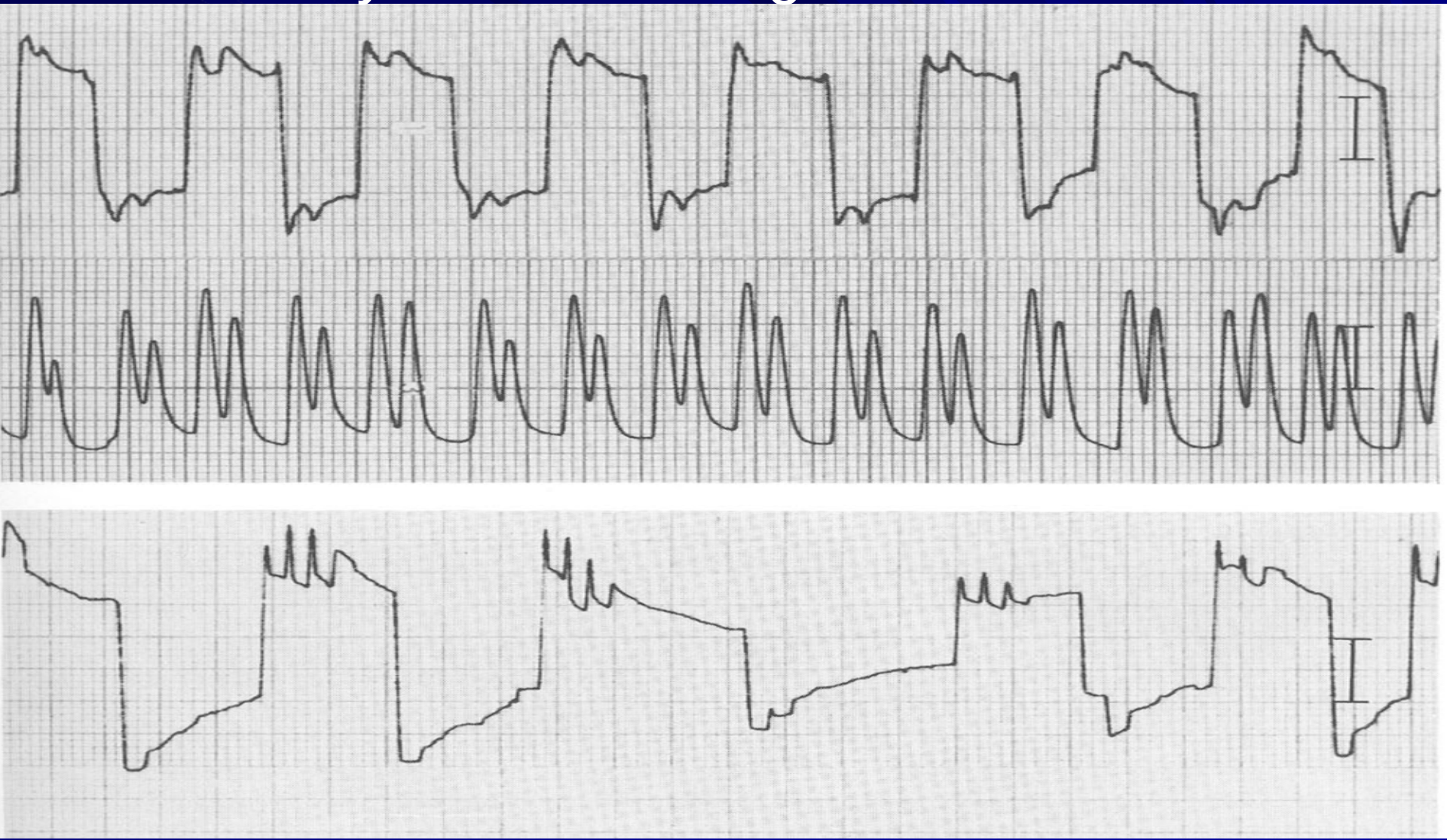
Saccades of an inattentive patient



Hypermetric Saccades – ocular dysmetria

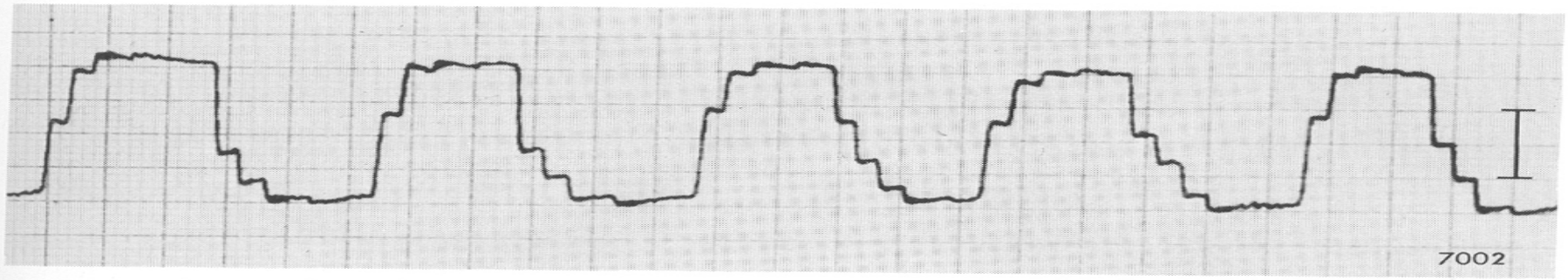


Eye blinks during saccades



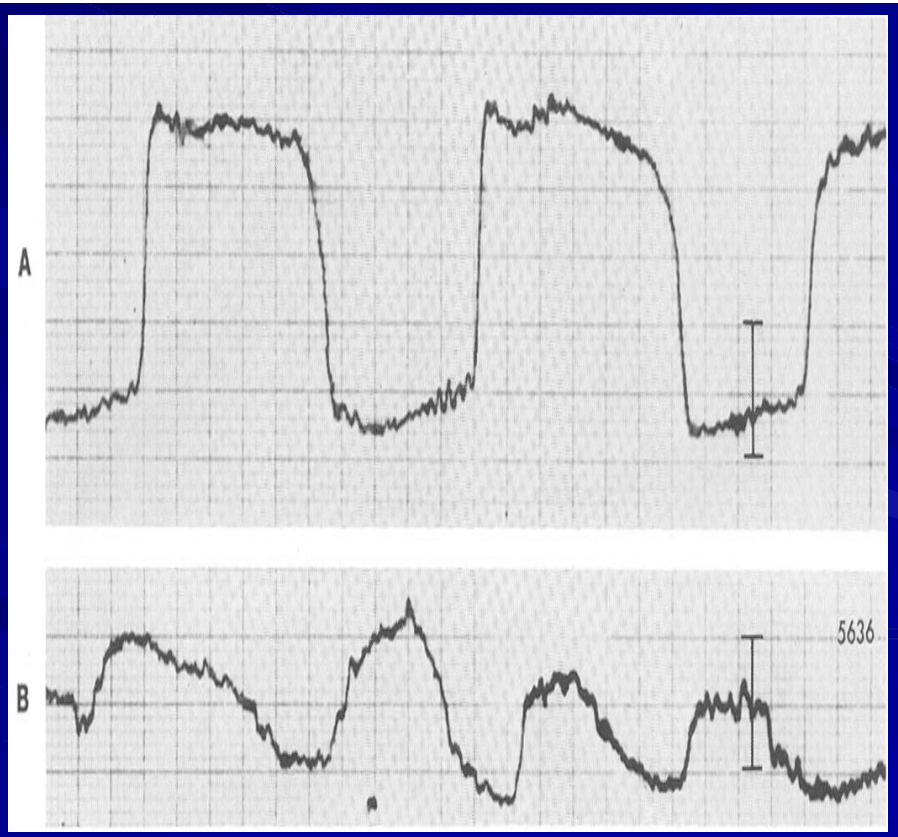
True overshoots in brainstem encephalitis

Hypometric saccades - ocular dysmetria



Marked slowing of horizontal saccades

Loss of vertical saccades esp downward saccades (advanced SN palsy)



Optokinetic Test

Here eye movement is examined while under stimulation by large moving pattern

Comes into play

1. When Vestibular system fails to “keep up” during sustained head rotation

or

2. When the subject is stimulated by full field visual movement

Optokinectic testing ….

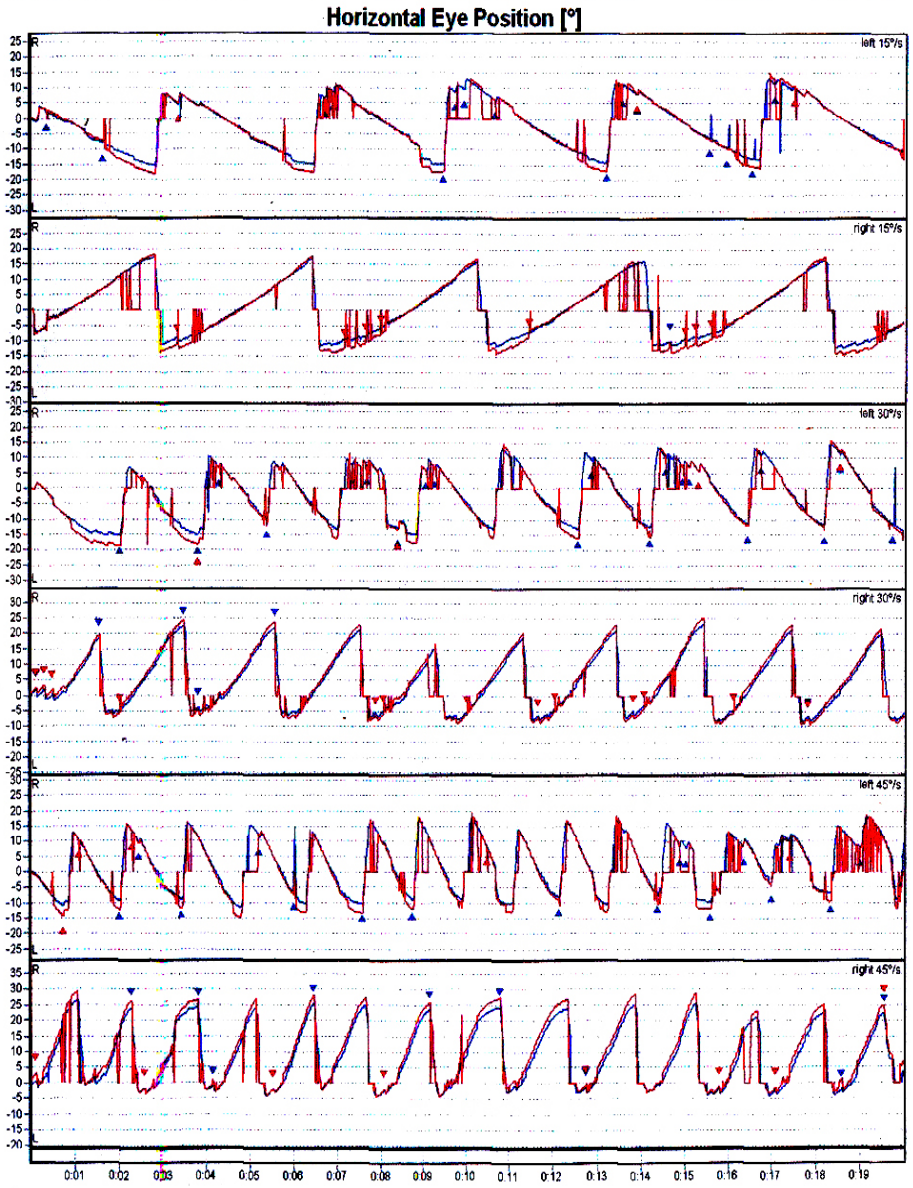
- Optokinetic nystagmus can be stimulated by exposing pt to repetetive full field moving visual stimulation

