

THE EFFECTS OF PNEUMONIA AND OF POST-MORTEM CHANGES ON THE PERCENTAGE OF WATER IN THE BRAIN OF THE ALBINO RAT

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A. THE EFFECTS OF PNEUMONIA

The determination of the percentage of water in the brain and in the spinal cord of the normal albino rat between birth and maturity, recently published (Donaldson '10), has made it desirable to test how far this character might be modified by disease. For this purpose rats suffering from a common lung infection, usually designated as 'pneumonia', were used. This disease causes marked emaciation in its advanced stages and generally some loss in the weight of the brain. It attacks rats when they are half-grown, runs a variable course and usually appears to be fatal.

Some of the rats used in this investigation were found dead, others were killed because a loss of weight and general behavior indicated illness. In the latter instances, when the autopsy showed pneumonia, the brain of the animal was used.

Taken altogether, 51 infected animals were examined, of which 22 were males and 29 were females. In making the records it was noted whether the infection was beginning, as indicated by a congested condition of the lungs, or had proceeded further; the later stages of the disease being designated as moderate, bad, or very bad.

The technique of measuring the animal, removing, weighing and drying the brain was similar to that described in the paper by Donaldson ('10). The exact ages of the diseased rats were not

known, but this difficulty has been met in a manner which will be described later.

When the 22 males were grouped, it was observed that five of them had been found dead; the records for these animals were placed in a series by themselves. In four of the other animals the disease had made little progress; these rats were also grouped by themselves. The remaining 13 males belonged to the group of animals designated as 'seriously affected,' and were therefore classed together.

It seemed desirable, in the first instance, to know whether the percentage of water in the brains of the (4) lightly affected animals was different from that in the brains of the (13) more seriously affected. A direct comparison between the two groups does not give this information because the animals are not of the same size, and consequently probably not of the same age. It is important, therefore, to learn whether in the group consisting of the 13 seriously affected animals those which were longer (larger) were also probably older. To test this point the 13 records were arranged in the order of the increasing body length in subgroups of 4, 4 and 5. Table 1 gives the average body length in mm., and the average percentage of water for the three subgroups named.

TABLE 1

MALES

NUMBER OF CASES	AVERAGE BODY LENGTH IN MM.	AVERAGE PERCENTAGE OF WATER IN BRAIN
4	173	77.92
4	195	77.64
5	209	77.58

As will be seen from an examination of this table, increasing body length gives a decrease in the average percentage of the water in the brain. In general then, the longer animals are older animals, as we should expect, for with advancing age would go an increase in the body length and a decrease in the percentage of water in the brain.

When the records for the females are treated in the same way, we have a total of 29, reduced by 8 which were found dead, and again by 2 which were in the early stages of the disease, leaving a series of 19 animals which were seriously affected.

If these latter are divided into three subgroups of 6, 6 and 7, after the manner used for the males, and the averages taken, the relations exhibited in table 2 are obtained. As these relations are susceptible of exactly the same interpretation as that given for table 1, it is probably that in both series increase in body length indicates an increase in age.

TABLE 2

FEMALES

NUMBER OF CASES	AVERAGE BODY LENGTH IN MM.	AVERAGE PERCENTAGE OF WATER IN BRAIN
6	166	77.82
6	178	77.60
7	194	77.44

It now becomes possible to compare the 'lightly affected' individuals with those in which the disease had become more or less serious.

Among the males there are four cases showing only the beginning changes of pneumonia. The average body length of these individuals is 198 mm., and the percentage of water in the brain is 78.21 per cent which is some 0.6 of a per cent more than that of the subgroup of males in table 1, the body length of which (195) is nearest to 198.

Similarly in the case of the females, there are two cases showing early stages of the disease, which have an average body length of 170 mm., and a percentage of water 78.26 per cent, which is something over 0.4 of a per cent more than that in the first subgroup of females to the body length of which (166) these come nearest.

This seems fair proof, when both sexes are considered, that at the beginning of the disease the percentage of water in the brain is higher than it is when the disease has progressed for some time.

Theoretically the percentage of water in the brains of the groups but slightly affected by the disease should be approximately normal. To determine whether this was the case, the following plan was pursued. From the data contained in a study "On the relation of the body length to the body weight and to the weight of the brain and of the spinal cord in the albino rat," (Donaldson '09) it has been possible to form tables for each millimeter of body length, giving the corresponding weights for the body, brain and spinal cord of both sexes. From this table the normal weights of the slightly affected groups, as based on their body lengths, can be obtained.

In a more recent paper by Donaldson ('10) there is a table giving the percentage of water in the brain according to the body weight of the males, and calculation shows that, within the limits for which it is desired to use this table, the percentage of water for the brain of a female of the same body weight as a given male is, on the average, 0.33 of a per cent less than that tabulated for the male.

Using these data to obtain standard values, it appears that normal males with a body length of 198 mm. might be expected to have 78.08 per cent of water in the brain, and that females with a body length of 170 mm. should have 78.22 per cent. In both cases it is seen that the coincidence between the observed percentage of water and that calculated in the manner given is sufficiently close to warrant the statement that slightly affected animals have the normal percentage of water in the brain. These results are brought together in table 3.

TABLE 3

Animals slightly affected by pneumonia

NUMBER OF CASES	BODY LENGTH	PERCENTAGE OF WATER OBSERVED	PERCENTAGE OF WATER CALCULATED
4 M.	198	78.21	78.08
2 F.	170	78.26	78.22

Since it has already been shown that in those cases in which pneumonia is well developed the water content of the brain is somewhat less than that in the brain of the slightly affected groups, it follows that the tendency of this disease is to cause a slight reduction in the percentage of water in the brain.

