Parasitic infection of the nervous system

Sireethorn Pienchitlertkajorn, MD

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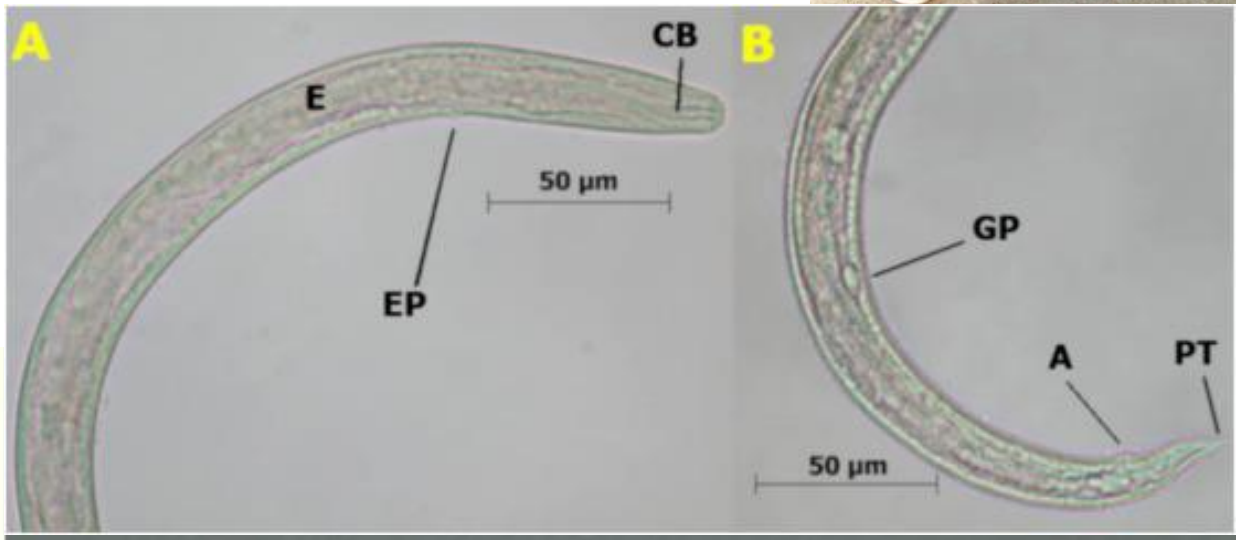
Life cycle & Host

- **Life cycle**
  - 1) Complete life cycle in one host
  - 2) Need two different hosts
- **Host**
  - **Definitive host (primary host / final host)**
    - the one which harbors the adult parasite and where **the parasite reproduces sexually.**
  - **Intermediate host (secondary host)**
    - the host which harbors the **larval stage** or **the asexual forms** of the parasite.
  - **Paratenic host (transfer host / transported host)**
    - a potential or substitute intermediate host that **serves until the appropriate definitive host is reached,** and in which no development of the parasite occurs
    - It may or may not be necessary to the completion of the parasite's life cycle.
  - **Accidental host**
    - one that accidentally harbors an organism that is not **ordinarily parasitic in the species**.

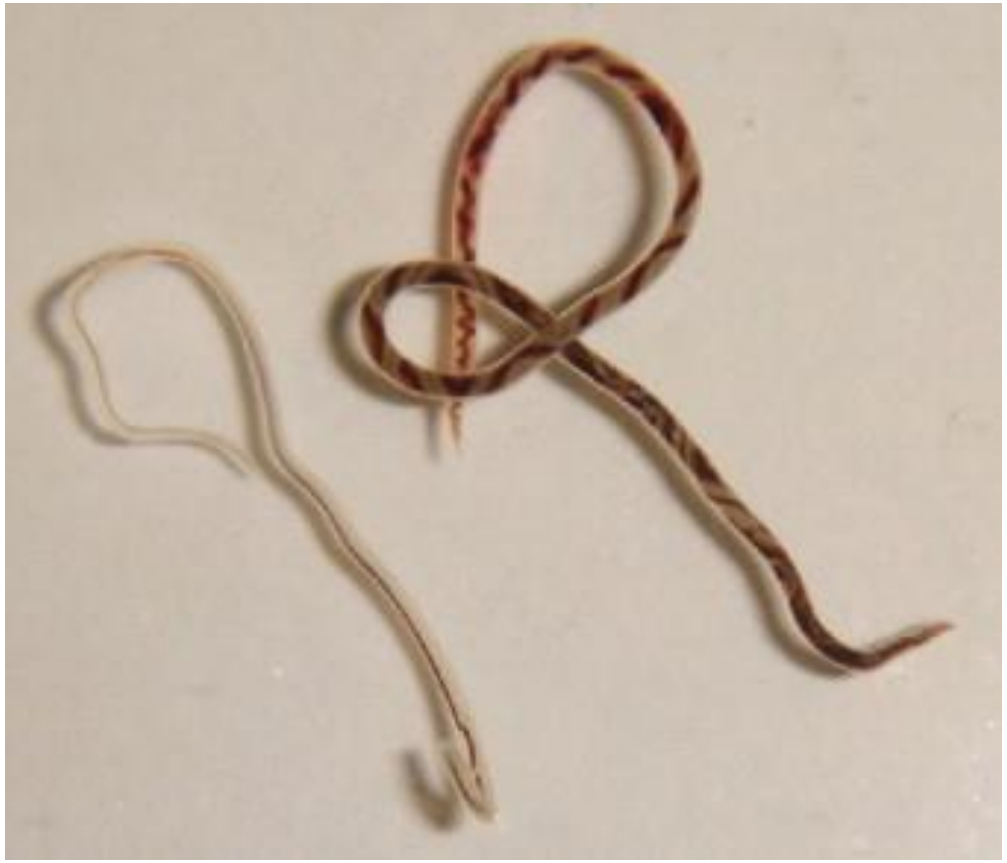
Angiostrongylus cantonesis (Rat lung worm; พยาธิปอดหนู)

Most common CNS parasitic infection



Angiostrongylus cantonesis

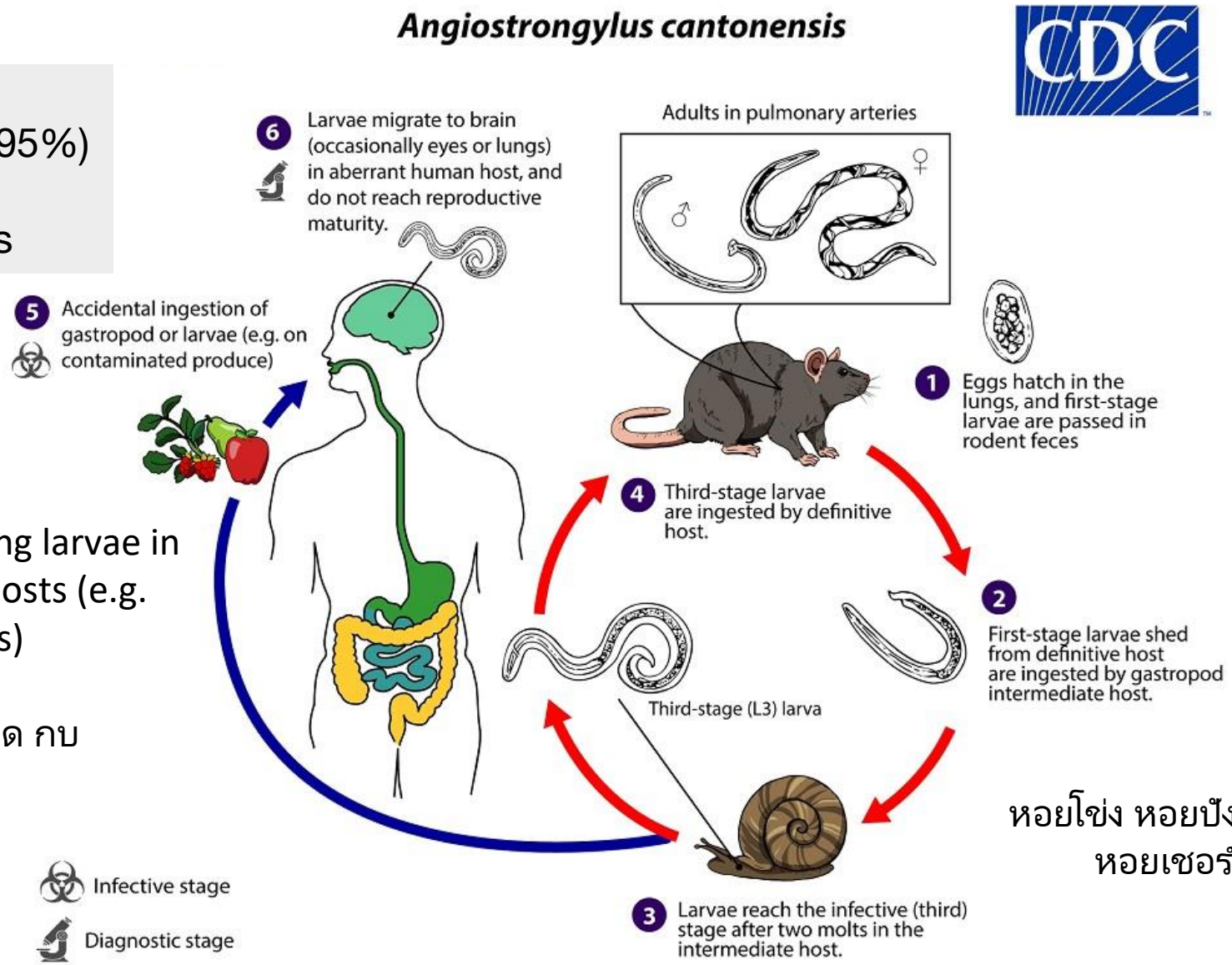
- Left male (body length 13–20 mm)
- Right, female (body length 16–26 mm)



Angiostrongylus cantonesis

3 Main manifestations

- Eosinophilic meningitis (95%)
- Encephalitis
- Ocular angiostrongyliasis



Humans are infected by eating larvae in undercooked intermediate hosts (e.g. snails, slugs, crabs, or prawns)

หอย กุ้งเต้น ตับตะกวดดิบ ปูน้ำจืด กบ

Incubation period
1-3 weeks

หอยโข่ง หอยปัง หอยขม หอยจุ๊บ
หอยเชอร์รี่ หอยทาก

Angiostrongylus cantonesis

- **Ocular angiostrongyliasis**
  - **Clinical**
    - Visual loss
    - Found parasite at retina or vitreous

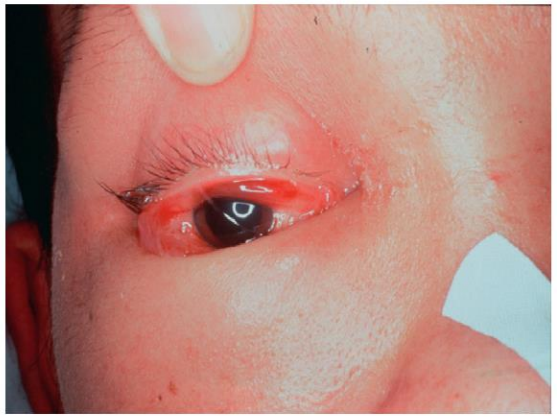


Fig. 15.3. A patient with ocular angiostrongyliasis. Blurred vision with chemosis is presenting symptom.

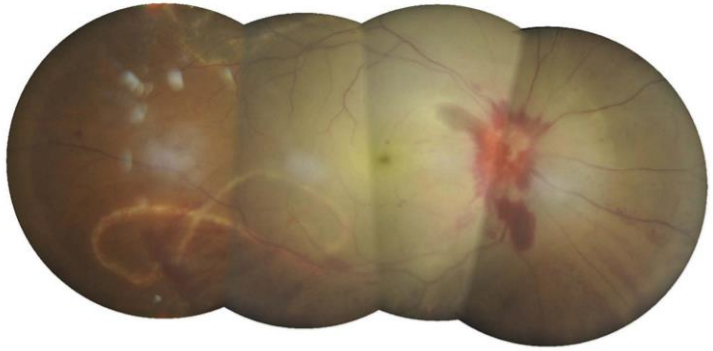


Figure 2 Large subretinal angiostrongyliasis with severe disk hemorrhage and extensive retinal whitening.

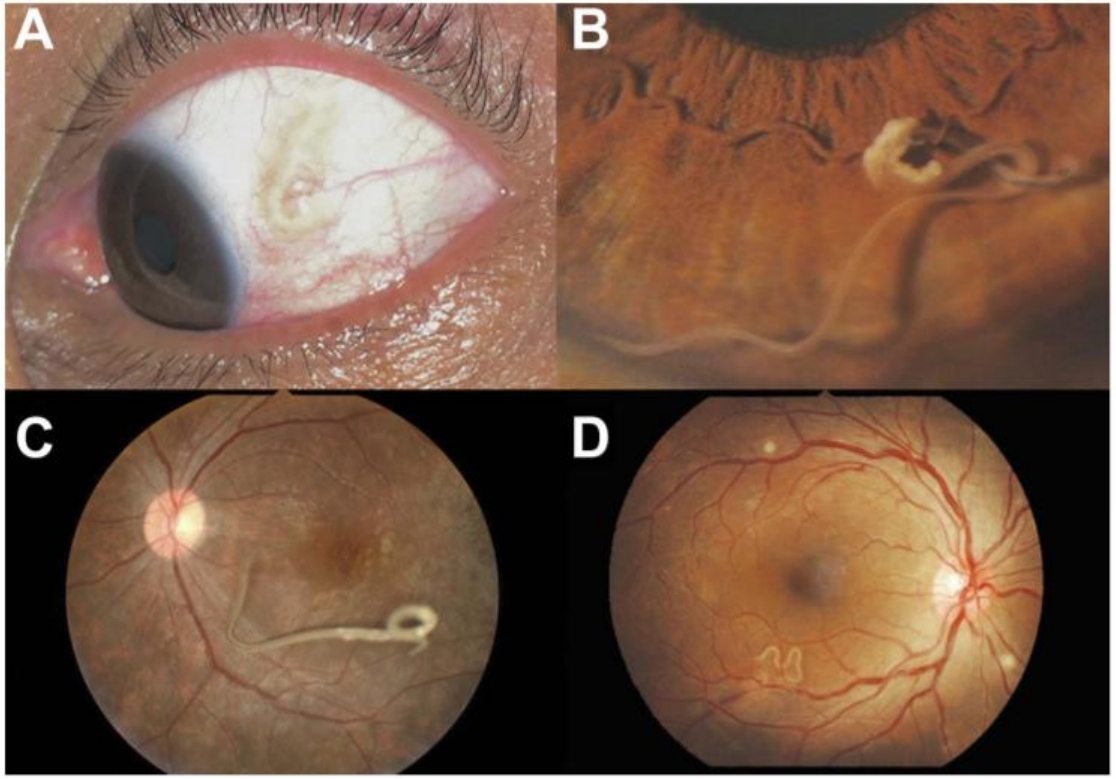


Figure 1 *Angiostrongylus cantonensis* larvae in subtenon space (**A**), aqeous humour (**B**), vitreous cavity (**C**), and subretinal space (**D**).

Sinawat S, et al. Ocular angiostrongyliasis in Thailand: a retrospective analysis over two decades. Clinical ophthalmology. 2019

Angiostrongylus cantonesis

- **CBC** – Eosinophilia
- **LP** – confirmed eosinophilic meningitis
  - Rarely found parasite in specimen
- **CT/MRI brain**
  - Non-specific
- **Serology**
  - ELISA/Western blot in blood
    - Detect Specific Ab to 29kDa or 31kDa of Ag to parasite
    - Sensitivity 93.5%, specificity 91.5%, PPV 79%, NPV 97.5%
- **PCR**
  - high specificity; rarely use

ตารางที่ 3 การตรวจทางห้องปฏิบัติการ
ในผู้ป่วยเยื่อหุ้มสมองอักเสบชนิดอีโอสิโนฟิลิก

Blood eosinophilia (> 700 cells/mm3)	78%
CSF abnormalities	
High opening pressure (>300 mm H2O)	38%
WBC/mm3	711 (85-5,700)
Eosinophilia, %	45 (10-84)
Protein content, mg/dl	111 (27-574)
Glucose ratio, CSF/blood,	44 (17-100)

high protein
normal/low glucose ratio

Something floating in Coconut juice

(Light reflection from eosinophil granule)
Angiostrongylus cantonensis

Tangwanicharoen T, et al. CSF fluid analysis in Eosinophilic Meningoencephalitis. SEA J Trop Med Public Health. 2001.

Angiostrongylus cantonesis

MRI features

TABLE 3 Magnetic resonance features of *Angiostrongylus cantonensis* infection

MR diagnosis	Case number	T1WI	T2WI	FLAIR	Enhancement	Enhanced FLAIR
Simple meningitis	16	—	—	—	The pia mater shows marked linear/nodular enhancement	The pia mater shows mild-to-moderate linear/ nodular enhancement
Meningitis with encephalitis	4	Multiple small patches of iso/ hypointensities	Small areas of hyperintensity	Small areas of hyperintensity	Nodular enhancement and perichondrial enhancement	Enhancement of the pia mater
Simple encephalitis	4	Multiple iso/hypointensities	Hyperintense nodules	Hyperintense nodules	Nodular enhancement within the lesion	/
Meningitis with vasculitis	1	Flowing avoid effect of multi- ple blood vessels around the meninges	Multiple perimeningeal vascular thickening	Multiple perimeningeal vascular thickening	Nodular enhanced perichon- drium and thickened blood vessels	The pia mater pre- sents linear/nodular enhancement
Simple vasculitis	2	Flowing avoid ef fect of multi- ple blood vessels around the meninges	Multiple perimeningeal vascular thickening	Multiple perimeningeal vascular thickening	Clear enhancement of thick- ened vessels	Perimeningeal multiple thickening flow empty vascular

Note: — Indicates that there was no abnormality in the sequence; / Indicates that the sequence was not scanned.
Abbreviations: FLAIR, fluid-attenuated inversion recovery; MR, magnetic resonance, T1WI, T1-weighted imaging, T2WI, T2-weighted imaging.

Brain and Behavior. 2019;9:e01361.
https://doi.org/10.1002/brb3.1361

Angiostrongylus cantonesis

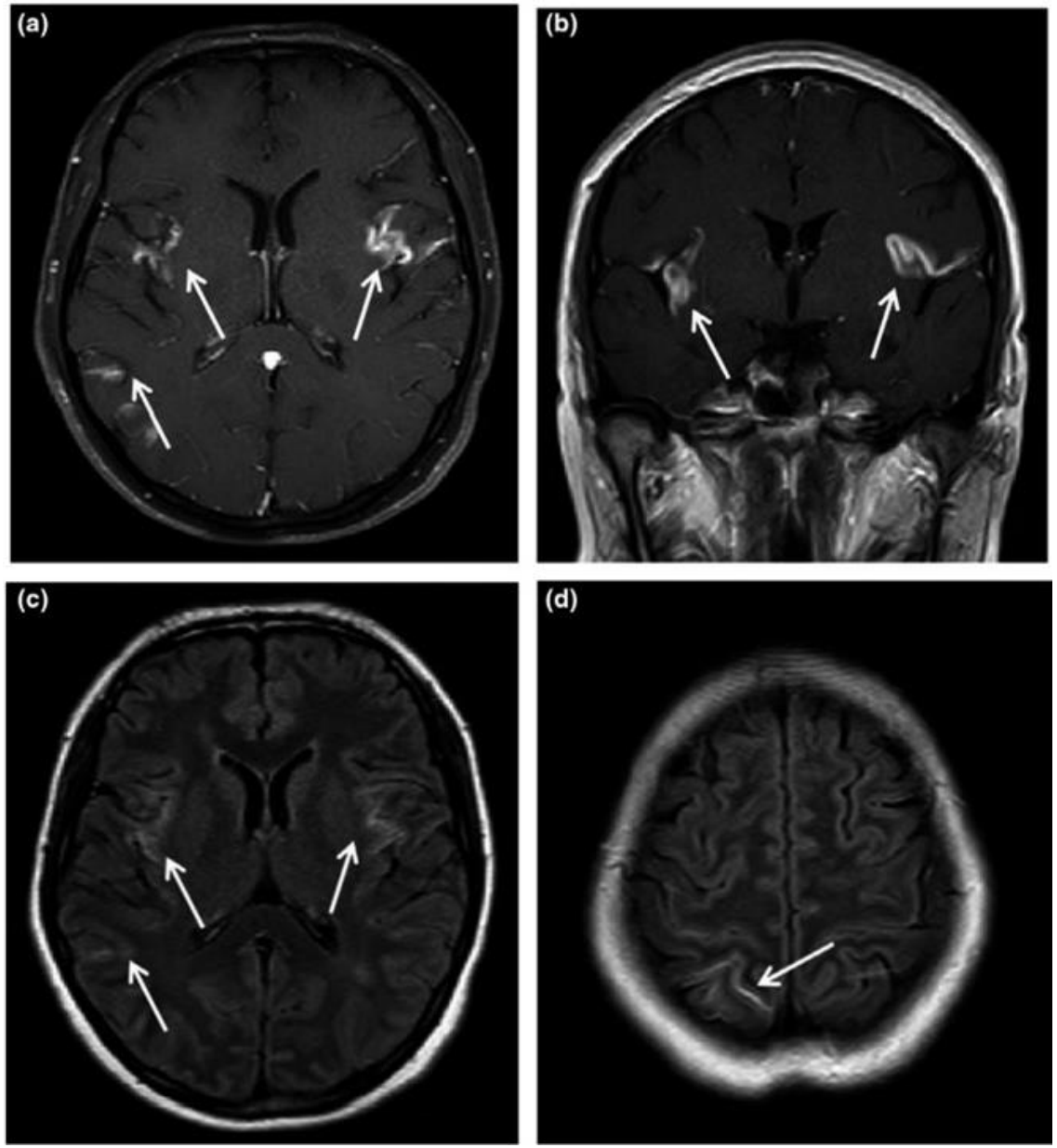


FIGURE 2 (a–d) A male, 35 years old. (a, b) Axial and coronal enhanced T1WI scans showing multiple long, abnormal enhancements in the pia matter. (c, d) Axial enhanced FLAIR image showing multiple long, abnormal enhancements in the pia matter, slightly lower than in the enhanced T1WI scan