- The clinician primarily evaluates symmetry & gain of the response

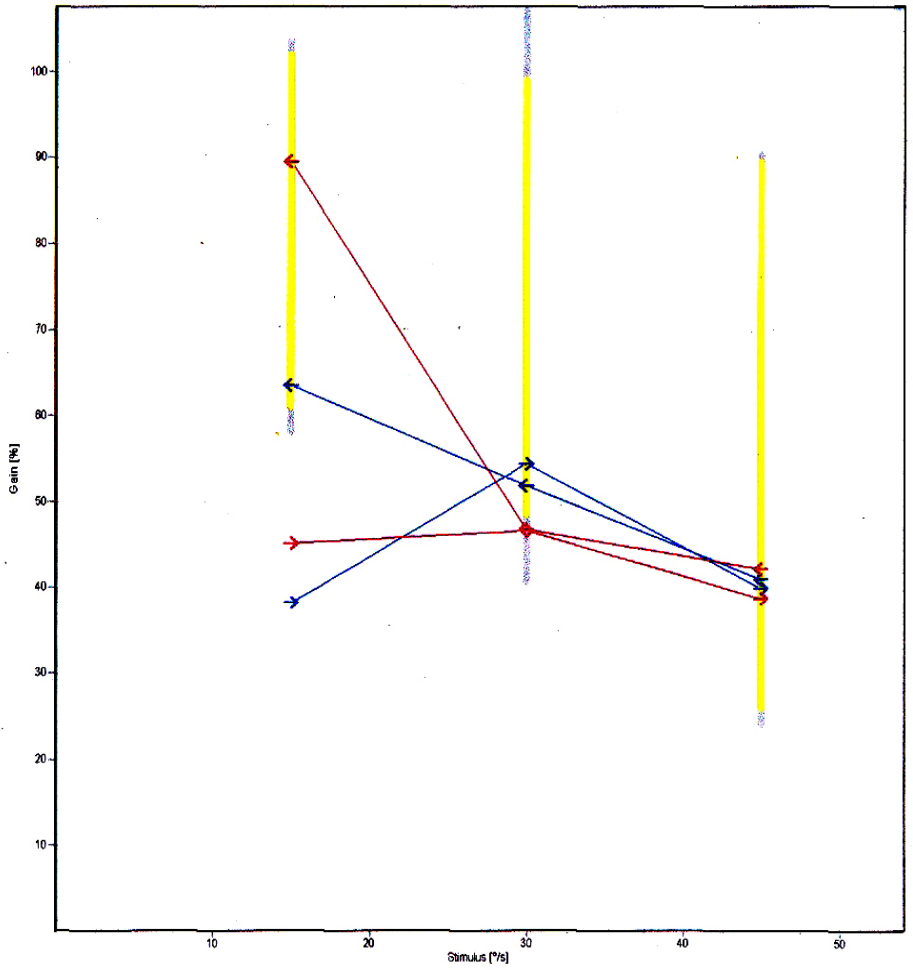
- If responses are not symmetrical, CNS pathology may be suspected


OPTOKINETIC

Optokinetic testing



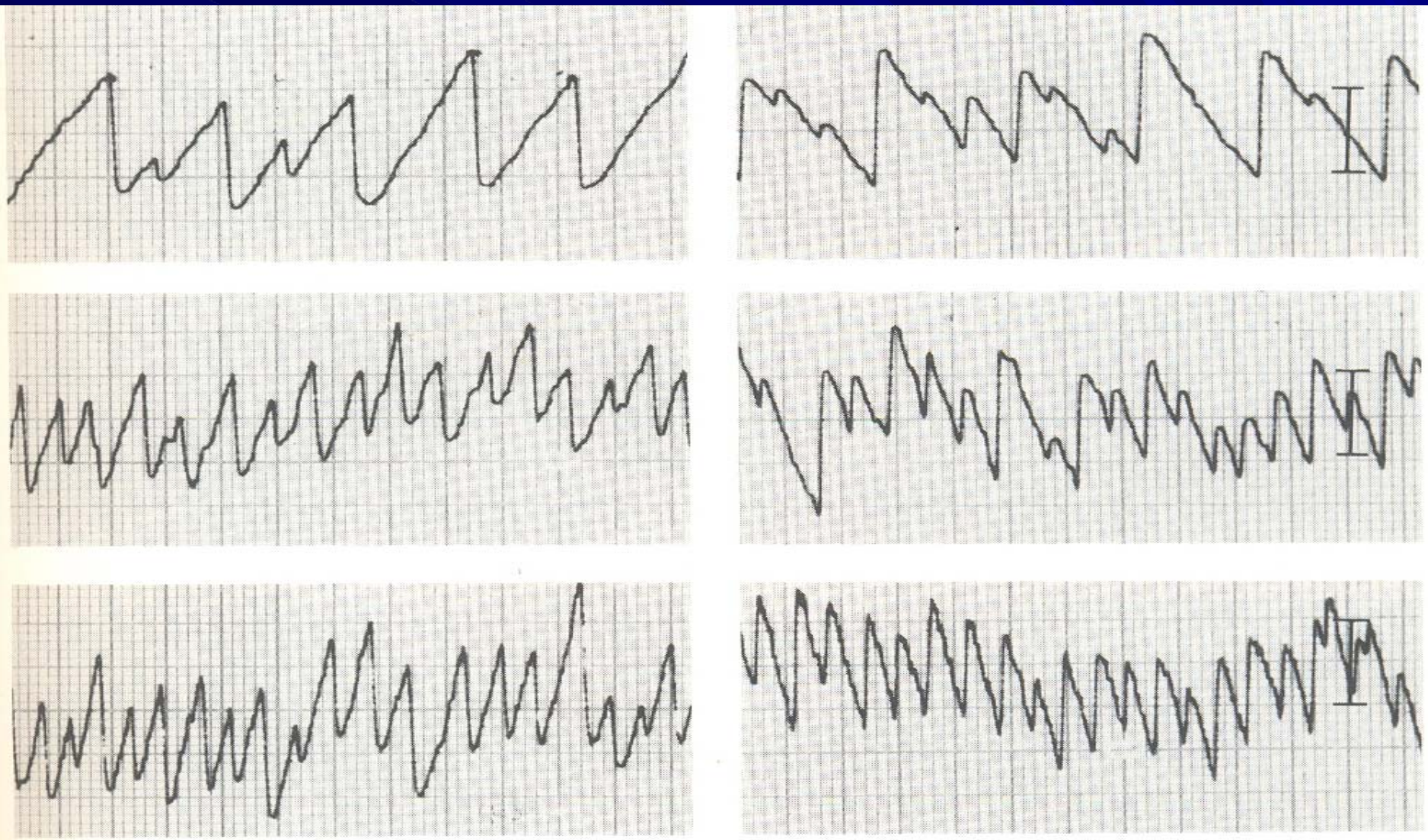
Stimulus	Right Eye a.SPV [°/s]	Right Eye Gain [%]	Left Eye a.SPV [°/s]	Left Eye Gain [%]
left 15°/s	13.4	89.5	9.5	63.5
right 15°/s	6.8	45.1	5.7	38.2
left 30°/s	14.0	46.8	15.5	51.8
right 30°/s	14.0	46.6	16.3	54.4
left 45°/s	19.0	42.2	18.5	41.0
right 45°/s	17.4	38.8	18.0	40.0



