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CEREBROSPINAL FLUID EXAMINED BY ULTRA-VIOLET LIGHT.

By

E. FRETSON SKINNER, SHEFFIELD.

DURING the course of some examinations of cerebrospinal fluid in cases of chorea the idea suggested itself that some form of physical examination of the fluid might give interesting results.

Cerebrospinal fluid contains, amongst other things, colloid bodies, and under certain pathological conditions the amount of these colloids and probably the kind of colloid seem to vary. Such variation is demonstrated by the ordinary gold test. This test probably depends on precipitation of metallic gold from a colloidal solution by changes in the electrical charges on the surface of colloidal particles, and as it seemed possible that the interposition of cerebrospinal fluid in the beam of the spectrum might show some absorption such as is seen in the well-known hæmoglobin bands, a series of observations was planned to ascertain whether such absorption would occur. I may say at the outset that the method has not realised this hope and my only excuse for recording these observations is that there is some slight indication that, at times, in certain conditions, there appears to be some clinical application.

All known forms of radiant energy are probably due to wave motion in the ether, various forms of energy differing only in wave length. If we represent diagrammatically all these forms of energy by a horizontal series of vertical lines, each one of which corresponds to a definite wave length, we obtain a long band such as is indicated in the diagram below (Fig. 1.*).

From this diagram it will be seen that the differences in wave length are enormous. If all the waves between the visible spectrum and the gamma rays of radium were represented on this diagram by the horizontal space of 1 cm., in order to present all the other wave lengths a horizontal band of about

*Copied from "X-Ray" by Schall, p. 51.

the width of the Atlantic Ocean would be required. In the diagram the infra-red portion has been enormously shortened, whilst the ultra-violet portion has been similarly lengthened. The actual wave lengths of these various forms of energy vary from 35,000 metres (20 miles approx.) to a "tenthmetre," which is one ten-thousand millionth of a metre.

These various waves can be appreciated in various ways, some of them by means of our unaided senses, for example some of the heat waves below the red end of the visible spectrum, as well as the visible spectrum itself; whilst others require special apparatus to enable us to be aware of them, e.g., the presence of

FIG. 1.

Diagrammatic representation of electromagnetic waves showing their numerical relationship.

ultra-violet waves can be detected by their action on a photographic plate, the Hertzian waves by means of the thermionic valve, etc. But wherever these wave-forms occur in the band of radiant energy, they are all the result of some force which has set in action vibrations with a definite periodicity.

The fragment of this vast series of wave-like forms of energy with which I am going to deal is one which comprises wave lengths varying from 7,594 Angstrom units at the red end of the visible spectrum to 2,149 Angstrom units at the end of the ultra-violet band.

If a beam of monochromatic light be passed through the narrow slit of a spectroscope a brilliantly coloured image of this slit is seen on the screen; for example, if sodium chloride is burned in the non-luminous flame of the Bunsen burner two brilliant yellow images of the slit are formed, due to the

monochromatic light emitted from sodium vapour. Similarly a salt of thallium will produce a bright green image, but this green image will be in a different situation from that of the yellow sodium images, and by appropriate means the positions of these bright images can be shown to be fixed in the band of the visible spectrum. Almost all the elements can be made to produce luminous coloured bands on the spectroscopy screen, which bands correspond to definite wave lengths—in other words, the wave length determines the colour of the image seen.

Kirchoff (1859) showed that if the rays from a source of intense white light which consists of innumerable waves of monochromatic light, such as that produced by a carbon arc, were passed through the spectroscopy, the usual prismatic colour spectrum was produced, but if a Bunsen burner with sodium chloride burning in it were interposed between the carbon arc and slit of the spectroscopy there appeared in the colour spectrum two dark lines in the neighbourhood of the yellow bands, and these were found to be identical in situation with the luminous images given by sodium vapour.

