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Diagnosing neurocysticercosis in skeletonized human remains of forensic importance

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Abstract

Neurocysticercosis is endemic in many parts of the underdeveloped and developing countries, with continuous presence in developed countries due to the influx of migrants from regions where the diseases are endemic. Neuroimaging, anatomic pathological techniques, immunodiagnostic tests, clinical examination and epidemiologic considerations will easily provide the diagnosis. However, physicians in developed countries are perhaps progressively missing the diagnosis, and need to re-acquaint themselves with the condition and acquire a high suspicion index. The authors present a medicolegal case where the forensic team made a conclusion of neurocysticercosis (among other diagnoses), following post mortem examination of a largely skeletonized and mummified human remains. Characteristic changes were observed in the calvarium of the decedent at autopsy. Review of the antemortem medical records revealed that Computed Tomography (CT) scan had 12 years earlier, suggested diagnostic features in a Hispanic migrant, but the attending surgeons failed to consider the possibility of the condition. Physicians should pay attention to suggestive clinical findings especially when attending to individuals coming

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from endemic parts of the world. Cysticercosis remains endemic and a misdiagnosis can potentially attract medical malpractice suits. Forensic pathologists should also consider the possibility of uncommon clinical disorders, even in skeletonized remains. Perhaps an earlier diagnosis might have altered the outcome in the decedent.

Keywords: Neurocysticercosis, Medicolegal autopsy, Skeletal changes, Neuroimaging, Endemic regions, Missed diagnosis

1. Introduction

Neurocysticercosis is essentially a zoonotic disease caused by a cestode, the causative agent of cysticercosis. This parasitic infection is caused in humans by the larval form of *Taenia solium*, which grows in the lung, liver and brain of man and animals, where it could reside for months or years.[1,2] The disease, which is also referred to as taeniasis, has attracted the attention of WHO as a *neglected tropical disease* (NTD),[3] which because of immigration, remains very common but underdiagnosed in industrialized countries.[4] It is commonly found in underdeveloped and developing countries of Africa, Asia, Middle East Central and South America and in the Far East like China.[1,5–8]

The adult form of the tapeworm, *T. solium* (pork tapeworm), grows in man's large intestine as a parasite. The pig is an intermediate host, while man is the definitive or accidental host. Humans acquire the disease through the ingestion of contaminated food or water; ingestion of raw or poorly cooked pig is a common source. The live *T. solium* cyst develops in man's intestine to the adult form, and sheds eggs regularly. Following the ingestion of the eggs, the larvae can migrate to other tissues like muscle and becomes encysted.

When the human carrier sheds the eggs in feces and the latter is improperly disposed, the eggs can be ingested by pigs. In the animal, the larval cysts develops and these can be found in muscle, lung, brain, etc. (porcine cysticercosis). If the improperly cooked pork meat is consumed by man or if he ingests the eggs, the larval form can continue to develop in the latter. The development and formation of the larval form in the human brain is called neurocysticercosis (NCC); this is the commonest parasitic infection of the central nervous system, and perhaps the commonest in association with epilepsy in developing countries.[9–12] In the brain (parenchymal NCC), larval encystment can also occur in the ventricles, or the subarachnoid space within the

brain and spinal cord (extraparenchymal NCC). Some of these patients might therefore present with increased intracranial pressure, hydrocephalus, fascio-paresis, or stroke. Neurocysticercosis is generally endemic in Africa, Central and South America and India.[5,9,11]

The diagnosis of NCC is essentially based on neuroimaging [computed tomography (CT) and magnetic resonance imaging (MRI) techniques], and tissue identification of encysted larvae from biopsy materials (histopathological/cytopathological techniques) derived from the ventricles, brainstem, or cerebral lesions. The characteristic picture in the CT scan is the presence of 'scolex in the cyst' appearance, in addition to calcified lesions; the MRI shows perilesional edema and cysticerci may be identified within the ventricles and brain stem.[13–17] The tissue diagnosis is premised on the histological or cytological identification of the scolex, characteristic convoluted spiral canal with inward buddings, central rostellum with two rows of refractile hooklets, suckers, and possibly the undulating bladder wall.[11,13,14] Figs. 1–3 show scolex from departmental archival material in one of the cases of neurocysticercosis.