Normal symmetrical Optokinectic N

Lt beating

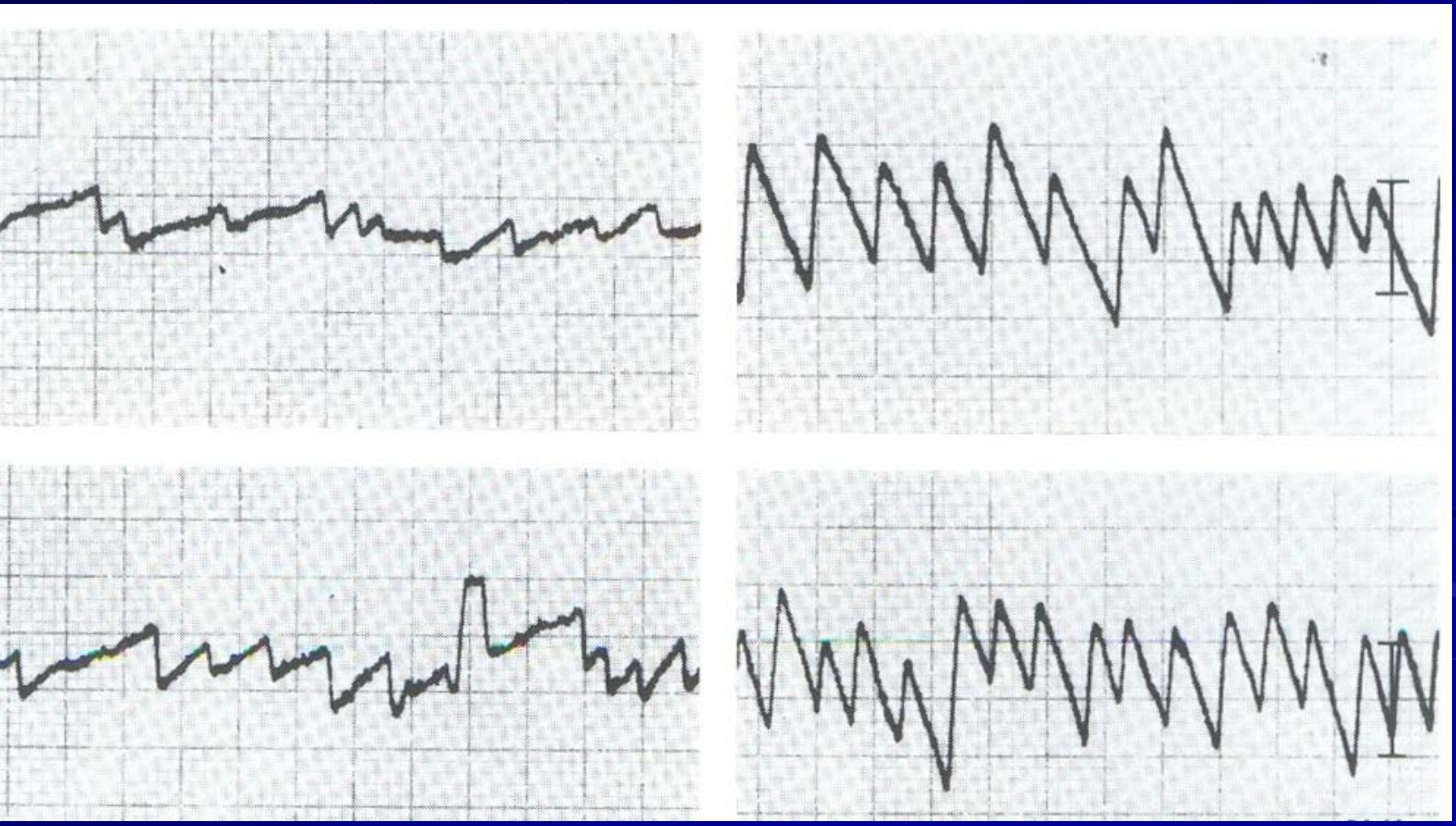
Rt beating



Optokinectic Asymmetry

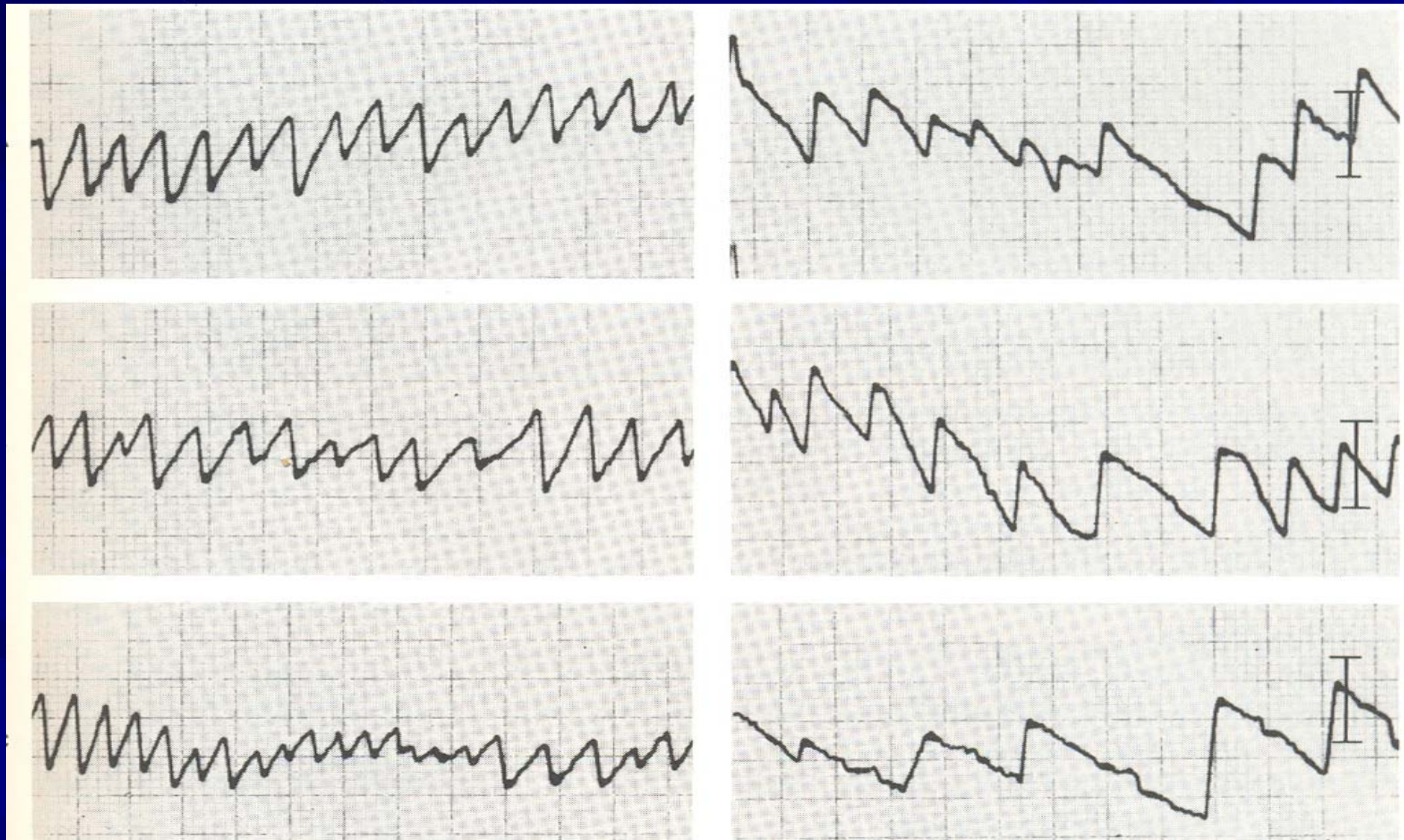
Medullary compression- arnold chiari malformation

(asymmetry is greater at greater target velocity)



Optokinectic Asymmetry

Large glioma of lt temporal lobe – asymmetry in higher stimulus



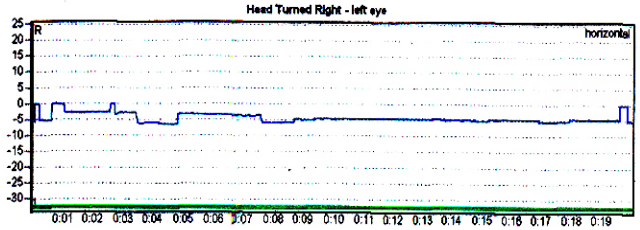
Declining response to increasing velocity

Multiple sclerosis (symmetrical but low in intensity)

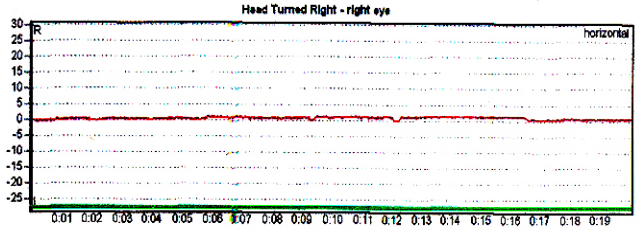
Positional tests – Multicondition

- Performed to determine whether the vestibular system responds normally and symmetrically to changes in head position
- If positive means incomplete compensation in that different position
- Look for objective (nystagmus) and subjective (dizziness)
- Only dizziness –non vestibular cause

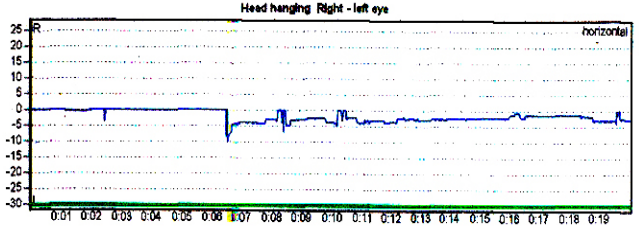
Multi condition test



	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0



	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0



	Beating left	Beating right
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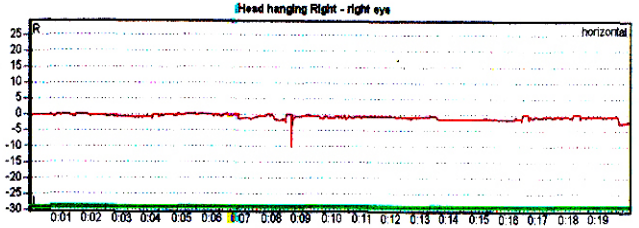

	Beating left	Beating right
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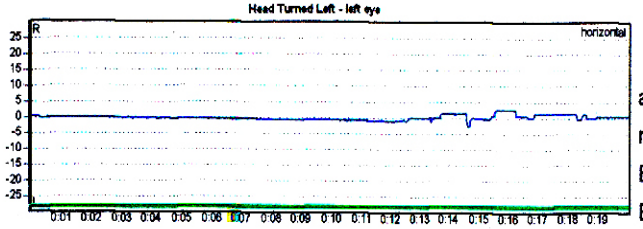
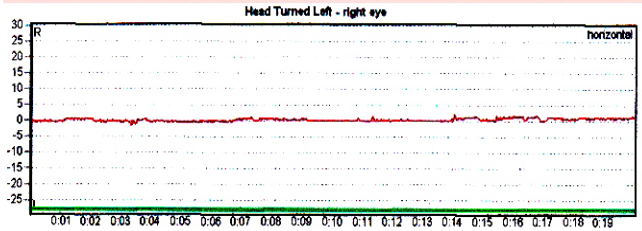
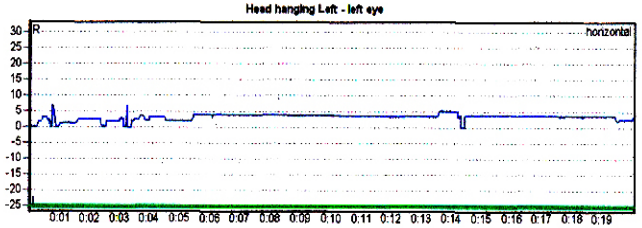
Beats/s	0.0	0.0
Beats	0	0



