THE ROLE OF THE CEREBRAL CORTEX IN NARCOLEPSY; THE CLASSIFICATION OF NARCOLEPSY AND ALLIED DISORDERS

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PHYSICIANS writing on the anatomical substrate of narcolepsy have focussed their attention on the sleep centre thought to exist in the neighbourhood of the third ventricle. Relatively little consideration has been given to the possible rôle of the cerebral cortex. I shall try to show that, so far as this problem is concerned, consideration of the cortex is of great importance.

Even if we had not the advantage of Pavlov's work on inhibition, it would be evident that the cortex has something to do with sleep. If there is any truth in the universal assumption that the cortex is the organ with which we comprehend, reason and initiate voluntary movements, then, since these functions are (with insignificant exceptions) in abeyance during sleep, one must conclude that during sleep the cortex is in a state of inactivity. Pavlov's work, showing that sleep is a state of cortical inhibition, clinches this conclusion.

When one falls asleep, then, it is the cortex which, so to speak, 'falls asleep.' I do not deny that there is a sleep centre. For the sake of argument I shall assume there is. But I submit that it would be one-sided to consider sleep from the standpoint of only the sleep centre.

What is the functional relation of the sleep centre to the cortex? The answer can only be surmised. It seems probable that the sleep centre helps to regulate the frequency, duration and depth of sleep. It probably does not *cause* sleep. Sleep must be *caused* by the fact that cortical cells, in consequence of their activity, become 'fatigued,' whereupon inhibition supervenes to restore them to normal irritability. Perhaps the sleep centre in some way neutralizes the effects of fatigue, thereby prolonging wakefulness and increasing the efficiency of the cortex as an adaptive instrument. Perhaps, on the other hand, the centre acts in the opposite direction by increasing the effects of fatigue, thereby diminishing any possibility of the destruction of cortical cells from overwork. Which, if either, of these guesses is correct is a question with which, in this paper, we need not be concerned. I shall only assume that the sleep centre in some way regulates the frequency,

duration and depth of sleep, emphasizing again that sleep is a state of the cortex and not of the sleep centre.*

If this assumption be granted, it follows that there is no compulsion to regard *all* cases of morbid somnolence as due to a perturbation of the sleep centre; *some* cases *may* be due to perturbations of the cortex. An analogy may be seen in cases of inability to use a limb. Besides the arm proper, there is a nervous mechanism regulating the movements of the arm. Not all cases of disability of the arm are due to perturbations of its nervous mechanism: in some cases the disability results from a fracture of the humerus or a boil in the axilla. In these cases the disability occurs *in spite of* the integrity of the nervous mechanism. Similarly, I submit that while some cases of morbid somnolence may be due to faulty regulation exercised by a disordered sleep centre, there must be other cases resulting from a disordered cortex, the cortex being excessively 'inhibitable,' i.e. succumbing with undue ease to the spread of inhibition *in spite of* the integrity of the sleep centre.

In a given case of morbid somnolence, how may one determine whether there is excessive cortical inhibitability? In answer to this question I offer two propositions.

1. *When the patient's only complaint is morbid somnolence, there is, in the present state of our knowledge, no way to tell whether the seat of the trouble is the sleep centre or the cortex.* Conceivably the sleep centre may be at fault, permitting a healthy cortex to 'fall asleep' too easily; or the cortex may be at fault, being unduly inhibitable.

2. *When the symptoms include 'localized sleep' in any of its forms, it would seem obligatory to infer that one or more parts of the cortex are unduly inhibitable.* This proposition must be presented more fully.

In a recent paper¹ I pointed out that certain clinical phenomena may be regarded as special instances of a general phenomenon designated by Pavlov as 'localized sleep.' The following are the most important examples.

(a) *Sleep-paralysis.*—It is convenient to cite this first. Sleep-paralysis exists in two varieties: *predormital paralysis*, in which the patient, while falling asleep, suddenly finds himself paralysed, remaining so until he lapses into slumber a few minutes later (unless, as sometimes happens, the paralysis is accompanied by anxiety and the return of full awakeness); and *post-dormital paralysis*, in which the paralysis is on waking. In each variety the patient is conscious. It seems permissible to say that in sleep-paralysis the 'motility substrate' is, in comparison with the 'substrate of consciousness,'

* It may be objected that decorticate animals have regular cycles of sleeping and waking. This by no means proves that the cortex has nothing to do with sleep. Unquestionably, sleep involves probably every part of the brain, indeed probably every part of the body. But when one thinks of a person asleep, the picture that comes to one's mind is of a person who makes few or no movements, who is unaware of the environment and whose thinking, if any, is reduced to the most primitive terms—a picture, that is, of a person whose cortical function is in partial, if not complete, abeyance.

unduly inhibitable. Thus, in the postdormital variety, when the substrate of consciousness is released from inhibition (the patient waking), the motility substrate continues for several minutes under the inhibitory spell. If the motility substrate were not unduly inhibitable, it would be released from inhibition precisely at the same moment as the substrate of consciousness, and the patient would be able to move the moment he awoke.

