February 16, 1899.

The LORD LISTER, F.R.C.S., D.C.L., President, in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The President announced the acceptance by the Council of a portrait of Lord Kelvin, presented to the Society by Dr. Thorpe, on behalf of a large number of the Fellows.

The following Papers were read:—

I. "On the Reflex Electrical Effects in Mixed Nerve, and in the Anterior and Posterior Roots." By Miss S. C. M. SOWTON. Communicated by Dr. A. D. WALLER, F.R.S.

II. "The Characteristic of Nerve." By A. D. WALLER, M.D., F.R.S.

III. "Observations on the Cerebro-spinal Fluid in the Human Subject." By STCLAIR THOMSON, M.D., L. HILL, M.B., and W. D. HALLIBURTON, M.D., F.R.S.

IV. "The Thermal Deformation of the Crystallised Normal Sulphates of Potassium, Rubidium, and Cæsium." By A. E. TUTTON, B.Sc. Communicated by Captain ABNEY, F.R.S.

"Observations on the Cerebro-Spinal Fluid in the Human Subject."

By STCLAIR THOMSON, M.D., LEONARD HILL, M.B., and W. D. HALLIBURTON, M.D., F.R.S. Received January 31,—Read February 16, 1899.

One of us (StC. T.) has had under his care for some years a young woman who has suffered from continuous dripping from the nose. The case has not been amenable to any treatment. At first it was thought to be one of nasal hydrorrhœa, but certain characters in the affection convinced the observer that this could not be so, and that the fluid, which dropped from one nostril only, was cerebro-spinal fluid. This was supported by the results of the chemical examination of the fluid. The escape of cerebro-spinal fluid from the nose has long been known to follow traumatic injury to the cribriform plate of the ethmoid bone, but the possibility of its spontaneous escape from the nose does not

appear to have been fully established before the present instance. However, considerable research into the literature of the subject has shown that there are several cases recorded in which, though no history of injury existed, the flow of fluid from the nose was of such a character that they must have been similar to the present case, although in the majority of instances the true nature of the fluid escaped observation.

Many of these patients exhibited cerebral symptoms in the course of the disease, and some ultimately died from inflammation of the cerebral meninges, which had probably spread from the nose through some opening in the bony lamina that normally separates the cranial and nasal cavities. The full clinical details of this rare case and of the similar ones just referred to are, however, reserved for publication elsewhere. The present paper is concerned only with the composition of the fluid and the variations it presents under different circumstances.

Characters of the Fluid.

Our opportunities for examining the fluid chemically have been fairly frequent. The fluid was always collected in sterilised glass vessels, and the examination made as soon as possible by one of us (W. D. H.) at King's College, London.

The fluid is perfectly clear and colourless, looking like water; its reaction is faintly alkaline; its specific gravity is about 1005. On microscopic examination it shows no cells or other deposit. It gives no precipitate with acetic acid. It contains a trace of proteid, coagulable by heat, but the quantity is too small to give more than an opalescence. In another portion of the fluid it was ascertained that this proteid is precipitable by saturation with magnesium sulphate; it is therefore a globulin. Albumin and other proteids are absent.

The fluid contains a substance which reduces Fehling's solution. A portion of the fluid was treated with excess of acidified alcohol; the proteid so precipitated was filtered off. The filtrate was evaporated to dryness over a water bath; the dry residue was taken up with alcohol, filtered, and again evaporated to dryness. Part was evaporated to dryness on a glass slide; the residue examined microscopically was seen to contain the needle-like crystals, occurring singly and in bundles, similar to those previously described and figured by one of us (W. D. H)* as obtainable from cerebro-spinal fluid. The residue had also the characteristic pungent taste of pyrocatechin.

The remainder of the dry residue was dissolved in water and filtered. The filtrate reduces Fehling's solution well, but it does not ferment with yeast, nor does it give any osazone crystals on treatment with phenylhydrazine hydrochloride and sodium acetate. Control experiments with a weak solution of dextrose, which gave about the same

* 'Journ. of Physiol.,' vol. 10, p. 248.

amount of reduction with Fehling's solution, gave both these tests in a typical way.

The fluid was tested for creatinine with negative results.