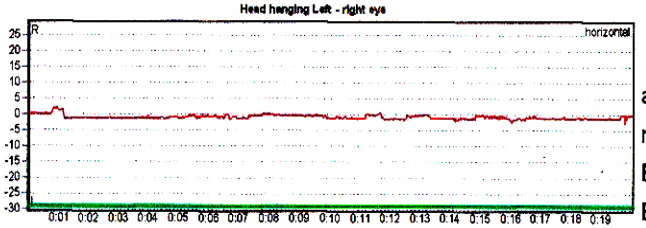
	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0



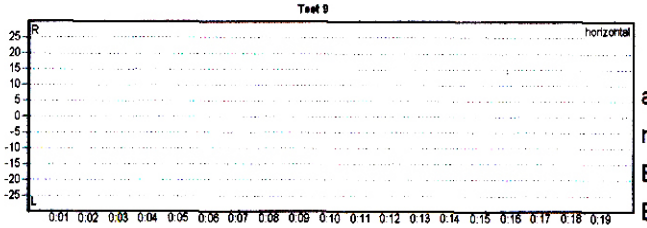
	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0



	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0

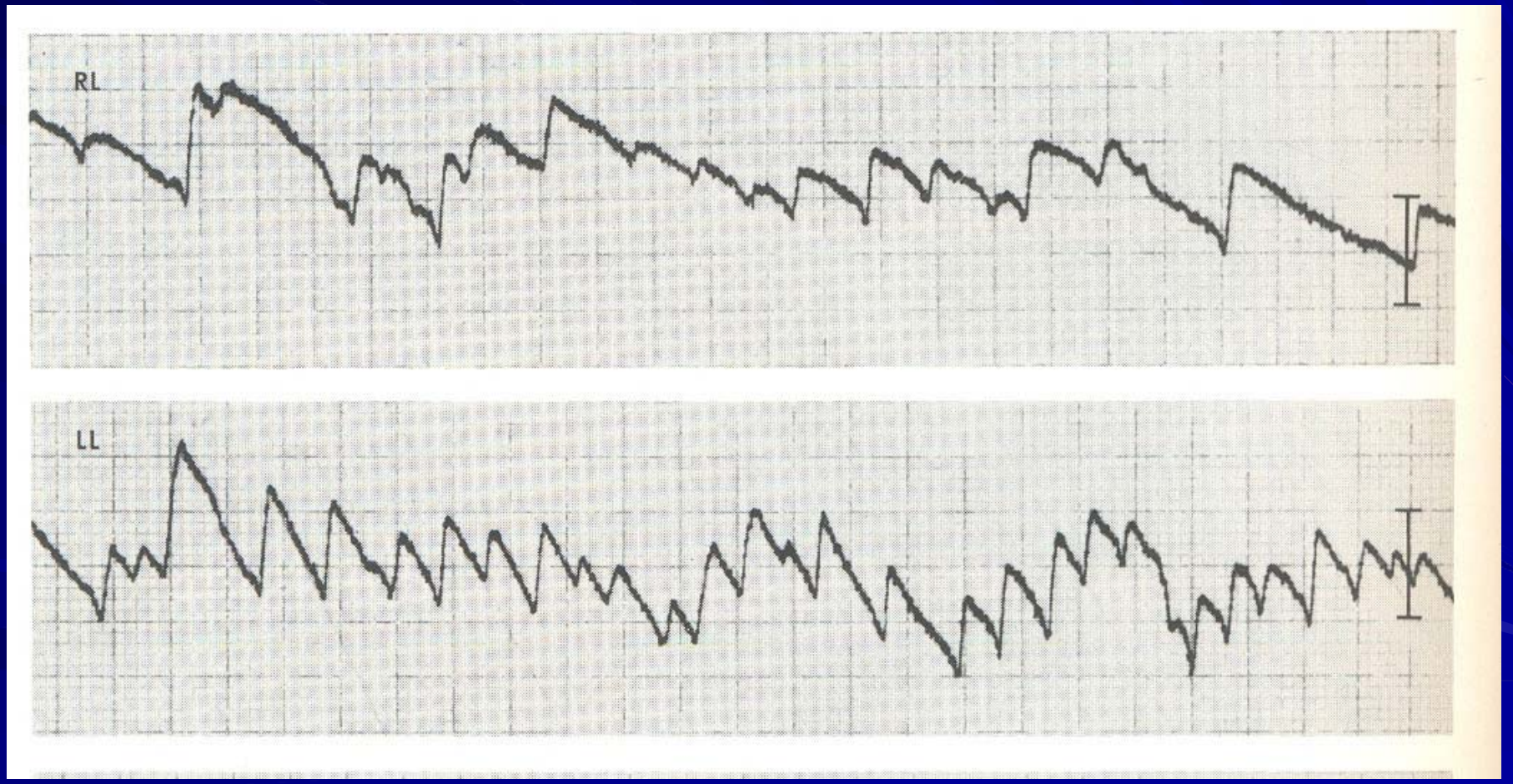


	Beating left	Beating right
a.SPV	0.0	0.0
m.SPV	0.0	0.0
Beats/s	0.0	0.0
Beats	0	0



	Beating left	Beating right
a.SPV	---	---
m.SPV	---	---
Beats/s	---	---
Beats	---	---