Brain and Behavior. 2019;9:e01361.
https://doi.org/10.1002/brb3.1361

Angiostrongylus cantonesis

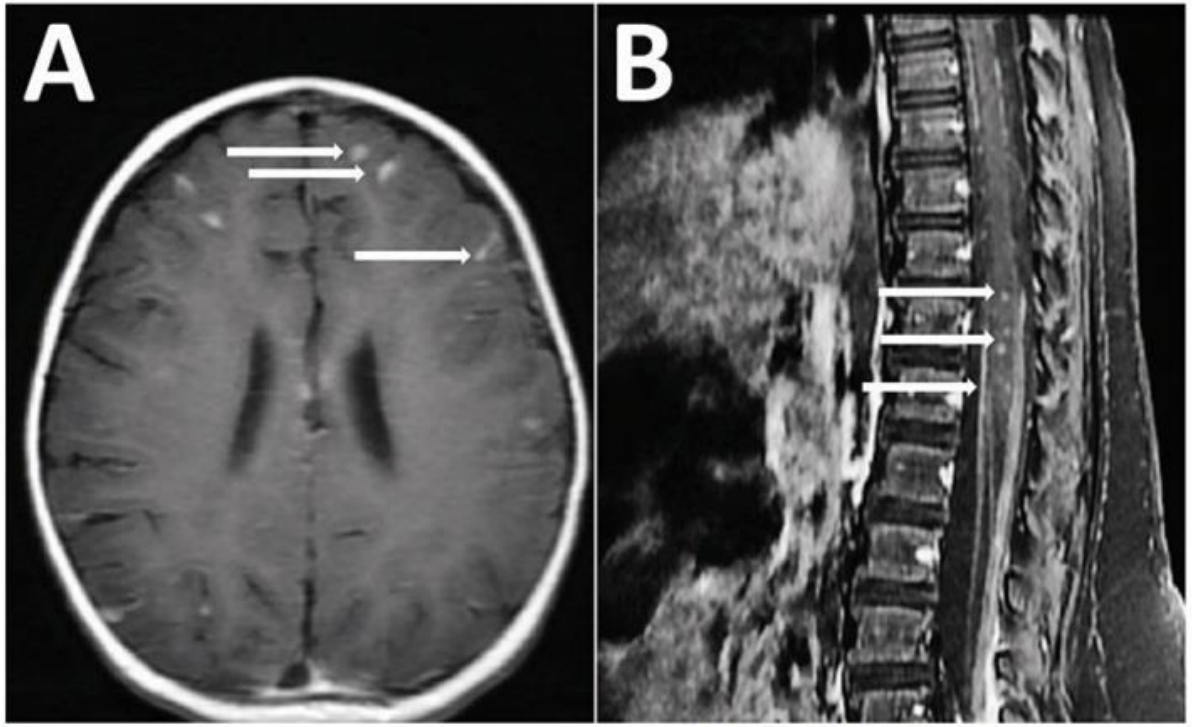


Figure. Magnetic resonance imaging (MRI) of the brain (A) and the spine (B) showing meningitis and myelitis in a 12-month-old girl with *Angiostrongylus cantonensis* infection, Houston, Texas, USA. A) Axial T1 post contrast sequences showing diffuse leptomeningeal enhancement (arrows). B) Sagittal T1 postcontrast sequences showing intramedullary enhancement in the thoracic and lumbar spinal cord T8–L5 with diffuse leptomeningeal enhancement (arrows).

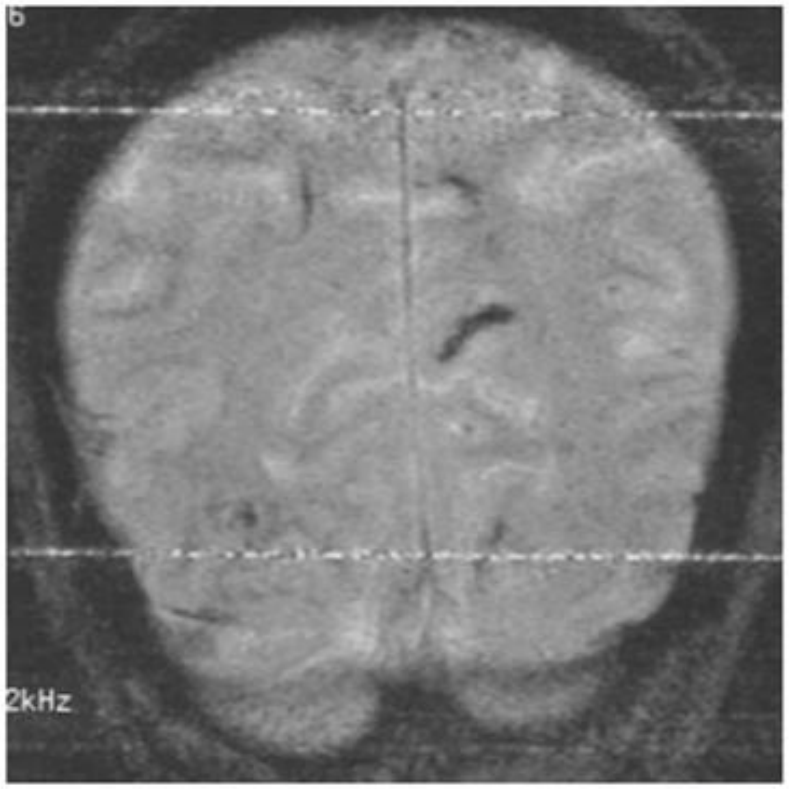


FIG 3. 64-year-old man. Coronal gradient-echo MR image (640/25/2) shows linear hypointense subcortical lesions, which might represent hemorrhagic tracks.

Kanpittaya J, et al. MR Findings of Eosinophilic Meningoencephalitis Attributed to *Angiostrongylus cantonensis*. AJNR.

Roukaya Al Hammoud. Angiostrongylus cantonensis Meningitis and Myelitis, Texas, USA. Emerging Infectious Diseases . June 2017

Angiostrongylus cantonesis

- **Meningitis**
  - **Specific treatment** combination
    - **Albendazole 15 mg/kg/day divided in bid dose x 2 weeks**
    - **Prednisolone 60 mg/day x 2 weeks**
      - **Main therapy (more important than albendazole)**
      - Reduce inflammation
      - Decrease headache + pain medication
      - Decrease frequency of LP for releasing pressure
  - **Supportive**
    - Large volume LP releasing pressure 20-40 ml in case of high ICP
  - **Prognosis**
    - Usually, Self-limited with good recovery within 4-6 weeks
    - Encephalitis - High risk of mortality

Ansdell V, et al. Guidelines for the diagnosis and treatment of neuroangiostrongyliasis: updated recommendations. Parasitology. 2021

Angiostrongylus cantonesis

- **Ocular angiostrongyliasis**
  - **Focal laser photocoagulation**
    - eradicate subretinal angiostrongyliasis
  - **Laser treatment prior to surgical removal**
    - eliminate intracameral and intravitreal angiostrongyliasis.
  - **IVMP**
    - may be beneficial in cases of acute optic neuritis.
  - **Anti-helminthic** in case of meningitis
  - The visual prognosis mainly depends on
    - ocular pathology
    - parasitic migration pathway.

Table 1 Patient demographic data, ocular findings, management, and visual outcome

Sex	Age (y)	Meningitis	Duration (weeks)	Ocular exam (initial)					Investigation		Treatment				Final VA
				Eye	Location	VA	RAPD	Ocular findings	Eosinophilia	Stool exam (eggs)	Laser	Antihelminthic	Steroid	PR	
M	27	Preceded	3	Left	Intravitreal	1/60	+	Chorioretinitis, subretinal track	–	NA	+	Albendazole ×7	Topical prednisolone	+	1/60
M	21	Coexisting	1	Left	Intravitreal	2/60	+	RPE alteration	+	NA	+	—	Oral prednisolone	–	2/60
M	47	—	3	Left	Intracameral	CF	+	RPE alteration, disk swelling, intraretinal hge	NA	Sarcocystis Opisthorchis	+	Albendazole ×14	IV, oral, topical prednisolone	+	1/60
F	44	—	0.5	Right	Subretinal	LP	+	Subconjunctival hge subretinal track, serous R.D, macular opacification, peripapillary hge, vitreous hge	NA	Not found	+	Albendazole ×14, ivermectin once	Oral, topical prednisolone	–	no LP
F	36	Preceded	1	Left	Intravitreal	CF	+	RPE alteration, disk swelling	+	NA	+	—	Oral prednisolone	+	CF
F	41	—	4	Left	Subtenon	6/6	–	Conjunctival injection	NA	*Enterobius*, hookworm	–	Albendazole ×7	Topical prednisolone, subconjunctival dexa	+	6/6
M	50	—	2	Left	Subretinal	CF	+	RPE alteration, subretinal track	+	Not found	+	Albendazole ×7	Topical prednisolone	+	CF
M	76	—	2	Right	Intracameral	6/60	–	Corneal scar, fibrin in anterior chamber	NA	Opisthorchis	–	Praziquantel ×7	Topical prednisolone	+	6/36
F	63	—	8	Left	Intracameral	LP	–	Corneal scar, hyphema, vitreous hge, preretinal hge	–	Not found	–	Albendazole ×7	Topical prednisolone, Subconjunctival dexa	+	HM
F	51	—	2	Left	Intravitreal*	HM	–	Focal iris atrophy, choroiditis	+	*Strongyloides* larva	+	Albendazole ×7	Topical prednisolone	–	HM
F	22	—	8	Right	Intravitreal	1/60	+	RPE alteration, disk swelling	–	NA	–	—	Oral prednisolone	+	1/60
F	28	—	0.5	Right	Subretinal	6/24	–	Subretinal track	–	NA	+	—	Oral prednisolone	–	6/24
M	36	—	1	Right	Subretinal	CF	+	Macular edema	NA	Echinostoma	+	Albendazole ×7	Topical prednisolone	+	2/60
M	39	—	1.5	Right	Intravitreal	6/6	–	—	NA	NA	+	—	—	–	6/6
F	33	—	1	Left	Subretinal	1/60	+	RPE alteration	–	NA	+	—	Oral prednisolone	–	5/60
M	27	—	4	Right	Subretinal	CF	+	Subretinal track	NA	NA	+	Albendazole ×7	-	–	CF
M	46	—	3	Right	Intracameral	CF	+	RPE alteration, vitritis	–	NA	+	—	Oral, topical prednisolone	+	CF
M	46	—	1	Right	Intravitreal	CF	+	RPE alteration, vitritis	–	Not found	+	Albendazole ×7	Topical prednisolone	+	6/60

Note: *The parasite migrated from anterior chamber to vitreous cavity.
Abbreviations: VA, visual acuity; CF, counting finger; hge, hemorrhage; HM, hand motion; LP, light perception; PR, parasitic removal; RPE, retinal pigment epithelium; dexa, dexamethasone; RAPD, relative afferent pupillary defect; NA, not available.

Sinawat S, et al. Ocular angiostrongyliasis in Thailand: a retrospective analysis over two decades. Clinical ophthalmology. 2019

Angiostrongyliasis

- Angiostrongylus cantonesis
- Angiostrongylus malaysiensis

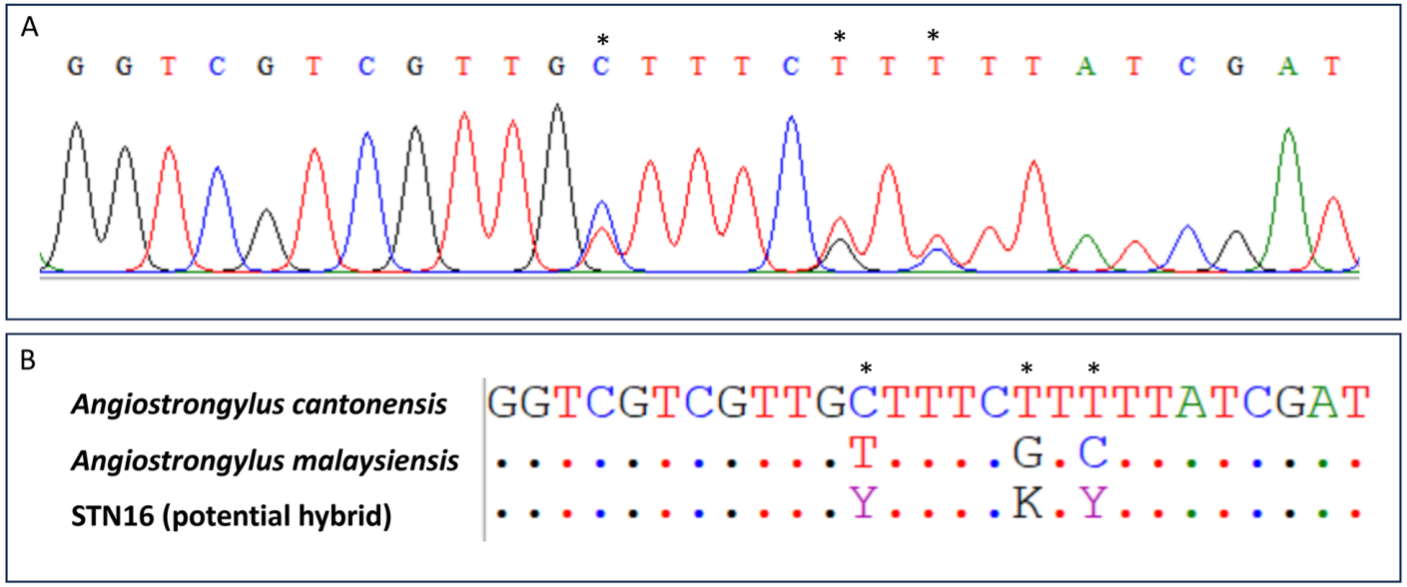
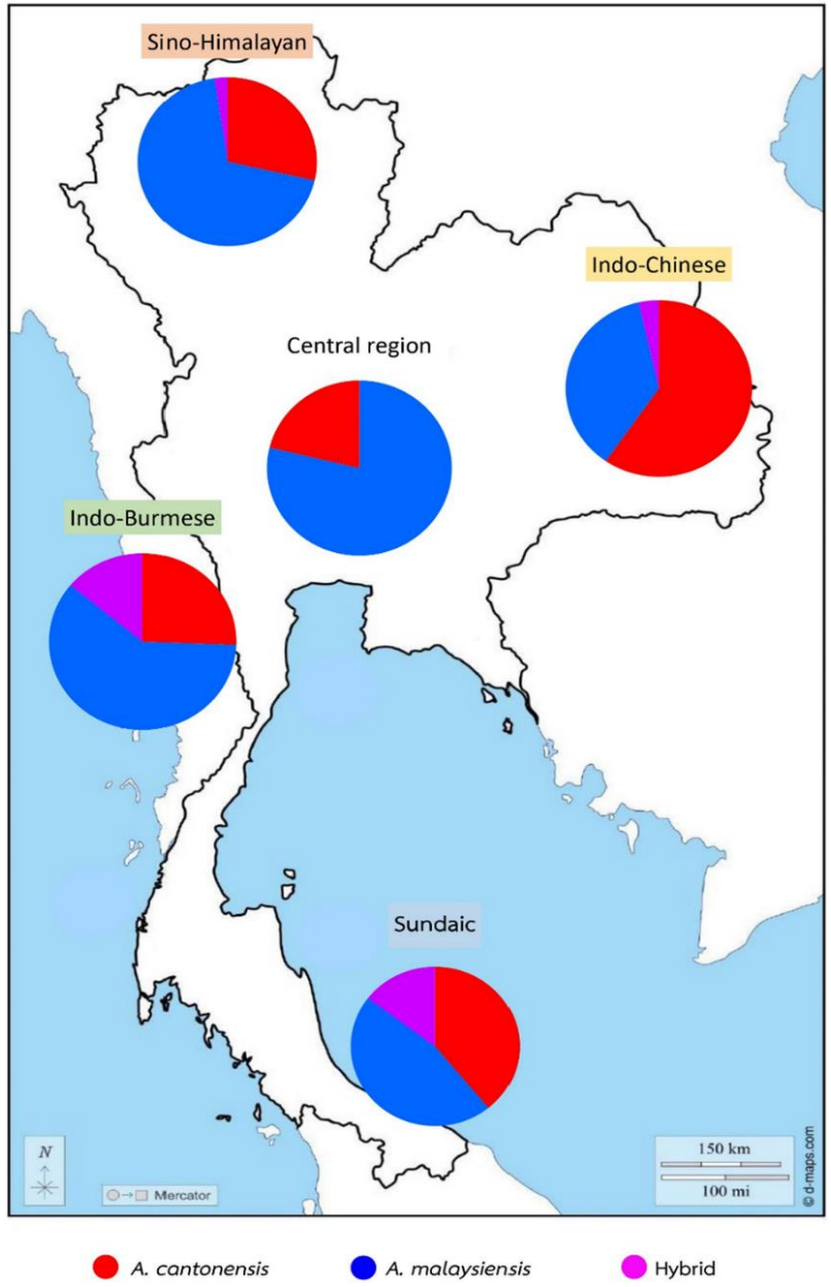


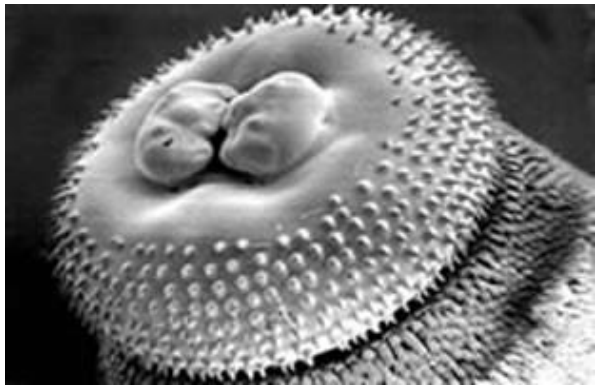
Fig. 2 Evidence of the hybrid form of *A. cantonensis* and *A. malaysiensis* in the **A** electropherogram and **B** sequence alignment. An asterisk (*) indicates the position of the double peaks observed at the fixed difference positions

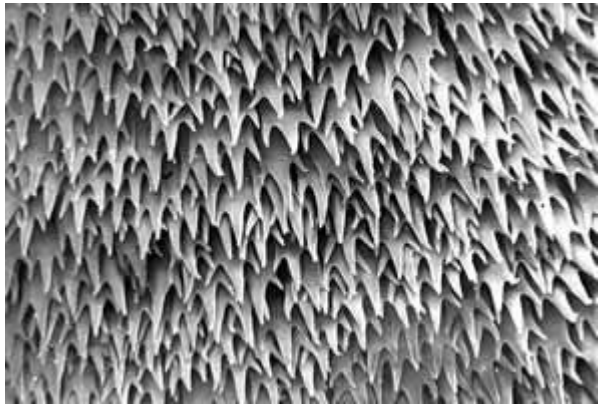


Kaenkaew et al. Parasites & Vectors (2024) 17:56
https://doi.org/10.1186/s13071-024-06140-9

Gnathostoma spinigerum
(พยาธิตัวจี๊ด)