The same results relative to the reducing substance have been obtained over and over again in various specimens of this fluid. They agree with the observations of nearly all writers on the cerebro-spinal fluid, but differ from those of Nawratski,* who in a recent paper has affirmed, principally from observations on the cerebro-spinal fluid of the calf, that the reducing substance present is dextrose.

The principal points to be noticed in the properties of the fluid which lead to the conclusion that it is cerebro-spinal fluid are the following:—

(1) Its clear, watery character.
(2) Its low specific gravity.
(3) The small amount of proteid in it and the absence of albumin.
(4) The presence in it of a substance which reduces Fehling's solution, but is not dextrose. It is possibly a substance related to pyrocatechin.

In comparison with this fluid, we examined also the secretion in some cases of true nasal hydrorrhœa. This fluid is opalescent, somewhat viscid, and on microscopic examination shows amorphous matter with mucous corpuscles. It gives with acetic acid a precipitate of mucinoid nature. It sometimes does and sometimes does not contain a reducing substance, and this substance when present is sugar.

A quantitative analysis of one of these nasal fluids showed that the percentage of solids, especially organic solids, is higher than in cerebro-spinal fluid. The results of the analysis are as follows:—

	Per cent.
Water	98·792
Total solids	1·208
Proteids (including mucin).....	0·260
Other organic substances	0·163
Inorganic substances	0·785

Our observations on the characters of the cerebro-spinal fluid were followed by others in which we sought to answer the following questions:—

The rate of flow.
The difference of composition at different times of the day.
The influence of straining, posture, and abdominal compression on the flow and composition of the fluid.
The effect on blood pressure of intra-venous injection of the fluid in animals.

* 'Zeits. f. Physiol. Chem.,' 1897, vol. 23, p. 532.

The Rate of Flow.

One portion, collected by the patient herself in the course of an hour, measured 4 c.c. Another portion, collected under the supervision of one of us (StC. T.) in ten minutes, measured 3·9 c.c.

If the first portion is taken as a measure of the rate of secretion, the amount formed in the day will be 96 c.c. Taking, however, the second observation as being more accurate, the amount formed in the twenty-four hours will be over half a litre (561·6 c.c.). It is possible that this estimate is too high, as doubtless the patient, being under the observation of a physician, would be somewhat excited, and the consequent alteration of the circulation would, as we shall immediately see, cause the flow to become more abundant.

Comparison of the Morning and Evening Fluid.

Cavazzani,* from experiments on dogs, found that the cerebro-spinal fluid collected in the morning was more alkaline than in the evening, and contained more solid residue. He considers that this is related to the activity of the nervous system, and that it confirms Obersteiner's theory of sleep. He obtained corresponding results in the case of a man with traumatic fistula of the frontal bone.

We considered it worth while to repeat this observation.

The qualitative examination of the fluid collected first thing on several mornings gave the same results as that of specimens collected the last thing in the evening. Both were distinctly alkaline, but no estimation of the relative alkalinity was made. The following table gives in percentages the results of the quantitative analyses:—

	Morning fluid.	Evening fluid.
Water	99·004	99·027
Solids	0·996	0·973
Organic solids	0·118	0·100
Inorganic solids ...	0·878	0·873

The evening fluid is thus slightly poorer in both classes of constituents than that of the morning; the difference is chiefly due to an alteration in the organic solids. This is just what we should expect, as the decreased capillary pressure during sleep would lessen the rate of exudation of water. Without committing ourselves to any theory on nervous activity or sleep, we may say that our experiments confirm those of Cavazzani.

* "Sul Liquido Cerebro-spinale," 'La Riforma Medica,' Anno VIII, 1892, vol. 2, p. 591.

The Influence of Straining and Posture on the Flow and Composition of the Fluid.

In a monograph on the cerebral circulation* one of us (L. H.) put forward the view that the rate of secretion of the cerebro-spinal fluid, when the cranio-vertebral cavity is opened, depends directly on the difference between the pressure in the cerebral capillaries and that of the atmosphere. At the same time it was shown that cerebral capillary pressure varies directly and absolutely with vena cava pressure. Thus the cerebral capillary pressure can be raised with great ease by any agency which causes a rise of pressure in the vena cava or cerebral veins. On the other hand, cerebral capillary pressure varies directly, but only proportionately, with aortic pressure, for between the aorta and the capillaries there lies the peripheral resistance.