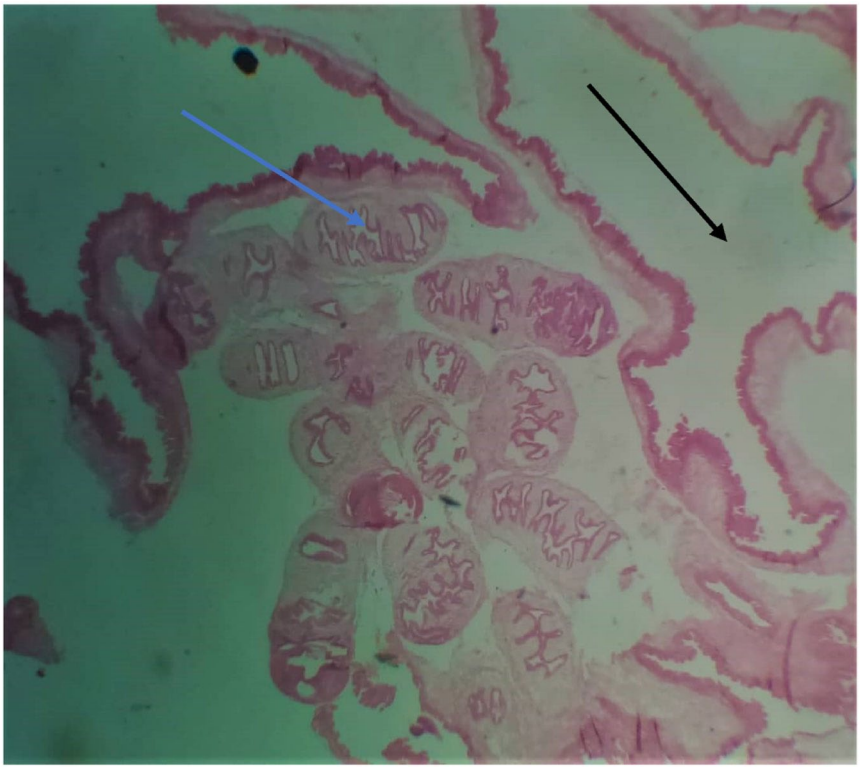

Fig. 1. Bladder wall – Black arrow; Spiral canal – Blue arrow.

