Chapter 1

Introduction

The vestibular system is important in the control of posture and movement. Its influence is excerted in part by means of direct axonal projection to the spinal cord (Brodal and Pompeiano, 1957; Carpenter, 1978), extraocular neurons (Brodal and Pompeiano, 1958; McMasters,Weiss and Carpenter, 1966; Tarlov, 1970) and the cerebellum (Brodal and Hoivik, 1964; Ito, Highstein and Fukuda, 1970).A major input to the vestibular nuclei comes via afferent vestibular nerve. This nerve run together with cochlear nerve (vestibulocochlear nerve or the cranial nerve VIII) from the internal auditory meatus to the cerebellopontine angle, where they enter the brain stem. Each of these nerves has distinctive central nuclei and connections (Walberg, Bowsher and Brodal, 1958; Powell and Cowan, 1962). The vestibular nerves arise from bipolar cells in the vestibular ganglion (Scarpa's ganglion), consist of peripheral branches that pass to the neuroepithelium in the ampullae of the semicircular canals and in the macula of the utricle and saccule,and central branches that enter the brain stem at the junction of the pons and medulla and end in the four vestibular nuclei (Brodal and Pompeiano, 1957;Walberg et al., 1958; Ito, Hongo,Yoshida and Obata, 1964; 1969; Wilson, Wylie and Marco, 1968; Kawai, Ito and Nozue, 1969)

A small number of fibers passes directly to the ipsilateral side of the cerebellum, via the juxtarestiform body to terminate in the flocculonodular lobe and adjacent vermian cortex (Jansen, 1961; Brodal, and Hoivik, 1964).

The vestibular nuclei lie in the floor of the fourth ventricle in both the pons and medulla. The nuclei of this complex consist of (Fig. 1)

1. The superior vestibular nucleus (nucleus of Bechterew) is situated in the angle of the floor and lateral wall of the fourth ventricle. These nuclei recives afferent fibers from the cristae of the semicircular canals.

2. The medial vestibular nucleus (nucleus of Schwalbe), is composed of occupies parts of the area acoustic of the rhamboid fossa and contains relatively few fibers from the cristae of the semicircular canal and the macula of the utricle.

3. The lateral vestibular nucleus (nucleus of Deiters) is next to the inferior cerebellar peduncle at the level of the vestibular nerve entrance, is composed of giant cells. Afferent fibers terminating in these nucleus arise from the cristae of the semicircular canal and the macula of the utricle.

4. The inferior vestibular nucleus extends rostally to the level of entrance of the vestibular nerves and lie medially to the inferior cerebellar

