CHARACTERISTICS OF BACKGROUND UNIT ACTIVITY IN THE
NUCLEUS RETICULARIS OF THE HUMAN THALAMUS

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Background firing activity was examined in 240 neurons belonging to the thalamic nucleus reticularis (Rt) in the unanesthetized human brain by extracellular microelectrode recording techniques during stereotaxic surgery for dyskinesia. The cellular organization of Rt was shown to be nonuniform, and distinguished by the presence of three types of neuron: one with arrhythmic single discharge (A-type, 40%), another with rhythmic (2-5 Hz) generation of short high-frequency (of up to 500/sec) burster discharges (B-type, 49%) and a third with aperiodic protracted high-frequency (of up to 500/sec) bursting discharges separated by "silent" intervals of a constant duration of 80-150 msec (i.e., C-type, 11%). Differences between the background activity pattern of these cell types during loss of consciousness under anesthesia are described. Tonic regulation of neuronal type was not pronounced but a tendency was noticed in the cells towards a consistent rise in firing rate, rhythmic frequency and variability, etc. in both A and B units, especially in the latter. Findings pointing to the absence of a direct relationship between rhythmic activity in the Rt and parkinsonian tremor were confirmed. Background activity in B-type cells was found to increase and then stabilize with a rise in the degree of tremor. The nature of regular bursting activity patterns in B and C neurons is discussed in the light of our findings.

INTRODUCTION

The study of the thalamic nucleus reticularis (Rt), the function of which as yet remains unclear, is most important for grasping the mechanisms underlying integrative activity in the human brain. The major part played by this structure in the reticulo-thalamo-cortical relationship has been demonstrated during animal experiments [1, 5, 9-11, 21, 22]. Some workers view the Rt as an individual type of "integrating filter" which modulates thalamic cell activity [1, 5, 9-11, 18, 19, 21, 22]. We obtained findings during our earlier research on humans indicating Rt involvement in mechanisms associated with the performance of goal-directed motor and mental activities accomplished with participation of brain systems connected with speech [3, 4, 16]. The subject of Rt function and its role in movement organization is of clinical interest, since surgical destruction of this nucleus is known to reduce some aspects of motor impairment in parkinsonism.

This article will be making a detailed study based on techniques for statistical analysis of background firing activity (BFA) patterns in Rt neurons of the human brain, recorded by means of microelectrode techniques during stereotaxic surgery for dyskinesia and parkinsonism in particular.

METHODS

Neuronal activity was recorded using microelectrode techniques during stereotaxic surgery to enable functional identification of subcortical structures and identification of the location of pathological areas to be surgically destroyed. According to our findings and those of the literature [4, 6, 8, 14, 16], this functional control during surgery allows for individual correction to be made in the stereotaxic calculations and renders surgery on deep-lying brain structures more effective.

Extracellular recording of firing activity was performed using Tungsten microelectrodes with a resistance of 1-5 MΩ with a 1 μm diameter at the tip, inserted into the brain using...
purpose-built equipment [4]. The microelectrode was advanced along a single trajectory from
the premotor cortex in the direction of the thalamic ventrolateral (VL) nucleus (the main sur-
gical target) and was controlled under x-ray. The spatial location of key points was estab-
lished according to a stereotaxic atlas within a three-dimensional system of the main cere-
bral x-ray stereotaxic coordinates. Standard recordings were also made of EEG as well as ENG
readings from the flexor and extensor muscles of the patient's fingers together with tremoro-
grams at the same time as recording firing activity. Features of the techniques used have
already been described in detail [4, 16].

Results were analyzed by computer and a special analyzer. Data processing was performed,
depending on aspects of the time course of BFA, by producing histograms of current firing
rate with a bin of 10-100 msec and of interspike (HII 0.5-20 msec), intraburst (0.2-0.5 msec),
and interburst (10-20 msec) intervals as well as graphs showing probable distribution and
autocorrelation (0.2-20 msec), cross-correlations between neuronal activity and pathological
(5 ± 1 Hz) tremor (10-20 msec), dynamic spectral density of the flow of impulses (0.1-0.8 Hz)
describing changes in the timing of BFA frequency pattern, and so on. An approach based on
the creation of a multi-parameter data bank was adopted in order to study the relationship
between unit activity pattern and aspects of the spatial location and the connection with the
motor pathology peculiar to parkinsonism (i.e., tremor). To this end, each Rt site investigated
was described by a set of up to 25 parameters, covering quantitative aspects of BFA based
on analytical classification — numbers of neurons with single, bursting, and rhythmic dis-
charges, spike rate, length of interburst and intergroup intervals, variability of rhythmic
pattern, number of spikes per burst and per group, etc; aspects of spatial location of Rt
neurons as calculated by x-ray techniques, and a number of clinical indicators, rate,
variability, and degree of tremor and so on. A secondary analysis was carried out on the
basis of our findings to reveal sets of associated parameters and express statistical rela-
tionships between them. The analysis involved calculating a matrix of whole and partial
correlations in order to exclude the influence of variable correlates and their own vectors
and numbers (the primary factor method) and producing a multiple regression equation for
each chosen parameter. Results with a fairly high probability level (p < 0.001-0.1) were
taken into account.

A total of 240 neurons found at 115 Rt sites during 37 stereotaxic operations were in-
vestedigated. Research was conducted on clusters of cells located in the dorsoventral portions
of the rostral Rt.

RESULTS

Analysis of BFA pattern in different portions of the Rt revealed the presence of three
main types of unit. The BFA of the first type of cell, or A neurons (95 out of 240, = ~ 40%)
took the form of single irregular spikes following at the rate of up to 10 Hz (mean value
X = 3.6; standard deviation: o = 2.7 — see Fig. 1a). The activity pattern was marked by a
blunted, diffuse BFA configuration free of narrow localized modes and of level autocorrela-
tion on the histogram (Fig. 1b, c, d). A trend towards spikes grouped in the second range
was observed in 70% of A neurons (Fig. 1d) with a variation in the duration of group and
intergroup intervals (0.2-1.0 sec and 0.5-3.0 sec respectively), intensifying under different
forms of functional testing. A total of 11% A cells were "silent". Activity was only dis-
played by these neurons during presentation of functional tests and/or during the refractory
period. It was only possible to record the activity of several adjacent A neurons simulta-
neously using a single microelectrode in a limited number of cases; these were generally found
to operate according to an asynchronous pattern.

The BFA of type II (burster) cell, or B neuron, representing 118 out of 240 cells, or
49%, displayed short (10-20 msec), high-frequency (up to 500/Hz), bursts of impulses consist-
ing of 3-6 spikes (X = 3.4; o = 0.5) with an interspike interval of 2-5 msec (X=3.2; o = 0.8)
— Fig. 2a. An autocorrelator analysis of B neurons indicated a regular succession of spikes
within the bursts as revealed on graphs of probable density in the presence of a periodic
component in the 2-5 msec range (Fig. 2c); width of mode: not more than 1.2 msec. One typical
feature found in 76% of B neurons was the trend towards periodically occurring bursting
volleys in the 2-5 Hz range (X = 4.0; o = 0.8). This periodic rhythmic component was found-
on the histogram of interspike intervals in the form of one 30-110 msec wide mode (Fig. 2b)
in the autocorrelation function, in the form of a clear-cut rhythmic pattern (2e), and again,
in the case of dynamic spectral analysis, in the presence of a frequency mode in the region
of 2-5 Hz (2d). The periodically occurring groups of between 3 and 7 rhythmically succeeding

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