The Vestibuloocular Reflex and the Yoked Extraocular Muscles
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Abstract

Problem Addressed: The neuroanatomy of the vestibuloocular reflex (VOR) and the anatomy and function of the isolated extraocular muscles are complex. Descriptions of the whole muscles are difficult to find. The purpose of this paper is to provide a conceptual framework of cephalic muscles, the anatomy of the various nuclear groups involved in the VOR (Figure 1), delineate their connections, and describe the anatomy of yoked eye muscles and their function following unilateral and bilateral surgical ablations of the canal cupulae.

Methods and Measures: The English world literature on this subject was identified by entering appropriate keywords into MEDLINE from 1966 to date. The selection of the published world literature in English on this subject was based on their relevance to the subject. Data were extracted from appropriate key words into MEDLINE from 1966 to date. The selection of the published world literature in English on this subject, from papers that described the experimental delineation of nuclear groups of the VOR, as well as from clinical case reports describing VOR deficits resulting from brain lesions.

Results: Unilateral surgical elimination of the semicircular canal results in conjugate eye movements even though the interaction of each set of extraocular muscles is understood. This is because the VOR pathways cross, and because of the horizontal and vertical gaze centers, the PRDF and the HULF. A detailed description of all nuclear groups and pathways are provided.

Conclusions: Stimulation of any semicircular canal results in conjugate eye movements. Clinical Significance of Study: Theories regarding the mechanisms of benign paroxysmal positional vertigo should be better understood. The pathways and triggers for the fast phases of vertical and torsional nystagmus are described.

Introduction

Descriptions of the VOR and the conjugate actions of the yoked eye muscles are scattered throughout the literature of several disciplines. A single comprehensive account of cephalic mechanics, the VOR, and the function of the yoked eye muscles is difficult to find. The purpose of this paper is to provide a conceptual framework of cephalic mechanics, the anatomy of the various nuclear groups involved in the VOR (Figure 1), delineate their connections, and describe the anatomy of yoked eye muscles and their function during individual semicircular duct (SD) ablation.

Methods

The published world literature in English on this subject was identified by entering relevant key words into MEDLINE from 1966 to date. The selection of the published world literature in English on this subject, from papers that described the experimental delineation of nuclear groups of the VOR, as well as from clinical case reports describing VOR deficits resulting from brain lesions.

Results

• Angular anatomy:
  • The ampullated end of each SD is partitioned by solid ridge, the crista ampullae.
  • Vestibular hair cells are located on the surface of the crista.
  • Saccular and cristaline of the inner ear project into the posterior end of the SD.
  • The cristaline of the utricular ampullae are placed in the inner ear.
  • The cristaline of the saccule are placed in the inner ear.

• Cupular physiology:
  • Vestibular neurons have a resting discharge of about 60 spikes.
  • Horizontal SD - deflection of the cupula towards the crista (ampullofugal) causes upregulation of discharge, and deflection of the cupula towards the utricular side (ampullopetal) causes downregulation.

Conclusions

Anatomy of right horizontal SD afferents - the slow phase of horizontal nystagmus (Figure 2):

- Path 1: Right VN afferents – cross midline – left VN nerve motor nucleus – left MLF (right MLF) – left abducens internuclear neurons – left lateral rectus.
- Path 2: Right VN afferents – cross midline – left VN nerve motor nucleus – right MLF (left MLF) – right abducens internuclear neurons – right lateral rectus.

The pre-motor neurons for torsional and downward fast phase eye movements are located in the riMLF. The right riMLF triggers clockwise rotation, while the left riMLF triggers counterclockwise rotation.

Discussion

Reafferent VOR eye movements have a common final pathway from the 5th, 6th and 7th cranial nerves to the lateral and interstitial nucleus of the spinal trigeminal tract and nucleus. The pre-motor neurons for torsional and downward fast phase eye movements are located in the riMLF. The right riMLF triggers counterclockwise rotation, while the left riMLF triggers clockwise rotation.

References