Far-field Responses of Acoustic Brain Stem Potentials in the Thalamus and the Subthalamic Area

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Abstract

Short latency evoked potentials in response to acoustic stimulation can be recorded from the thalamus and the subthalamic during stereotactic surgery for relief of intractable pain or tremor.

The wave shape, polarity, amplitude and latencies of such responses do not change in wave I-V (wave VI and VII are exceptions) with different electrode positions from the cortical surface to the subthalamic area. Wave I-V may be generated at the midbrain stem, but wave VI-VII must be generated at the thalamic level. The amplitude of the potentials recorded at the thalamus and the subthalamic area, on the other hand, is enhanced after producing a lesion at the recording site.

The results also indicate that short latency evoked potentials to clicks recorded from electrodes in the thalamus and the subthalamic area, or from an electrode at vertex, are volume-conducted far field potentials emanating from the brain stem.

Key words: Acoustic response, short latency, thalamus, subthalamic area and stereotactic surgery

Introduction

In human subjects, a series of evoked potentials consisting of 5–7 negative peaks of submicrovolt amplitudes can be recorded at the vertex within 10 msec of click stimulation (Jewett et al. 1970).3) Jewett et al. (1970, 1971)3,4) and Buchwald et al. (1975)1) suggested that such responses might be volume conductive potentials of the action potentials which are generated at the acoustic nerve, the cochlear nucleus, the superior olivary complex and the inferior colliculus on click stimulation in animal experiments. Those responses occurring at the vertex in response to acoustic stimulation would disappear whenever a selective lesion was made in the lower midbrain of monkey by a linear accelerating impact (Tsubokawa et al 1977).9

However, there is no sufficient evidence to support that those acoustic potentials recorded at the vertex are far field potentials of the midbrain acoustic action potentials in human subjects.

In order to clarify this matter, a short latency response to acoustic stimulation was examined in the subcortical area, the thalamus and the subthalamic area during stereotactic surgery. Likewise, the wave shape, latency and polarity of these potentials were studied to compare them with short latency acoustic responses at the vertex before and after making a lesion at the deep recording area.

Methods

At forty-five points of the subcortical, thalamic and subthalamic areas, the short latency potentials that occurred in response to acoustic stimulation were recorded in five patients ranging in age from 45 to 62 years, who were suffering from intractable pain or tremor.

The deep recording electrode is a monopolar stainless needle with a 2 mm-bared tip, and it was inserted stereotactically. A conventional disk electrode covered by silver chloride was used to record at the vertex (Cz).

Auditory clicks were delivered via a pair of
cushion type stereoearphones at intensities up to sensation level. The clicks were generated by passing 2 msec square wave pulses.

The responses were recorded by both the deep electrode in various parts of the brain and the disc electrode at the vertex along with an inactive electrode which was placed at the earlobe or the frontal area. Connections with an ordinary RC-amplifier and 1000 sweeps (display time 10–20 msec) were incorporated into an averaging computer.

The location of the deep electrode tip was estimated by conventional neuroradiological method, whenever short latency acoustic responses were recorded.

When the deep electrode was inserted into the target area (the ventrolateral thalamus, centromedian nucleus, subthalamic area), a lesion 5–7 mm in diameter was made by a high frequency generator.

After making the lesion, the responses were also recorded by the same procedure as stated above.

Results

Short latency potentials that were evoked by auditory stimulation and derived from the vertex consisted of 5–7 components during initial 10 msec following a click signal. The latency of V wave was 5.1 ±0.37 msec.

The same responses were recorded at all 45 points in the subcortex (5 points), the thalamus (25 points), the subthalamic area (10 points) and the others (5 points). At any point of these recording areas, the potentials that were evoked by auditory stimulation were completely the same in latency, polarity and amplitude as the potentials recorded at the vertex (Fig. 1).

The anatomical distributions of those recording points are the frontal subcortex (5 points), the caudate (4 points), the internal capsule (1 point), the dorsomedial thalamic nucleus (8 points), the central lateral nucleus (2 points), the centromedian nucleus (5 points), the ventrolateral nucleus (10 points), and Forel H area (10 points).

These distributions are just to line up the electrode tracts from the frontal area to the target point. Therefore, there is no recording point to be related with the lateral geniculate body of the thalamus and its vicinity.

After correct insertion of the deep electrode into a ventrocaudal part of the centromedian nucleus for intractable pain or into the ventrolateral nucleus or the subthalamic area for tremor, short latency auditory responses were recorded in the same way as the potentials were recorded in other areas (Fig. 2). There were not much changes in the responses except for an increase of their amplitudes even after making the brain lesion at the tip of electrode as shown in Figure 2.

According to these results, it can be said that: 1) a series of evoked potentials consisting of 5 negative peaks with submicrovolt amplitude can be recorded not only at the vertex but also in various thalamic nuclei and the subthalamic area; 2) the amplitude (0.76±0.37 µV) and latency (5.1±0.30 msec) of wave V are not only equal in different recording sites, but those of the wave forms I, II, III and IV are also equal; and 3) The amplitude is not reduced but increases after making a brain lesion at the recording site. The amplitude and shape of wave VI and VII changes depending on the electrode position as indicated in Fig. 1, which indicates that wave VI and VII may be generated at the thalamic area.
Fig. 2 The alteration of auditory early evoked potentials recorded at the thalamus before making lesion (A) and after making the lesion. Note that wave I–V do not change at all but wave VI and VII change to low amplitude and monophasic potential.

Discussion

Short latency auditory potentials recorded at the vertex of humans were first reported by Jewett et al. in 1970.3) Jewett and Williston (1971)4) and Buchwald and Huang (1975)5) suggested in their animal experiments that the generating site of these potentials recorded at the vertex is located at the specific auditory ascending neurons of the brain stem and in the acoustic nerve itself. Stockard et al. (1976),8) Starr and Achor (1976)7) and Tsubokawa et al. (1977)9) were unsuccessful in recording any auditory potentials at the vertex in patients who had a lesion in the lower midbrain.

If the short latency potentials evoked by auditory stimulation and recorded at the vertex are propagated from auditory responses in the lower midbrain, the question is how to explain the conductive mechanism. There is no specific conductive system, and the potentials recorded in various parts of the brain are not much different in latency and only slightly different in amplitude. As can be noted from the foregoing, there is evidence that a series of auditory potentials in the non-specific thalamic nuclei or the subthalamic area is completely the same as are potentials recorded at the vertex and the amplitude is slightly increased after producing a lesion at the recording site. They might be volume conductive far field potentials.

It is concluded that a series of short latency auditory potentials consisting of 5 negative peaks recorded at the vertex, the non-specific thalamic nuclei and the subthalamic area is far field potentials of the action potentials at the brain stem and the acoustic nerve that are evoked by auditory stimulation.

References