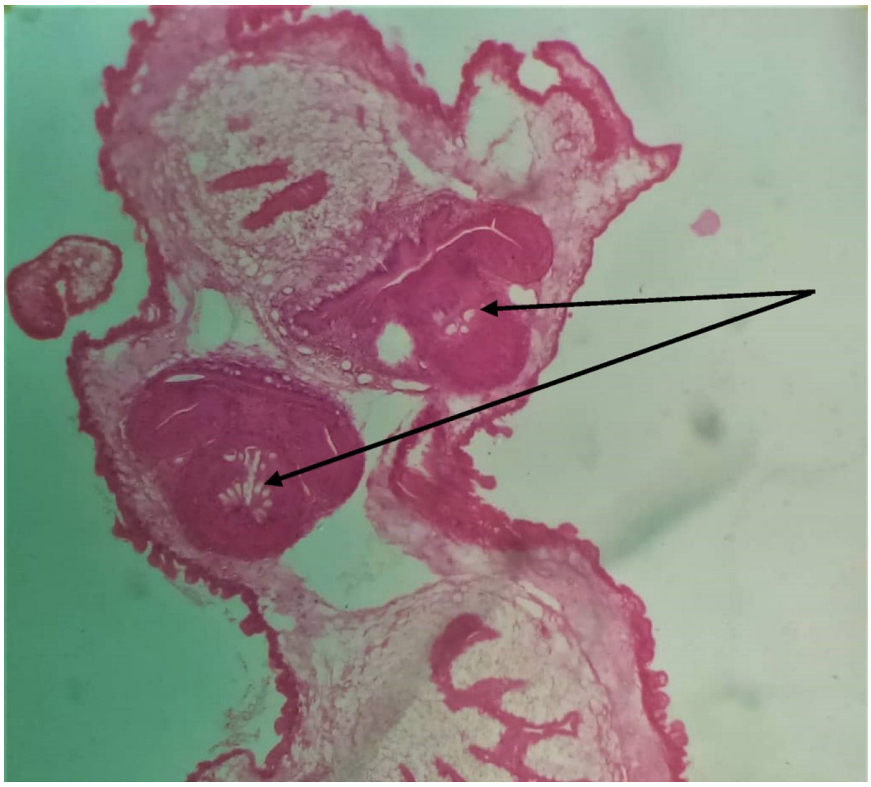

Fig. 2. Two suckers shown by black arrows.

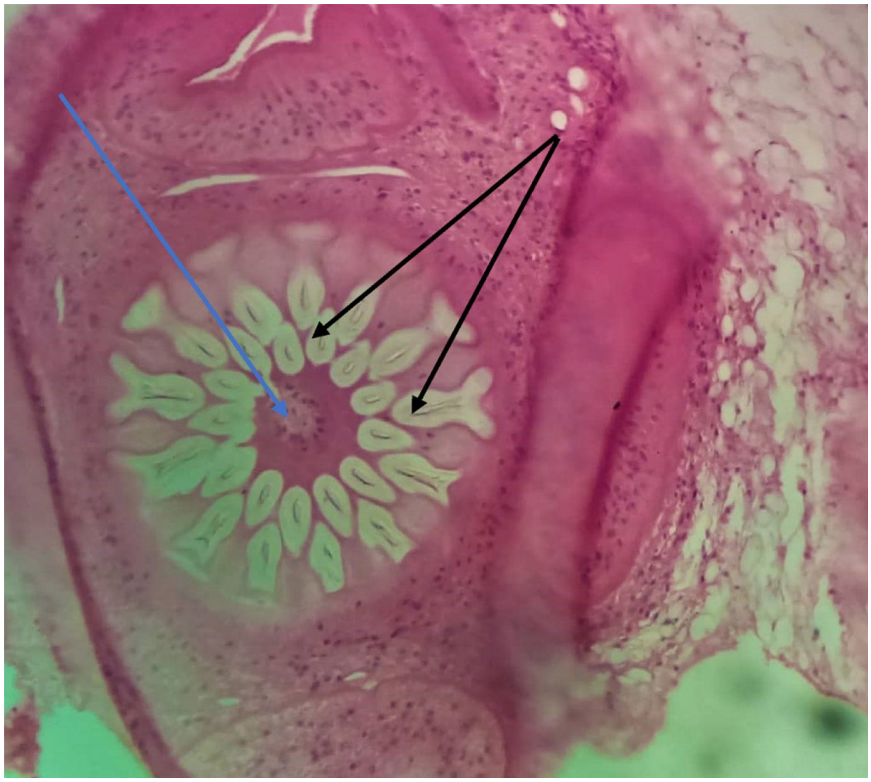

Fig. 3. Inner and outer rows of refractile hooklets shown with black arrow; the central rostellum is shown in blue arrow.

Other radiological findings in antemortem cases include lytic lesions in bones, areas of infarction, necrosis, erosions or other defects, especially involving the skull bones.[14,18,19] The lytic skull lesions containing the larvae, can extend into the subarachnoid space. It is noteworthy that the study by Gomez et al., using CT and MRI techniques, identified other conditions that might mimic NCC and how these can be excluded. These include a variety of systemic diseases, (osteoporosis, renal osteodystrophy, chronic anemic states due to thalassemia, sickle cell disease), benign neoplasms (fibrous dysplasia, osteoma, vascular malformations, ossifying fibroma), malignant neoplasms (osteosarcoma, malignant meningioma, chordoma, multiple myeloma, metastatic tumors to bone), and other localized conditions like arachnoid granulation, hyperostosis and parietal thining.[20]