Direction- fixed posistional nystagmus.
Peripheral vestibular origin

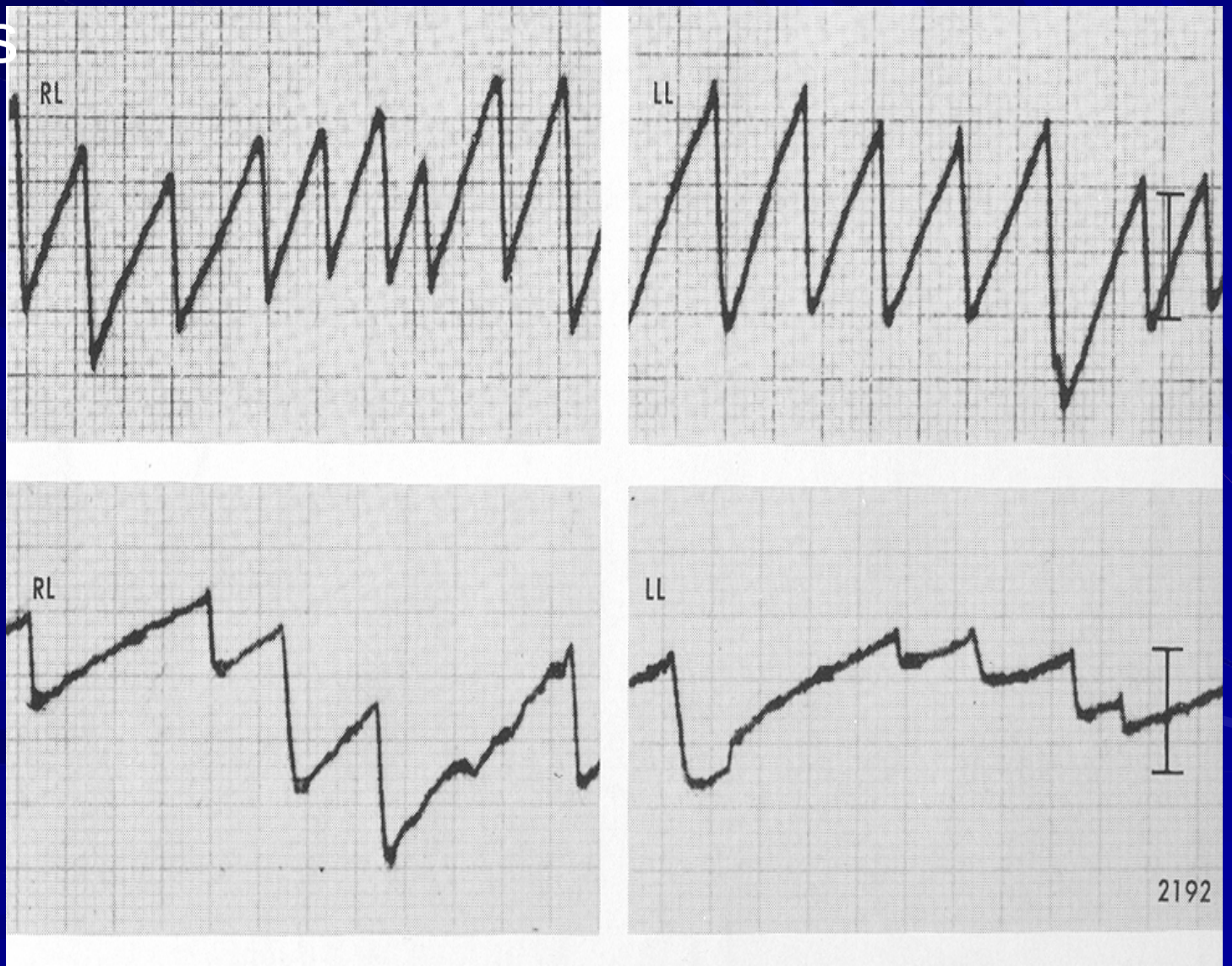


Rt sided vestibular neuronitis

Spontaneous nystagmus

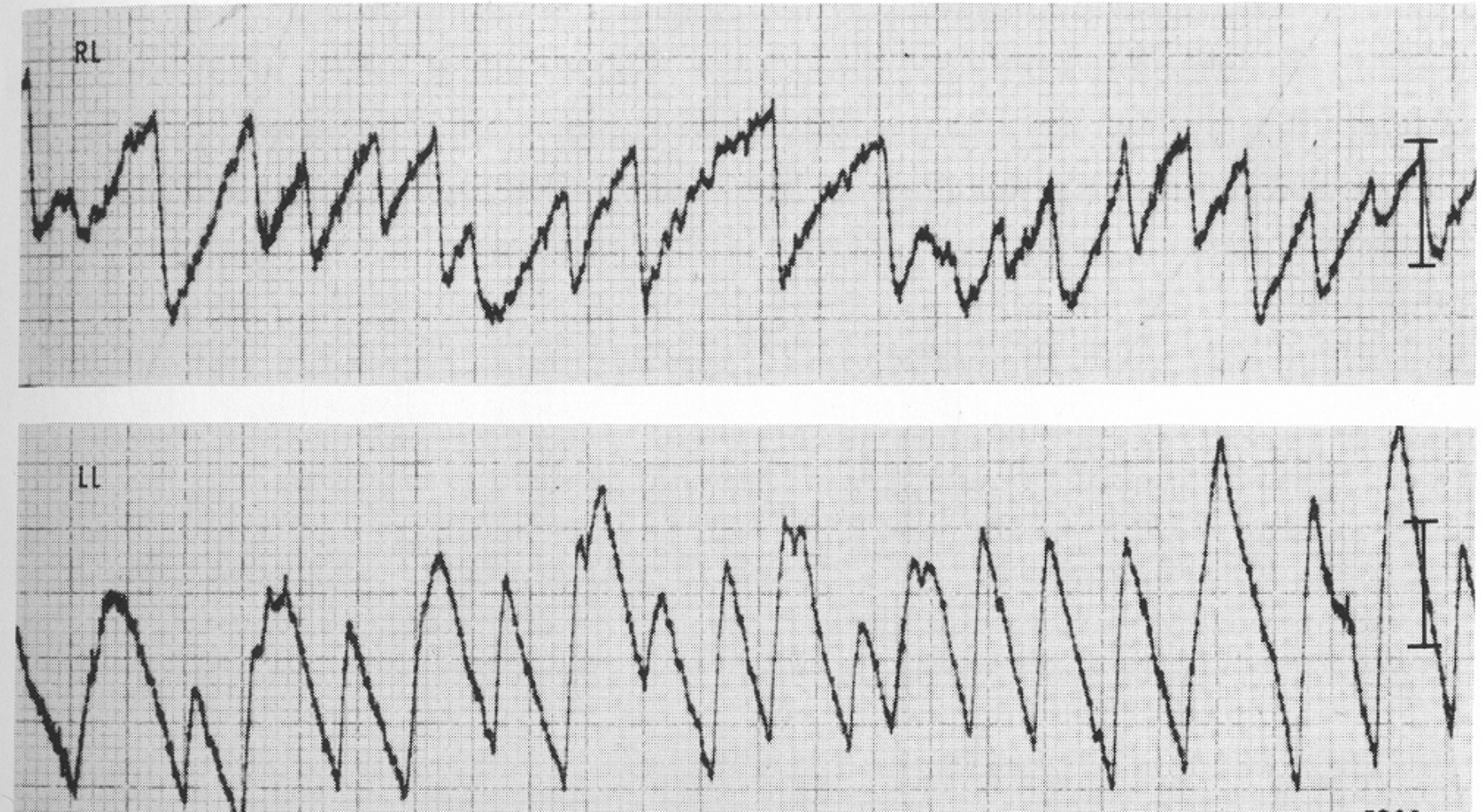
evolution

Direction fixed nystagmus



Direction changing positional nystagmus

Brain stem infarct



POSITIONING TEST

- Patients with BPPV present with a geotropic rotary nystagmus
- The clinician must use only infrared technology or Frenzel lenses to observe the direction of rotation.
- Look for latency, direction and duration
- keeping the eyes open in a room with enough light for the examiner to observe eye movements may not allow accurate representation of the response.

DIX-HALLPIKE maneuver

- If rotary nystagmus is observed, the results must have the following 4 characteristics to be considered classically positive:
  - Delayed onset - After 20 seconds of observation
  - Transient burst of nystagmus - Lasts approximately 10-15 seconds
  - Subjective report of vertigo
  - Fatigability
- When BPPV occurs, a peripheral lesion on the side that is down when the nystagmus occurs may be indicated.

Contd…

In BPPV if the test is negative consider 3 possibilities

- Patient may be in spontaneous remission

- Dispersion of otoconia within the posterior semicircular canal - *PROBABLE FATIGUED BPPV*

- Last episode could have occurred few hrs before the test -*PROBABLE FATIGUED BPPV*

CALORIC TESTS

- Only test that evaluates the function of 1 vestibular apparatus at a time
- Widely described by Fitzgerald and Hallpike
- Causes a non physiologic response.Temp changes - changes the density of endolymph –causes fluid motion – nystagmus and subjective vertigo and nausea

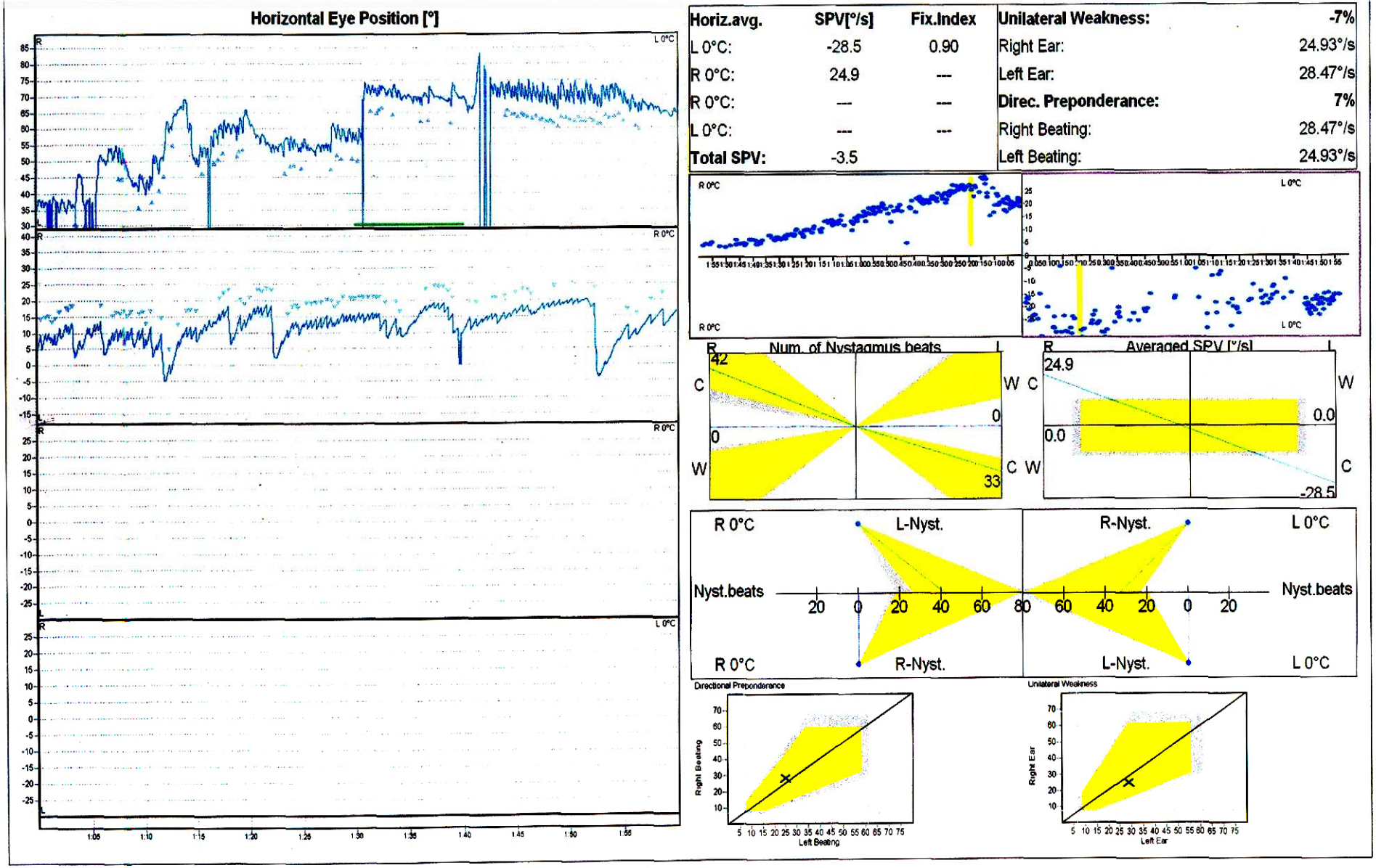
CALORIC TESTS contd..

