CRYSTAL FORMATIONS IN THE SPINAL FLUID AND THEIR DIAGNOSTIC SIGNIFICANCE

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SURVEY OF THE PHYSIOLOGICAL COMPOSITION OF THE SPINAL FLUID

The formation of crystals by the dehydration of spinal fluid is in close correlation with its chemical composition, which condition it is therefore necessary briefly to discuss.

On the whole, normal spinal fluid has a constant composition and, seen in comparison with the electrolytes, its content of organic ingredients is poor. Favourable conditions are accordingly present for the formation of crystals by dehydration of the fluid, and it was therefore to be expected that the crystals formed would give pictures of diagnostic value. It is well known that the crystal picture is dependent upon the extraneous conditions under which it is formed. Rapid dehydration gives small crystals, slow dehydration produces large crystals. A solution of a single pure crystalline substance will, by crystallization under certain conditions, yield a characteristic crystal-form. If several crystalloids are mixed together in the same solution, the crystallization will produce crystal aggregates. If, further, organic and colloidal substances are added, the crystal aggregates become very complicated. The laws governing these aggregate formations are still unrevealed.

The spinal fluid is clear and weakly alkaline, with pH about 7.5 and with specific gravity about 1007.6. It contains a few cells and a small part of colloidal substances in the form of protein, sugar and some other organic ingredients. It is thought that the colloidal substances and the cells originate from the perivascular lymph-ducts in the central nervous system. In proportion to the organic, inorganic substances are present in overwhelming amount. Of the inorganic salts, sodium chloride forms the principal part, but other salts of K, Na, Ca are also found.

Normal fluid has the following composition (Demme, Die Liquordiagnostik, 1935, p. 51):

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total protein</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Globulin</td>
<td>2.5</td>
<td>9</td>
</tr>
<tr>
<td>Albumin</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Sugar</td>
<td>45</td>
<td>75</td>
</tr>
</tbody>
</table>
The total quantity of fluid is calculated to be about 146 c.cm.; in old people, owing to atrophy of the nerve tissues, it may rise to double that amount.

Cerebrospinal fluid is thought to be of significance for the nutrition of the nervous system. Mestrezat designates it as 'serum mineral,' the chemical nature of which forms the optimal condition for the maintenance of the function of the nerve cells. Halliburton considers cerebrospinal fluid as the ideal physiological salt-solution for the maintenance of the osmotic equilibrium of the nerve-cells. Much doubt, however, still exists as to how far it governs directly the nutrition of the nerve-cells.

Conditions in respect of the colloids in this 'serum mineral' demand a close study. It is of interest to mention that after malaria treatment of general paralysis an increase of K and Mg is found, whereas there is a decrease of Ca values.

Under pathological conditions the factors for crystallization in the spinal fluid are altered, and it was thought that the shape of the crystals might afford diagnostic indications.

At the stage I have now attained and on the basis of the crystal-picture available, I am able to diagnose general paralysis.

**PERSONAL EXPERIMENTS**

The investigations, the result of which I submit in this work, were begun in 1932, demonstrated at the Psychiatric Clinic and before the Neurological Association in Oslo in 1933, and delivered as a lecture before the Medical Association, Oslo, in December, 1933.

The purpose of these investigations is to show that it is possible at the present stage of our knowledge to distinguish 'normal' spinal fluid from
typical paralysis fluid, and, further, that the crystal-formations change during malaria treatment and remission. In the present publication I show the pictures of normal fluid crystals alongside of paralysis fluid crystals in order to demonstrate the difference as distinctly as possible. It may at first prove difficult to classify these pictures, but gradually all that is typical in them will emerge clearly. My further plan is to investigate whether other organic and 'functional' nervous diseases have crystal pictures possessing diagnostic value.

**METHOD**

With an ordinary pipette for blood testing measure 20 to 25 c.mm. spinal fluid, the drop is placed on a perfectly clean object glass, 2 to 3 drops individually after each other for the sake of control. The preparation is air-dried under a bell-glass at room temperature (about 19° C.). It does not greatly matter if the temperature is 2° to 3° above or below 19° C. The dried preparation is examined uncovered and under a slight magnification...
(Zeiss objective a₁ or a₂ and medium-strong eyepiece). For investigation with dark field illumination the preparation is to be embedded in Canada balsam with glass cover.

**DESCRIPTION OF THE CRYSTALS**

*The Normal Crystal Picture.*—By normal spinal fluid is meant the fluid which gives normal reactions according to the usual clinical scheme of investigation and which comes from patients not suffering from clinically demonstrable nervous diseases or from other internal illnesses which may be thought to exercise an influence upon the composition of the spinal fluid. A normal crystal picture of such nature is seen in fig. 1, where part of the
dehydrated drop with border zone is given. There will be observed in the picture a large quadrilateral crystal-form (a), representing a pyramid-shaped regular sodium chloride crystal as is found in all normal pictures. In addition to these large and very frequently singly-lying crystals, formations of finer and coarser needles (b) are found. These are arranged in lines, and in most cases are geometrically ramified at right angles, as is apparent in figs. 1 to 4.

