Some Observations during Stimulation of the Human Hypothalamus

S. KALYANARAMAN

Institute of Neurology, Government General Hospital, Madras

Until about ten years ago, knowledge of the structure and functions of the human hypothalamus was derived largely from animal studies. Hess [2] and Kabat et al. [3] have carried out some of the most extensive studies on the hypothalamus of the cat.

The first stimulation studies of the human hypothalamus were published by Sano et al. [4]. Balasubramaniam et al. [1] and Schwarcz et al. [5] have confirmed many of the earlier findings.

Sano et al. [4] showed that changes in blood pressure, pulse, respiration and pupils as well as ocular movements were produced on stimulation in the region of the ergotropic triangle. Less than 1 mm from the wall of the third ventricle and more than 5 mm away from it, parasympathetic types of responses were obtained. Within the zone, 2–3 mm from the wall of the third ventricle, sympathetic types of responses were reported. The responses in the different parameters of respiration, blood pressure, pulse, pupils and ocular movements showed no zonal grouping with respect to each individual function.

The present study was undertaken to study these responses in detail. The stereotaxic operations were done using the Leksell machine, and stimulation studies of the hypothalamus were carried out preliminary to controlled heat coagulation lesions in the posteromedial hypothalamus to ameliorate aggressive behaviour disorder.

The radiological target in the posteromedial hypothalamus was that described by Sano et al., [4] a point 3 mm below the midcommisural point and 3 mm lateral to the wall of the third ventricle.

Eight postencephalitic cases, six postepileptic cases and one with paranoid schizophrenia were operated for aggressive behaviour disorder or
extreme hyperkinesis. Of these, five had operations on one side and ten had surgery on both hemispheres. Nine were primary hypothalamotomies and six were secondary hypothalamotomies. Thirteen were males and two females. There were six patients in both the first and second decades and three in the third.

There was no mortality in this series. There was no significant or permanent postoperative complication. In particular, there was no gastrointestinal bleeding, pulmonary oedema or diabetes insipidus.

Bipolar stimulation with a Grass stimulator and a Hankinson's electrode was done. The interelectrode distance was 1 mm. The usual parameters of stimulation were 100 Hz, 1 msec, 3–12 V and 5–10 sec. Sometimes parameters used by Hess [2] in animal experiments were employed to facilitate comparison of results. The electrode was introduced up to a point about 8 mm above the calculated target and stimulation was started. Stimulation was repeated every 0.5 or 1 mm till the electrode reached 3 mm below the target. Often a similar procedure was carried out on a parallel track, medial, lateral, anterior or posterior to the standard track. Thus a volume of tissue about $11 \times 8 \times 4$ mm was explored. However, not more than three electrode insertions were done during one operation.

A total of 605 stimulations were done in 15 patients during 25 operations. Changes noted in the pupils were equal or unequal dilatation and sometimes hippus. In this study pupillary constriction reported by others as a parasympathetic effect was not observed even once. The optimum voltage required to elicit responses was important. For example, in operation No. 21, stimulation at 3 V during insertion of the electrode produced no response, while stimulation at 6 V during withdrawal caused marked pupillary responses. This effect was not due to stimulation of remote neurons by a higher voltage. For example, in case No. 4, stimulation, even with 20 V at 2 mm above target, caused no response while just 1 mm below this point, stimulation with 8 V caused pupillary changes.

In some cases, increasing the voltage of stimulation increased the intensity of response, but dilatation was followed by constriction after a time although stimulation was continued. Longer stimulation with higher voltage resulted in hippus. Sometimes asymmetrical dilatation was noted. Greater dilatation of the ipsilateral pupil was observed in superior zones, whereas a few millimeters inferiorly, greater dilatation of the contralateral pupil was observed.

Respiratory responses elicited were arrest, decrease or increase of rate, decrease or increase of amplitude and irregularity of respiration. Usually
apnoea and slowing were observed in superior and anterior zones while tachypnoea was observed more inferiorly and posteriorly. Just as pupillary dilatation was followed by constriction during stimulation, sometimes initial slowing of respiration was followed by hurried respiration during stimulation. On two occasions, stereotaxic hypothalamotomy was attempted through the anterior route by a supraorbital burr hole since the patient has had a stereotaxic basofrontal tractotomy on a previous occasion. Stimulation at 8 mm anterior to Sano’s target caused complete respiratory arrest for 45 min. An identical phenomenon was seen during stimulation on the opposite hemisphere also. It is likely that a highly sensitive area to stimulation lies in this region or it may have been sensitized by a previous basofrontal tractotomy.

Movements of the eye in response to stimulation may be upward or downward deviation, ipsilaterally or bilaterally. Sometimes there may be a medial, lateral or conjugate deviation as well as nystagmus or rotation.

On comparison of the sites where respiratory and pupillary responses were obtained, it was seen repeatedly that respiratory responses occurred at sites above and anterior to the points where pupillary responses were elicited. This was seen in case No. 24, where maximal pupillary dilatation appeared several millimeters below and behind the zones of respiratory responses. Another instance is case No. 5, in whom apnoea occurred above and in front of the area of pupillary dilatation which again was situated above and in front of the area of ocular movement. This pattern was seen repeatedly. Even when the zones of responses of respiration, pupils and eye movements overlapped, it was seen that the same anatomical orientation was maintained.

The following conclusions appear justified on the basis of this study. Pupillary dilatation appeared to be the most common and reliable sign of correct electrode placement. The responses obtained during hypothalamic stimulation were modified by correction responses by the unstimulated regions. The results may be an over-correction or repeated unsustained correction like hippocus, nystagmus or irregular respiration. The concept of two parasympathetic zones on either side of a central sympathetic zone has not been definitely confirmed in this study. Sympathetic and parasympathetic responses appeared to be intermingled to a great extent. There appear to be three zones of responses from above to below in the hypothalamus, where respiratory responses, pupillary responses and ocular movements are elicited, respectively. There appeared to be again an anteroposterior distribution in the same manner. There appears to be an an-
terior hypothalamic posterior orbital zone capable of producing respiratory arrest on minimal stimulation. Whether this zone is highly sensitized after a previous basofrontal tractectomy is not yet certain. Responses are not simple reactions of a sympathetic or parasympathetic type. They are the results of complex neuronal interactions in which the brain tries to obtain a new equilibrium with varying degrees of success.

I cannot conclude this presentation more aptly than by quoting the Nobel laureate, W. R. Hess: 'Actually there is a constant play of forces acting on the central nervous system simulating inactivity when there is a state of equilibrium, appearing as function when there are shifts of equilibrium and manifesting itself as a pathologic symptom when only a disequilibrium exists.'

References