Size is <u>larger</u> than ***Angiostrongylus spp.***



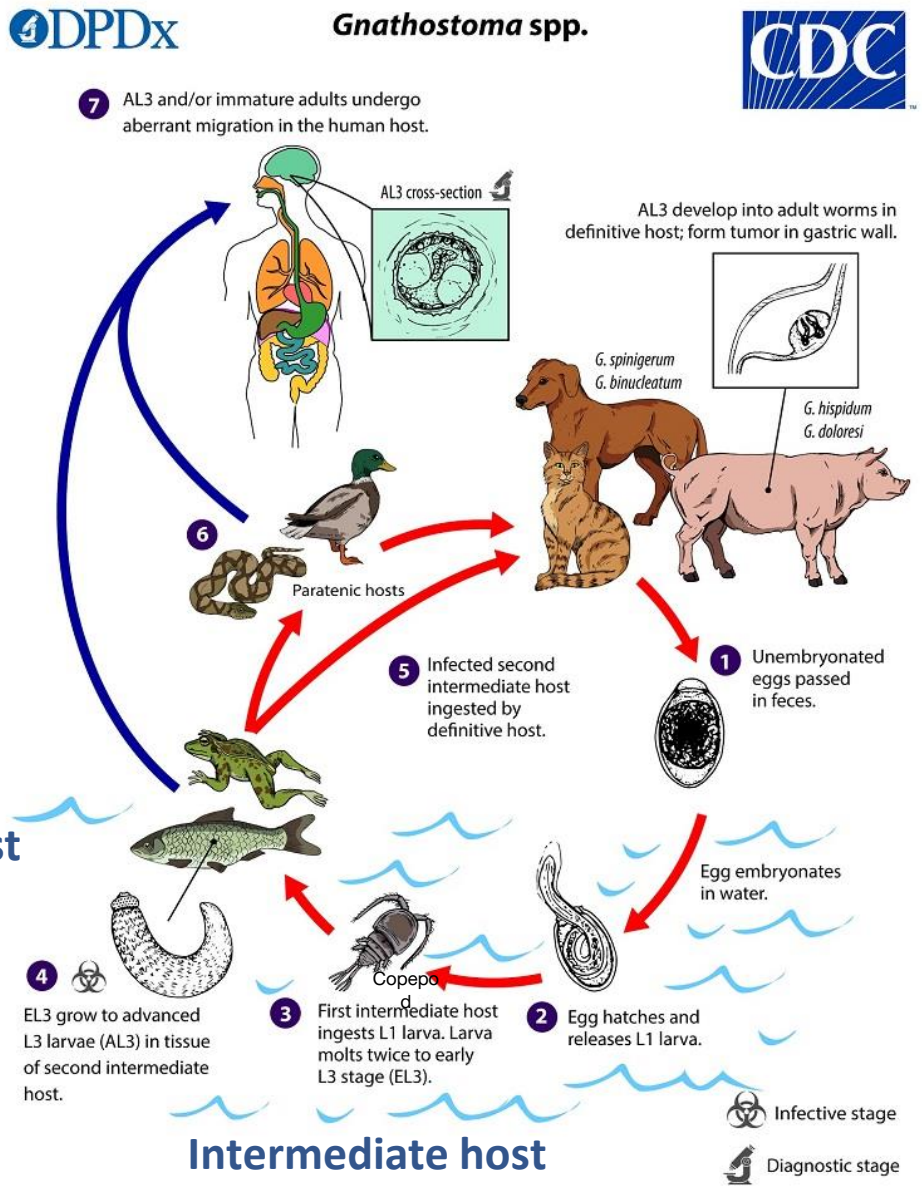


Gnathostoma spinigerum

Accidental host

ปลาส้มฟัก ปลาย่าง
ก้อย
ไก่ เป็ด กบ นก หนู งู

Paratenic host



Definitive host

Intermediate host

Intermediate host

Rare cause
- Skin
- Prenatal

Gnathostoma spinigerum

- **4 main clinical presentations**
  - **Radiculomyelitis, myelitis, myeloencephalitis (55%)**
    - Sharp radicular pain and a spinal syndrome (paraplegia, monoplegia, quadriplegia, bladder dysfunction, sensory disturbances), can progress to cerebral involvement (myeloencephalitis)
    - Entry : Intervertebral foramina along the spinal nerves and vessels
  - **Meningitis, meningoencephalitis (30%)**
    - Severe headache, stiffness of the neck, cranial nerve palsies, disturbance of consciousness, focal neurologic signs
    - Entry : Neural foramina of the skull base along the cranial nerves and vessels
  - **Intracerebral hemorrhage (ICH) (8%)**
    - Headache, sudden-onset focal neurologic signs
    - Entry : Intervertebral or neural foramina
  - **Subarachnoid hemorrhage (SAH) (7%)**
    - Thunderclap headache, meningeal signs
    - Entry : Intervertebral or neural foramina

Juri Katchanov, et al. Neurognathostomiasis, a Neglected Parasitosis of the Central Nervous System. *Emerging Infectious Diseases*: 2011

Gnathostoma spinigerum

- **Clinical clues for diagnosis**
  - **Intermittent migratory swelling**
    - Itching & Pain ; migratory area
    - Average 1-2 wk (range 2-3 d to 1 mo)
  - Creeping eruption (rare)
  - Found parasite in other organs
    - Eye - Unilateral eyelid swelling
    - Opening route – mouth, genitalia, KUB, ear, GI

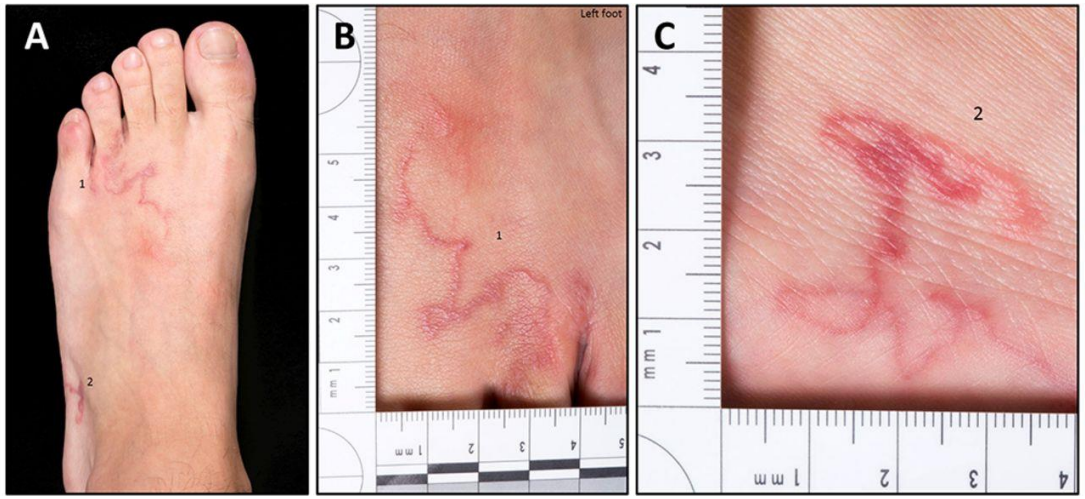


Fig. 15.6. Migratory swelling on left forearm caused by *G. spinigerum*.

Gnathostoma spinigerum

- **CBC**
  - Eosinophilia of patients >30%
- **LP** – confirmed eosinophilic meningitis
  - Pressure – normal, high
  - SAH – bloody CSF or Xanthochrome
  - WBC < 500 + Eosinophils
  - Slightly elevation of protein
  - Normal sugar
- **Serology**
  - ELISA/Western blot in blood
    - Detect Specific Ab to 21kDa or 24kDa of Ag to parasite

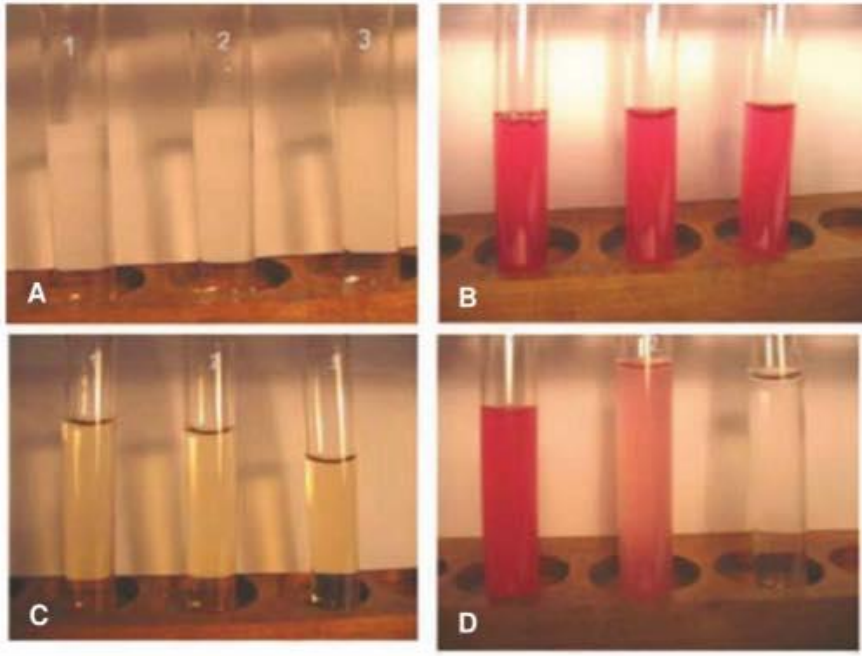
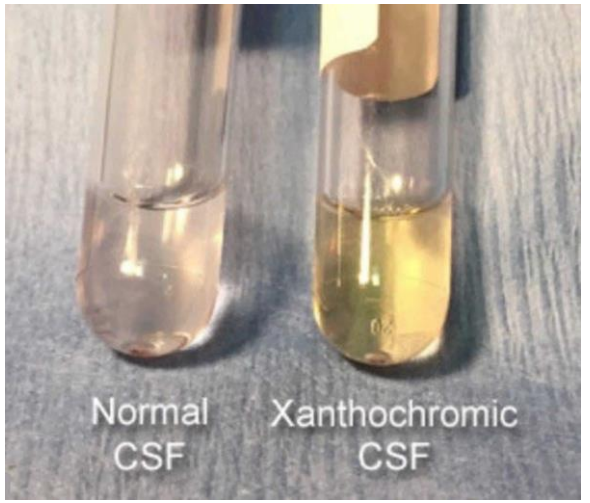


Figure 12-5. Comparison of cerebral spinal fluid appearance between **(A)** normal CSF, **(B)** red CSF from fresh hemorrhage, **(C)** xanthochromic CSF from old hemorrhage, and **(D)** CSF from a traumatic tap.



Gnathostoma spinigerum

Table 2. Neuroradiologic features of neurognathostomiasis*

Site	Procedure	Findings
Brain	CT	Parenchymal (single or multiple), subdural or subarachnoid hyperdensities corresponding to intracranial hemorrhage
	MRI	Multiple (worm-like) T2-weighted hyperintensities or hypointensities in both hemispheres and the cerebellum of ≥3 mm diameter (hemorrhagic tracks) with or without gadolinium enhancement
Spinal cord	MRI	Dilatation/swelling of the spinal cord with multisegmental T2-weighted hyperintensities, frequent gadolinium enhancement (slight to moderate) on T1 postcontrast images

*CT, computed tomography; MRI, magnetic resonance imaging.

Juri Katchanov, et al. Neurognathostomiasis, a Neglected Parasitosis of the Central Nervous System. *Emerging Infectious Diseases*: 2011

Gnathostoma spinigerum

Fig. 15.8. MRI of the brain showed hemorrhagic tract at corpus collasum and subarachnoid hemorrhage at left sylvian fissure caused by *G. spinigerum*.

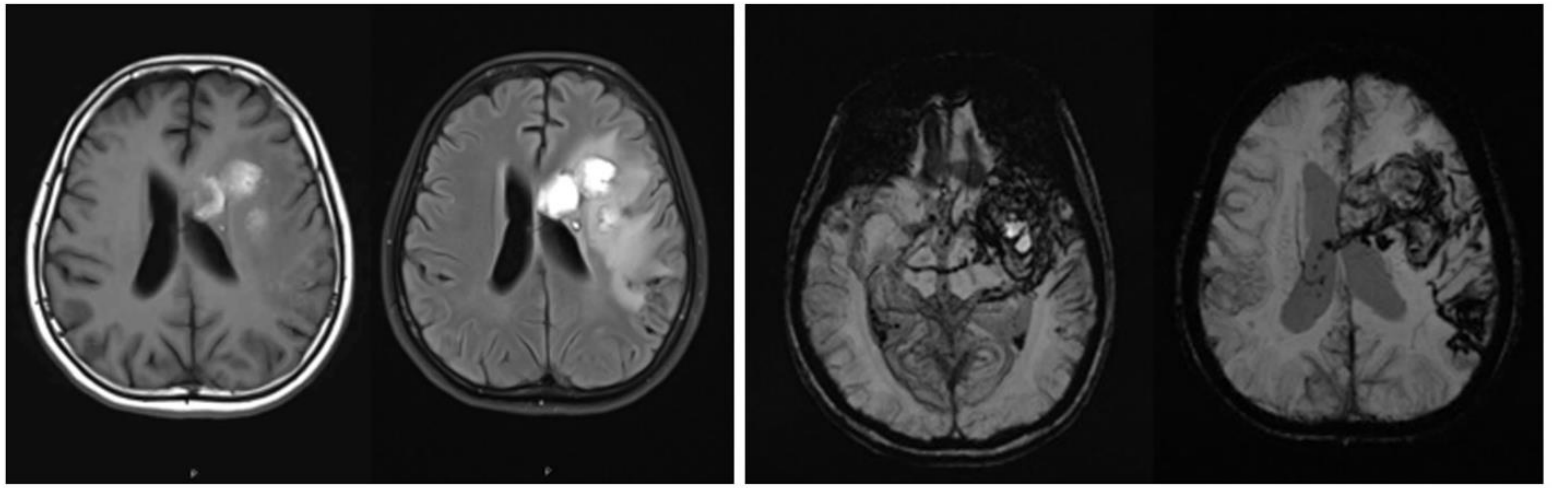
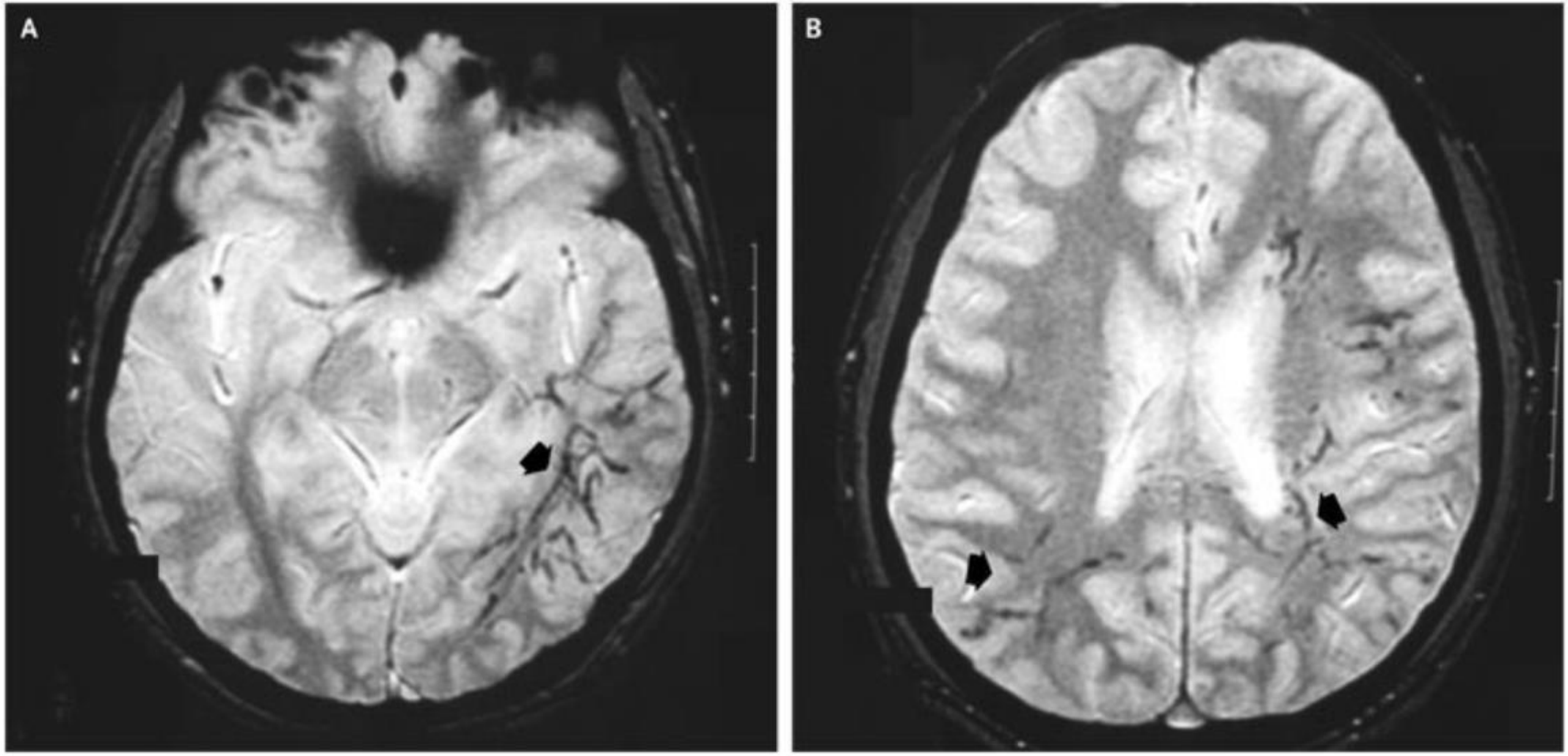


Figure 1. The MRI brain scan shows a 4.5x4.4x3.6-cm subacute hematoma in the left basal ganglion and also in the left insular lobe. Multiple sites of subacute to old hemorrhages in bilateral cerebral hemispheres and thin low intensity hemosiderin stained tracts are observed.

Sorakai Wongpaiboonwatana. Neurognathostomiasis Presented with Multiple Episodes of Intracerebral Hemorrhage: A Case Report. JINFECT DIS ANTIMICROB AGENTS 2020

Gnathostoma spinigerum



Sithinamsuwan P, Chairangsaris P. Gnathostomiasis — Neuroimaging of Larval Migration. NEJM. 2005

Gnathostoma spinigerum

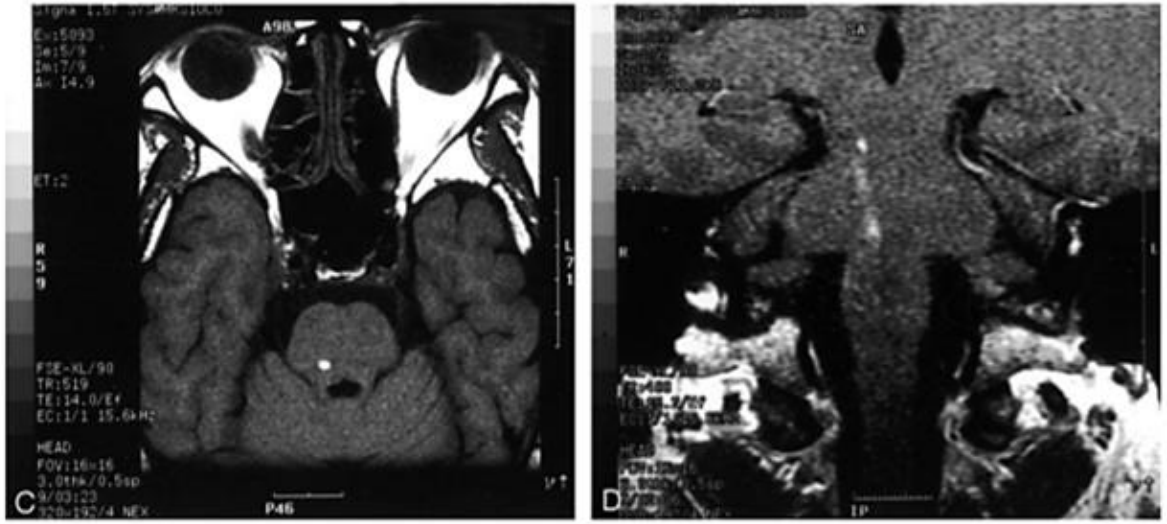


FIG 1. Case 1. MR images of spinal cord and brain.
A and *B*, Sagittal T2-weighted images, showing diffuse cord enlargement with abnormal high signal intensities.
C, Axial T1-weighted image, showing hemorrhagic spot at posterior midpons.
D, Coronal T1-weighted postgadolinium image, showing hemorrhagic tract at posterior midpons level.

Sawanyawisuth K, et al. MR Imaging Findings in Cerebrospinal Gnathostomiasis. AJNR. 2004

Gnathostoma spinigerum

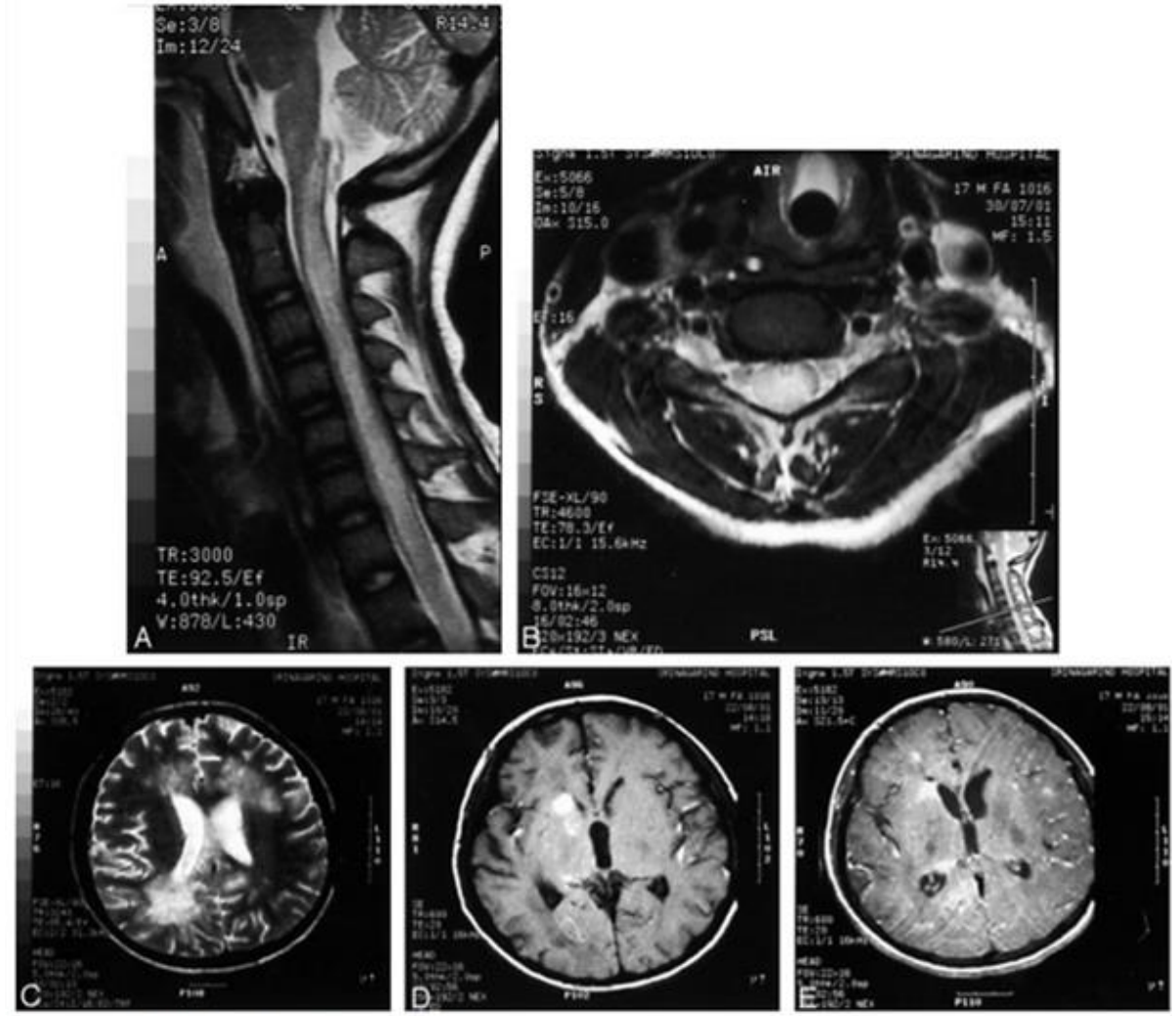


FIG 2. Case 2. MR images of cervical cord and brain.
A, Sagittal T2-weighted image, showing diffuse cord enlargement with ill-defined area of increased signal intensity.
B, Axial T2-weighted image, showing hyperintense lesion within central gray matter.
C, Axial T2-weighted image, showing fuzzy hyperintense lesion at both periventricular white matter regions.
D, Axial T1-weighted image, showing intracerebral hemorrhage at right caudate nucleus and posterior part of basal ganglia.
E, Axial T1-weighted postgadolinium image, showing scattered tiny nodular enhancement at both frontoparietal regions.

