The Morphology of Cysticercus racemosus and the Determination of the Cysticercus Species

J. Šlaís

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

Abstract. Three observations of the racemose form of cysticercosis of the human brain were analysed histologically. It was found that the racemose cysts originate from the extreme proliferation of the bladder of Cysticercus cellulosae. The active growth of the bladder wall of the cysticercus, twice observed directly, has not yet been described in the literature. The proliferation of the bladder wall of the cysticercus, in which the scolex has either been destroyed or was not developed, manifests itself by buds, originating from all histological components of the wall. The lumen in these buds develops in secondary succession.

The finding of the lobate and branched form of the brain cysticercus, localized predominantly at the base of the brain, is very rare. Virchow (1860) first gave attention to the existence of some noticeable formations at the base of the brain. With unique precision he recorded almost all characteristic signs: the structure, comprising bladders of various sizes joined into a single body—the so-called grapes; the fine ducts and stalks connecting all groups of bladders; the close adherence to the vessels without coalescing either with them or with the tissues of the leptomeninges. In addition, he also drew attention to the similarity with the hydatid mole and to the characteristic shagreenous appearance of the bladder surface. He was doubtful, however, about the parasitic origin of these structures although he found a dead and calcified cysticercus in the brain of one of his observations. Zenker (1882) proved the parasitic origin of these formations, designating it Cysticercus racemosus, but there are still some questions about their occurrence and origin, which have not been explained. Since the second half of this century, mainly the problem, which of the species this cysticercus belongs to, has been greatly discussed in the literature in connection with the confirmed findings of Coenurus cerebralis in man.
MATERIAL

By courtesy of prof. Dr. B. Bednář, we received the material from three cases of a racemose form of brain cysticercosis, found at the 1st Department of Pathology of the Faculty of General Medicine, Charles University, Prague. This material was used for our detailed histological evaluation. In the following text, the anamnestic data and post mortem findings of these observations are reviewed:

Observation 1. A. P. (1st Surgical Clinic, Prague, Case No. 12, 177/1964) a female aged 54; no previous records of any severe illness. At first, the patient developed an unsteadiness of gait, progressing steadily until she was unable to walk. Then, her vision became worse. The ECG and PEG examinations revealed an intracranial expansive process localized in the ventral cranial fossae in the area of the septum pellucidum. After six months from the onset of the disease, the patient was operated with the diagnosis: Tumor septi pellucidi with signs of an intercranial hypertension. During the operation, a cyst was found in the septum pellucidum. This was partly removed and taken for histological examinations. After the operation, the patient remained in a semi-coma, followed by death after a decrease of blood pressure.

In the post mortem, carried out 48 hrs after the death of the patient at the 1st Department of Pathology in Prague (No. of autopsy record: 1,119/64), the brain was found asymmetrical, the left hemisphere, especially its frontal lobe, was bulging out. The operational wound, opening into the anterior corner of the greatly dilated left cerebral ventricle, was surrounded by softened and hemorrhagic brain tissue. The arachnoids at the base of the brain, especially near the carotids and on the pons Varolii, were opaque and irregularly thickened. On the section, isolated, small, yellowish white encapsulated nodules and small cysts filled with a jelly-like content were observed. In the septum pellucidum (Plate I, Fig. 1) a spherical, fibrously encapsulated formation of 2.5 cm in diameter, consisting of a yellowish granular substance was found. The endothelium of the lateral ventricles, especially of the left ventricle, was coarse. The whole system of ventricles was generally dilated, especially the lateral ventricle. The third ventricle contained coagulated blood.

The histological examination (autopsy record No. 4, 167) revealed that the large focus in the septum pellucidum and also the small yellowish foci in the leptomeninges at the base are formed by a granular eosinophilic substance with signs of a lobate and wave-like stratification in some places, which have different staining properties. The focus was situated inside a thick layer of connective tissue with many giant cells of foreign bodies; in some of them a section of the wavy membrane, answering to the bladder wall of the cysticercus, had been retained. These preserved parts of the bladder wall were shrivelled, sometimes fusing with the substance of the focus. The necrotic collapsed bladder wall and the necrotic cell exudate of the focus could be proved by silver impregnation. At the base of the brain, the bladder wall was retained especially in places, where the macroscopical cyst with the jelly-like content adhered to the yellowish focus. On the preparations we could trace the direct passage of the bladder wall into these formations with the coagulated homogeneous eosinophilic content. The nearby tissues of the meninges were thickened and infiltrated. At the internal side of the encapsulation of the parasitic bladder, the inflammatory exudation continued and there, a histocytic and giant cell reaction was starting. A flattened cystic formation with its wall completely necrotic except for the part, where the histological structure was still recognizable to some extent, was lying in the posterior part of the cistern of the chiasma, adherent to the pons.