Kirchoff explained the phenomenon by stating that the amount of light proceeding from the sodium vapour is relatively so small that the only effect to be considered is that which the presence of this vapour may have on the rays proceeding from the white hot body of the carbon arc. The ether waves proceeding from this white hot body will pass readily through the sodium vapour, except those vibrations whose wave lengths are the same as those of the screen of sodium vapour which absorbs them.

This simple experiment explains the Fraunhofer lines in the solar spectrum. The body of the sun is so much hotter than the surrounding incandescent vapour (photosphere) that the rays of light pass through a relatively cooler vapour in which are various elements whose vibratory periods are the same as some of the waves coming from the sun's body, and which, consequently, absorb those particular waves, producing black lines on the solar spectrum.

This brings me to the reason of my paper. Absorption spectra are merely spectra in which certain waves are damped or absorbed by some substance through which they have to pass.

The various absorption spectra of hæmoglobin and its derivatives are all familiar, and since absorption bands are so very definite and so mathematically constant I thought it would be of interest to see whether cerebrospinal fluid would give any such bands. When it is remembered that the number of leucocytes may vary in the cerebrospinal fluid from one to eight hundred per c.mm. or more, and that the constituent colloids may show very considerable variations, as may also the salts, it seemed possible that some variation in the spectrum might occur if cerebrospinal fluid were interposed in the path of the rays of light passing into a spectroscopy.

The recording of spectra on photographic plates depends on the action of ultra-violet rays, so it was necessary to choose as an emitting body some

substance which, when raised to a white heat, would give off ultra-violet radiations. The copper arc was chosen because it is fairly rich in ultra-violet rays and possesses a number of very clearly defined lines in its spectrum. Tungsten is richer in ultra-violet rays but it is very expensive and burns away very quickly, whilst iron has so many fine lines that they are difficult to calibrate.

The apparatus I used was very simple, consisting of a copper arc, enclosed in a light-proof box, a small quartz cell for containing a few c.c. of cerebro-spinal fluid, and a spectrometer for analysing the light rays and recording them photographically.

As I stated previously, I have been disappointed in not finding any selective absorption in the spectra I have examined, but such results as have been obtained are described below.

In the first place, Fig. 2 represents the normal spectrum of incandescent copper in which it will be seen there are a large number of very clearly defined lines whose wave lengths are known and which can be easily identified. It comprises a series of wave lengths varying in magnitude from 5,782 Angstrom units to 2149 Angstrom units; that is, it begins at and includes the visible spectrum and a considerable amount of the ultra-violet band.

FIG. 2.

The next two figures (Figs. 3 and 4) show the amount of absorption which occurs when ultra-violet rays are passed through distilled water and normal saline respectively, and it will be seen that the amount of absorption is very slight, occurring at the right-hand of the band.

FIG. 3.

FIG. 4.

It was necessary in the first place to examine a number of normal lumbar fluids, in order to ascertain what kind of absorption occurred. It is not easy to obtain normal cerebrospinal fluid since lumbar puncture, though a simple procedure, is not without a slight risk of grave consequences, so that it is not undertaken unless there is an indication for it, in which case the cerebrospinal fluid cannot be considered normal. However, I have managed to obtain several samples from individuals who volunteered and who, so far as I could ascertain, were absolutely healthy. These fluids were examined with various arcs and they all showed the same type of result, general absorption occurring about two-thirds of the way down the band. Fig. 5 shows the normal spectrogram of cerebrospinal fluid, using copper to produce the ultra-violet rays.

FIG. 5.

The most striking changes in cerebrospinal fluid that one meets with in ordinary routine clinical work are perhaps found in cases of general paralysis. In these cases the fluid often contains a very large number of leucocytes as well as a considerable increase in the amount of proteins present, and the colloidal gold test is usually very definite. In view of these striking changes some cases of general paralysis were first of all examined and after a large number had been submitted to the test it appeared that very often a fairly definite spectrogram was obtained. This spectrogram is shown in Fig. 6, in which it will be seen that complete absorption of the rays occurs below a wave length whose value is 2,961 Angstrom units, with the exception of one well-marked band which corresponds to a wave length of 2,618.