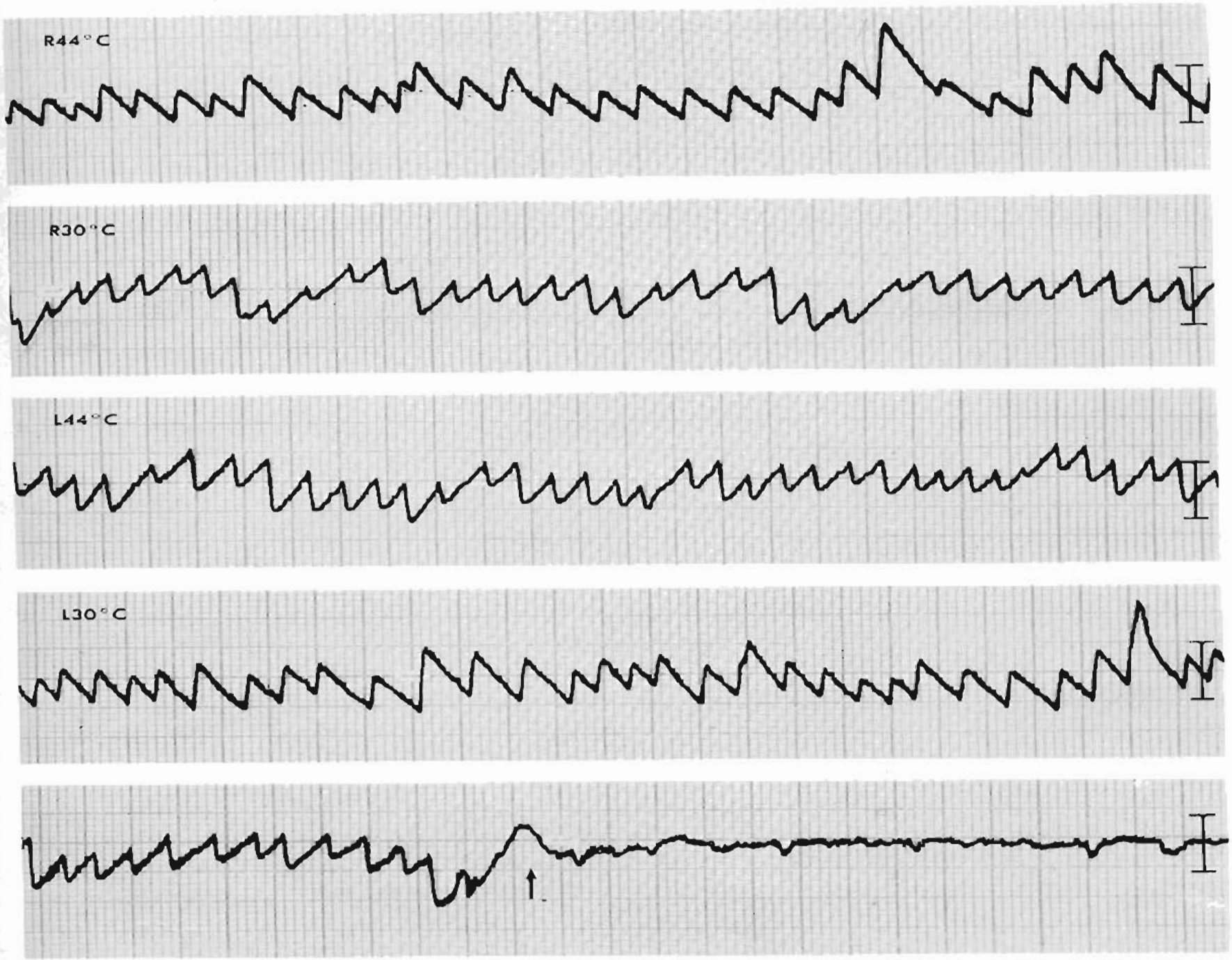
- Warm water results in excitatory response on the irrigated side
- Cold water results in inhibitory response and nystagmus away from the irrigated ear
- Purpose of the test – to determine – ***presence and symmetry of vestibular responses*** .If no response

do

- Ice water caloric test as it is a stronger stimilus
- Ice water calorics are used to determine whether *residual vestibular function exists in patients*

Caloric test




R44°C
R30°C
L44°C
L30°C

- Unilateral weakness

Compare responses provoked by Rt ear irrigations with Left ear irrigations

INTERPRETATION

The 95%limit of normal variation was 25% for UW and 29% for DP

- Directional Preponderance

Represents the diff in intensity between 2 rt beating nystagmus responses and 2 left beating nystagmus responses

Caloric inversion

Caloric response nystagmus beats in the direction opp to that expected

Caloric perversion

Occurrence of vertical or oblique nystagmus in response to caloric irrigation

VESTIBULAR EVOKED MYOGENIC POTENTIALS
ITS INDICATIONS & CURRENT STATUS

VESTIBULAR EVOKED MYOGENIC POTENTIALS

- An otolith (saccule)-mediated short - latency reflex recorded from averaged sternocleidomastoid electromyography in response to clicks or tonebursts
- Increasingly used in the evaluation of patients with vertigo

- Conventional vestibular assessment - evaluation of horizontal semicircular canal
- VEMP – evaluation of saccule, inferior vestibular nerve & vestibulocollic pathway
- VEMP is a polysynaptic response & helps in the assessment of ***lower brainstem function***, unlike the caloric tests & ABR which assess ***the upper brainstem***

- Saccule and saccular nerves have the lowest threshold response to acoustic stimuli – ***basis of VEMP test***
- This sound sensitivity is thought to be a remnant from the saccule's use as an organ of hearing in lower animals

HISTORY OF VEMP

- Sound-evoked vestibular responses in humans were described by Tullio (1929) & Von Békésy (1935)
- Townsend et al.noticed the true origin of these potentials was the saccule
- Colebatch and Halmagyi first recorded VEMPs (1992)
- Kovach reintroduced VEMP (1994)
- Clinically used since 1992

VEMP - INDICATIONS

- Indicated in the diagnosis of peripheral and central vestibulopathies
- Differentiation of labyrinthine from retro labyrinthine lesions
- Used to monitor the efficacy of intratympanic gentamycin treatment
- Can be used in intraoperative, neurophysiological monitoring

VEMP - PATHWAYS

Sound stimulation of saccule

↓

Inferior vestibular nerve

↓

Vestibular nucleus

↙ ↘

MVST → Accessory nucleus & Nerve → Sternocleidomastoid muscle

LVST → Leg muscles

VEMPS are ipsilateral

VEMP methods

- Click evoked VEMP – most reproducible, symmetric, and technically easy to perform.
- Air- and bone-conducted short tone bursts
- Bone conduction VEMP
- Galvanic VEMP
- Forehead taps

EQUIPMENT

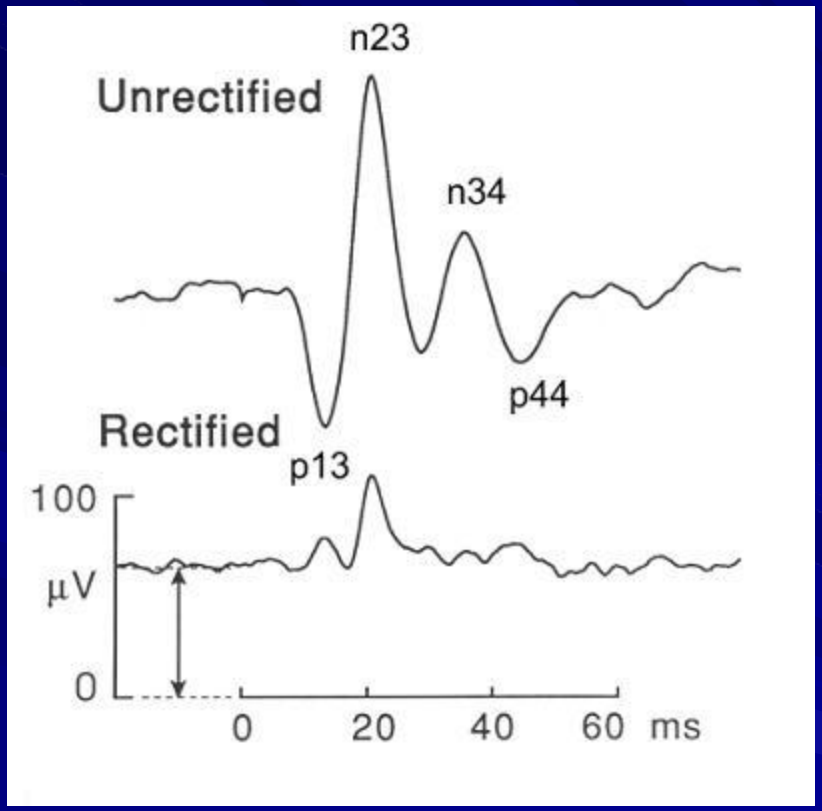
- Evoked response computer
- Sound generator
- Surface electrodes to pick up neck muscle activation

VEMP - technique

- Subjects are instructed to tense the muscle during runs of acoustic stimulation, relax between runs
- Inserts are preferable to headphones
- The response is ipsilateral, hence bilateral stimuli and bilateral recording is done
- Loud clicks (0.1 msec) or tone bursts (typically 95-100 dB nHL or louder) are repetitively presented to each ear in turn at 200 msec intervals (5/second)
- Optimum frequency: 500 - 1000 Hz

- Myogenic potentials are amplified, bandpass filtered (5-1K Hz), and averaged for at least 100 presentations
- The response evoked in the neck EMG is averaged and presented as a VEMP
- VEMP is recorded in the first 30 ms after the stimulus
- The latency, amplitude, and threshold for the p13-n23 wave is measured

NORMAL VEMP



The initial biphasic p13 and n23 response is larger
The late response (n34 and p44) represents cochlear stimulation.

VEMP measures

- **Threshold - most clinically useful**

  - measures threshold in four different frequencies (250,500,750 and 1000Hz)

  - third window in the inner ear - decreased threshold

- **Latency** - prolonged in multiple sclerosis and acoustic neuroma

- **Amplitude** - *measured from the P13 to N23*

  - fairly variable response, even between ears of the same patient

ABNORMAL VEMP

- Asymmetry is calculated by Amplitude Asymmetric ratio
- $(A_1-B_1)/(A_1+B_1)$ X 100
- If the ratio is more than 33% then asymmetry exists
- Absent (no reproducible wave, or P1 latency outside of norms)

