

ALIMENTARY BEHAVIOR IN CATS FOLLOWING LESIONS OF THE VENTROMEDIAL HYPOTHALAMUS

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The problem of the role of various parts of the hypothalamus in the regulation of food intake in animals is still not clear in spite of numerous studies concerning this subject. It is generally accepted that lesions in the ventromedial nucleus of the hypothalamus (VMH) produce hyperphagia leading to obesity (Hetherington and Ranson 1940, Anand and Brobeck 1951, Anand et al. 1955, Mayer et al. 1955, Hamilton and Brobeck 1964, Satinoff 1967). However, the extent and localization of lesions in particular papers are far from being uniform. Some authors doubt the possibility of obtaining hyperphagia as a result of ventromedial hypothalamic lesions (Holmes and Fraser 1965, Rosen 1968). In some cases a slight increase in food intake was produced by these lesions but it failed to lead to obesity (Lewińska 1964, 1967).

Less numerous are the papers concerned with stimulation of this region which give the opposite effect — inhibition of the food intake (Wyrwicka and Dobrzańska 1960).

In recent years strong criticism was put forward to the VMH nucleus lesions technique arguing that anodal coagulation of the VMH nucleus causes an irritating effect upon the hunger center situated in the lateral hypothalamus (Reynolds 1963, 1965, Rabin and Smith 1968). On the other hand Hoebel's opinion (1965) is different because he did succeed in obtaining hyperphagia by electrocautery with radio-frequency current.

To our knowledge there are few papers which clearly confirm the hyperphagic symptoms after injuries of entire VMH nucleus in cats. Such lesions are performed by Morgane and Kosman (1960) but according to their data the increase of food intake is not convincing.

The aim of this paper is to elucidate this problem and to see whether we can make such lesions in the VMH nucleus of the cats leading quantitatively to the same effects as those obtained by Anand and Brobeck (1951) in rats.

MATERIAL AND METHOD

Experiments were performed on 35 cats of both sexes. The instrumental alimentary conditioned reflex (CR), consisting in putting the right foreleg on the food-tray was established. The sound of a bell was the conditioned stimulus (CS). The instrumental response was reinforced by small pieces of raw horse meat. During a daily experimental session, which consisted of 10 trials, each cat was fed with 30 g of meat. Irregular intervals between trials did not exceed 2.0 min. The daily intake of milk and cereal with horse meat (at a ratio of about 1 kg cereal to 1/2 kg of meat) was assessed. Both the pre- and post-operative observation period amounted to six weeks.

The electrocoagulation of the ventromedial areas of the hypothalamus was performed in the Horsley-Clark stereotactic apparatus under Nembutal anesthesia (40 mg/kg). The coagulating electrode, 0.3 mm in diameter, made of stainless steel, was insulated except for its 0.3 mm long tip. Coordinates, establishing the position of electrodes were given according to the Jasper and Ajmone-Marsan atlas (1954). The ventromedial area of the hypothalamus was bilaterally coagulated with a 3 ma direct anodal or cathodal current for 30 sec.

The CR experiments were as a rule resumed on the second day after surgery. After the completion of a series of experiments the animals were sacrificed and their brains perfused with 10 per cent formalin. Paraffin sections 20 μ thick were sliced in the frontal plane. Every tenth one of them was stained alternately by Nissl's and Klüver's methods.

RESULTS

Group I. Lesions exerting no effect on food intake or yielding hypophagic symptoms (26 cats)

Both cathodal and anodal lesions including the whole VMH nucleus did not produce any significant changes in the daily intake of milk and cereal (Fig. 1A). When lesions were larger and particularly extended beyond the VMH nucleus in the dorsal and/or caudal direction, there appeared a decrease of cereal and milk intake which occasionally lasted throughout the observation period (Fig. 1BC).

When the lesions were not very extensive and concerned only the dorsolateral aspect of the VMH nucleus, the milk intake was temporarily reduced but the intake of cereal was increased (Fig. 1D). On the contrary when lesions included the ventrolateral part of the VMH nucleus, there was a transient decrease of the intake of cereal and an increase in the milk intake (Fig. 1E).