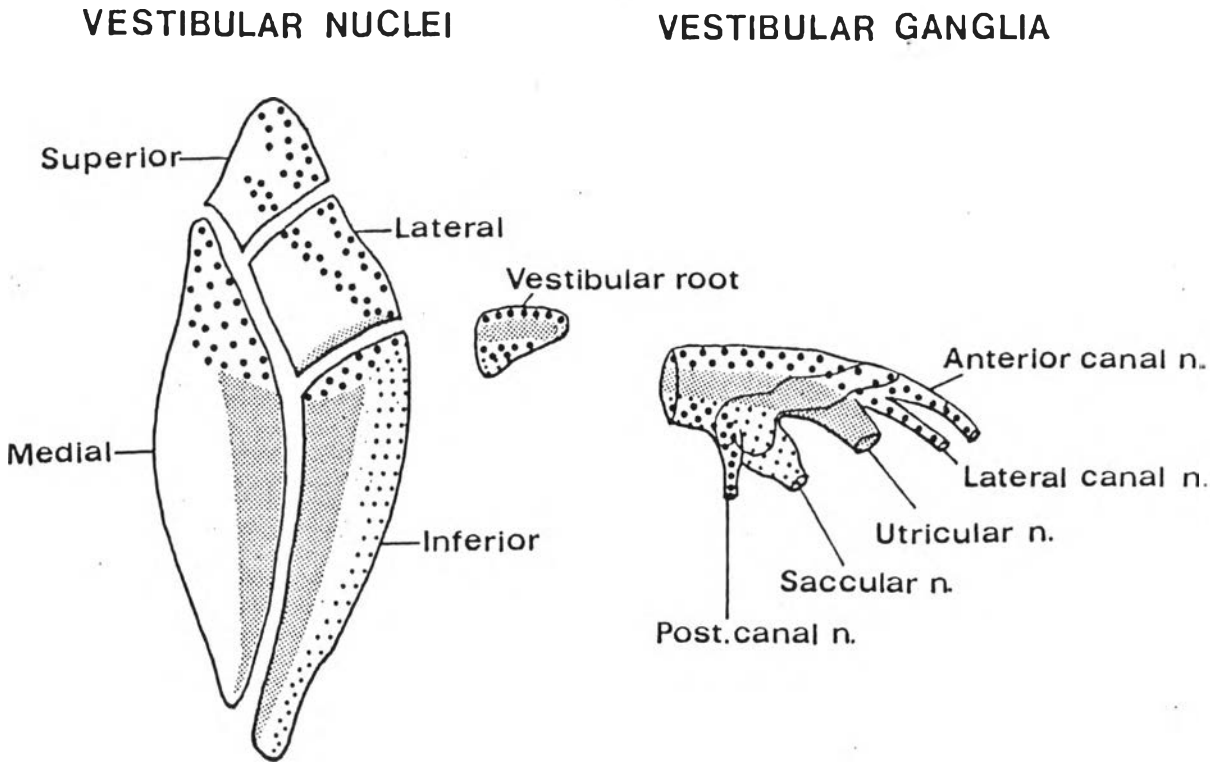

Figure 1. Diagrammatic representation of the relationship between the vestibular ganglia and central fibers projecting to parts of the vestibular nuclei complex.

peduncle and dorsal to the spinal trigeminal tract. Afferent fibers to these nucleus are drived from the macula of the utricle and saccule.

Electrophysiological studies of the vestibular nerves on cell in the vestibular nuclei

A number of electrophysiological studies have been performed on the vestibular system. It was demon strated that electrical stimuation of the ipsilateral vestibular nerve evokes remarkable field potential in the vestibular nuclei (Akaike and Wilson, 1968; Ito et al., 1969). Precht and Shimazu (1965) made the first detailed analysis of single unit activity and field potentials produced in the vestibular nuclei by stimulation of the vestibular nerve. These potential consist of (Fig. 2)

1. The initial positive-negative (or sometime positive alone) wave (P wave) representing the arrival of afferent impulses.

2. The negative N_1 potential (N_1 wave) representing the monosynaptic activation of vestibular nuclei cells, the latency of this activation was ranging from 0.8-1.2 msec. The threshold of the N_1 potential is similar to the threshold of the largest vestibular nerve fibers, the strength of vestibular nerve stimulation has usually been expressed as a multiple of N_1 potential (X N_1T)

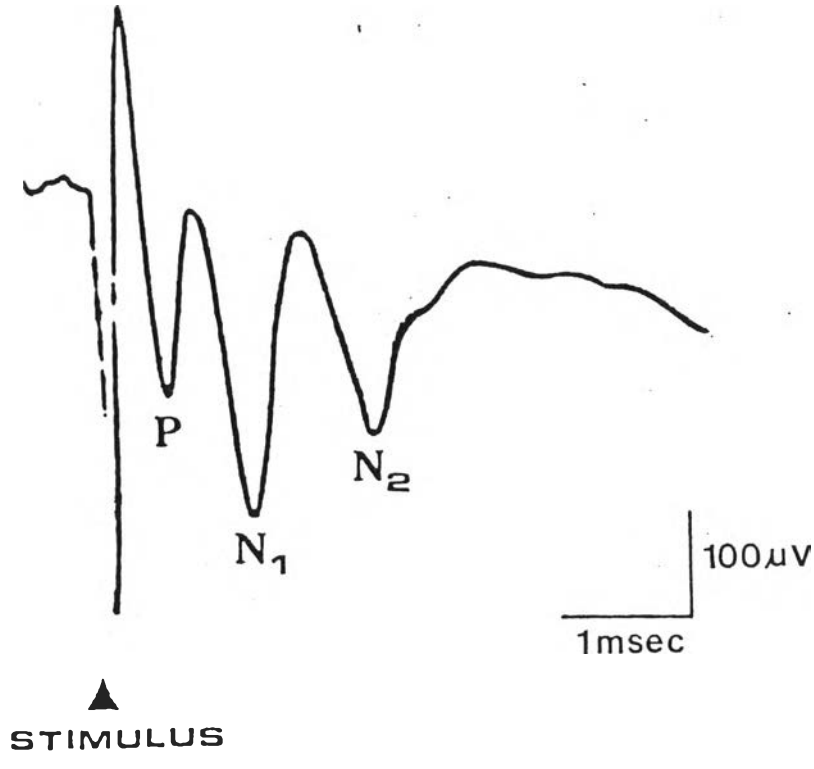

Figure 2. The oscillographic record of field potential in vestibular nuclei complex following stimulation of the vestibular nerve (100 μV).