Immunological tests directed to detect serum enzyme-linked *anti*-cysticercal antibodies have been employed towards the diagnosis.[13,20,21] The response observed in the patient with the use of antihelminthics like Albendazole or Praziquantel, such as, the resolution of intracranial lesions, have also been used in making diagnosis.[13] Epidemiological records indicating household contacts, migration from areas with known endemicity or history of frequent travels to endemic areas have proven helpful in establishing diagnosis. Clinical examination of the fundus might reveal the encysted parasite in positive cases.[13]

The combination of all the above diagnostic parameters have led to the classification of the degree of diagnostic accuracy to Definitive, Probably, and Possibly, using what are described as major, minor and epidemiologic criteria.[13,22–26]

2. Case history

The authors present a case of a partially mummified human remains found in a wooded area with complete skeletonization extending from the cranium to the lower lumbar area. The area of the fourth lumbar downward show mummification. The circumstance required the forensic team, comprising anthropologist, entomologist, pathologist, and odontologist, to assist the Police in identifying the decedent and determining the cause and manner of death.

Based on the wallet found in the pocket of the decedent, anthropological determinations and odontological assessment, the victim was

identified as a Hispanic of Mexican extraction, aged 45–65 years and 167.6 cm tall. The wallet revealed that he was born in Northern Mexico, from where he migrated to Texas.

Subsequent review of his medical records revealed that he was a homeless man who had been admitted into a hospital twelve years earlier after a fall which caused comminuted fracture of the right temporal and parietal skull bones. He also suffered intracranial hemorrhage; he was found to be acutely intoxicated and diabetic. Computed tomographic Scan confirmed the cranial fracture and hemorrhage. In addition, this examination by the attending radiologist reported three small hypodensities in the upper parts of both parietal lobes; these hypodense areas contain centrally placed internal densities. Few tiny suspected calcifications were also noted bilaterally. The areas of hypodensities also showed marginal parenchymal edema. The medical team ignored these neuroimages and focused only on the fractures and acute bleed. A sub-temporal craniotomy was done to remove the blood clot, elevate the depressed skull fracture, and remove some tiny bone fragments. Cranioplasty using a bone flap was performed. A follow-up CT scan performed five days later revealed that the repair was successful. However, the radiologist also reported few bilateral focal punctate cerebral calcifications; these findings were not given any further considerations and consequently, no immunological studies were considered. The patient was moved to a Rehab Care a week after surgery, and in the absence of any other complications, he was discharged home after another nine days. He was counselled on his drinking habits, obesity, and commenced on treatment for his diabetes.

He was seen briefly in hospital ten years later for cellulitis, and treated as a day case. The next time he was seen was when his dead body was found after another two years. Autopsy on this last occasion attributed death to a head injury, probably secondary to a fall with blunt force trauma sequel to a seizure attack; the manner of death was ruled as accident. It is noteworthy that skull examination at autopsy revealed thinning of the cranial cap, parallel to the sagittal suture line, and posterior to the coronal suture line. Endocranial pits were also observed (Figs. 4 and 5).