It is perhaps fairest to measure the amount of this reduction by the same procedure which was employed above to show that in the slightly affected groups the percentage of water in the brain is about normal. Following this plan the normal percentage of water was calculated for each of the 13 males and the 19 females which were in advanced stages of pneumonia when killed. The average of these percentages is compared in table 4 with that of the percentages of water actually observed in these groups.

TABLE 4

NUMBER OF CASES	PERCENTAGE OF WATER OBSERVED	NORMAL PERCENTAGE OF WATER (CAL.)	DEFICIENCY OF WATER (PNEUMONIA RATS)
13 M.	77.68	78.19	0.51
19 F.	77.61	78.04	0.43

The deficiency in the amount of water in the brains of rats suffering from well marked pneumonia, as shown in table 4, is about the same as that found when the brains of animals slightly affected are compared with those of the groups in more advanced stages of the disease. It should be added that while this deficiency does not occur in each individual case, yet it is found in 12 of the 13 males, and in 16 of the 19 females. Taking the mean obtained from both of these series it seems evident that, where pneumonia is well marked, the percentage of water in the brain has been reduced as a result of the disease by from 0.4 to 0.5 of a per cent below normal. By using a larger series and separating the cases in which the disease was moderately developed from those where it had reached the last stages, graded results would probably be obtained. At present it does not seem advisable to follow the matter further.

B. THE EFFECTS OF POST-MORTEM CHANGES

The study of the influence of post-mortem changes on the percentage of water in the brain of the albino rat was suggested when the data for the rats previously mentioned as "found dead" were compared with those obtained from the foregoing specimens which had been dissected immediately after being killed with ether.

The determinations for the 5 males and for the 8 females found dead are given in table 5 and are there compared with the values for the percentage of water which might be expected in normal animals of the same size.

TABLE 5

NUMBER OF CASES	PERCENTAGE OF WATER OBSERVED (RATS FOUND DEAD)	PERCENTAGE OF WATER CALCULATED (NORMAL)	EXCESS IN RATS FOUND DEAD
5 M.	78.39	78.00	0.39
8 F.	78.46	78.17	0.29

All of the rats found dead exhibited the lesions of pneumonia in an advanced form, and if they had been killed with ether and examined immediately after death would probably have shown a percentage of water from 0.4 to 0.5 per cent *less* than normal. As can be seen from table 5, these rats actually have from 0.3 to 0.4 per cent *more* water in the brain than normal. This increase was found in 4 of the 5 males and in 5 of the 8 females.

It was estimated that, on the average, these animals had been dead from six to eight hours at room temperature before they were dissected and examined. During this period, therefore, they not only gained in their brain tissue the water lost as the result of pneumonia, but they added also enough to increase the amount from 0.3 to 0.4 per cent above what we should have expected to find in the brains of normal animals.

This result, of course, was obtained in animals undergoing post-mortem changes after dying from an extensive infection of the lungs. In considering the results, therefore, the post-mortem influence of the infection has to be regarded.

Following the suggestion of these observations, I have sought to determine experimentally what the influence of a post-mortem interval of eight hours at room temperature (May and June) would be on the percentage of water in the brains of healthy rats.

The procedure was to kill with ether four animals (members of the same litter) early in the day, examine two of them immediately, but leave the others on the table for eight hours and at the end of that time remove and weigh the brains. In this manner five litters, represented by 20 animals, were studied. The ages of the litters were from 91 to 97 days, and the sexes were equally divided between the fresh and the stale groups within each litter.

The outcome of this investigation was as follows: In eight of the ten comparisons the stale animals showed more water in the brain than did the normal. In each of the five litters the average of the percentage of water in the brains of the stale rats was greater than that in the case of the rats examined immediately after being killed. Table 6 gives these results in detail.

TABLE 6

LITTER	PERCENTAGE OF WATER IN THE FRESH BRAIN	PERCENTAGE OF WATER IN THE STALE BRAIN (8 HOURS POST-MORTEM)
1	78.90	79.08
2	78.80	78.84
3	78.47	78.98
4	78.85	79.01
5	78.74	79.42
Average.....	78.75	79.06

Excess = 0.31. per cent

From the foregoing table it is plain that the changes occurring during eight hours post-mortem, under the conditions outlined above, cause a rise of about 0.3 per cent above the normal amount of water in the grain.

In table 5 it is seen that the rats found dead also had about 0.3 to 0.4 per cent more water in the brain than was to be expected

in the normal. It is to be further noted in their case, however, that the brain, owing to pneumonia, probably had at the moment of death from 0.3 to 0.4 per cent less water than is present in the brains of normal animals. It is evident, therefore, that the infected animals must have undergone a greater post-mortem change than did those of the five normal litters described above.

From these several series of observations it follows that:—

1. Pneumonia in the albino rat reduces the percentage of water in the brain by 0.4 to 0.5 per cent.

2. Post-mortem changes occurring during the first eight hours after death cause an increase in the percentage of water in the brains of normal rats amounting to 0.3 per cent. In the case of rats dying from pneumonia the increase in the amount of water in the brain is about 0.7 to 0.8 per cent above that probably present at the time of death.

LITERATURE CITED

- DONALDSON, H. H. 1909 On the relation of the body length to the body weight and to the weight of the brain and of the spinal cord in the albino rat (*Mus norvegicus* var. *albus*). Jour. Comp. Neur. Psych., vol. 19, no. 2, pp. 155-167.
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