Observation 2. R. G. (1st Surgical Clinic, Case No. 128, 773/1947) a male aged 27. Tb of the lungs. For 10 months the patient had suffered from headache and a tinnitus in the left ear. After determining intracranial hypertension by ventriculography, a tumor of the temporally-parietal region was diagnosed. During the operation, a tumor of the left parietal lobe was found and removed. In the records of this operation, the finding of yellowish cysts, which were almost as big as a small cherry and sometimes joined with the dura mater, is described. In the depth of the brain (at the left in the posterior half of the frontal lobe) a delimited tumor of the size of a small egg was found.
The material removed by this operation was of ovoid shape, hard, opaque and giving the impression of metastases.

The material, examined biopically at the 1st Department of Pathology in Prague (Record No. 2,302), was finally diagnosed to be of parasitic origin with all characters of a cysticercus. However, this finding differed slightly from the standard racemose cysticercus. The parasitological examination of the feces was negative, the material was not examined serologically. The patient recovered and was perfectly well when released from hospital. This observation was not published in the press, but only presented by prof. Šíkl at a meeting of the Society of Czech Physicians in Prague in 1948. The paraffin blocks, deposited in the archive, were again cut, some of them were made into series of sections, and stained by routine and special staining methods.

Observation 3. M. K., a female aged 71 was admitted to the neurological clinic (Case No. 2,207/49) with a central right-sided hemiplegia. The death-cause was bronchopneumonia. In autopsy, the meninges, especially those at the base of the brain, appeared fibrously thickened and opaque, mainly in the area of the left insula. A grape-like formation of 2.5 cm in length with several shrivelled cysts of the size of a bean and filled with fluid was anchored in them by a pedicle. The next most attacked area of the meninges was the region of the chiasma, in which also a widely branched cysticercus formation of about 1 cm in length was hanging down.

This observation was studied and published by Karpišek et Valach (1952) and determined as racemose bladders of a cysticercus, partly progressively resorbed in the thickened meninges at the places of insertion of the macroscopically observable body. Neither the scolex nor any hooks were found by these authors. On the grounds of new sections cut from the paraffin blocks we came to the conclusion that the findings concerned are the collapsed bladders of the cysticercus with its characteristic structure of the wall and, especially, with the noticeably developed wart-like surface of the cuticle and also branched cysts with either a wart-like or smooth surface, forming even compact parenchymatous shoots in some places.

HISTOLOGICAL FINDINGS

Observation No. 1. The intact parts of the membrane show the typical structure of the bladder wall of the cysticercus (Plate I, Fig. 2). In its folds, the parenchymatous layer is relatively thick, with cell nuclei dispersed in it and of a typically spongy appearence. The surface of the membrane is folded, the surface of the cuticle is bordered with hair-like processes. The layer of the subcuticular cells is often disconnected. In places, where the membrane forms a cystic body, the wall becomes very attenuated and its surface smooth. Under the cuticle, especially where its surface is wart-like, short muscle fibrils, receding in garland-like arches from their cuticular insertions, become visible after staining with Mallory’s phosphowolfram hematoxylin. Staining with hematoxylin-eosin reveals crescent-shaped minute areas of an indistinct structure which, even when treated by Gomori’s method for staining reticular fibers, remain unstained.

Examinations of this body in the septum pellucidum, performed on series of histological sections showed that the formation concerned is the large shrivelled bladder of a cysticercus with a multifolded wall. The whole formation was located in the rostral part of the sulcus corpus callosi; by pressing in its growth into the septum pellucidum, it caused an atrophy of the cortex in these places. Further to the caudal side its delimitation by the attenuated cortex was retained. It could also be proved that this shrivelled bladder passed directly into the mass of cystic
formations of the parasitic membrane, which continued from there through the fissura interhemisphercica (Plate II, Fig. 1) to the base of the brain, enveloping both A. cerebralis anterior and the A. communicans anterior. Round this artery, the bunch of parasitic cysts merged with the same formations in the thickened meninges at the base of the brain.

Neither in the focus of the shrivelled large bladder nor in the other foci with a parasitic membrane did we succeed to find the parenchymatous part of the cisticercus with the invaginated scolex; no hooks of the parasite could be found in the tissue, encapsulating the foci.

**Conclusion:** The large bladder of the brain cisticercus, in which no scolex was proved, grew first in the sulcus corporis calosi under the septum pellucidum, decaying gradually after some time. However, the bladder wall continued to proliferate and extend on the base of the brain like a typical racemose cyst. In spite of the advanced necrosis and autolysis of the parasite, some parts, still bearing all histological characters of the proliferating bladder wall of the cisticercus, were discernable.