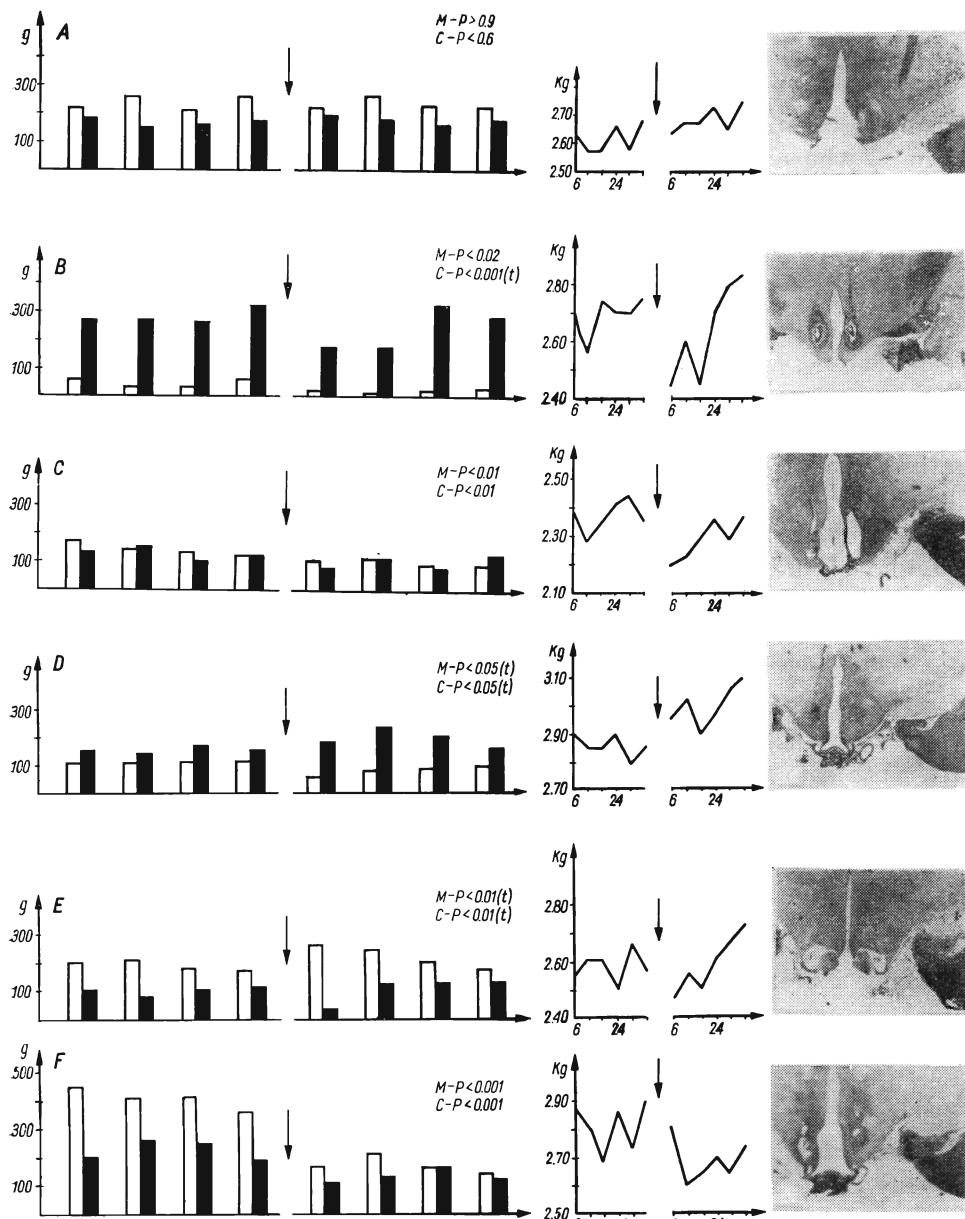


Fig. 1. The effects of representative lesions of the ventromedial hypothalamus on the daily food intake and body weight in cats. Left part of the figure: intake of milk (white bars), and cereal (black bars) before and after hypothalamic lesions. Each bar denotes the average intake for 9 days. Arrows, lesions; M, milk intake; C, cereal intake; t, transient changes in food intake. Middle part of the figure: body weight before and after lesions. Abscissa, time in days. Right part of the figure: the location of lesions. Further explanations in text

The lesions of the posterior part of the VMH nucleus and of the adjoining region extending posteriorly to the frontal plane 9.5 caused a durable decrease in the intake of both solid food and milk (Fig. 1F). Drinking of milk was more strongly decreased after dorsal than ventral lesions, whereas after the ventral lesions the ingestion of cereal was more strongly impaired (Fig. 2AB).