Inhibition of the motility substrate may also occur without relation to falling asleep or waking, as in (b) and (c).

(b) *Cataplexy*: attacks of powerlessness, with unimpaired consciousness, precipitated by laughing and other emotions. Two facts are noteworthy. (1) The cataplectic attack is identical with an attack of sleep-paralysis (save in regard to the precipitating circumstances); in each the patient is conscious, powerless and atonic. (2) The cataplectic attack sometimes passes over into sleep, i.e. the inhibition presumed to exist in the motility substrate 'irradiates' to the substrate of consciousness.

(c) *Attacks of powerlessness, with unimpaired consciousness, occurring 'spontaneously,'* i.e. without antecedent emotion and without relation to falling asleep or waking.

The three examples just given have this in common, that the motility substrate is inhibited but not the substrate of consciousness. The reverse holds for the next example.

(d) *Increased Motor Activity during Sleep*.—Contrary to a belief once prevalent, many, if not most, narcoleptics are restless during nocturnal sleep. Moreover, when diurnal sleep supervenes during some motor performance, the patient sometimes continues while asleep to perform the movements automatically; if, for example, he falls asleep while walking or riding a bicycle, he may wake up some distance away. Here one may assume inhibition localized in the substrate of consciousness. Answering to inhibition of this substrate, the patient is asleep; answering to the absence of inhibition of the motility substrate, there are movements instead of muscular relaxation and inactivity.

The crux of this paper lies in my contention that (1) when clinically significant manifestations of localized sleep occur, it would seem obligatory to assume an abnormality of the cortex—an abnormality exhibiting itself in lack of uniformity in the degree of inhibitability of various parts of the cortex, some parts being more inhibitable than others; (2) there is no such obligation when the patient has morbid somnolence but not localized sleep. When his only symptom is that he too often falls asleep, there is no way to tell whether his cortex is unduly inhibitable, or whether it is a normal cortex responding with morbid somnolence to abnormal conditions in the sleep centre. On the other hand, when a patient (with or without morbid somnolence) shows signs of localized sleep, one cannot escape the conclusion that some (if not all) of his cortex is unduly inhibitable. Taking a specific example, it is hard to imagine a perturbation of the sleep centre that could account for sleep-

paralysis. Assuming in the sleep centre a perturbation such as would produce a sleep attack lasting 10 minutes, the patient—if his cortex is normal—should respond with a sleep attack and nothing more; i.e. he should fall asleep in a normal way and, after 10 minutes, wake up in a normal way, without showing any phenomena that do not accompany the falling asleep and waking of a healthy person. If, instead of falling asleep normally, he first passes through a stage of paralysis, or if on waking there is paralysis, it would seem necessary to assume that his motility substrate is appreciably more inhibitable than his substrate of consciousness.

When, as I have already tried to show, a patient has morbid somnolence and not localized sleep, one cannot tell whether the sleep centre or the cortex is at fault. On the other hand, if it is correct to assume that localized sleep points to a disturbance of the cortex, one may, in a case of morbid somnolence and localized sleep, surmise that the somnolence is *probably* of cortical origin, in keeping with the principle that one disturbance if possible should be postulated to account for the symptoms of a given case.

The vast majority of patients with localized sleep also have morbid somnolence. For example, cases in which there is only cataplexy are rare, while cases of cataplexy and morbid somnolence are relatively common. In other words, cases are rare in which there is undue inhibitability of only one part of the cortex. Once a part of the cortex begins to show signs of undue inhibitability, other parts are apt to show the same quality.

Where, as regards localized sleep, shall one draw the line between normal and abnormal? This cannot be satisfactorily answered, and physicians must for the present rely on clinical common sense. When a patient complains that on hearty laughter he falls helpless to the ground, it is easy to recognize the symptom as abnormal. By contrast, I have seen a patient in whom strong emotion led to manifestations so nearly normal that it would be hard to say whether they are of clinical importance. The question is especially difficult in relation to restlessness and elaborate motor activity during sleep. Many narcoleptics fall asleep while walking and continue walking, but this happens also in the healthy; soldiers, for example, sleep on forced marches. Still more difficult is the question of the minor degrees of restlessness which occur during the sleep of the healthy as well as the narcoleptic.