It follows from the above that the easiest methods of raising the cerebral capillary pressure in man are:—

(*a*) By compression of the abdomen.
(*b*) By the assumption of the horizontal posture. In this position, however, the rise of venous pressure may be compensated by the fall of arterial pressure, which normally occurs when the body is at rest. This is, no doubt, the case during sleep.
(*c*) By straining or forced expiratory effort, with the glottis closed.

By all these methods the vena cava pressure is considerably raised; and by the last method the venous inlets into the thorax may be completely blocked, and the pressure in the cerebral capillaries raised to something like aortic pressure.

It is true that by such a forced expiratory effort the aortic pressure is lowered. Nevertheless, the total effect on capillary pressure is a very great rise, for a fall of aortic pressure of 25 mm. of mercury produces a fall in cerebral capillary pressure of less than 5 mm. of mercury, while a rise of vena cava pressure of 25 mm. of mercury produces a rise of cerebral capillary pressure of 25 mm. Hg.

The present case gave us a unique opportunity of testing the correctness of these views on the living human subject, and our experiments entirely confirm them. As will be seen from the following figures, the flow of cerebro-spinal fluid is accelerated by all those circumstances which raise the cerebral capillary pressure. The increase in flow is, moreover, accompanied by a decrease in the percentage of solid matter.

The experiments were conducted under the supervision of two of us (StC. T. and L. H.); the chemical investigation of the fluid was performed, as before, by the third (W. D. H.).

* 'The Physiology and Pathology of the Cerebral Circulation,' by Leonard Hill, London, Messrs. Churchill, 1896.

1. Patient sitting quietly without straining. In five minutes 23 minims (1·357 c.c.) were collected.

2. Patient sitting and straining. In five minutes 35 minims (1·965 c.c.) were collected.

3. Patient sitting quietly. In five successive minutes the amounts collected were, respectively, 8, 7, 5, 5, 5 drops. The total measured 19 minims (1·021 c.c.).

4. Subsequent to this, five minutes were occupied by the patient in straining, and the amounts collected in consecutive minutes were 12, 10, 8, 9, and 10 drops respectively. The total measured 33 minims (1·947 c.c.).

5. Patient lying down and not straining. The drops fell as follows in five consecutive minutes—9, 6, 5, 5, and 5, and the total measured 27 minims (1·593 c.c.). Here the arterial pressure was probably not decreased owing to mental excitement, while the cerebral venous pressure was increased.

6. Patient lying flat on the stomach and head hanging over the end of a sofa. The drops fell as follows in five consecutive minutes, 8, 7, 6, 7, and 7. The total measured 28 minims (1·652 c.c.).

7. Finally, after the last experiment, the following was collected during quiet dropping, while the patient was sitting with the head forward. The drops fell as follows:—5, 4, 4, 4, and 4, in five successive minutes; and the total measured 15 minims (0·885 c.c.).

The following is the report on the chemical examination of the fluids:—

So far as the small quantities available admit of analysis, the fluids are the same qualitatively. The liquid which escaped passively, and that which passed under straining, both contained a small quantity of organic and inorganic solids. Among the organic substances present are the reducing substance and a trace of proteid. Judged by the amount of precipitate produced by alcohol in equal amounts of the two fluids, the proteid is less abundant in the fluid passed during straining, but the amount is too small to weigh.

Determination of the total solids gave the following results, expressed in percentages:—

A. The fluid passed passively, 1·1 per cent.

B. The fluid passed during straining, 0·43 per cent.

Even the higher of these numbers is less than in cases of cerebro-spinal fluid from meningocele and hydrocephalus, previously recorded by one of us (W. D. H.).*

In addition to the foregoing, two specimens were collected at home by the patient herself. Analysis of these gave the following results:—

A. Fluid collected while patient was sitting upright quietly. The percentage of solids was 1·11.

* 'Journ. of Physiol.,' vol. 10, p. 232.