The medial lesions including the bottom and walls of the third ventricle produced usually a very strong decrease of food intake which soon turned into full aphagia (Fig. 2C). It should be mentioned that in some cats of this group the clear symptoms of polyuria and polydipsia were seen. These symptoms were always accompanied with prominent hypophagia of the solid food.

All cats in which the lesions included the entire VMH nucleus refused to eat raw horse meat. Most often they smelled it and even licked it, but did not take it into the mouth. After about two weeks they accepted the horse meat but they ate it slowly and reluctantly till the end of the observation period.

As far as the food CRs are concerned in the early postoperative period they were strongly impaired. This was due to the aversion of the animals towards the horse meat which was presented as reinforcement. It was observed that in the first trials after operation the instrumental response to the bell was present, although the animals refused to take food. Thereafter the cats walked away from the foodtray. After two weeks, when the animals again started to eat meat, the instrumental responses were restored, but the trained movement was performed slowly and with longer latency.

Group II. Lesions yielding increase in food intake (9 cats)

Some increase (on the average by 25 per cent) in the intake of cereal and milk was observed after lesions which included the lateral part of the VMH nucleus and an adjoining region (Fig. 2D). In one case an increase in the intake of both cereal and milk was obtained after a ventral lesion extending anteriorly beyond the VMH nucleus (Fig. 2E).

Concerning the instrumental CRs the cats of this group did not display in general any observable deficit. Some cats manifested very transiently the symptoms described for group I, but after a few days they returned to normal.

Within six weeks after the surgery, the body weight of the animals of group I either did not change or, as a result of hypophagia decreased within limits of a few to about 15 per cent. A larger decrease was noticed in cases of aphagia. An increase in body weight of cats of group II reached about 14 per cent.

As far as the general emotional changes in our operated cats are concerned, they were observed after partial lesions of the VMH nucleus: the appearance of the aggressive behavior was observed mostly after dorsal lesions whereas an increase in the timidity or anxiety occurred after the lesions of the ventral areas.