3. The negative N_2 potential from some areas due to polysynaptic activity with a latency longer than 1 msec (2.2-2.7 msec) (Ito et al., 1969; Kawai et al., 1969), the average threshold of polysynaptically drive cell was 1.6 times the threshold of monosynaptically driven cells (Wilson et al., 1968),and the polysynaptic e.p.s.p's are smaller than monosynaptic ones(Wylie,1973).

By mean of anatomy and electrophysiological studies, The functional organization of the vestibular nuclei and their projection have been presented. However, there are still needs for more studies to elucidate chemical substances utilized by this system as neurotransmitter (s) for complete understanding of its function and dysfunction.

In recent investigation a variety of electrophysiological, histochemical and biochemical technique have suggested that aspartate and glutamate act as putative excitatory neurotramsmitter in various areas of the brain stem. But until now the neurotransmitter(s) released from afferent vestibular nerve terminals.are unknown.

There has been an investigation of the excitatory effect of glutamate, introduced into the cat labyrinth, on the spontaneous and induced activity of secondary vestibular neurons (Dechesene, Raymond and Sans, 1984). From radioautographic studies by injecting

labelled aspartate into the cat vestibular nuclei, a retrogrode axonal transport by the vestibular nerve fibers was observed in the vestibular ganglion neurons and also in the nerve fibers (Dememes and Raymond,1984). In another study, the uptake of labelled glutamate ocurred at vestibular nerve ending, and a significant decrease in high affinity glutamate uptake was observed in the vestibular nuclei which lost their ipsilateral projection (Raymond, Nieoullon,Dememes and Sans, 1984). Additionally iontophoretically applied aspartate and glutamate have been produced marked excitation of all spontaneously firing vestibular neurons, while their antagonists : glutamic acid diethylester(GDEE),D-∝amino adipic acid (D∝AA) caused inhibition of spontaneous firing of the vestibular neurons with GDEE being more effective. These antagonists also blocked the evoked excitation following stimulation of the vestibular nerves, as demonstrated by a marked decrease in N_1 (and N_2) potentials as well as a depression of the induced spike potential (Saengchantra, 1986).

For the cochlear system, glutamate and aspartate are presents at highest concentration in the cochlear nucleus (Wenthold and Gulley, 1978) and cochlea nerve lesion produces a decrease in aspartate and glutamate which parallels the morphological degeneration of the primary auditory terminals (Wenthold and Gulley, 1977; 1978; Wenthold, 1978), inadditional enzymes

glutaminase and aspartate aminotransferase (Wenthold, 1980), whereas the content of other amino acids and enzymes:choline acetyltranferase,glutamate decarboxylase and tyrosine hydroxylase do not change(Wenthold and Fex, 1976;Wenthold and Morest,1976;Wenthold and Gulley,1977). Futhermore ablation of this nerves led to a fall in the evoked release of endogenous amino acids (Wenthold, 1979; Canzek and Ruebi, 1980). Iontophoretic application of glutamate and aspartate produced exitation of the cells in the cochlear nuclei (Martin, 1980; Caspary, 1981).

Finally, recent immunohistochemical study by injecting labelled glutamate and aspartate into the cochlear showed that both amino acids were transported to the cochlear nucleus. Densest labelled glutamate was found in region applied with the densest input of primary afferent (Kane, 1979).

Since the vestibular and cochlear nerves originate embryologically in the same statoacoustic ganglion, we were led to hypothesize that the vestibular afferent system may also use glutamate and/or aspartate as synaptic neurotransmitter(s).

The aim of the experiment reported here was to investigate the efflux of amino acids from afferent vestibular nerve terminals induced by depolarizing stimuli.