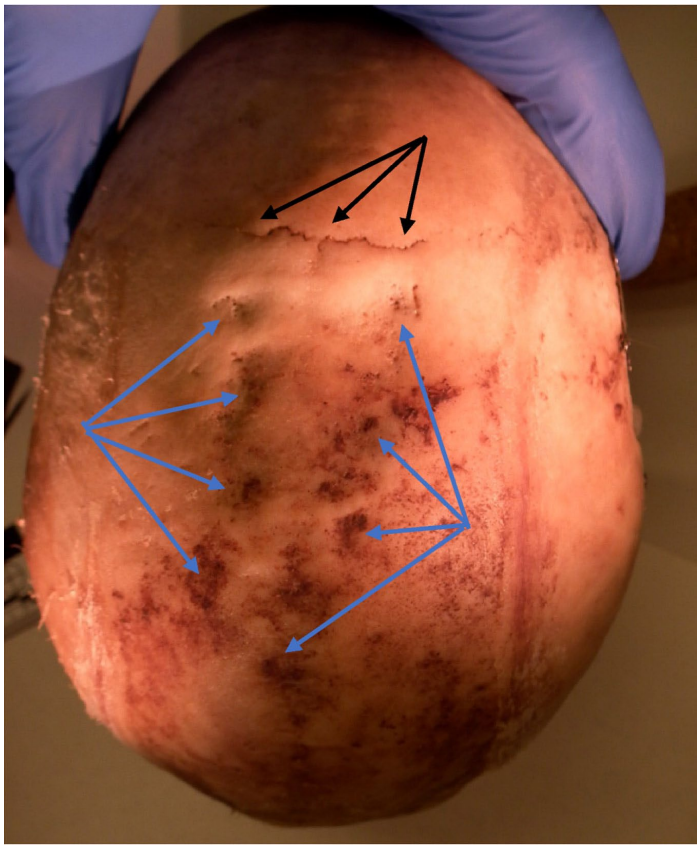

Fig. 4. The vertex of the skull shows the partly occluded ectocranial surface of the coronal suture line of the calvarium (black arrows). There are thinned out parasagittal depressions (blue arrows) on the vertex; the ectocranial surface of the sagittal suture line is completely occluded.

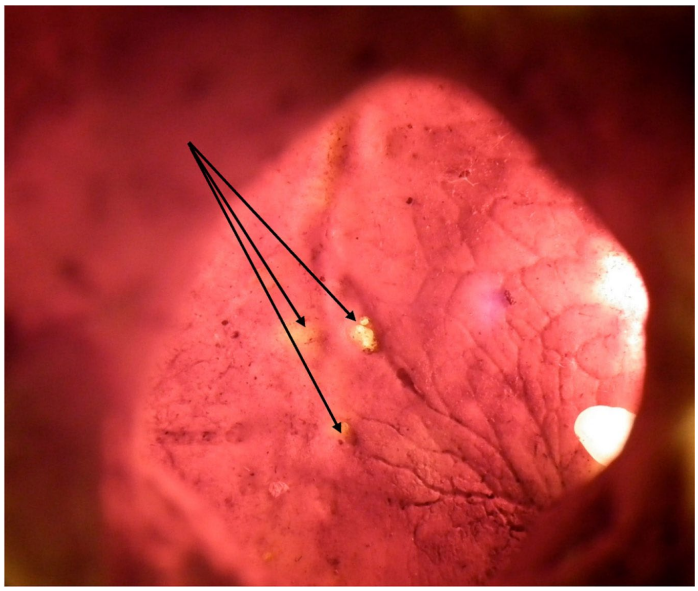

Fig. 5. Endocranial view of the calvarium through the foramen magnum. There are endocranial pits (black arrows), parallel to the obliterated sagittal suture line.

3. Discussion

Neurocysticercosis is fairly easy to diagnose where diagnostic tools like CT scan and MRI used for neuroimaging are readily available, and are complemented by histopathological/cytopathological techniques, as well as, immunodiagnosis. In other words, its detection should be easy in developed countries. However, the diagnosis requires that the attending medical team would have had adequate exposure to tropical diseases during training, develop a high suspicion index. The latter attribute would explain the ease of diagnosis in parts of South America and Africa.[11,14]

The United States of America, as with other industrialized countries, is witnessing more cases of NCC with the continued influx of migrants, particularly from places where the disease is endemic.[4,27–30] The number of cases are believed to be underreported in Central America and the Caribbean which also contribute a large immigrant population to the USA.[31] The disease is understandably commoner in the Texas-Mexico axis, and other States like California, Oregon, Colorado and Illinois with a high Hispanic population.[27–30] The estimated incidence rate of NCC is approximately 0.2–0.6 per 100,000 in the general population in these southern States, and 1.5–5.8 per 100,000 among the Hispanic population; an estimated 1320–5050 new cases are reported annually in the USA.[27–30] Detection of these cases can be partly attributed to the availability of the CT and MRI, coupled with the immunodiagnostic assay methods.[26–30] The importance of the contributory role of the immigrant population is buttressed by the fact that most cases occur amongst them, sero-positivity is highest among the Hispanic population (especially among the closed cohort of farm workers), with far fewer cases attributable to household contacts.[27–30] In fact the disease is more common among Hispanics born overseas when compared to those born in the USA[30]; the former group show incidence rate close to those observed in some Latin American countries.[27,30,32]