Sawanyawisuth K, et al. MR Imaging Findings in Cerebrospinal Gnathostomiasis. AJNR. 2004

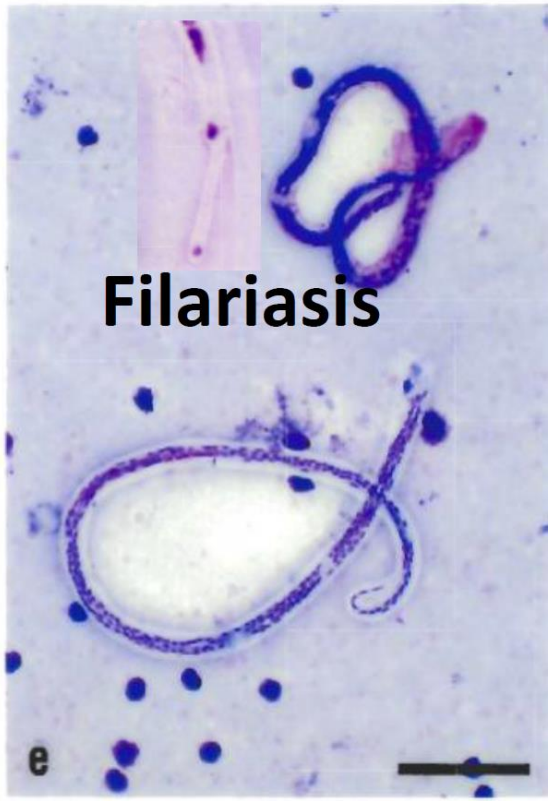
Gnathostoma spinigerum

- **Specific treatment**
  - **Albendazole** 400 mg/day x 21 days OR **Ivermectin** 200 mcg/kg single dose
  - Reported cure rates at 6 months after treatment with *albendazole are >90%* and after treatment with *ivermectin range from 76–95.2%*
- **Symptomatic treatment**
  - Pain control – Headache, Root pain
  - **Steroid** – usually recommend in case of using Antiparasitic agents
    - Prednisolone 60 mg per day for seven days
- **Prognosis**
  - Generally self limited with fully recovery
  - Poor prognosis – severe bleeding and alteration of consciousness
  - unfavorable outcome, e.g., death or severe persistent disability, was reported in 78 patients (32%) [1].

[1] Juri Katchanov, et al. Neurognathostomiasis, a Neglected Parasitosis of the Central Nervous System. *Emerging Infectious Diseases*: 201

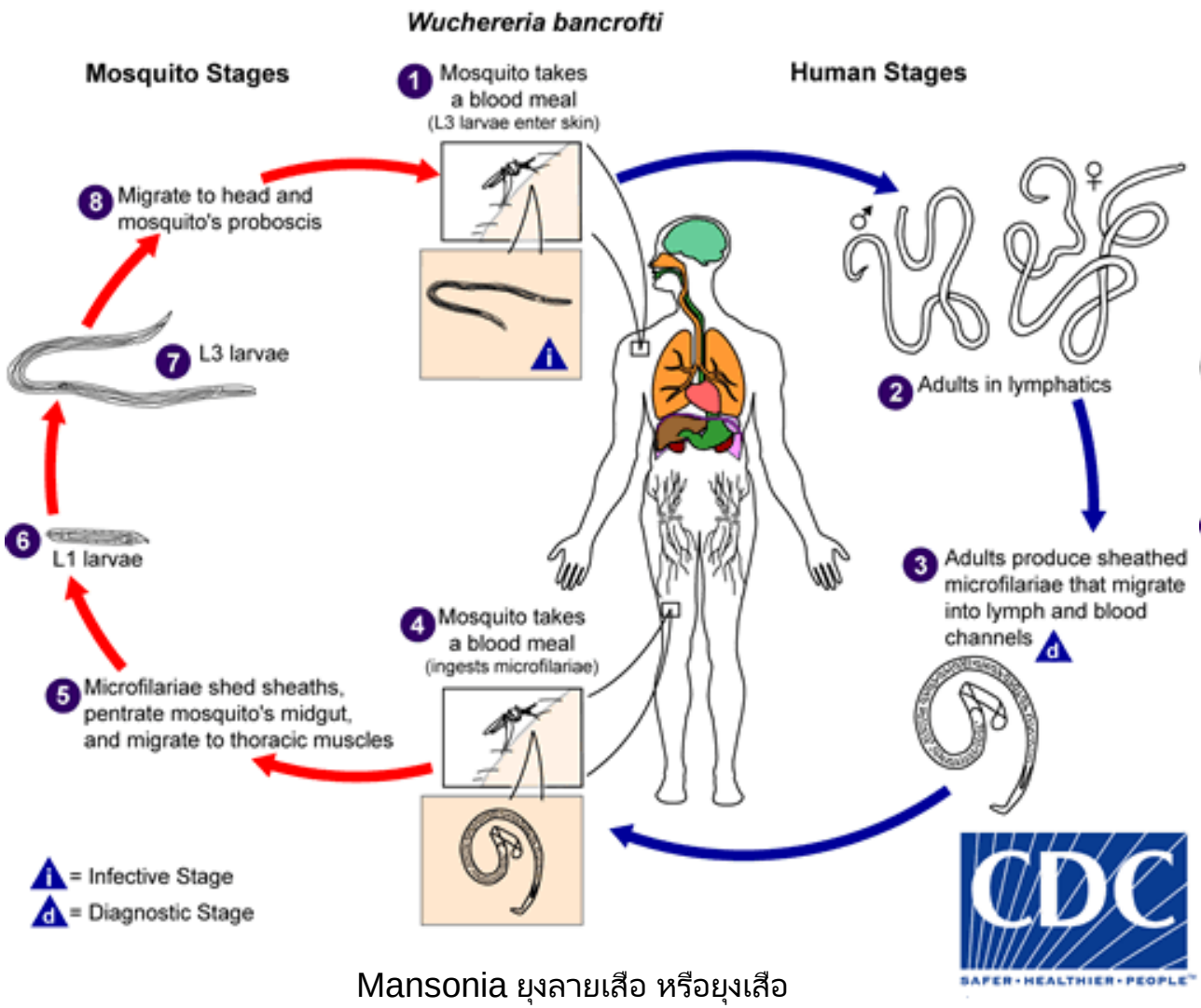
Sithinamsuwan P, Chairangsaris P. Gnathostomiasis — Neuroimaging of Larval Migration. NEJM. 2005

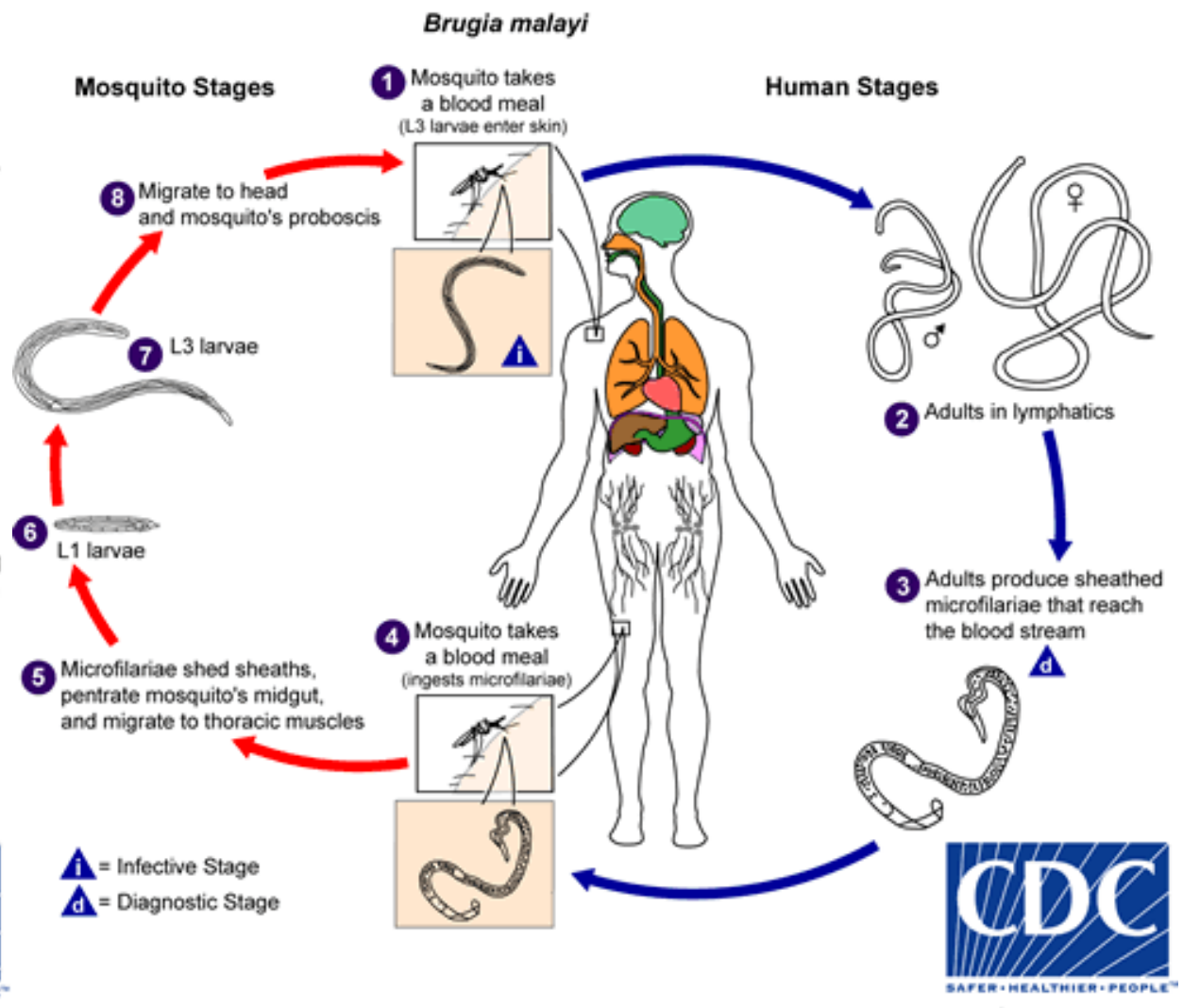
Filariasis
(พยาธิโรคเท้าช้าง)



B. malayi (upper) and ***W. bancrofti*** (lower) microfilariae in the same field of a Giemsa-stained blood film (e). The pink-stained sheath and the darkly stained, compact column of nuclei identify ***B. malayi*** and distinguish it from ***W. bancrofti***

Filariasis





Mansonia ยุงลายเสือ หรือยุงเสือ

Filariasis

- In Thailand
  - *Wuchereia bancrofti – CNS complication*

Possible neurological complications of various filariae

Filariae	Microfilariae	Location of adult filariae	Neurological complications
Dracunculiasis medinensis	Subcutaneous	Subcutaneous	Medullar compression
Loa loa	Blood	Subcutaneous	Epilepsy, meningitis
Onchocerca volvulus	Skin	Subcutaneous	Epilepsy
Wuchereria bancrofti	Blood	Lymphatic vessels	Encephalitis
Dipetalonema perstans	Blood	Peritoneal	Headache

Filariasis

- **CNS manifestation – Encephalitis**
  - **RARE**
    - High load of infection
  - Pathogenesis – complex
    - Mechanical disruption as they migrate through or disrupt tissues or vascular lesion or vascular block of cerebral vessels, or via immune response to infection
  - Degeneration is often followed by granulomas, which can cause fibrosis or mass effects on other tissues or induce disordered inflammatory responses resulting in meningitis, encephalitis, or localized inflammatory responses

Filariasis

- **CBC** – Eosinophilia
- **Thick blood smear with Giemsa**
- **PCR**

Fig. 18.3. Microfilariae of *W. bancrofti* in thick blood smears stained with Giemsa. (Images courtesy of the Oregon State Public Health Laboratory and Centers for Disease Control and Prevention.)

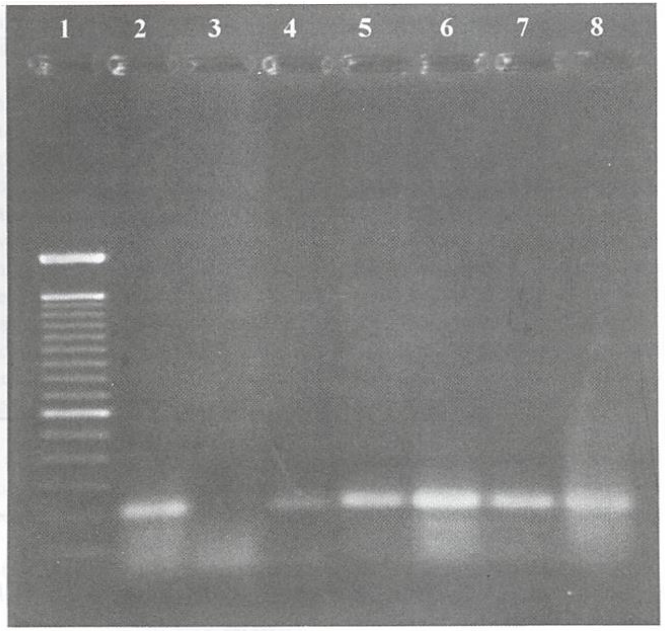


Fig. 1. Detection of 188-bp *Ssp* I repeat by a PCR assay on a 2% ethiduim bromide-stained agarose gel. Lane 1: 100-bp marker, lane 2: positive control using *W. bancrofti* genomic DNA, lane 3: negative control using blood sample from non-infected healthy volunteers, lanes 5-8: five representative samples positive for *Ssp* I repeat by the PCR.

Nuchprayoon S, et al. Endemic Bancroftian Filariasis in Thailand: Detection by Og4C3Antigen Capture ELISA and the Polymerase Chain Reaction. J Med AssocThai 2001; 84: 1300-1307

Filariasis

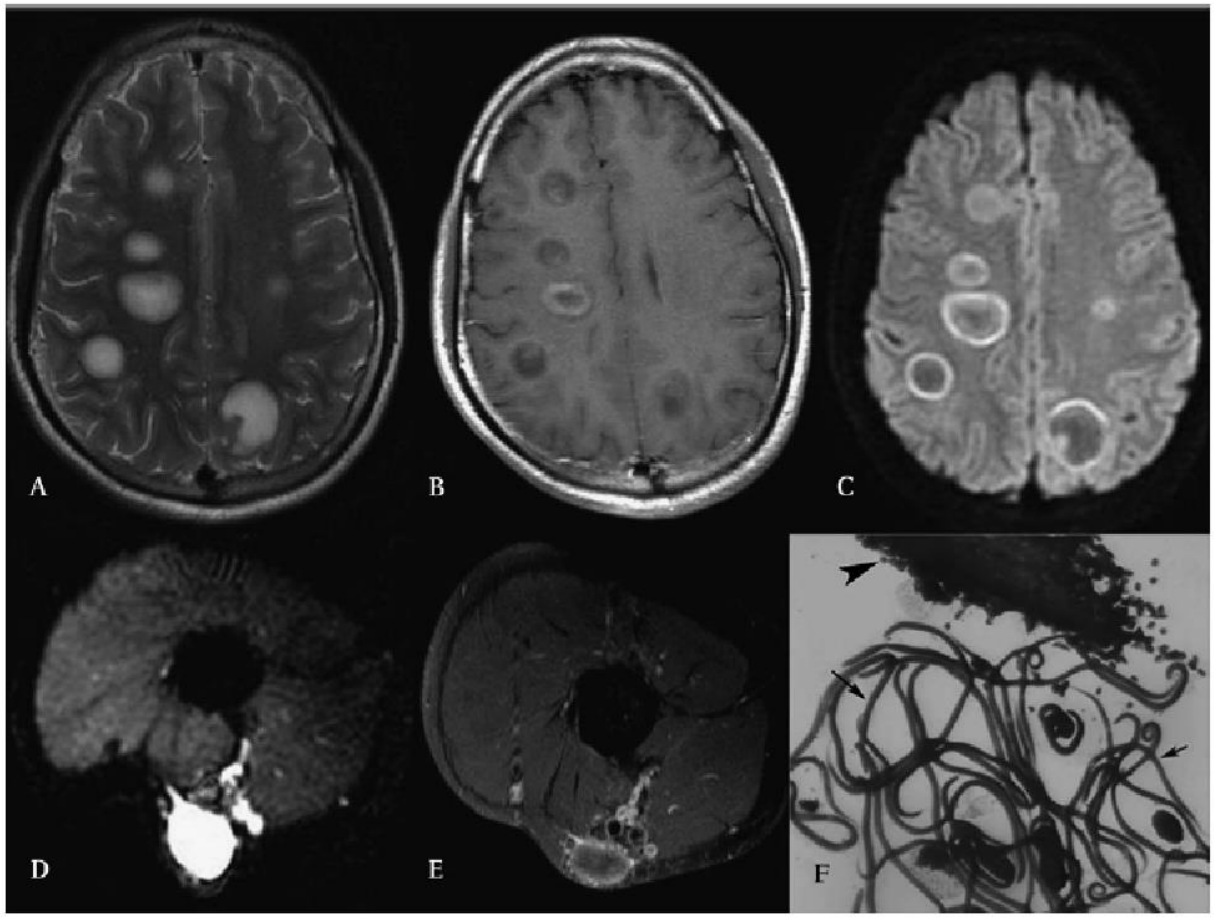


Figure 1 Cranial magnetic resonance images showing multiple bilateral T2 hyperintense lesions (A), which show variable enhancement on post-contrast T1 (B) and peripheral restricted diffusion on diffusion-weighted MRI (C). Axial imaging through the arm shows hyperintense subcutaneous swelling (D) that also shows ring enhancement (E) consistent with infective pathology. Fine needle aspirate of arm swelling (F) shows numerous microfilariae (arrows) of *Wuchereria bancrofti* along with adult female worm (arrow head) (May–Grunwald–Giemsa stain, 40×).