A transition stage can be traced between these needle formations and the large pyramid-shaped crystals, as the latter by axial prolongation of one diagonal assume a spear or arrow-tip shape or dagger-like form, as in figs. 4a, 5a. Taking all the normal crystal pictures together (figs. 1 to 11), it may be observed that the large pyramid-shaped crystals lie isolated and are without ramifications, whereas the dagger and arrow-tip-shaped crystals usually have a needle-like prolongation of one or several of the diagonal
corner points (figs. 5a and 7a). These needle formations ramify further at right angles. At first it may seem difficult to systemize them, but it will be seen from a closer examination that ramification on the whole follows a right-angled construction. One is even able to see at some places that the

needle ramification is slightly tapered and angular (figs. 7a, 8, 9, 10a, 11). In my opinion the angularly-tapered needle-formations provide a transition stage leading to the pathological forms.

I have schematically depicted in fig. 12 the variations of crystal formations in the normal and pathological spinal fluid picture.

*The Crystal-Picture in the Spinal Fluid of General Paralysis.*—The
characteristics of the crystal-picture in the spinal fluid during paralysis generalis are as follows:

1. Varied forms of the large crystals. The regular pyramid-shaped crystals have disappeared, and instead are seen many that are star- or dagger-shaped (figs. 16, 19), besides more amorphous forms (figs. 13 to 16), and, at times, disintegrated crystals which seem as if they have been torn apart (figs. 23a, 23b, 25a). Further, at several places we see hexagonal stars—like starfish—which always seem to indicate a pathological process (figs. 17, 19a, 26a).
2. Growing from the corners of the large crystals are ramifications of irregular needle formations tapering angularly, which may assume the shape of (a) an oak tree (figs. 18a, 14a); (b) a bush (figs. 15a, 16a, 19, 21, 27a); (c) a fir tree (fig. 28); and (d) rosette forms (figs. 14b, 15b, 17a).

3. Between the various crystal aggregates is a structureless zone which appears to be of an amorphous nature and where the extreme delicate needle formations lose themselves (figs. 13 to 19, 21, 23, 27).

It is still too early to form any definite idea whether the pictures I have described above are pathognomonic in respect of general paralysis, but they certainly seem of such a typical character that they will prove to be of diagnostic value.

During malaria treatment of paralysis the crystal picture changes. In the same manner as the fluid alters during malaria treatment, a change in
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Fig. 21.—General paralysis (before malaria treatment).

Fig. 22.—General paralysis (after malaria treatment: same patient as in Fig. 21).

Fig. 23.—General paralysis (before malaria treatment).

Fig. 24.—General paralysis (after malaria treatment: same patient as in Fig. 23).

Fig. 25.—General paralysis (after malaria treatment).

Fig. 26.—General paralysis (after malaria treatment).
Fig. 27.—General paralysis.

A. Prior to successful malaria cure.
B. Immediately after.
C. Four months after.
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the crystal picture is observed in a normal direction. The more complete the remission is, the more normal the crystal picture becomes. The needle-forms become simpler and the angles straight. It is very often seen that the crystal needles arrange themselves in straight, usually parallel rows, looking like spear-point upon spear-point (figs. 26, 27C). As an example of the influence of malaria treatment on crystal formations, reference is made to fig. 18 (mainly right-angled rosette shape), fig. 19 (prior to) and fig. 20 (after-treatment; same patient); the same for figs. 21 and 22, 23 and 24. Fig. 27 shows the crystal picture prior to, immediately after, and four months after, a successful cure. Fig. 26 shows a picture of the fluid taken for control a lengthy period after treatment, and fig. 28 depicts one taken from a patient eight years after a successful cure for malaria.

My material includes 322 cases with registered photographs. Of these, 66 are paralysis, the remainder being divided among other nervous diseases such as tabes, latent lues, lues cerebrospinalis, psychopathic cases, schizophrenia, dementia, tumor cerebri, cramp attacks, peripheral nervous disease as well as milder forms of neurasthenia without any organic foundation and without demonstrable change in the spinal fluid. These forms of neurasthenia always show the picture I have presented as being the normal crystal picture, which agrees with the crystal picture in the case of patients not having any organic or functional nervous disease.

In addition to those photographs, I have observed the same number of preparations many times over. My experience is that the crystal picture of untreated general paralysis is so typical as to provide a secure foundation for the diagnosis.

The major part of this work has been carried out at the Psychiatric Clinic, Oslo, and I wish now to tender my warmest thanks to Professor Dr. Med. Ragnar Vogt, the Principal. Further, due to the kind consideration
of the principals concerned, I have been able to employ material at the Psychiatric Department of the Oslo Municipal Hospital at Ullevaal, the chief of which is Dr. Sæthre; the Nervous Diseases Department of the State Hospital, Professor Dr. Med. Monrad Krohn as Principal; and Section VIII of the Oslo Municipal Hospital at Ullevaal, with Dr. Med. Carl Müller as Head. I have also made use of private cases of my own.
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