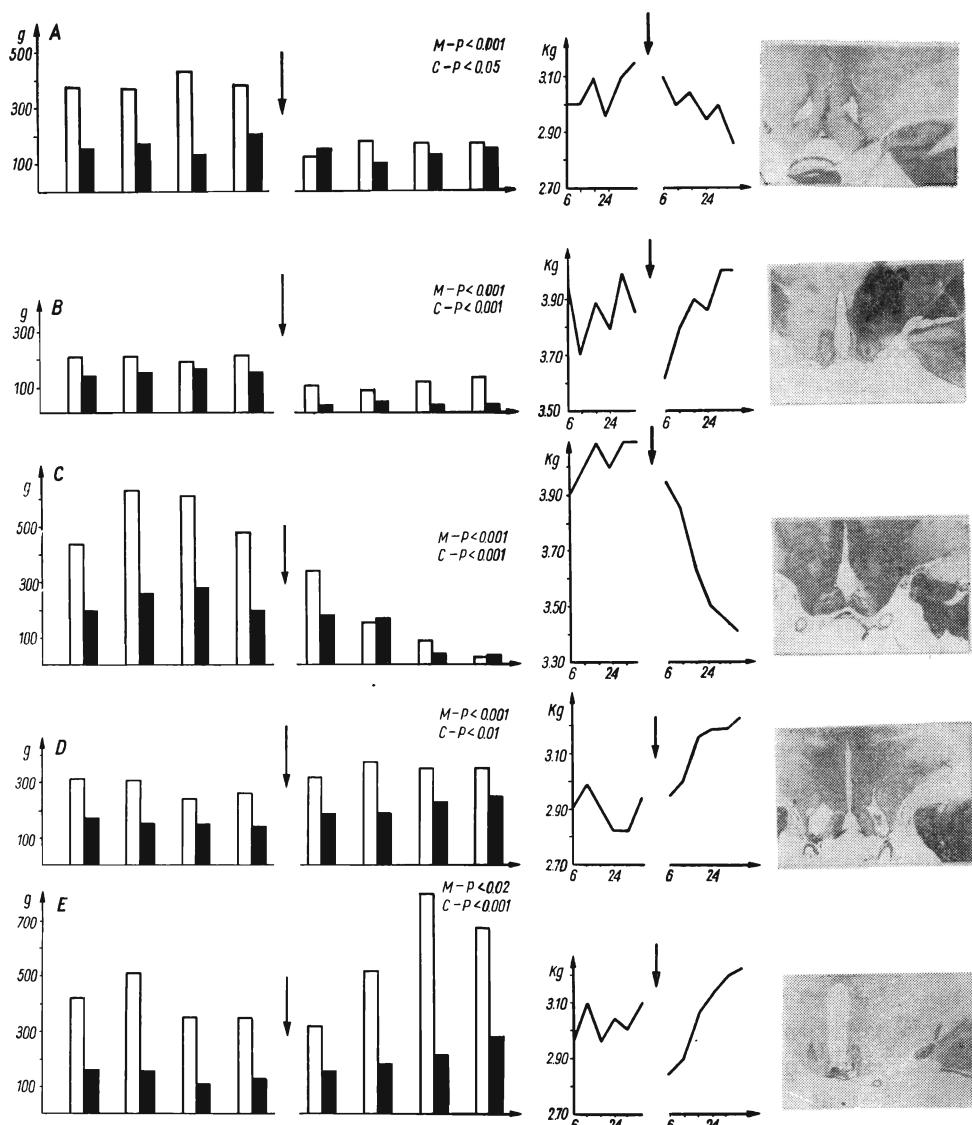


Fig. 2. Denotations as in Fig. 1

DISCUSSION

Our data in the cat indicate that lesions in the VMH nucleus produced either no changes in the food intake, or its moderate increase, or else a decrease sometimes to a degree of full aphagia and adipsia.

The increase in the solid food and milk intake occurred chiefly after the lesions in the lateral part of the VMH nucleus. Since our lesions were performed either with cathodal or anodal current, the Reynolds (1963) criticism of the lesions technique seems not to be relevant in respect to our experiments.

As was shown (Lewińska 1968) stimulation of the lateral part of the VMH nucleus produced suppression of the food intake and of alimentary instrumental CRs.

Taking all these data into account it may be concluded that the lateral part of the VMH nucleus should rather be regarded as the "satiety center" described in other animals. The only difference between the effects of lesions in cats and those in rats is that the increase of food intake was in cats insignificant and did not lead to obesity.

There may be two explanations of these differences. On the one hand, it can be assumed that in cats the neurons responsible for satiation and those responding for hunger are intermixed within the VMH nucleus, and therefore their joint destruction cannot lead to a pure hyperphagic effects. On the other hand, it may be supposed that the Carnivora in contradistinction to Rodents do not need to have any well developed mechanism of suppression of the food intake. This is because in their life conditions the food is only rarely available and when the pray is attained the animals eat it practically ad libitum.

Lesions situated in more medial parts of VMH nucleus led in our animals to a very clear opposite symptoms, namely to hypophagia, hypodipsia, or even aphagia. The effect was most prominent with regard to raw horse meat to which the cats exhibited strong aversion for some time after the operation. These results are in good agreement with our earlier experiments which have shown that stimulation of these regions elicited an enhancement of instrumental responses and hastening of the food intake (Lewińska and Romaniuk 1966, Lewińska 1968). The intake of food was also observed by Robinson and Mishkin (1968) during stimulation of the medial hypothalamus in satiated monkeys.

What is the cause of the decrease of the food intake after the lesions closely adjoining to the third ventricle? Whether this region should be regarded as another center controlling the food intake, or whether it comprises fibers running from other structures involved in control of food intake, should be clarified by further experiments. Since as we

have seen the VMH nucleus and its close environment includes two antagonistic systems increasing and decreasing the food intake it may be understood why large lesions in this region often do not lead to any clear changes in the amount of food intake.

All these results seem to indicate that the "satiation center" in cats is situated in the lateral part of the VMH nucleus. On the contrary, the remaining region of the VMH nucleus is not concerned with satiation but rather controls to some extent the food intake.

SUMMARY

The effects of electrolytical lesions of the ventromedial hypothalamus on alimentary instrumental responses and daily food intake in cats have been investigated.

The lesions of the whole VMH nucleus produced no increase in daily intake of either cereal or milk. Lesions comprising medial and caudal parts of VMH nucleus caused a decrease of the intake of cereal and milk. Some medial lesions situated close to the walls of the third ventricle led to full aphagia and adipsia.

Hyperphagia and hyperdipsia of moderate degree was obtained mainly by injuries located in the lateral part of the VMH nucleus.

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