B. Fluid collected while she was lying down. The percentage of solids was 1·03.

The effect of the horizontal posture is in the same direction, though not so marked as the effect of straining. This is what was to be expected, for the horizontal posture would not raise the venous, and thus the cerebral, capillary pressure so much as powerful expiratory efforts would. Moreover, the arterial pressure falls during quiet rest in the recumbent posture, as one of us has determined (L. H.).*

In order to note the effects of straining on the retinal circulation, Mr. Vernon Cargill was asked to examine the patient, and he kindly reported as follows:—"I noticed that when a straining effort was mads, a decided but transitory narrowing of the retinal arteries on and adjacent to the disc, and also a marked pulsation in the trunks of the retinal veins occurred."

The transitory narrowing of the arteries points to the temporary lowering of the aortic pressure, while the pulsation of the veins is a sign of the capillary engorgement due to venous congestion.

Experiments made with Abdominal Compression.

These experiments were made in order to complete and confirm those just recorded. The patient was seated, and the abdomen was compressed as firmly and evenly as possible by one of us (StC. T.), spreading both hands over the front of the abdomen. The number of drops per minute were counted as before, and periods of compression lasting five minutes were alternated with periods of the same duration, during which the patient was sitting quietly.

The following table gives the results succinctly:—

Condition of patient.	Drops in successive minutes.	Total collected.	
		Minims.	c.c.
A. Abdomen compressed.....	11, 9, 8, 7, 5	27	1·593
B. Sitting quietly.....	4, 5, 3, 4, 4	14	0·826
C. Abdomen compressed.....	11, 8, 8, 6, 6	24	1·416
D. Sitting quietly.....	6, 7, 8, 6, 6	Measurement omitted	

The fluids from experiments "A" and "C" were mixed together; also those from experiments "B" and "D." Determination of the total solids gave the following results:—

"A" and "C." Fluid collected during abdominal compression. Percentage of solids, 0·68.

"B" and "D." Fluid collected while the patient was sitting upright quietly. Percentage of solids, 1·14.

* 'Phys. Soc. Proc.,' January 15, 1898.

The experiments confirm those recorded in the preceding section. Abdominal compression raises the vena cava pressure, and so leads to increased cerebral capillary pressure, and in this way to increase in the volume of the cerebro-spinal fluid secreted. Increase of volume, as before, is accompanied with fall in the percentage of solids present.

Intra-vascular Injection of the Cerebro-spinal Fluid.

One of us (W. D. H.), in conjunction with Dr. Mott, F.R.S., has been for some time engaged in examining the results of injecting into animals cerebro-spinal fluid removed from cases of brain atrophy, especially from cases of general paralysis of the insane. This fluid contains a toxic substance, choline, doubtless derived from the disintegration of lecithin in the brain. Injection of such fluid into the jugular vein of animals (dogs, cats, rabbits), anæsthetised with ether, causes a marked lowering of arterial blood pressure, which is partly cardiac in origin, but principally due to the local action of the poison on the neuro-muscular apparatus of the peripheral vessels, especially in the splanchnic area.*

The fluid obtained from the present case was also injected in a similar way. Quantities varying from 7 to 10 c.c. were injected into the circulation in dogs, but with entirely negative results. Such a quantity in the case of fluid from a general paralytic would be quite sufficient to cause a marked fall of arterial pressure.

Similar negative results, both as regards blood pressure and respiration, were obtained with other specimens of normal cerebro-spinal fluid removed from other animals, or from cases of meningocele and hydrocephalus in children. In all such cases, also, choline was searched for chemically, but with negative results.

"The Thermal Deformation of the Crystallised Normal Sulphates of Potassium, Rubidium, and Cæsium." By A. E. TUTTON, B.Sc. Communicated by Captain ABNEY, C.B., F.R.S. Received January 31,—Read February 16, 1899.

(Abstract.)

In this memoir are communicated the results of sixty-four determinations of the thermal expansion of the orthorhombic crystals of the normal sulphates of potassium, rubidium, and cæsium, carried out for the three axial directions of the crystals with the aid of the compensated interference dilatometer previously described by the author.†

* 'Physiol. Soc. Proc.,' Feb., 1897, and Feb., 1898 ('Journ. of Physiol.,' vols. 21 and 22).

† 'Phil. Trans.,' A, vol. 191, p. 313.