**Observation No. 2.** The complete encysted body, removed by operation, resembled a grape-like formation with cysts of various sizes attached to it. Some of them were spherical with a thin wall and of regular shape, others were lobate and of irregular shape, some of the lobes (Plate II, Fig. 2) were extended in a collection of branches and buds, which were also branching off. The buds were mostly solid, formed by the typical parenchyma of the bladder wall of the cisticercus with its system of canals and slits; in some of them the starting lumen could be observed. The surface of all formations showed all the features characteristic for the surface of the cisticercus bladder (hair-like processes on the cuticle and a layer of subcuticular cells). The surface was generally smooth and the expanded typical subcuticular muscles could be noted even under the cuticle of the buds and their branchings. The cuticle of some bladders, not enclosed in the granulation tissue, was sometimes of a wart-like appearance, which is typical for the *Cysticercus cellulosae* (Šlatis 1966). Most abundant and infiltrated was the granulation tissue in areas with a complicated network of branching bladders and buds; there, whole parts of these bladders became necrotic and the necrosis was also attacking the surrounding encapsulating tissue. In these parts we observed all grades of a resorbing reaction with the giant cells.

**Conclusion:** The material observed was a large, partly encapsulated formation consisting of a most proliferating collection of cisticercus bladders greatly succumbing to necrosis and being resorbed.

**DISCUSSION**

Zenker (1882) published a monograph on some older findings and on seven of his own observations of the racemose cisticercus. In his work, comprising 16 observations, great attention was given to the shape variations of the parasites, listed
under this designation. The author himself distinguished a number of formations, starting from the mere lobate bladders to formations of only some joined bladders, from the acinous forms consisting of a single cluster of secondary, sometimes pedunculate cysts on the original bladder to finally the true grape-like complicatedly branched formations attaining 20 or more cm in length, which is the only type fully in harmony with the term Cysticercus racemosus. This variety of shapes, also described by Štuchlík (1928) from his single observation, gives evidence about the various stages of the proliferation process of the cysticercus bladder. The active growth of the bladder wall was confirmed in our observation No. 1, but our observation No. 2 gives the unanimous proof and unique histological confirmation of the growing bladder wall, which is in perfect agreement with the proliferation of the bladder observed in the young stages of the cysticercus (Šlahis 1966). This intense growth of the brain cysticercus has not yet been described in the literature.

Zenker succeeded to prove by careful preparation the mutual relation of even the most intricately branched racemose cysts. Also Kocher (1911) proved the delicate connection between the individual parts of the cysticercus studied. Not only a less careful preparation, but also the reaction of the tissue may damage the connections between the individual parts of the cysticercus. It is therefore noteworthy that in most of the observations of the last century, reviewed by Zenker, the large racemose forms were not encapsulated, which fact was at that time considered even a feature characteristic for C. racemosus, while only slightly lobate, less large and less articulate forms were usually encapsulated. All the forms of the racemose cysticercus, observed later, were found with a progressed resorptive reaction (e.g. Mennicke 1897, Berlinger 1930 a.o.). Also Trelles (1961) demonstrated the marked thickening of the leptomeninges at the base of the brain, covering all the finer structures, as a typical example of the racemose cysticercus. A similar picture was found also in our observations. It is quite natural that the joining connections between the remnants of the racemose cysts are no longer provable in the stage of resorption.

Some earlier authors presumed that the missing fibrous encapsulation is responsible for the proliferation of the bladder expanding to the subarachnoid spaces. In our observations of a brain cysticercosis (Šlahis 1965) we found entirely free parasites under the leptomeninges in the basal cisterns at a stage of decay, while the shrinking bladder was of the appropriate size. This shows that the absence of the tissue reaction is not responsible for the transformation of the cysticercus to the racemose form. Our and some other observations have shown that even in this form the resorptive reaction starts evidently only at the time, when the parasite is dying, which is the same as in the standard brain cysticercosis. The picture of a severe, chronic basilar meningitis and of a chronic hydrocephalus accompanying this infection is, however, conditioned by the location of the racemose cysticercus.

According to Zenker, one of the factors responsible for the characteristic lobate appearance of the racemose cysticercus is the unhindered free growth of the parasite
in the subarachnoid spaces at the base of the brain, where the parasite can invade the brain ventricles, especially the fourth, and grow round the vessels. However, our own and other observations demonstrate clearly that even the growth of the bladders, forming the buds and the complicated branching processes, is also responsible for the origin of the racemose shape. Often, a connection was observed between the larger, rather simple cyst in another part of the brain and the racemose formation at the base of the brain, similar as in our observations. Sometimes, a racemose cysticercus and normal cysticerci were found coincidently in the brain of a patient, on the grounds of which only ZENKER succeeded to prove the cysticercus origin of even widely branching cysts, apart from the proof of the shagreenous surface of their membrane, which is a typical character of the bladder wall of the cysticercus. Later, he even found a scolex and hooks of the type Cysticercus cellulosae in one of his observations of a racemose cysticercus. But even this scolex showed signs of degeneration and, therefore, ZENKER emphasized that the proliferation of the bladder to such bizarre forms can only start after the decay of the scolex or, when the scolex was not developed. The connection of the scoleces with the racemose cysticercus, described in an earlier observation by MARCHAND (1879) was not sufficiently confirmed.