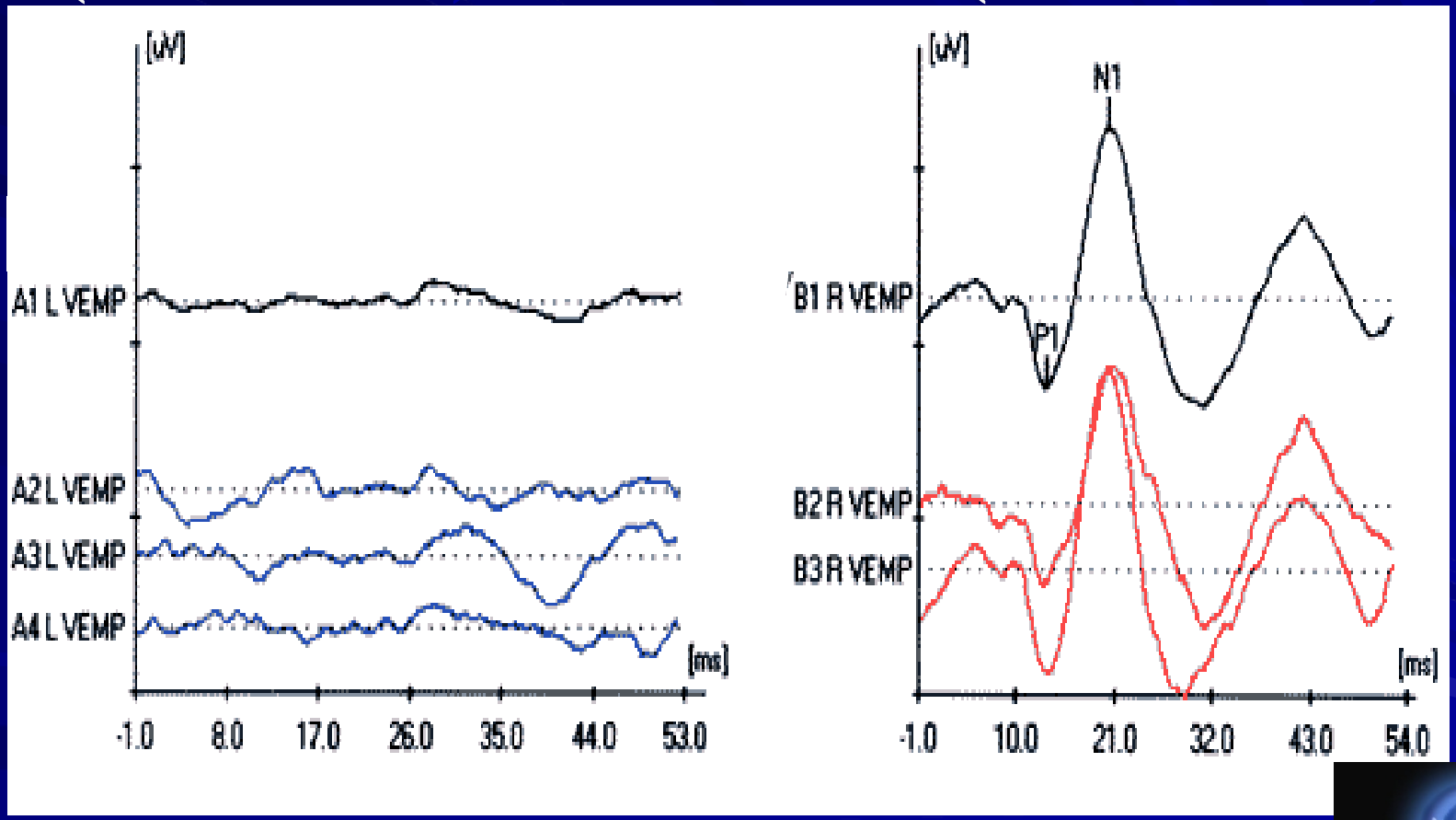
Attenuated or absent VEMP

- Conductive loss
- Herpes zoster oticus
- Meniere`s disease
- Aminoglycoside ototoxicity
- Vestibular schwannoma
- Post cochlear implantation
- Basilar artery migraine
- Cogan’s syndrome
- Mondini malformation
- Vestibular neuritis
- Idiopathic bilateral vestibulopathy (IBV)

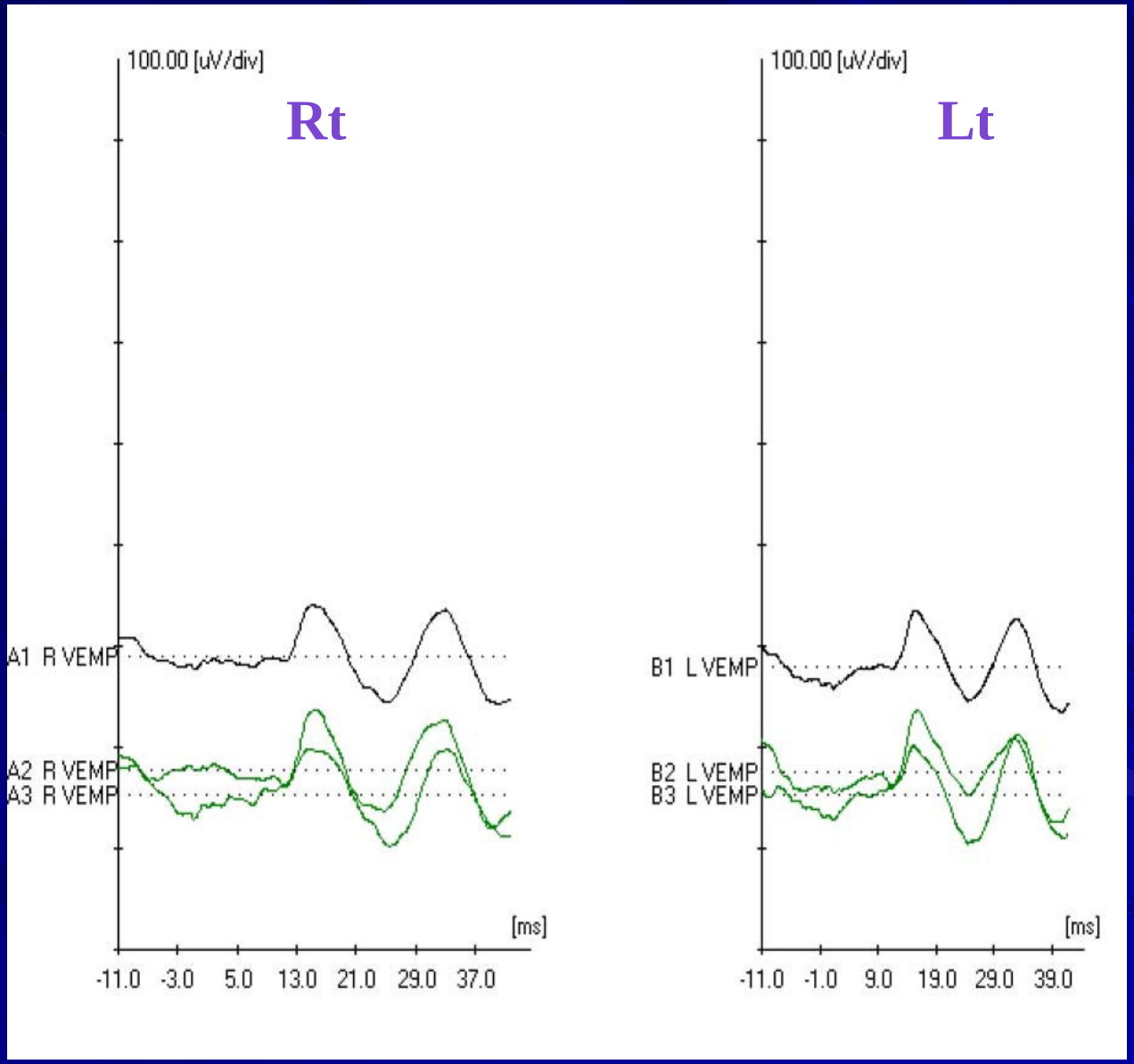
Conductive hearing loss

Left ear (Absent VEMP)

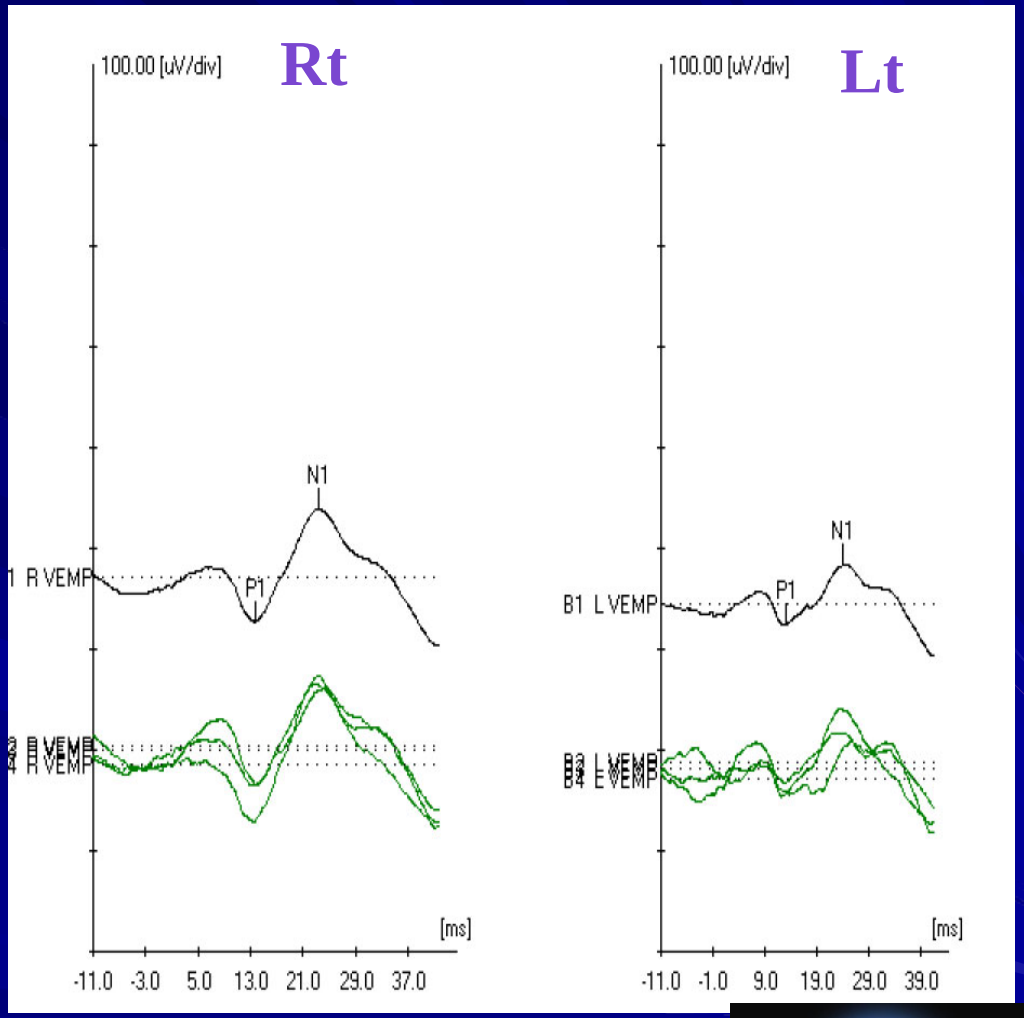
Right ear (Normal VEMP)



