logical disturbance observed after diminution of the intra-cranial cavity.

In the animals experimented on, any considerable increase of the intra-cranial pressure above the normal (about 10 mm. mercury) interferes with or arrests the cerebral circulation.

A further Result. November 27, 1893.

On driving salt solution coloured with methyl blue into the subdural space at the rate of 1 c.c. a minute, the urine which was collected from one ureter became of a blue colour in from 15 to 30 minutes. On *post-mortem* examination, the upper portion of the first lymph gland in the cervical chain was found to be coloured blue; in the central nervous system the blue colour was found limited to the cerebral hemisphere on the side of injection, the base of the brain, and the cervical region of the cord. Conclusion—The blood vessels form the pathway of absorption of fluid from the subdural space.

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II. "Experimental Researches into the Functions of the Cerebellum." By J. S. Risien Russell, M.D., M.R.C.P., Assistant Physician to the Metropolitan Hospital. Communicated by Professor Victor Horsley, F.R.S. Received December 14, 1893.

(From the Pathological Laboratory of University College, London.)

(Abstract.)

The views that have been expressed as to the probable functions of the cerebellum are briefly alluded to, and the results obtained by previous investigators, as the direct outcome of experimentation, are detailed at greater length.

The objects of the present research were to determine:

1. Whether each lateral half of the cerebellum is capable of acting independently, or whether it is necessary for the connexions between the two halves to be intact, in order that the functions of the organ should be properly performed.

2. If impulses pass from one side of the organ to the other before they are transmitted to the cerebrum or spinal cord.

3. What is the nature of the impairment of movement which results when portions of the organ are removed.

4. What relationship exists between one half of the cerebellum

and the cerebral hemisphere of the opposite side, and what is its probable nature.

5. Whether one lateral half of the cerebellum is related mainly to the same side of the spinal cord, to the opposite side, or to both, and what the nature of the relationship is.

6. What symptoms resulting from experimental lesions of the cerebellum are mostly to be relied on for localisation.

7. Whether any, and if so which, of the symptoms are dependent on interference with the labyrinth or 8th nerve when experimental lesions of the cerebellum are produced.

The procedures adopted in attempting to elucidate these problems were:

1. Median vertical section separating the two lateral halves of the cerebellum from each other.

2. Extirpation of one lateral lobe.

3. Removal of half the organ, *i.e.*, of one lateral lobe together with one lateral half of the middle lobe.

4. One or other of the last two methods of procedure as a preliminary, and subsequent comparative investigation of the excitability of the two cerebral hemispheres.

5. Similar preliminary methods as in the last instance, followed by the administration of the essential oil of absinthe, and comparison of the effect of the resulting convulsions on the muscles of the two sides of the body.

6. Removal of both lateral lobes of the cerebellum.

7. Extirpation of the whole or half of the posterior part of the middle lobe.

8. Ablation of the whole organ.

9. Control experiments on the labyrinth and 8th nerve, which consisted in:

(*a*) Extirpation of the labyrinth.
(*b*) Intracranial section of the auditory nerve.
(*c*) Chemical irritation of the auditory nerve.

The results detailed refer chiefly to dogs, but the effects of similar lesions of the cerebellum in monkeys are contrasted with these. The question as to whether the cerebellum exerts any trophic influence is separately considered, as is a case of defective development of the cerebellum in a cat.

The investigation of the excitability of the two cerebral hemispheres, as tested by the induced current, yielded results of more than ordinary interest, for, whereas the excitability was equal on the two sides when the cerebellum was intact, the opposite hemisphere was the most excitable after unilateral ablation of the cerebellum, which difference in the excitability persisted, and was still present

even three months after the half of the cerebellum had been removed. The results obtained when absinthe was administered to animals which had been deprived of half the cerebellum also yielded highly interesting and instructive results. The increased excitability of the opposite hemisphere was evidenced by the exaggeration of the convulsions on the side of the cerebellar lesion; and it became also evident that the convulsions on the opposite side were diminished. Further, the curves obtained from the extensor muscles of the anterior extremity on the side of the cerebellar lesion showed that there was a marked alteration in the second stage of the convulsive seizure, for the tonus characteristic of this stage of similar convulsions evoked in dogs whose central nervous system was intact was either replaced by clonic spasms, or a large element of clonus was superimposed on the tonus. The curves from the muscles of both anterior extremities showed this alteration in the second stage of the convulsions when the whole instead of the half of the cerebellum had been previously removed.

The chief conclusions which appear to be warranted are that the one half of the cerebellum does not, in any great measure, depend on the cooperation of the other half for the proper performance of its functions. The bulk of the impulses pass from one half of the organ to the cerebrum, or spinal cord, without passing to the other half. Three factors are responsible for the defective movements which result on ablation of different parts of the organ—incoordination, rigidity, and motor paresis. The last of these is probably directly due to the withdrawal of the cerebellar influence from the muscles, while the exalted excitability of the opposite cortex cerebri, which results after unilateral ablation of the cerebellum, is probably a provision for compensation in this and other connexions. The one half of the cerebellum controls the cells of the cortex of the opposite cerebral hemisphere, and those of the anterior horns of the spinal cord on the same side chiefly, and on the opposite side to a slight extent. It is further suggested that either the cerebral hemisphere whose excitability is increased inhibits the opposite hemisphere, or that, under normal conditions, one half of the cerebellum inhibits the other half, which inhibition being no longer operative, owing to ablation of half of the organ, allows the remaining half to exert an increased control on the opposite cortex cerebri, or on the spinal centres of the same side, or possibly in both directions; but which is the most probable explanation of the phenomena observed is at present left an open question.

The symptoms characteristic of unilateral ablation of the cerebellum are:

1. Rotation and reeling to the opposite side.
2. The side of the face corresponding to the side of the lesion is

directed up, and the spinal column is arched with its concavity to the side of the lesion.

3. Incoordination, chiefly in the limbs of the same side.

4. Rigidity, most marked in the extremities of the side of the lesion, and preponderating in the anterior extremity of the side.

5. Exaggeration of the tendon reflexes most marked on the same side.

6. Motor paresis affecting both extremities on the side of the lesion, and the posterior extremity of the opposite side.

7. Anæsthesia and analgesia having the same distribution as the motor paresis.

8. Deviation of the opposite eyeball downwards and outwards, while that of the same side, if deviated, looks upwards and to the side of the lesion.

9. Lateral nystagmus, the jerks being from the opposite side towards the side of the lesion.

The phenomena which characterise ablation of different parts of the middle lobe, and of the whole organ, are similarly described. Incoordination is next discussed, and it is urged that, instead of looking on the cerebellum as a distinct organ which has a special function, distinct from those subserved by other parts of the central nervous system, it would be more correct to look on it as a part of that system, having many functions in common with other parts of it, the chief difference between one part of this great system and another being the degree in which different functions are represented in any given part: *e.g.*, with regard to motor power, the anterior extremity is maximally represented in the cerebrum and minimally in the cerebellum, whereas the trunk muscles are minimally represented in the cerebrum and maximally in the cerebellum. Arguments are adduced in favour of looking on the ocular deviations which result from ablation of parts of the cerebellum as paralytic rather than irritative phenomena, and two forms of nystagmus are recognised as consequent on cerebellar lesions, one which is spontaneous, and the other which is only evoked on voluntary movements of the globes, and the probable difference in their ætiology discussed. Finally, the phenomena characteristic of unilateral ablation of the cerebellum are contrasted with those the result of extirpation of the labyrinth, and it is shown that no single phenomenon is the same in the two.