J Neurol Neurosurg Psychiatry: first published as 10.1136/jnnp-2011-300007 on 23 June 2011. Downloaded from http:
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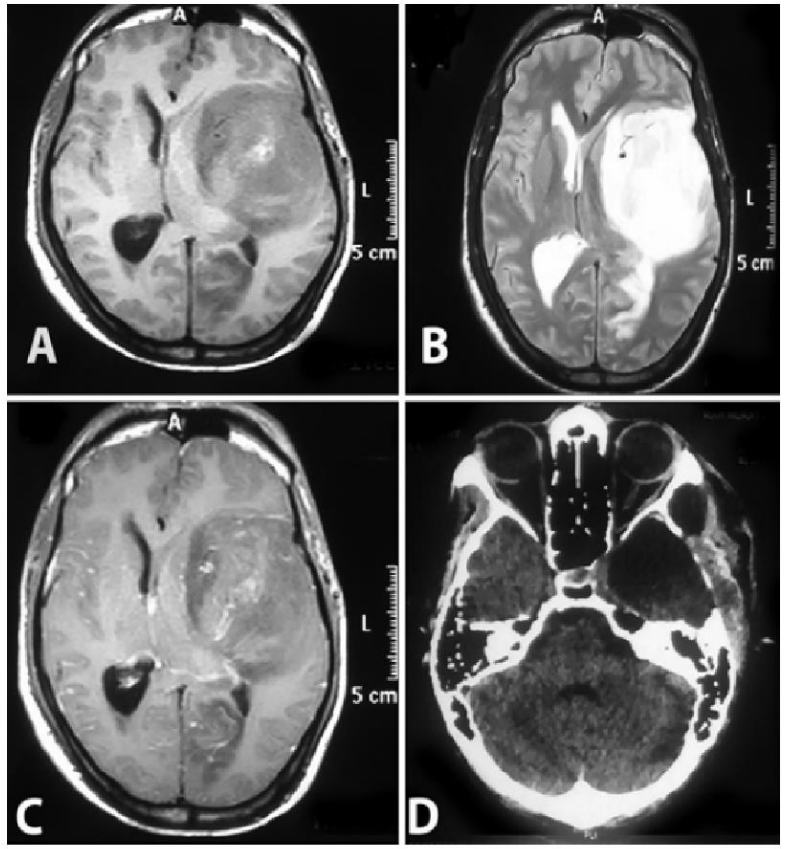


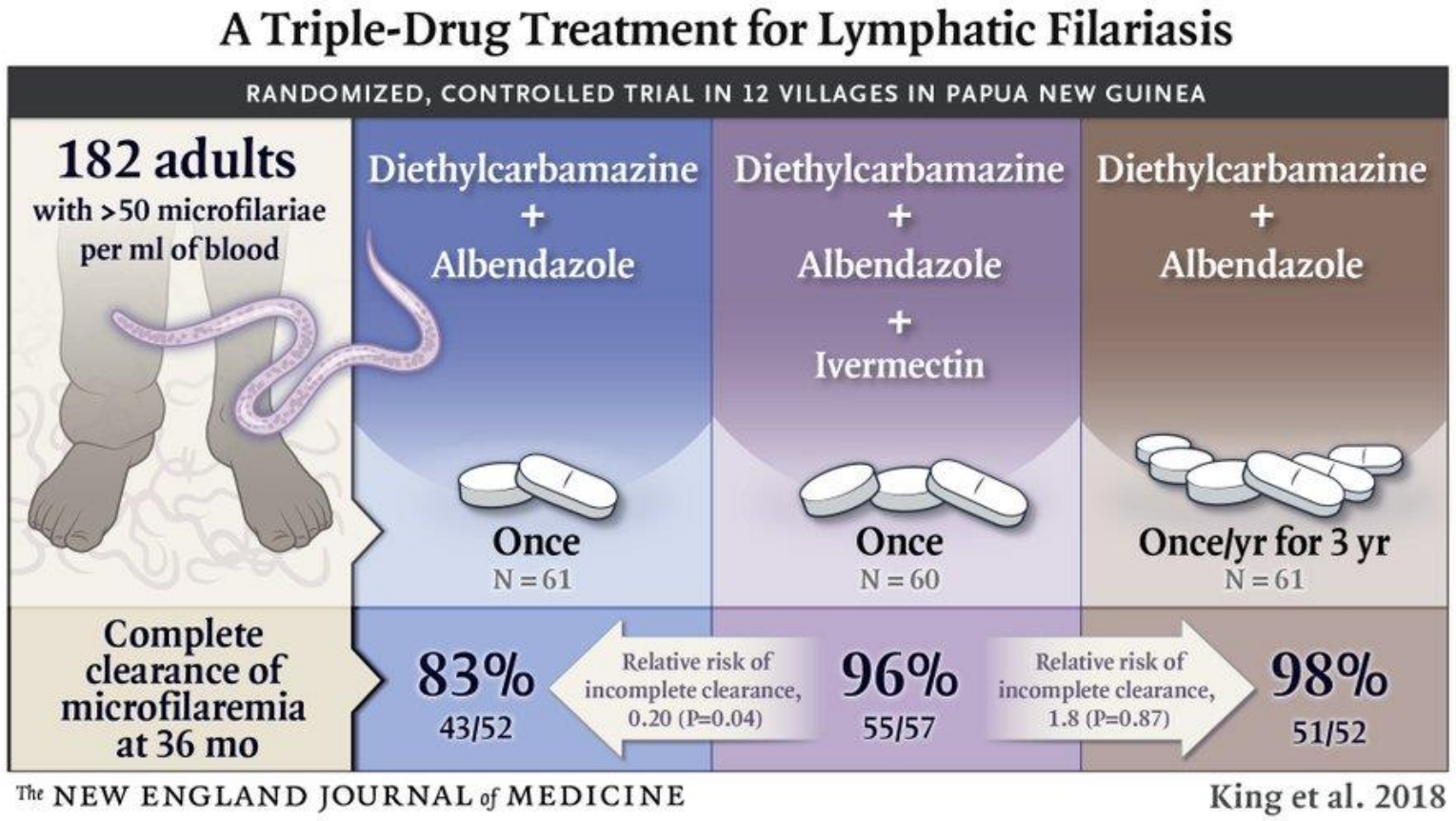
FIG. 1. Preoperative axial T1-weighted (**A**), T2-weighted (**B**), and gadolinium-enhanced TI-weighted (**C**) MR images showing a mass lesion. Postoperative CT scan showing complete resolution of the lesion after surgery and a course of the anthelmintic drug DEC (**D**).

Vimal K Paliwal, et al. Acute disseminated encephalomyelitis following filarial infection. J Neurol Neurosurg Psychiatry: 2012.

Filariasis

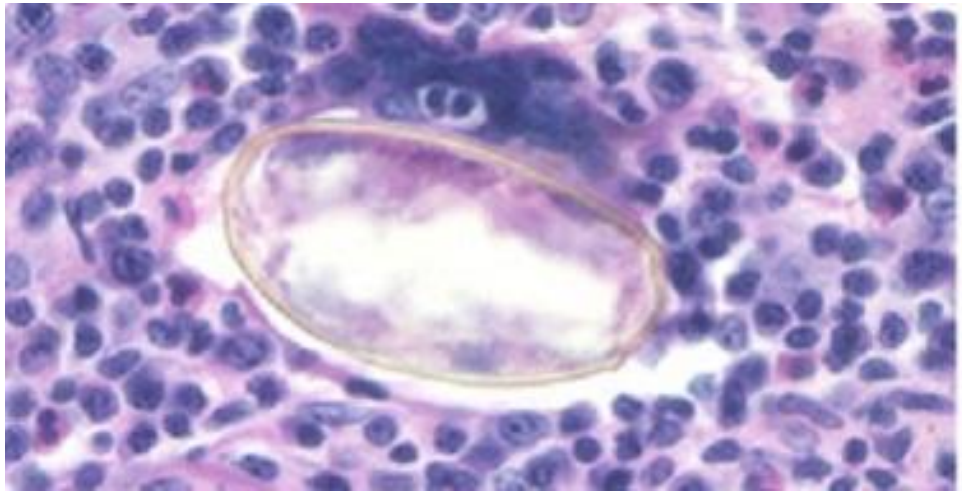
- Diethylcarbamazine citrate (DEC) - for 4 weeks

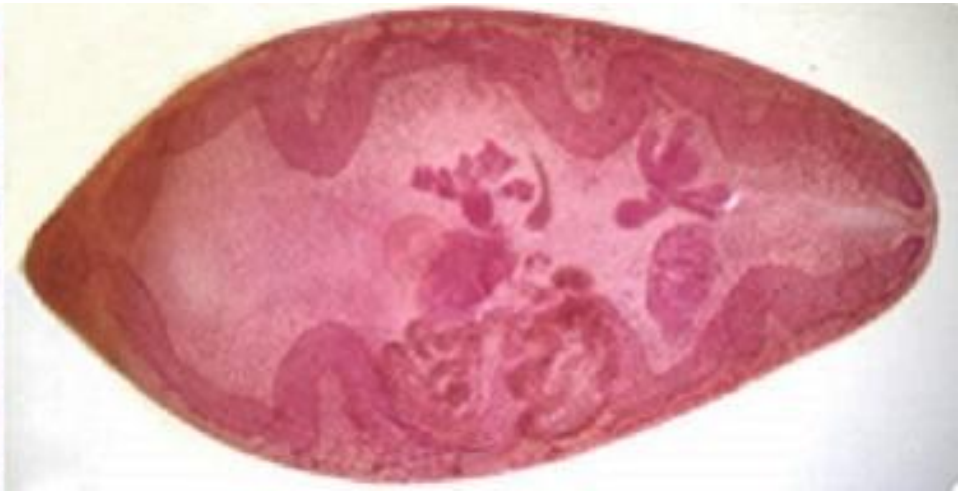
Wuchereia bancrofti



A Trial of a Triple-Drug Treatment for Lymphatic Filariasis. N Engl J Med

Paragonimiasis (Lung fluke)
(พยาธิใบไม้ในปอด)





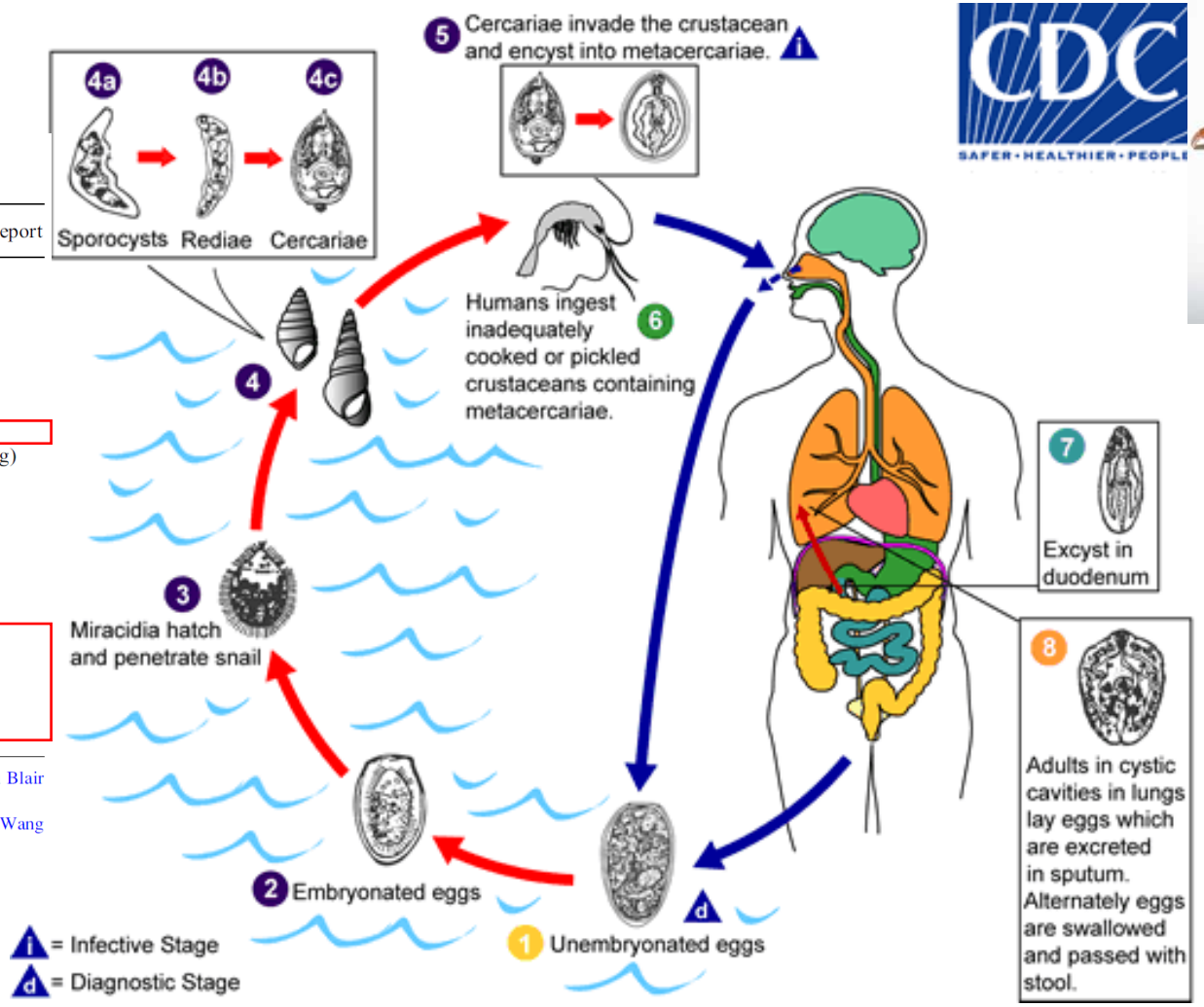
Paragonimiasis

Table 23.1

***Paragonimus* spp. reported from humans**

Species of Paragonimus	Country of first report
P. africanus	West Cameroon
P. heterotremus (syn. *P. tuanshanensis*)	China (Guangxi)
P. kellicotti	USA (midwest)
P. mexicanus (syn. *P. ecuadoriensis*, *P. peruvianus*)	Mexico
*P. siamensis**	Thailand
P. skrjabini (skrjabini) (syn. *P. hueitungensis*, *P. szechuanensis*, *P. veocularis*)	China (Guangdong)
P. skrjabini miyazakki (syn. *P. miyazakii*)	Japan
P. uterobilateralis	Cameroon
P. westermani (syn. *P. assymetricus*, *P. edwardsi*, *P. filipinus*, *P. macacae*, *P. philippinensis*, *P. pulmonalis*, *P. ringeri*)	India

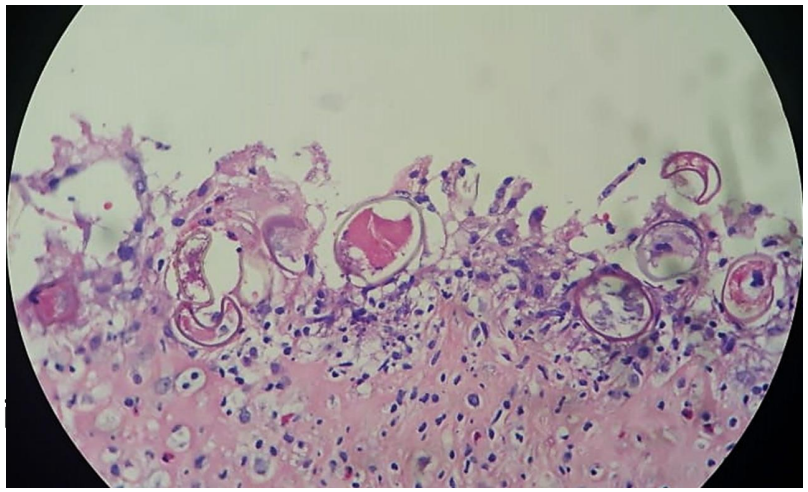
*The majority of the above information can be obtained from Blair et al. (1999).
This species has been added as a human-infecting species by Wang et al. (2011).



Human infection with ***P. westermani*** occurs by eating inadequately cooked *pickled crab* or *crayfish* that harbor metacercariae of the parasite

P. siamensis

Paragonimiasis



- **Cerebral paragonimiasis**
  - **General**
    - Usually accompanied by **pleuropulmonary infection**
      - Chronic cough, rusty-colored sputum (¼ hemoptysis), pleuritic chest pa
    - **Neurovascular invasion** hypothesis
      - larvae migrate through perivascular loose connective tissues around the jugular vein or carotid artery and enter the posterior circulation via the skull base foramina
  - **Pathology**
    - Early **granulomatous** lesion and later mass formation with **calcification and liquefaction**, surrounded by the fibrous capsule
    - Adult worms may disintegrate early, and **only irregularly shaped eggs are often observed in sections of the brain abscess cavity**
  - **Site** – Cerebral cortex (common) – parietal > occipital > frontal > temporal lobes
- **Spinal paragonimiasis** - Relative **RARE**
- **General symptoms**
  - acute syndrome with cough, abdominal pain, discomfort, and low-grade fever
  - Incubation 2 to 15 days after infection

Paragonimiasis

Table 23.3

Four types of intracranial calcifications in plain skull films of cerebral paragonimiasis patients

Type	Findings
Type I	Punctuate and amorphous calcified deposits and occasional formation of trabecular lined calcification
Type II	Round nodular calcifications in spotty arrangement with diameter ranging from 5 to 7 mm, with poor demarcation
Type III	Solitary, round, well-defined cystic calcification with diameter ranging from l0 to 20 mm
Type IV	Congregated, multiple, round or oval, cystic calcifications, the density is greater around the circumference and less in the center; diameter ranging from 7 to 30 mm. Because of clustering of calcified cysts, the appearance resembles "soap bubbles"

From Oh (1968c).

Table 23.4

CT/MRI findings of early and late-stage cerebral paragonimiasis (Procop, 2009)

Stage	Findings
Early	Conglomerated, multiple ring-shaped enhancements with surrounding edema, which appear as a cluster that resembles grapes (some patients may have solitary ring-shaped lesions) Nodules have iso- or hypodense centers with a hyperintense periphery (T1-weighted image) or iso- to hypointense peripheries compared with the center (unenhanced T2-weighted image) Localized hemorrhages
Late	Multiple, round or nodular, densely calcified areas that correlate with the "soap bubble" or type IV calcifications seen on plain skull films Nodules with peripheral low density and central hyperintensity (T1-weighted image) Peripheral regions of low intensity and areas of central high intensity (T2-weighted image) Large low-density areas connected with the calcified areas, and ventricular dilatation and widening of the cortical sulsi

Paragonimiasis

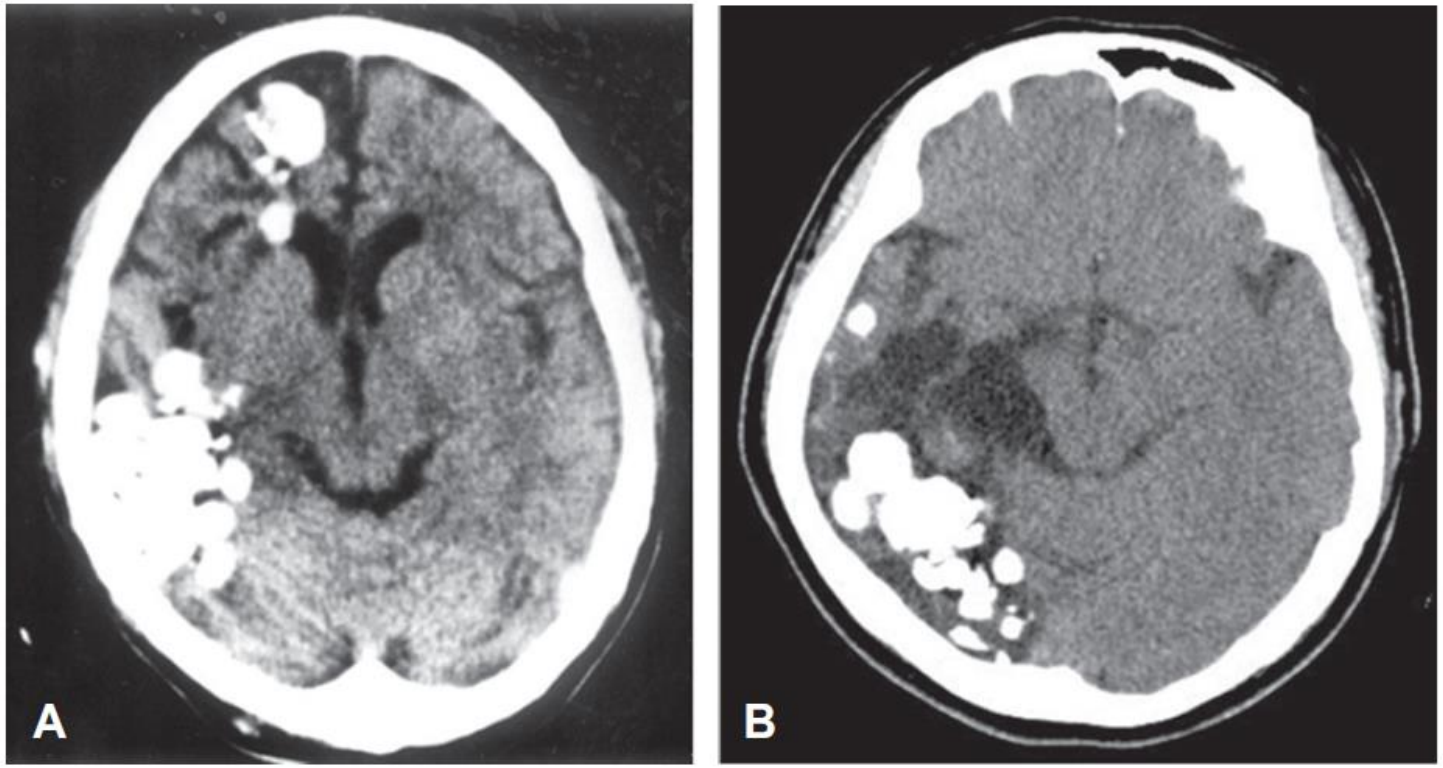


Fig. 23.5. Brain CT findings of chronic cerebral paragonimiasis. (**A**) A case reported by Kang et al. (2000) in Korea. Multiple calcified lesions with high density are seen in the right frontal and temporal areas of the brain. (Kindly provided by Dr. Sung-Jong Hong, Chung-Ang University, Seoul, Korea; this reproduction was permitted by the *Korean Journal of Parasitology*.) (**B**) Another case in Korea showing the typical "soap bubble" appearance in the right temporal areas of the brain.