CLASSIFICATION OF NARCOLEPSY AND ALLIED DISORDERS

In accordance with the foregoing discussion I suggest that cases of narcolepsy and allied disorders be divided into two groups.

Group One.—Cases of Morbid Somnolence, without Signs of Localized Sleep.—In these cases it is impossible, with present methods, to tell whether one is dealing with an unduly inhibitable cortex or with a normal cortex reacting to pathological influences extraneous to it.

Group Two.—Cases with Signs of Localized Sleep, with or without Morbid

Somnolence.—Here, as I have suggested, it would appear necessary to assume that part or all of the cortex is unduly inhibitable.

Occasionally there are cases of narcolepsy in which morbid somnolence appears first, cataplexy and other signs of localized sleep not appearing until much later. Such cases, prior to the onset of signs of localized sleep, would be regarded as belonging to Group One, whereas really they belong to Group Two. The fact that this error will occur in some cases does not render illogical the classification here proposed.

In Group Two, as in Group One, there are some cases that are 'idiopathic' and others that are symptomatic. The classification of ætiological factors proposed by Wilson ² is valid for Group Two no less than for Group One. I believe that even in the 'idiopathic' cases there is some abnormality of the brain, even if this cannot be detected with present methods.

The proper use of the word 'narcolepsy' has occasioned much dispute. Many authors have felt that the term should not be restricted to cases in which morbid somnolence and cataplexy coexist, but should be applied also to those in which the only symptom is morbid somnolence. In view of the foregoing discussion I cannot agree with this opinion. It is misleading to attach much importance to the fact that the two groups of cases have a common denominator, morbid somnolence. No one would think of classifying under the same heading a case of chronic nephritis and a case of diabetes mellitus, notwithstanding their common denominator polyuria. The polyuria has different meanings in the two cases; in the one it occurs because of disease of the kidneys, while in the other it occurs *in spite of* the normality of the kidneys. Similarly, morbid somnolence may have different meanings in different cases. A case belonging to my Group One is potentially different from one belonging to Group Two, since in the one there is no certainty whether the cortex or the sleep centre is involved, while in the other it seems certain that the involvement is of the cortex. It matters not to which group one wishes to apply the term; I submit only that the term cannot logically do for both. My own inclination would be to speak of Group One as cases of morbid somnolence, and of Group Two as cases of narcolepsy. I would apply the term 'typical narcolepsy' to those in which there are both attacks of powerlessness (whether spontaneous or in relation to emotion or to falling asleep or waking) and sleep attacks. There are a few cases in which the patient has attacks of powerlessness but no sleep attacks; to these I would apply the term 'atypical' or 'abortive' or 'rudimentary' narcolepsy, specifying in each case the symptom or symptoms present—e.g. 'a case of cataplexy,' 'a case of sleep-paralysis,' or 'a case of cataplexy and sleep-paralysis,' etc.

The atonia that accompanies cataplexy has been mentioned only in passing, since this paper is concerned chiefly with the rôle of the cortex. Obviously, inhibition in the cortex alone will not account for atonia; one must assume that there is also inhibition of certain subcortical centres.

SUMMARY

Consideration is given to the rôle of the cerebral cortex in the pathogenesis of narcolepsy. The cortex is, so to speak, the part that sleeps. In Pavlov's terms, sleep is a state of inhibition irradiated over the cortex. The probable function of the sleep centre is to regulate the frequency, depth and duration of sleep ; but it is the cortex that 'sleeps' and not the sleep centre.

Two groups of cases may be distinguished : Group One, consisting of cases of morbid somnolence, without signs of localized sleep ; and Group Two, cases with signs of localized sleep, with or without morbid somnolence. The four principal signs of localized sleep are cataplexy, sleep-paralysis, attacks of powerlessness occurring without relation to sleep or emotion, and increased motor activity during sleep.

In cases belonging to Group One it is impossible, with present methods, to determine whether the disturbance is in the cortex or the sleep centre. Conceivably in some cases the cortex is at fault, being unduly 'inhabitable' (i.e. succumbing to inhibition with undue ease), while in others the cortex is normal but responds with morbid somnolence to some perturbation of the sleep centre.

In cases belonging to Group Two there are, on the other hand, reasonable grounds for the belief that it is the cortex which is at fault, parts or parts of it being unduly inhabitable.

REFERENCES

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- ² WILSON, S. A. K., *Modern Problems in Neurology*, 1929, chap. V ('The Narcolepsies').