FIG. 6.

In certain cases of advanced general paralysis even this band, 2,618, disappears. Such a spectrogram is shown in Fig. 7.

FIG. 7.

The next series of fluids to be described were taken from cases of tabes of which Fig. 8 is an example, where it will be seen that absorption is not complete as is the case in fluids obtained from general paralytics, one other band being visible with a wave length value of 2,492 Angstrom units.

FIG. 8.

But here again in old-standing cases of tabes the spectrogram may be identical with that of general paralysis, and one is tempted to suggest that the absorption of tabetic fluids is an early stage of that given by general paralytics.

The most striking of all these spectrograms is given by fluids from cases of tuberculous meningitis. This is not a particularly common condition and I have not been able to examine a large number but, thanks to the courtesy of colleagues, I have obtained fluids from perhaps a dozen cases; all of these show rather a characteristic picture which is illustrated in Fig. 9, in which it will be seen that there is complete absorption from a wave length of 3,248 Angstrom units.

FIG. 9.

Although the number of cases so examined has been small I am inclined to think that this picture has some diagnostic significance, in support of which I might cite the following clinical case.

One afternoon, whilst working at these spectrograms, I was informed that a case of tuberculous meningitis had just been admitted to hospital and a lumbar puncture was being done. Some of the fluid was sent down to the laboratory in the ordinary way and some was sent to me for examination. I took a spectrogram and on examining the negative I felt sure that the case, which I had not then seen clinically, was not one of tuberculous meningitis. Going into the laboratory later I found the routine examination of the fluid had been carried out and the pathological opinion of tuberculous meningitis had been expressed on the grounds of a very considerable diminution in the chloride content. This was the only pathological change, as there was no increase in cells nor was the gold test positive. Next day I saw the child and clinically it certainly appeared to be a case of advanced meningitis, with head retraction, Kernig's sign and so on, and I must confess I was considerably shaken in my opinion. None the less I maintained it and within a few days it was obvious that the case was one of so-called meningismus and not true meningitis, since all the meningitic symptoms gradually abated and the child made an uninterrupted recovery. Fig. 10 shows this particular spectrogram.

FIG. 10.

Similarly, Fig. 11 is from a case in which the diagnosis of tuberculous meningitis was made on clinical grounds but which eventually determined itself to be a meningismus complicating a lobar pneumonia in a girl eighteen years of age.

FIG. 11.

The conditions I have cited seem to give spectrograms which appear more or less constant in type but on what they depend at present I cannot say. I am quite sure they do not depend on the number of cells present in the fluids, nor do the variations in the protein constituents appear to bear any fixed relationship. The only definite statement possible is that absorption seems to take place in toxi-infective conditions and varies directly with the severity of this process ; the nearer a fatal termination the more complete the absorption.

I have examined cerebrospinal fluids from a number of other clinical conditions but none of them produced such definite pictures as those I have mentioned. Disseminated sclerosis shows some absorption, but not nearly as much as in tabes, and of all the organic nervous diseases most nearly approaches that of normal cerebrospinal fluid (Fig. 12.).

FIG. 12.

I have tried to epitomise these results in the diagram (Fig. 13) but do not wish to present any claims for real usefulness for these spectrograms at present ; there are so many pitfalls and possibilities of error that I should not like anyone to suppose that I had advocated a new diagnostic procedure. But, at the same time, I think there are certain suggestive points in the observations which warrant a continuance of the experiments with more careful calibration and a more rigid technique, which I propose to do in the near future.

I should like to express my thanks to those of my colleagues who have provided me with fluids for examination ; to Professor Milner of the University for permission to work in the Physics laboratory and to Dr. J. N. Clarke for much extremely valuable expert advice and help.

FIG. 13.

Schema of absorbtion spectra of various cerebrospinal fluids.