Paragonimiasis

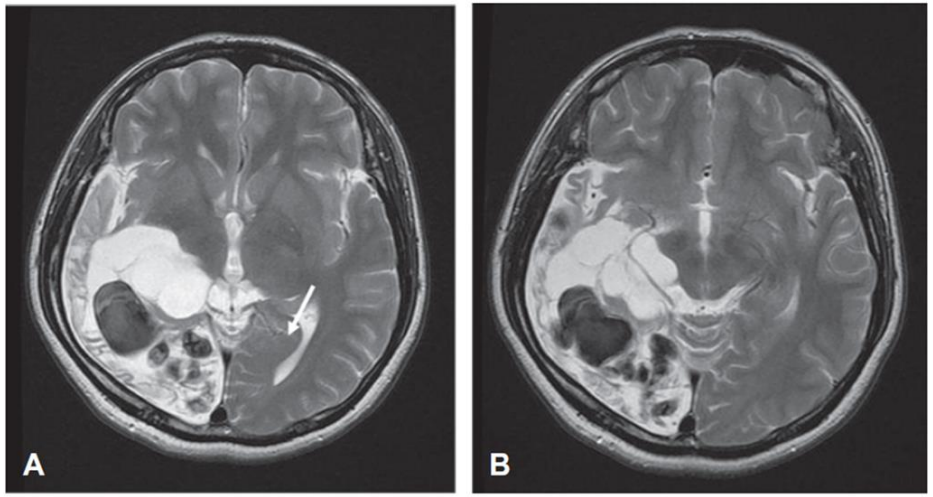


Fig. 23.6. Brain MR images (**A**, **B**) of cerebral paragonimiasis from a chronic case in Korea. T2-weighted axial image shows nodules with peripheral low density and central hyperintensity and inflammatory changes in the surrounding tissues in the right temporal areas.

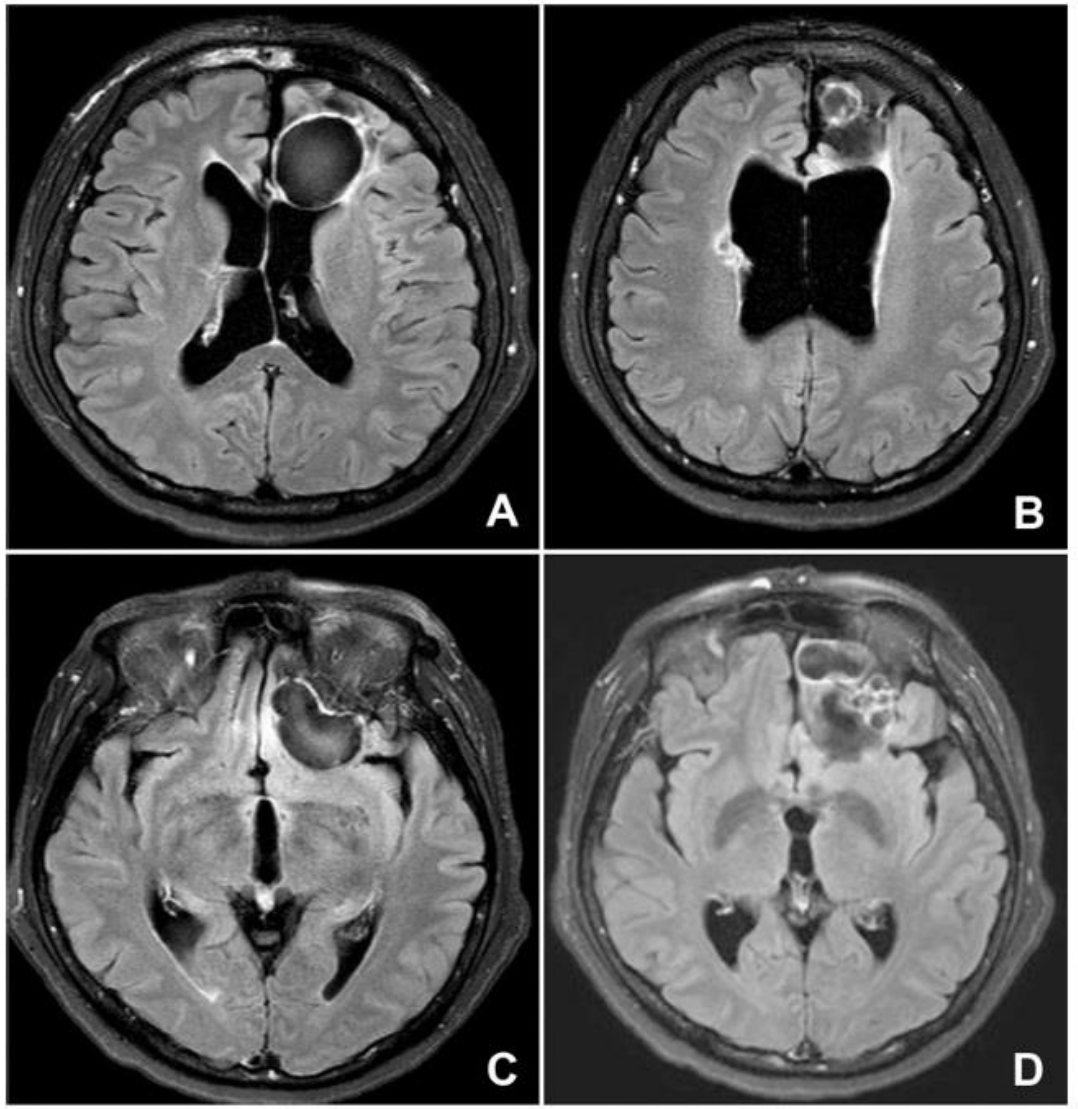


Fig 2. Fluid attenuated inversion recovery (FLAIR) sequence of brain magnetic resonance image of a 68-year-old female patient who suffered from dysarthria and right-sided weakness for 9 years. The laboratory results including eosinophil counts were within the normal range. The patient could not recall the consumption of freshwater crustaceans. The anti-*Paragonimus* specific IgG antibody levels against adult worm extracts were 0.31 (serum) and 0.26 (CSF), respectively. (A and B) FLAIR sequence shows cerebromalacia and ventriculomegaly with a round calcified mass on the left frontal lobe. (C and D) Several well-defined calcified masses in the left inferior frontal lobe are seen.

Kim JG, et al. (2022) Cerebral paragonimiasis: Clinicoradiological features and serodiagnosis using recombinant yolk ferritin. PLOS Neglected Tropical Diseases 16(3): e0010240. https://doi.org/10.1371/journal.pntd.0010240

Paragonimiasis

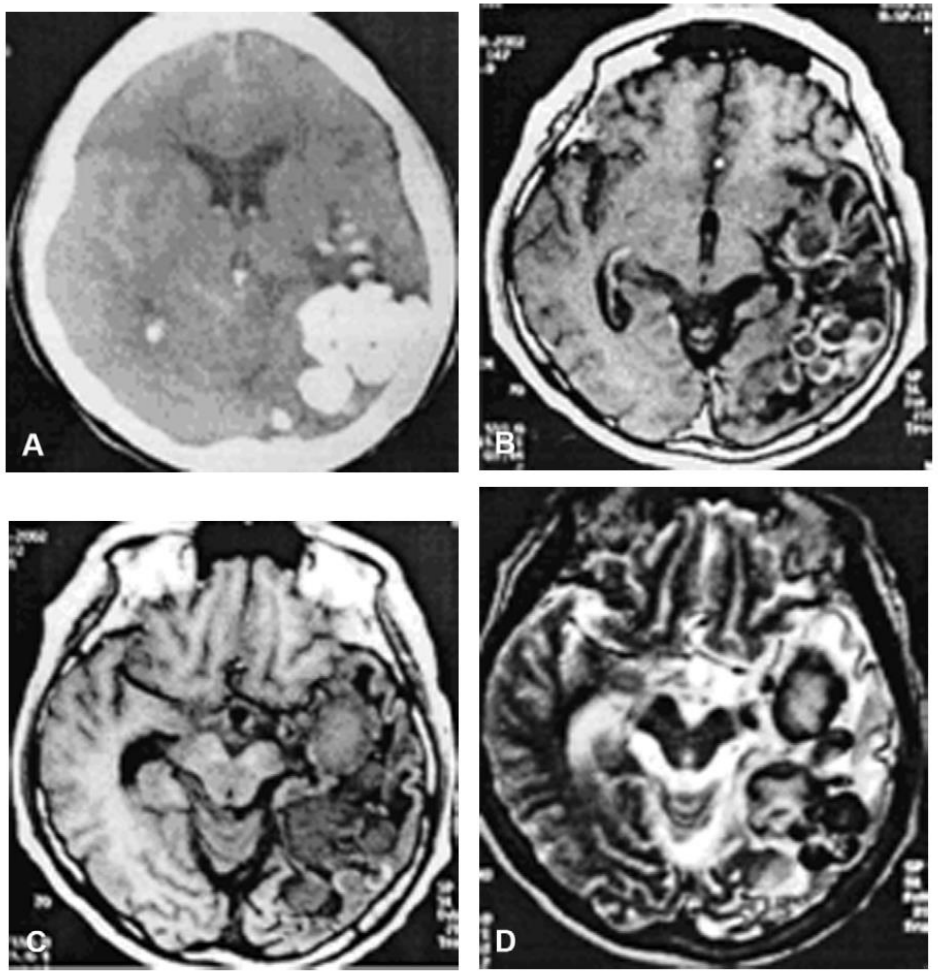


Fig. 4.15. (**A**) Unenhanced axial CT scan showing conglomerated high-density calcified nodules (5 × 5 cm in size) in the left temporo-occipito-parietal region and subarachnoid hemorrhage in the basal cisterns in a patient with paragonimiasis. (**B**) T1W, (**C**) T2W, and (**D**) contrast-enhanced T1W axial images showing conglomerated iso- or low-signal intensity round nodules with peripheral rim enhancement in the left temporo-occipito-parietal area. (With permission from Choo JD, Suh BS, Lee JS et al. (2003). Chronic cerebral paragonimiasis combined with aneurysmal subarachnoid hemorrhage. Am J Trop Med Hyg 69: 466–469.)

Paragonimiasis

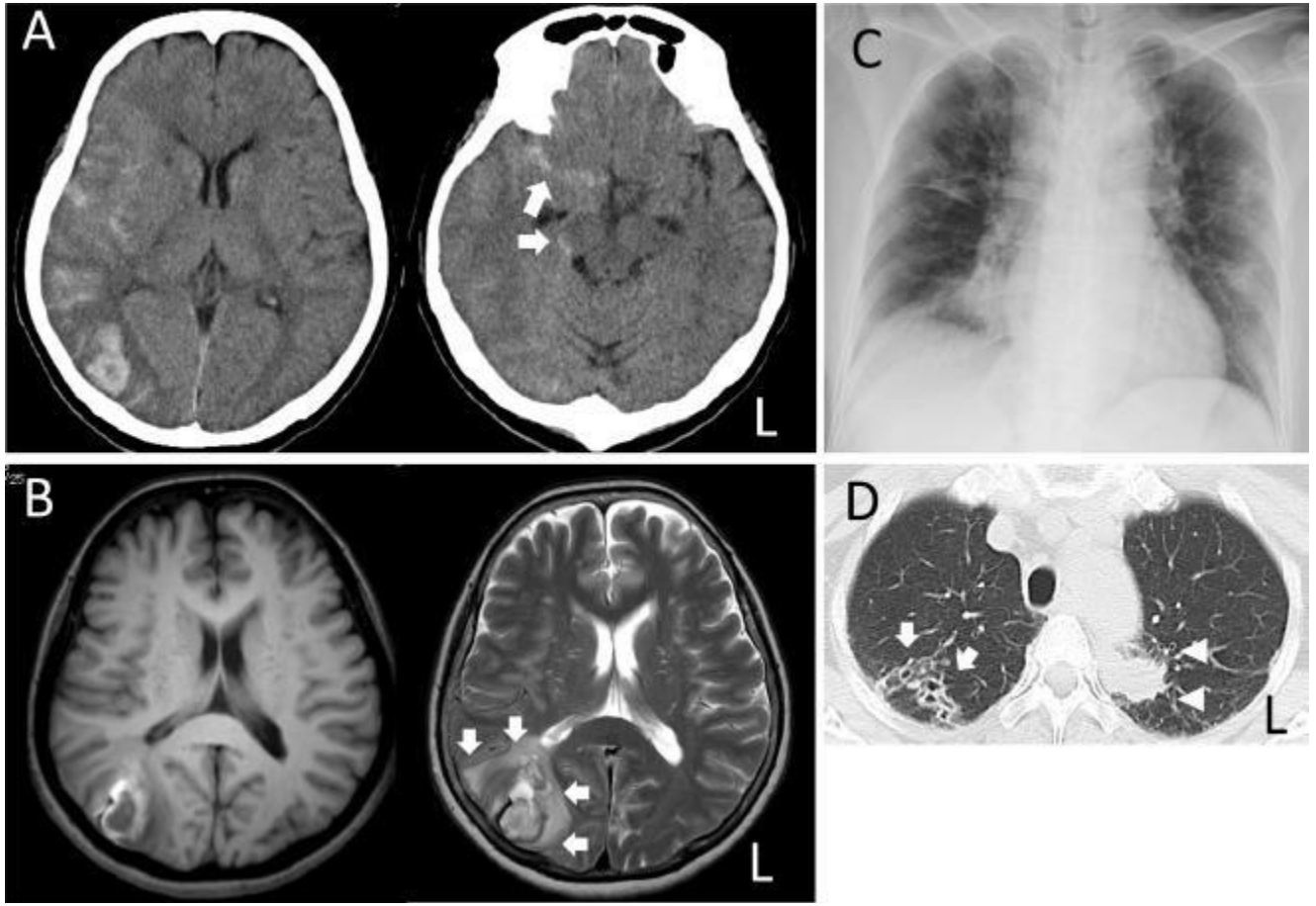
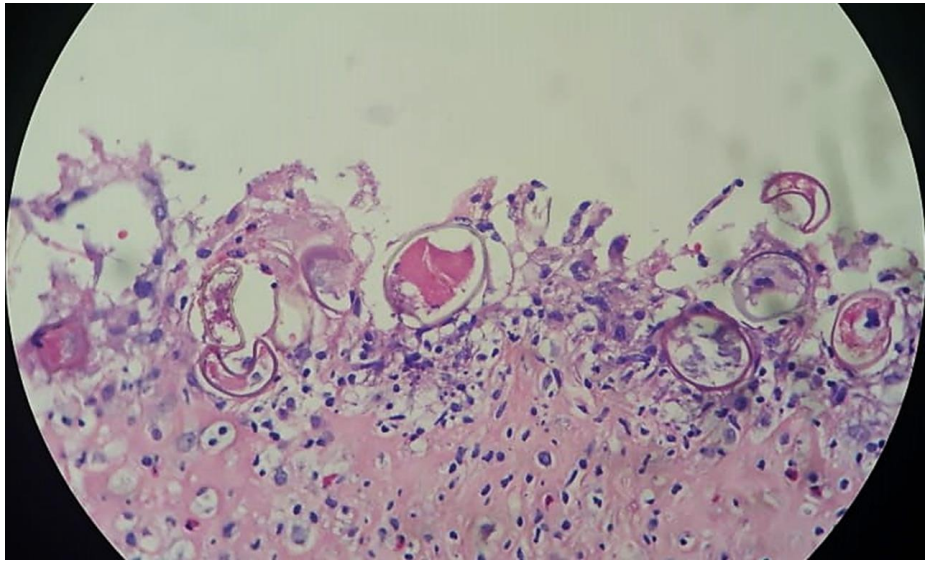


Figure 1 (A) A head CT scan revealed intracerebral and subarachnoid hemorrhage in the right temporal and occipital lobes, and subarachnoid hemorrhage was observed in the right Sylvian fissure and ambient cistern (arrow). (B) An MRI scan revealed low signal intensity with surrounding ring-shaped high signal intensity in T1WI. High signal intensity with peripheral visible circular low signal intensity was observed in T2WI. Unbalanced edema around the lesion was observed (arrow). (C) A chest X-ray film revealed multiple shadows. (D) A chest CT scan revealed conglomerated lesions in the right lung (arrow) and nodular lesions in the left lung (arrow head). CT, computed tomography.

Paragonimiasis

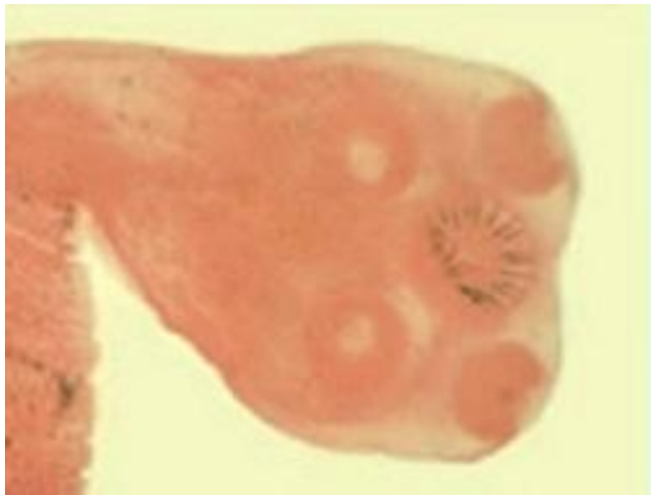


- **Direct examination of eggs in**
  - **Sputum**
  - Stool (coughed-up eggs are swallowed).
- **Tissue biopsy** – looking for eggs
- **Serology**
  - Specific and sensitive antibody tests based on *P. westermani* antigens

Paragonimiasis

- **Praziquantel**
  - *P. westermani* 25 mg/kg three times daily for 2–3 days
    - high ELISA titer and/or multiple pulmonary lesions >> second dose is considered

Neurocysticercosis (Pork tapeworm) (พยาธิตืดหมู)

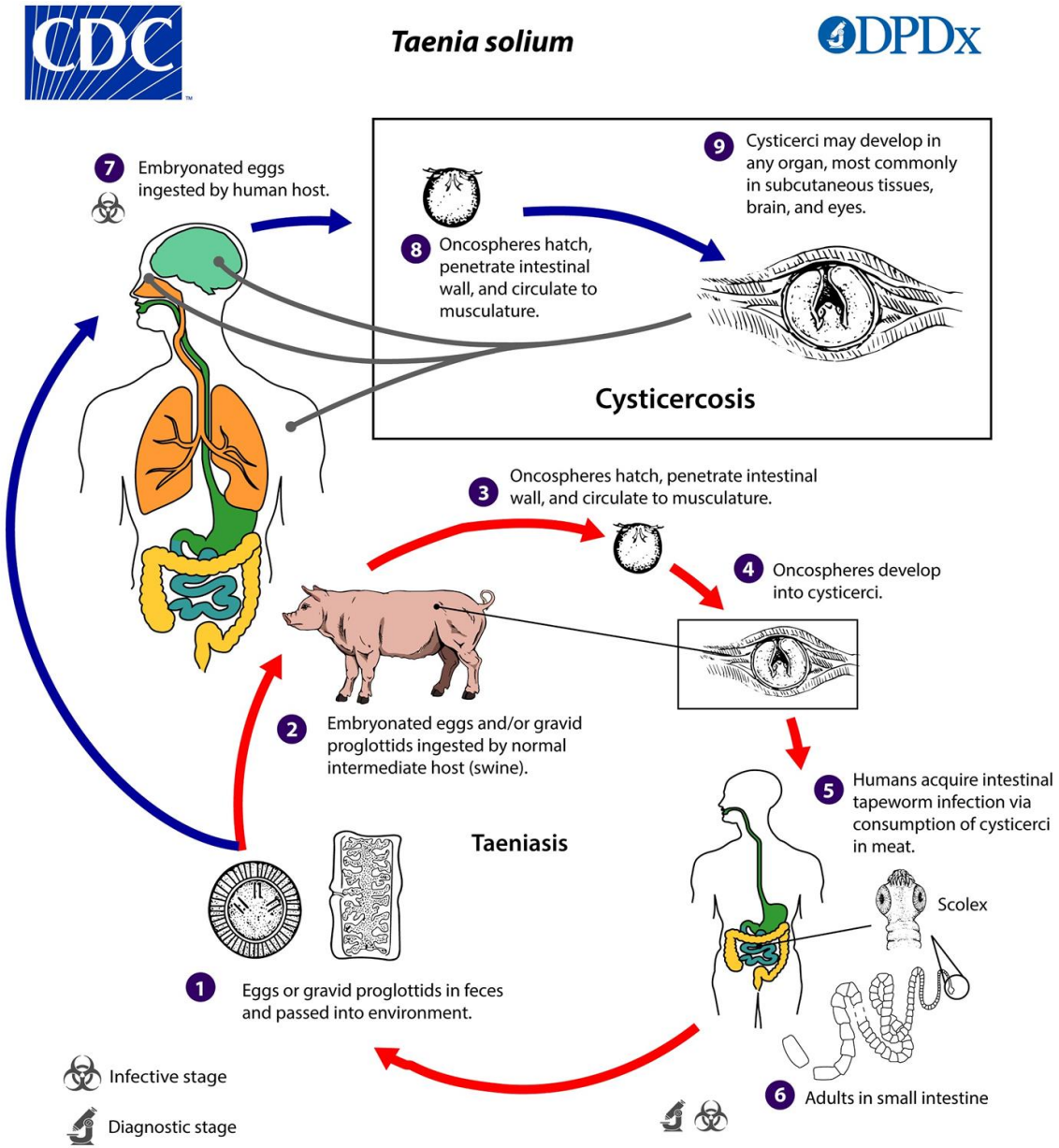


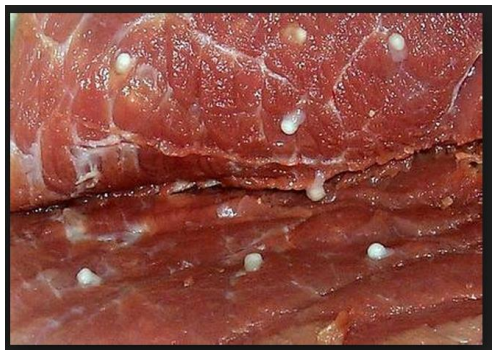
Neurocysticercosis

Fig. 15.9. Numerous subcutaneous nodules representing intramuscular cyst of *T. solium*.