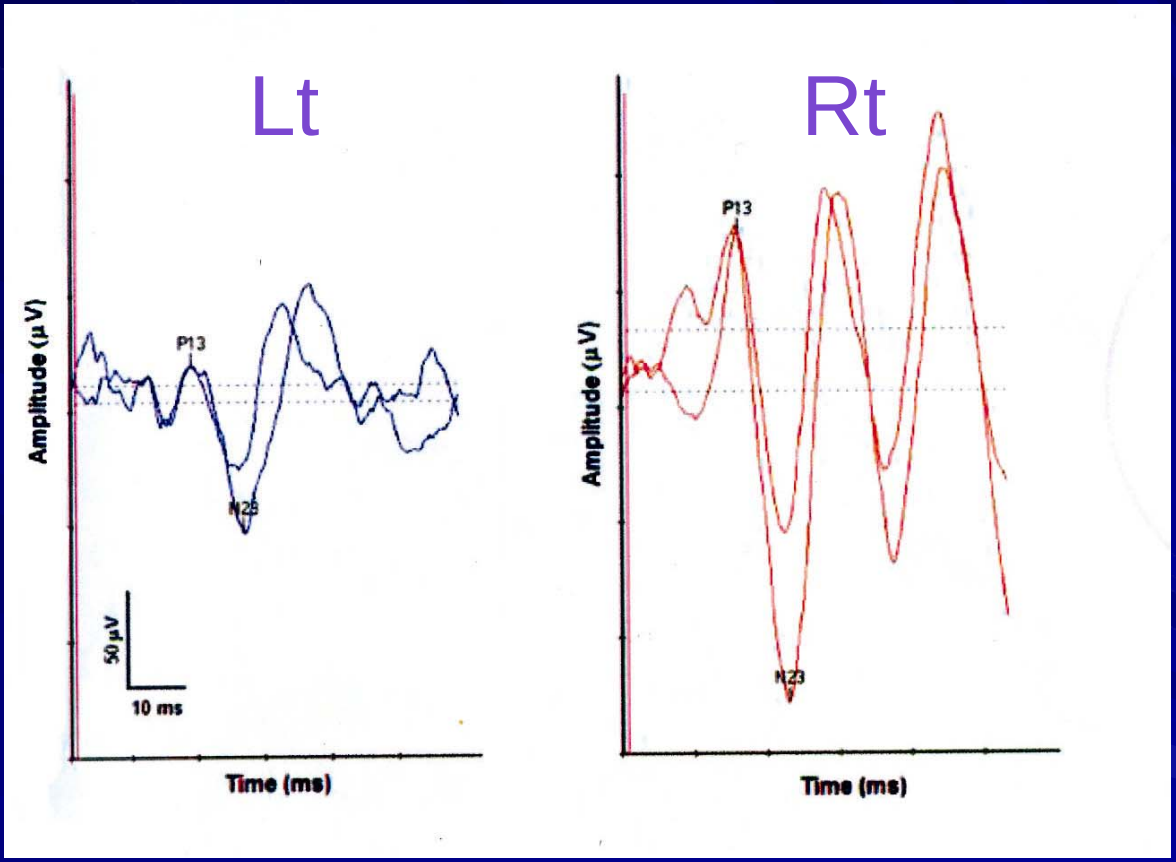
BILATERAL AMINOGLYCOSIDE OTOTOXICITY



LEFT ACOUSTIC NEUROMA



VEMP - Meniere's disease



Meniere’s disease

- VEMP amplitudes can be increased in early Meniere's disease
- Absent VEMPs in advanced disease may represent collapse of the saccule
- Altered VEMP after administering oral glycerol

VEMP

Increased

- Superior SCC dehiscence syndrome
- Perilymphatic fistula

Asymmetrical amplitudes

- Tullio's phenomenon
- Spasmodic torticollis

Delayed

- Technical error /elderly
- Central lesions

-Brainstem stroke

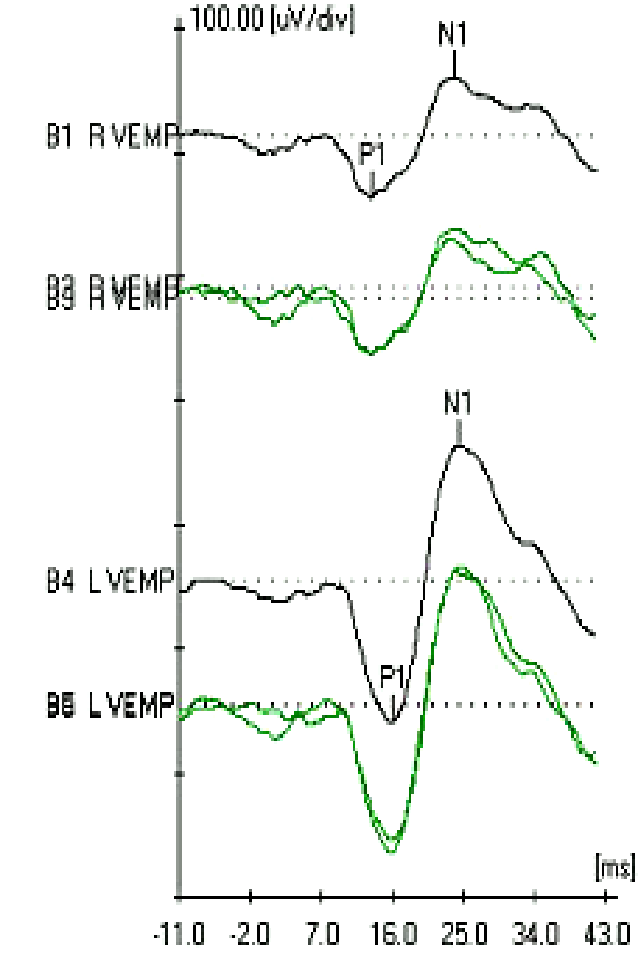
-Multiple sclerosis

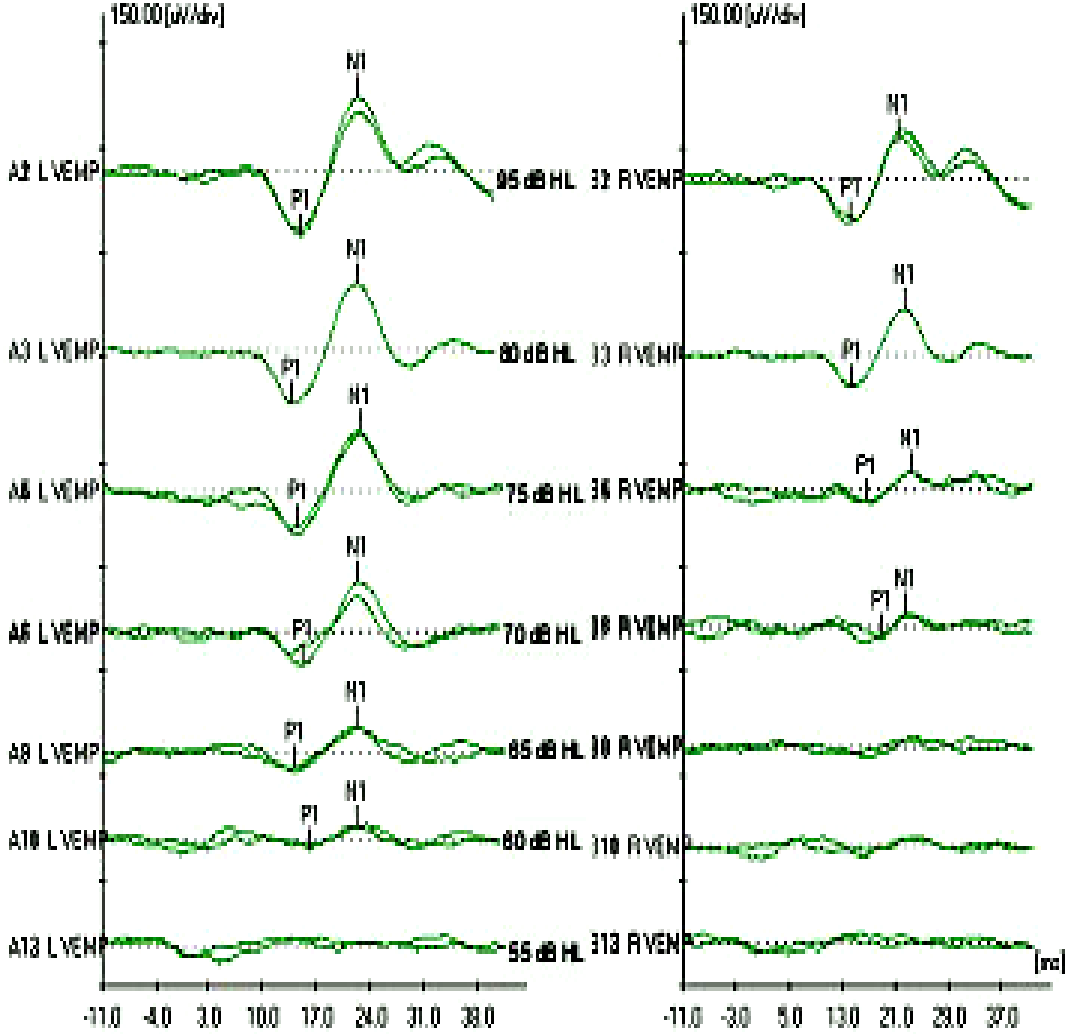
-Spinocerebellar degeneration

-Migraine

LEFT SUPERIOR SEMICIRCULAR DEHISCENCE

Prof Loyd B.Minor (2001)- third window





VEMP - ADVANTAGES

- Specific vestibular sensory system (saccule) is assessed
- Retained in patients with profound SNHL
- Used in infants (latencies are shorter)
- Highly sensitive in the early diagnosis of retrocochlear lesions
- Robust, reproducible screening test of otolith function
- Minimal test time
- Easy to obtain & interpret
- Non-invasive, bedside test
- Does not cause discomfort

LIMITATIONS

- Conductive hearing loss obliterates VEMP's - an absent VEMP does not mean absent saccule function
- A person with a present VEMP and conductive hearing loss may have Superior semicircular canal dehiscence

Conclusion

- Newer tests of vestibular function have added a measure of objectivity to the evaluation of a dizzy pt
- *Video oculography and VEMP with their obvious advantages have become an important tool in the armamentarium of the Neurotologist*

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