The detection of these cases can be accounted for by a combination of available diagnostic technology, training and perhaps a high suspicion index among the healthcare workers. In the index case, he was an immigrant from Mexico who suffered a fall. Granted that he was abusing alcohol, and diabetic, the radiologist reported areas of

hypodensities, foci of tiny calcification and what will pass for scolex in tiny cysts. These are diagnostic of NCC for the initiated, but the medical team ignored the classical findings.[13,22–26] It is not unlikely that the fall suffered by the victim which resulted in the severe head injury, was caused by an NCC-induced seizure, or at least, complemented the observed acute alcohol intoxication. Apparently, NCC was never in consideration as a primary (or contributory) cause of the fall; the team focused on the sequelae and the seemingly obvious predisposing factor. This can be attributed in the least to inexperience, low suspicion index, and remotely, medical negligence. The latter consideration is further highlighted by the fact that the repeat CT scan done five days after the cranioplasty again documented some calcifications in both cerebral hemispheres. Despite the consistency of the neuroimages with NCC, the medical team ignored the prompting; this in the least suggests unfamiliarity with the condition, low suspicion index, or both.

Autopsy revealed thinning of parts of the skull cap (Fig. 4) with presence of endocranial pits (Fig. 5) in the skeletonized remains. These are common findings in NCC.[11,14] It was not surprising that the forensic team in the index case attached significance to NCC and considered it as a possible contributory factor to the blunt force trauma. Probably the victim will still be alive if a diagnosis of NCC had earlier been made and 'treated' thus eliminating the possibility of another accidental fatal fall. The forensic pathologist must also be aware of the osteopathological conditions earlier mentioned,[20] especially the benign lesions that could cause calvarial depressions. A possible depression that could be seen in the sagittal or parasagittal areas is that due to Pacchionian granulations due to exuberant arachnoid granulation.[33] However, as with other possibilities of benign osteolytic conditions like osteoma, enchondroma, fibroma, or fibrous dysplasia, all these conditions lack the presence of characteristic foci of small calcifications observed on CT scans by the radiologist 12 years earlier in the index case. While that report by the radiologist assisted the forensic pathologist to favor NCC, a Pacchionian depression of the calvarium should be borne in mind among the list of possible considerations when confronted with skeletonized remains.

4. Conclusion

Neurocysticercosis remains a neglected tropical disease, that is continuously being encountered in developed countries as a result of immigration. Though the latter countries have all the diagnostic tools to make the diagnosis easy, their physicians need to be adequately trained and periodically retrained to treat immigrants. Healthcare workers must familiarize themselves with the diagnostic criteria, and take closer look at immigrants coming from regions of high endemicity of NCC, or constant travelers to these regions, presenting with intractable headaches, seizures or epilepsy. The neuroimages are fairly pathognomonic and should at least attract a second opinion. When in doubt, a serological study can be ordered. Finally, the forensic pathologist must realize that NCC has recognizable calvarial peculiarities, visible even in skeletonized remains.

5. Recommendations

i. Healthcare workers must remain acquainted with rare and neglected diseases, especially when confronted with immigrants from regions with certain endemic diseases.
ii. These workers should have a high suspicion index and pay attention to every clinical information.
iii. Forensic pathologist should continue to carefully search for, and review all available antemortem clinical records while considering possible differential diagnosis.
iv. Skeletonized remains can still reveal a lot of information and the assistance of forensic anthropologists must sought, particularly where one is available.

Author contributions
KR: Conceptualized, reviewed and edited the manuscript.
JOO: Prepared the original draft, sought for references and formatted the manuscript.

Competing interest The authors have no competing interests.

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