Without finding the scolex, it is very difficult to determine correctly the parasite species. Therefore, some authors considered the finding of racemose parasitic cysts at the base of the brain identical with coenurosis in man. This disease has been reported frequently from South Africa. According to ROBINSON (1962), the African Continent provided 70 per cent of all case reports. The disease occurs principally in regions with extensive sheep propagation, because the larval stage of the cestode Multiceps multiceps, the Coenurus cerebralis, develops mostly in the brain of sheep. A solitary finding of coenurosis in man was recorded by CORREA et al. (1962) from South America; records of this disease are also available from Mexico (CABALLERO 1956), where BRICENO et al. (1961) and BIAGI et BRICENO (1961) drew attention to the relatively high percentage of occurrence of the racemose cysticercus (25 %) in 97 cases of cysticercosis of man. The possibility of another parasite than C. cellulosae being responsible for the racemose form of brain cysticercosis, has been considered by these writers. Some few findings of this disease were reported from the U.S.A., Spain and England, where BICKERSTAFF (1955) studied fundamental questions about the nature of the solitary intraventricular cysts and the racemose cysts in connection with basilar meningoencephalitis. Some cases of coenurosis were also reported from France (BRUMPT 1913, ROGER et al. 1942, DUPLAY et al. 1955). There, also another species, Coenurus serialis, was found in man, although this species is known to parasitize generally the musculature of the rabbit (BONNAL et al. 1933, BRUMPT et al. 1934).

In cases of coenurosis, where many scoleces, occurring generally in the more advanced developmental stages of the parasites, are found, the diagnostic picture is very clear-cut, because the species can be determined by the shape and number of their hooks. Most of the records from South Africa were confirmed in this way
Fig. 1. Encapsulated spherical body in the septum pellucidum (on the section).

Fig. 2. Fold of the intact bladder wall with the typical spongy structure of the parenchymatous layer. The folded surface of the cuticle is bordered with hair-like processes (Hematoxylin-eosin. x 300).
Fig. 1. Encapsulated focus in the fissura interhemispherica—at the left margin the shrivelled and necrotic part of the bladder—at the right, its continuation in the intact part of the bladder wall with a wart-like surface. In the right half—the collapsed part of the bladder with a smooth wall (Hematoxylin-eosin. × 11).

Fig. 2. Part of the grape-like formation, showing the branching of the bladder into its branches and buds, separated from each other by an accumulation of inflammatory granulation tissue. (Hematoxylin-eosin. × 11).
by Becker et Jacobson (1951), Watson et Laurie (1955), Wainright (1957). In young cysts located usually at the base of the brain before starting to grow directly in the ventricles and brain tissue, the scoleces are not yet developed. Therefore, Becker et Jacobson (1951) assumed that all racemose and graphe-shaped formations, especially when located in the posterior fossa, are of coenuric origin. Contrary to that Duplay et al. (1955) pointed out that a number of cases with a doubtful parasitological determination and insufficient descriptions was included in the observations of Becker et al. and that their diagnosis was based solely on the fact that these cases occurred in sheep propagating regions. Bickerstaff et al. (1956) also mentioned that in an observation of a racemose cysticercus in the fossa posterior, typical cysticerci were found in other parts of the brain and that the coenurus cysts were not of the standard racemose appearance. The coincidence of normal brain cysticerci and of racemose cysts was also recorded by Haskovec (1929) and by Henner et al. (1946). Here also, without finding a scolex, the bladders of the coenurus are most difficult to distinguish from the racemose cysticercus especially in a progressed resorptive tissue reaction as pointed out by Angula et Roque (1948). Therefore, the histological structure of the bladder wall is of such importance. Brumpt (1949) noticed a certain difference between the bladder wall of C. cellulosae and Coenurus cerebralis. In spite of the sceptical conclusion by Wainright (1957) we succeeded to prove (Šlais 1966) that a histological differential diagnosis between C. cellulosae and Coenurus cerebralis can be made in such instances, where the histological structure of their bladder wall is still intact.

**CONCLUSION**

The active growth and proliferation of the bladder wall of the cysticercus was confirmed on the grounds of three observations of the racemose type of a brain cysticercosis. From the histological structure of the bladder wall of the racemose cysticercus it was possible to determine the formation as the bladder of C. cellulosae, which continued to grow into the subarachnoid spaces of the base of the brain either after the decay of the scolex or when no scolex was developed in it.

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