Cysticercosis (MSK Neuro)

ผักดิบ





Taeniasis

หมูดิบ/หมูสาคู

Neurocysticercosis

Common clinical presentation – depends on location

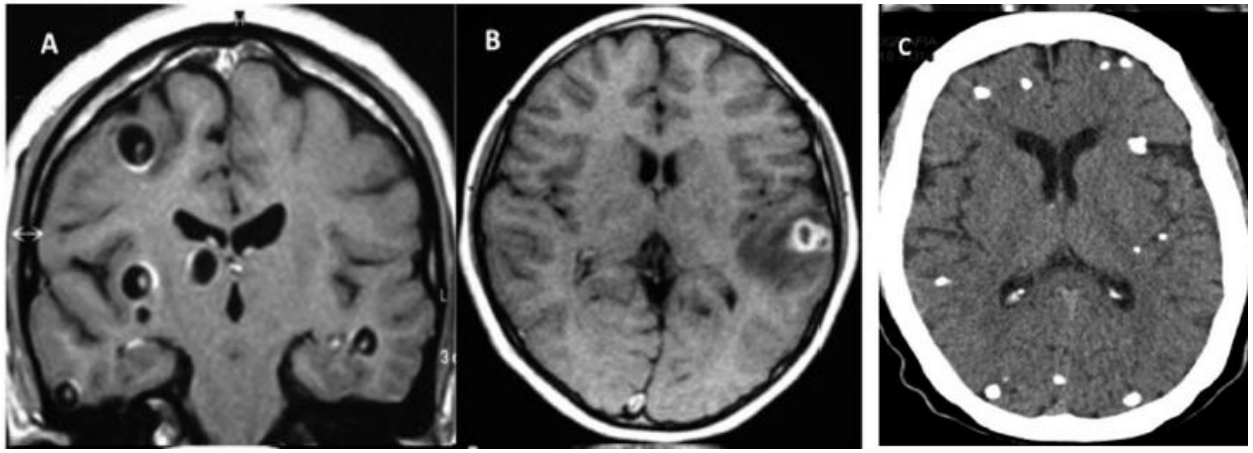
- Seizure
- Eosinophilic meningitis (less frequent than nematode)
- Increased intracranial pressure

5 main forms in CNS presentation

- 1) Parenchymatous form
- 2) Meningeal form
- 3) Ventricular form
- 4) Spinal form
- 5) Mixed form

Neurocysticercosis

- **1) Parenchymatous form**
  - Any area - commonly found at the gray-white matter junction
  - Inflammation & edema -> Gliosis -> Calcification (years)
  - **Evolutive stages**
    - **Vesicular stage** – a viable noninflamed cyst; could seen scolex
    - **Colloidal stage** – increased density of its fluid contents, local inflammation with edema, and contrast enhancement
    - **Granular/nodular stage –** parasite is nonviable, a small inflammatory nodule; disappeared
    - **Nodular calcified stage** – reappeared as a calcified scar (30-40%)



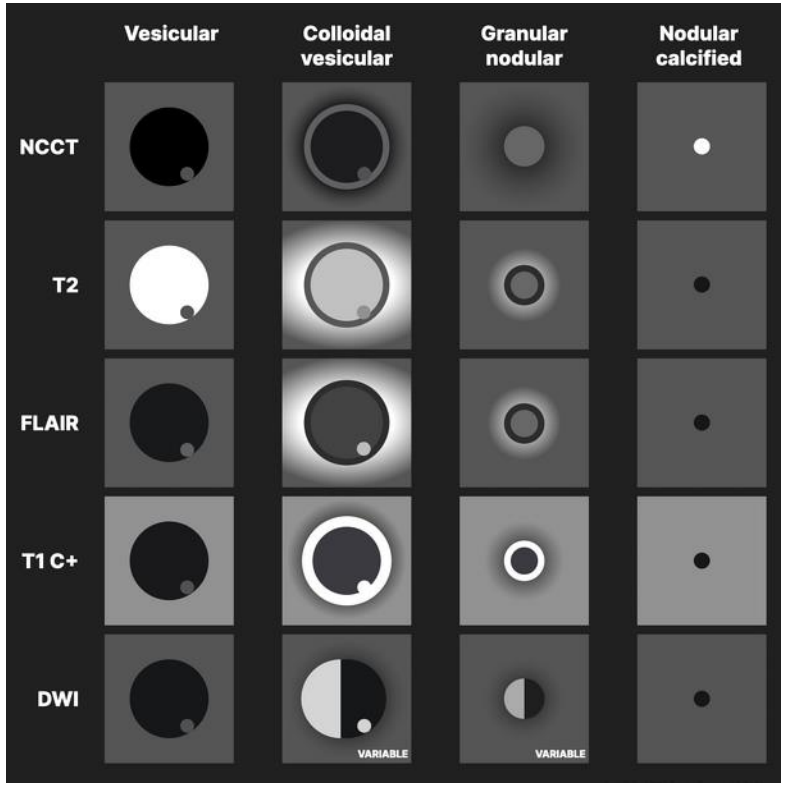
Vesicular cyst with scolex | Colloidal | Calcification

Neurocysticercosis

CT and MR Imaging Findings of Various Stages of Neurocysticercosis

Stage	CT Findings	MR Imaging Findings
Noncystic	Often invisible	Often invisible
Vesicular*	10–20-mm cyst with fluid attenuation; cyst wall is thin and smooth; little or no pericystic edema or contrast enhancement; scolex appears as a small, round, isoattenuating structure (hole with dot appearance)	Cyst signal intensity similar to that of CSF on T1- and T2-weighted images; cyst wall is well defined and thin, with little or no enhancement on gadolinium-enhanced images; scolex (hole with dot appearance); iso- or hypointense relative to white matter on T1-weighted images; iso- to hyperintense relative to white matter on T2-weighted images; best seen on proton-density–weighted images
Colloidal vesicular†	Cyst may be hyperattenuating, pericystic enhancement on contrast-enhanced images, edema may be seen	Cyst contents hyperintense on T1- and T2-weighted images (proteinaceous fluid), cyst wall is thick and hypointense, pericystic edema (best seen on fluid-attenuated inversion recovery images), pericystic enhancement on gadolinium-enhanced images
Granular nodular	Similar to colloidal vesicular stage but with more edema, thicker ring enhancement	Similar to colloidal vesicular stage but with more edema, thicker ring enhancement
Calcified nodular	Hyperattenuating calcific nodules, no edema, no enhancement	Hypointense nodules, no edema, no enhancement

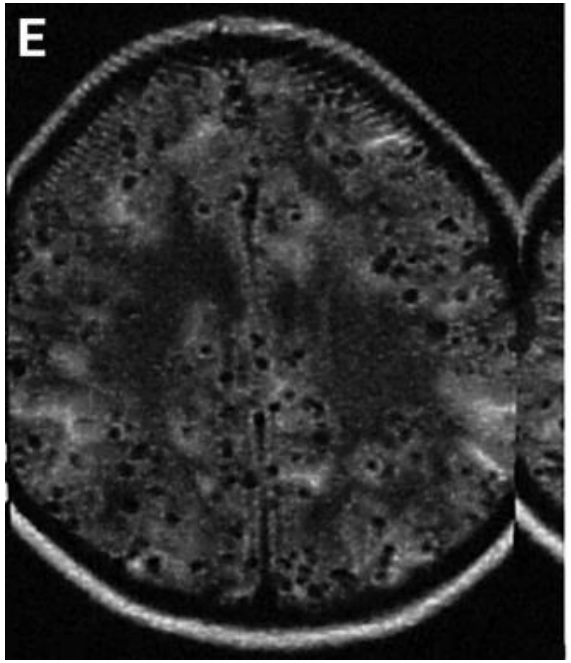
*In racemose neurocysticercosis, the scolex may not be seen.
†So-called encephalitic phase of neurocysticercosis.



Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

- **1) Parenchymatous form**
  - **Presentation**
    - Epilepsy/seizure – in both active & chronic form; focal or generalized
    - Headache – brain edema & increased ICP; +/- papilledema
    - Compressive symptoms – hemiparesis, ataxia, Parinaud's syndrome
    - Alteration of consciousness – encephalitic form
    - Cognitive decline



Encephalitis

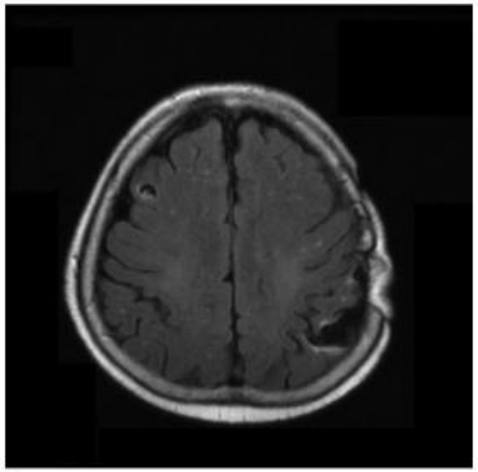
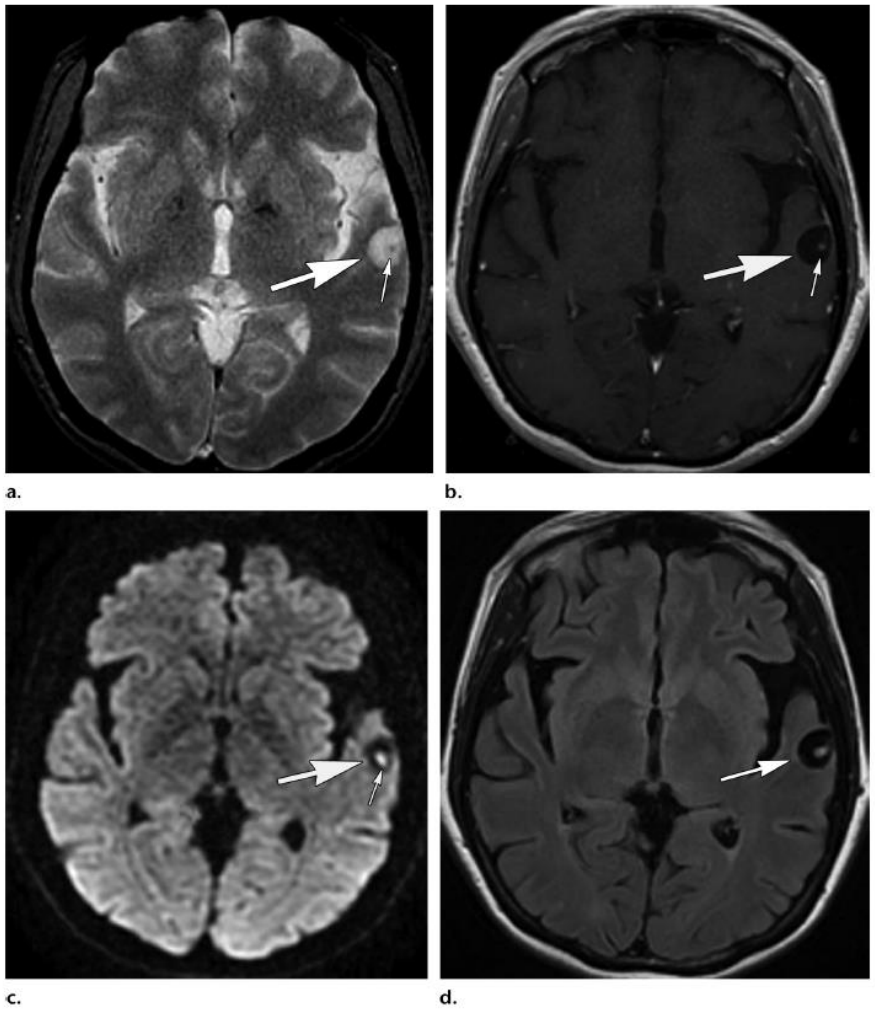
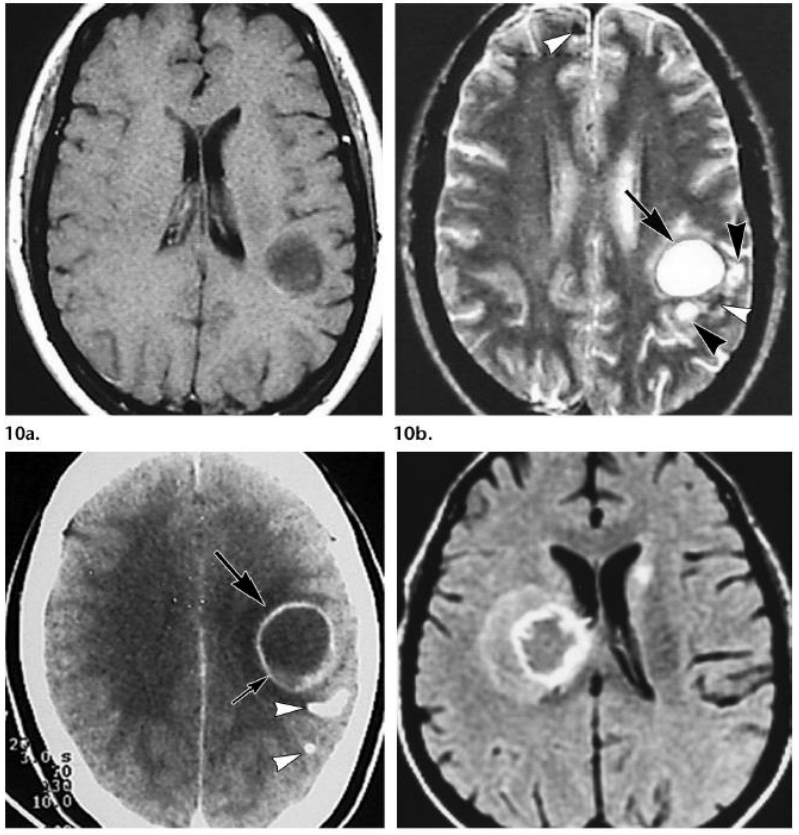


Fig. 2. Vesicular stage neurocysticercosis. (Case diagnosed by clinical and lab data, with medicine treatment follow up) A, Axial T2WI. B, Axial FLAIR. Note the CSF like cyst with an eccentric scolex in the right frontal region, obviously seen on FLAIR.

Neurocysticercosis





Figures 10, 11. (10) Calcified and degenerating colloidal vesicular neurocysticercosis in a 52-year-old woman with seizures. (a) T1-weighted MR image shows a cystic lesion in the left precentral gyrus. (b) T2-weighted MR image shows the lesion surrounded by edema (arrow), as well as two satellite cysts (black arrowheads). Calcified lesions are also seen (white arrowheads). (c) Contrast material–enhanced CT scan shows the lesion with marked ring enhancement (arrows). Arrowheads indicate calcified lesions. (11) Colloidal vesicular neurocysticercosis in a 35-year-old woman with seizures and headache. Gadolinium-enhanced T1-weighted MR image shows a large cystic mass with rim enhancement and peripheral edema exerting a mass effect on the right ventricle, a finding that represents colloidal vesicular neurocysticercosis. However, the differential diagnosis should include tumors and other infections such as tuberculoma or toxoplasmosis, and clinical correlation is mandatory in these cases.

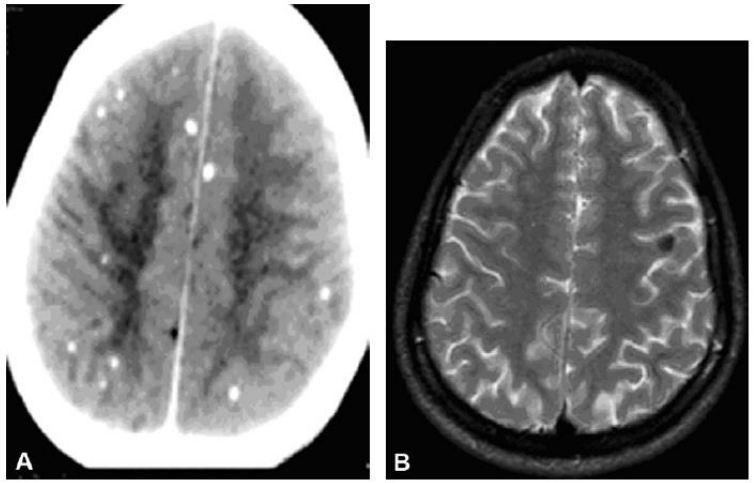
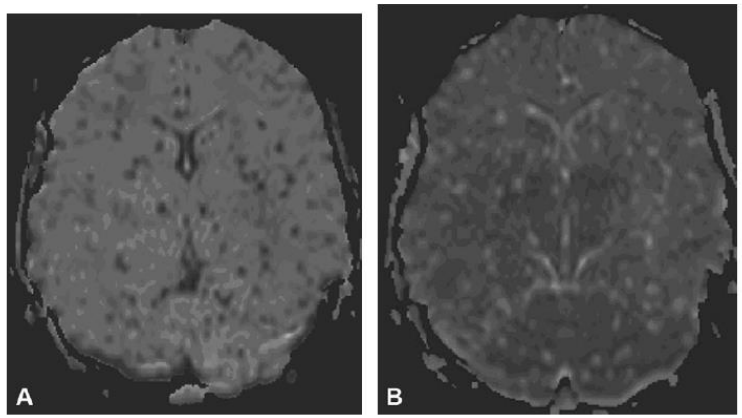


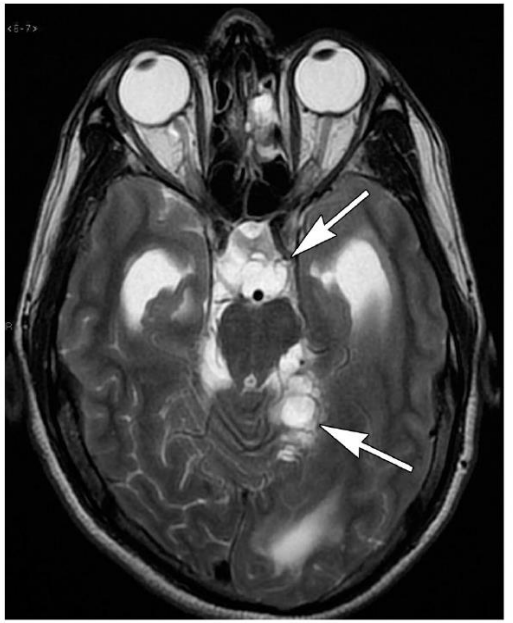
Fig. 4.22. Nonenhanced CT scan (**A**) showing multiple calcified cysticercal cysts in both the cerebral hemispheres. T2W MRI scan (**B**) shows a calcified cyst in the left frontal lobe. There is no evidence of perilesional edema.



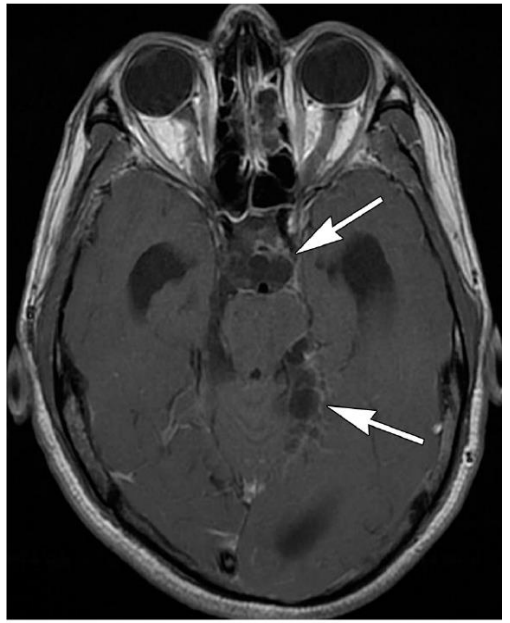
Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

- **2) Meningeal form**
  - Only **leptomeningeal**
    - Commonly found at brainstem
    - Sometimes obstruction of CSF >> hydrocephalus
  - Inflammation of vertebrobasilar system
    -> Ischemic stroke
  - **Clinical presentation**
    - Meningitis
      - CSF profile
        - Mononuclear + Eosinophil
        - Protein slightly elevation – high 100
        - Sugar normal or low
      - Headache
      - Cranial nerve palsy – Basal arachnoiditis/Fibrosis
    - Stroke syndrome
      - related to thrombosis of superficial cortical vessels owing to chronic meningitis, or fusiform aneurysms produced by weakening of wall of the vessels, or due to occlusion of small perforating vessels



14a.

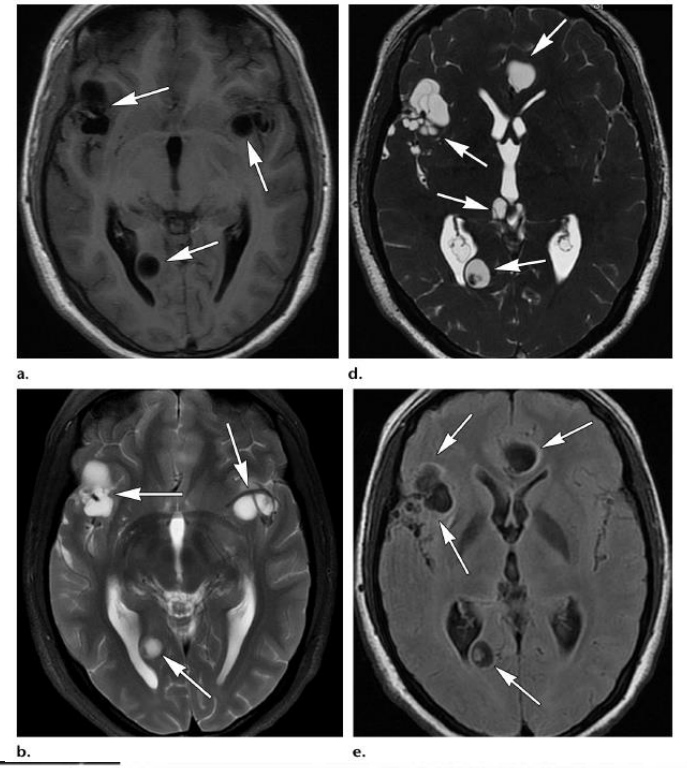


14b.

Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

- **2) Meningeal form**
  - **"Cysticercus racemosus"**
    - Grape-like appearance
    - Basal cistern, ventricle, subarachnoid



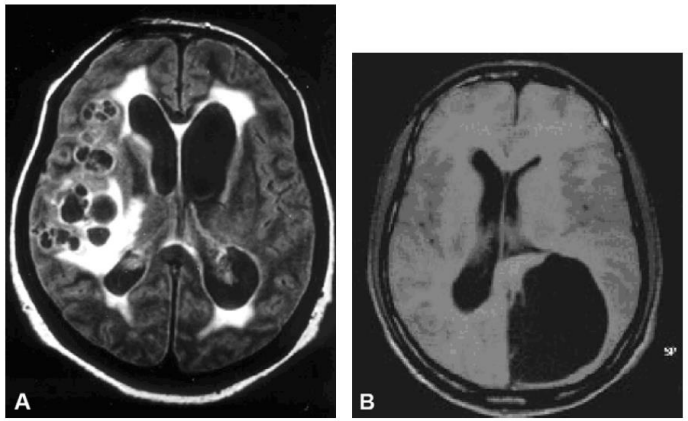
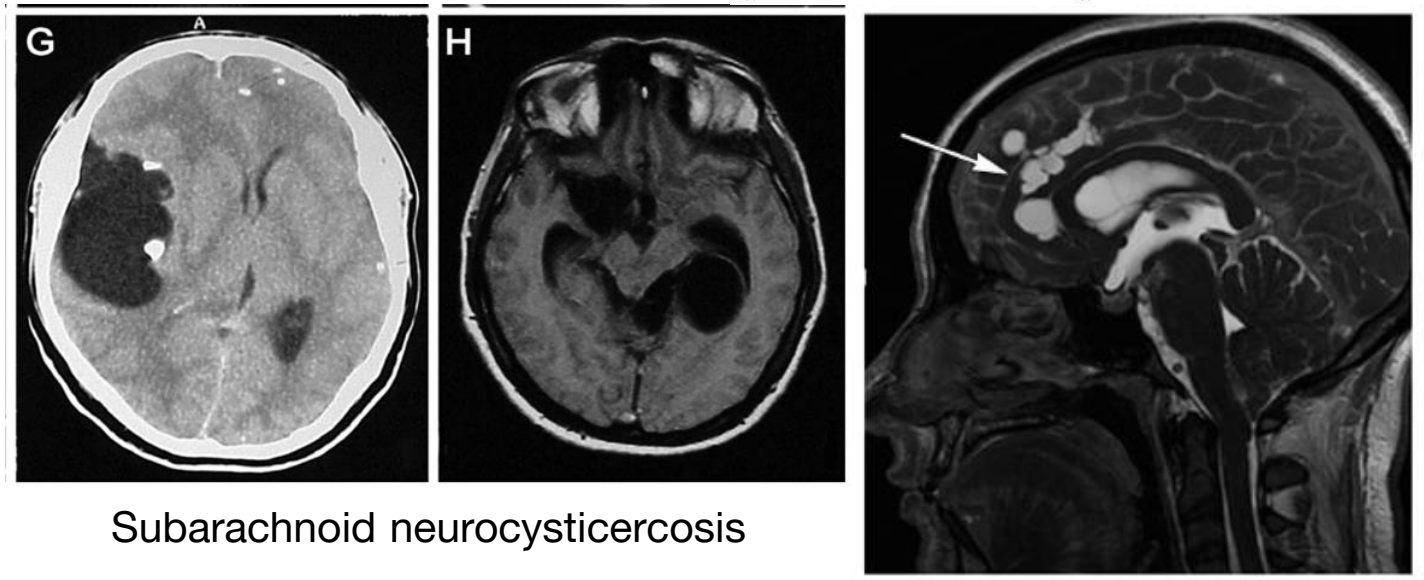


Fig. 4.25. (**A**) Axial FLAIR image at the level of the lateral ventricles shows multiple cysts in the right sylvian cistern. The cyst contents have similar intensity to that of the CSF. The ventricles are dilated. Edema appearing bright is seen in the brain parenchyma adjacent to the cysts and in the periventricular regions. (**B**) Axial T1W image at the level of the lateral ventricles shows a large racemose cyst in the left occipital region displacing the left trigone anteriorly. The content of the cyst has intensity similar to that of the CSF.

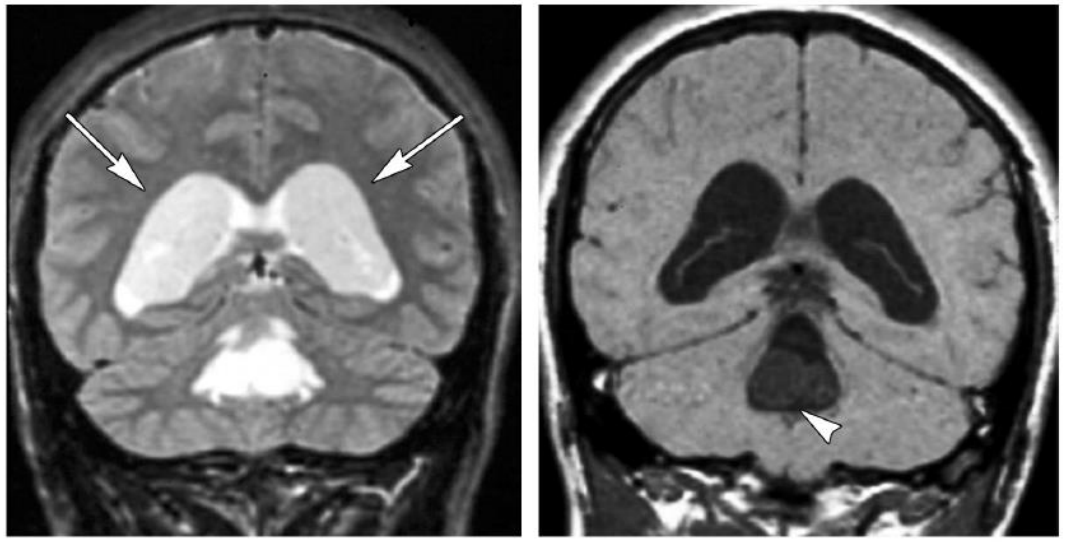


Subarachnoid neurocysticercosis

Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

- **3) Ventricular form**
  - Cyst in ventricle or attached with ependymal layer of ventricle
    - Sometimes pendulums
  - **Clinical presentation**
    - Obstructive hydrocephalus
      - Mimics NPH – chronic progressive dementia, gait, bladder
      - Papilledema
      - Could found in active or inactive form
    - Brun's syndrome
      - Episodic and recurrent headache, vertigo, ataxia, sometimes drop attack
      - Cyst floating in CSF and transient obstruction of CSF pathway



15a. 15b.

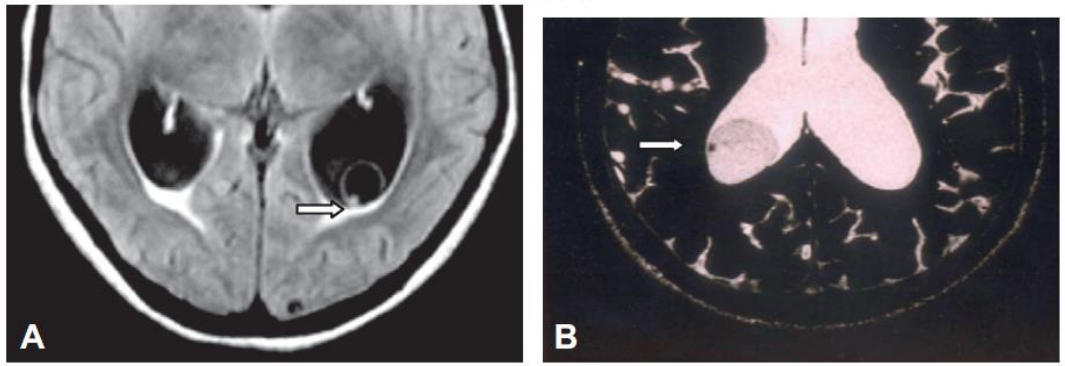
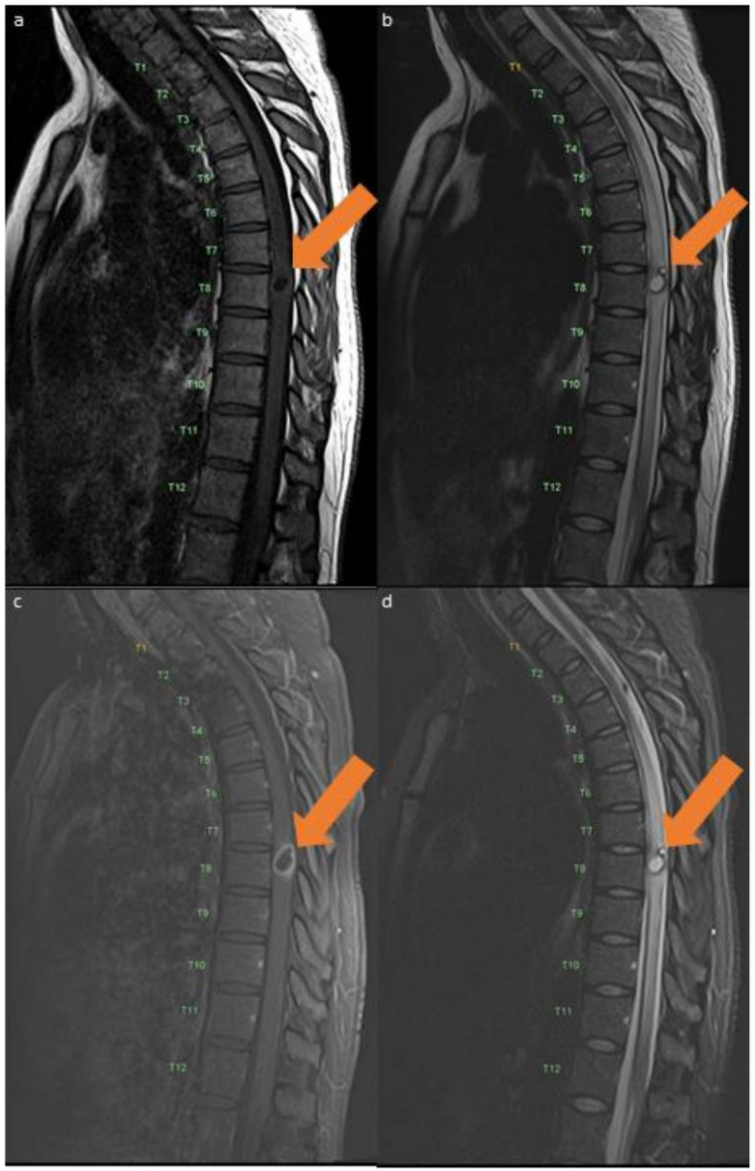


Figure 7. Photograph of a pathologic specimen shows intraventricular neurocysticercosis (arrow).

Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

- **4) Spinal form**
  - Rare
  - Cyst or racemose form intramedullary vs extramedullary
    - Compressive
    - Arachnoiditis
  - Clinical presentation – depends on location
    - Brown-Sequard syndrome
    - Paraparesis/Quadriparesis
    - Radicular pain
    - Cauda equina syndrome



Isolated Intradural-Extramedullary Spinal Cysticercosis

Figure 1 MRI of the lumbar spine. Left: Sagittal T1-weighted image before and after gadolinium administration disclosed the presence of two separate teardrop-shaped cystic structures beginning at level L1 and extended down to L4 with displacement of the roots peripherally. Right: Post-contrast images demonstrated there is peripherally an avid ring of enhancement along the cysts.

Journal of Travel Medicine 2011; Volume 18 (Issue 4): 284–287

Figure 1: 37-year-old Hispanic female diagnosed with Neurocysticercosis (NCC).

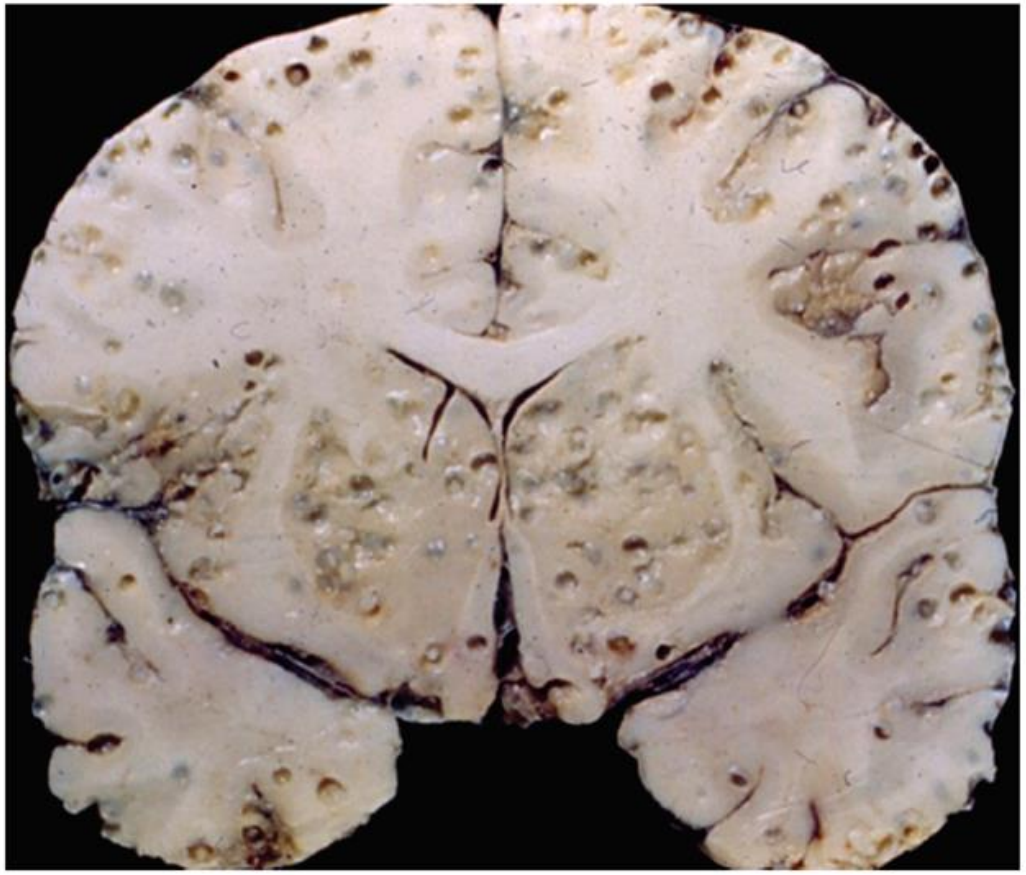
Findings: Sagittal pre- and post-contrast 3T MRI Images of the thoracic spine are shown above, with the arrows indicating an intradural, intramedullary spinal lesion which was determined to be NCC. These images show a T1w hypointense, T2w/STIR hyperintense, peripherally enhancing intradural, intramedullary lesion at the level of T8.

Technique: a) T1-weighted b) T2-weighted c) T1-weighted Post-Contrast d) STIR sagittal MRI of the thoracic spine.

Joseph Kus. Isolated Spinal Cord Neurocysticercosis. *Radiology Case:* 2022

Neurocysticercosis

- **5) Mixed form**



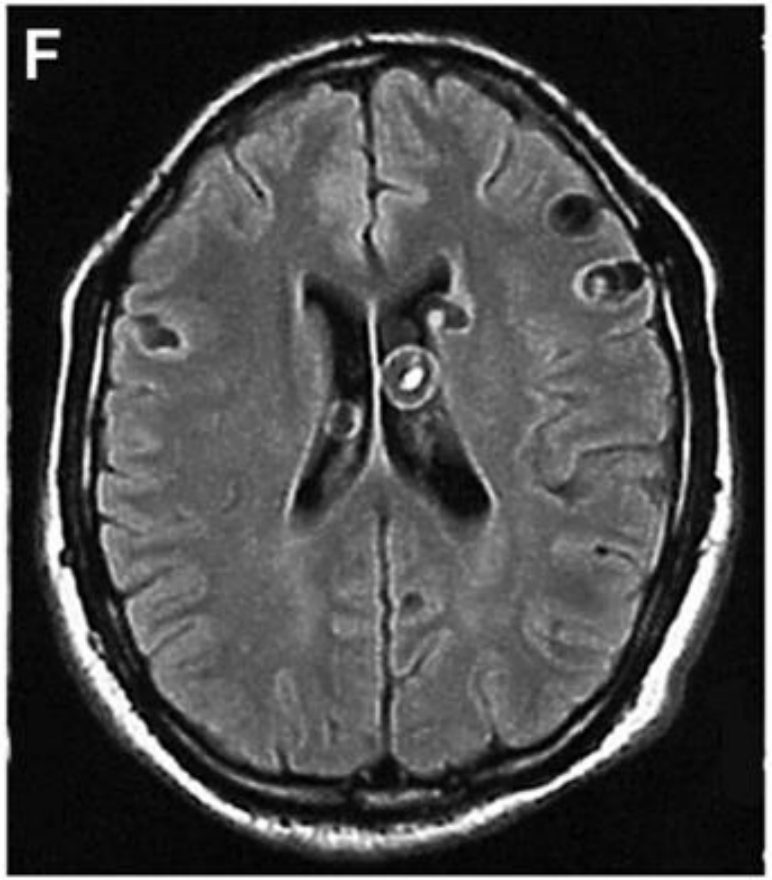


Figure 5. Photograph of a pathologic specimen shows subarachnoid-parenchymal neurocysticercosis.

Kimura-Hayama ET, et al. Neurocysticercosis: Radiologic-Pathologic Correlation. RSNA. 2010

Neurocysticercosis

Classification – location & stage of disease

Active form

- **Parenchymal cyst(s)**
- **Arachnoiditis**
- **Vasculitis**
- **Hydrocephalus**
  - **Inflammation**
  - **Intraventricular cyst**
- **Compressive symptoms**
  - Brain or Spinal cord

Inactive form

- **Parenchymal calcification**
- **Hydrocephalus secondary to meningeal fibrosis**
  - CSF profile - normal

Imaging criteria

Major Criteria	Confirmatory Criteria	Minor Criteria
Cystic lesions without discernable scolex	Resolution of cystic lesions after therapy	Obstructive hydrocephalus
Enhancing lesions	Spontaneous resolution of single small, enhanced lesions	Abnormal enhancement of basal leptomeninges
Multilobulated cystic lesions in the subarachnoid space	Migration of ventricular cysts on sequential studies	
Typical parenchymal brain calcifications		

Table 1: Summary table of neuroimaging criteria for the diagnosis of neurocysticercosis[11].

Joseph Kus. Isolated Spinal Cord Neurocysticercosis. Radiology Case. 2022

Standard diagnostic criteria for neurocysticercosis were first developed in 1996 and last updated in 2017

Revised Diagnostic Criteria and Degrees of Diagnostic Certainty for Neurocysticercosis[a]

Diagnostic criteria

- **Absolute criteria**
  - Histologic demonstration of the parasite from biopsy of a brain or spinal cord lesion
  - Visualization of subretinal cysticercus
  - Conclusive demonstration of a scolex within a cystic lesion on neuroimaging studies
- **Neuroimaging criteria**
  - Major neuroimaging criteria
    - Cystic lesions without a discernible scolex
    - Enhancing lesions[b]
    - Multilobulated cystic lesions in the subarachnoid space
    - Typical parenchymal brain calcifications[b]
  - Confirmative neuroimaging criteria
    - Resolution of cystic lesions after cysticidal drug therapy
    - Spontaneous resolution of single small enhancing lesions[c]
    - Migration of ventricular cysts documented on sequential neuroimaging studies[b]
  - Minor neuroimaging criteria
    - Obstructive hydrocephalus (symmetric or asymmetric) or abnormal enhancement of basal leptomeninges
- **Clinical/exposure criteria**
  - Major clinical/exposure
    - Detection of specific anticysticercal antibodies or cysticercal antigens by well-standardized immunodiagnostic tests[b]
    - Cysticercosis outside the central nervous system[b]
    - Evidence of a household contact with *Taenia solium* infection.
  - Minor clinical/exposure
    - Clinical manifestations suggestive of neurocysticercosis[b]
    - Individuals coming from or living in an area where cysticercosis is endemic[b]

Degree of diagnostic certainty

- **Definitive diagnosis**
  - One absolute criterion
  - Two major neuroimaging criteria plus any clinical/exposure criteria
  - One major and one confirmative neuroimaging criterion plus any clinical/exposure criteria
  - One major neuroimaging criterion plus two clinical/exposure criteria (including at least one major clinical/exposure criterion), together with the exclusion of other pathologies producing similar neuroimaging findings
- **Probable diagnosis**
  - One major neuroimaging criterion plus any two clinical/exposure criteria
  - One minor neuroimaging criterion plus at least one major clinical/exposure criterion

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[a] Reprinted with permission from Del Brutto OH, et al, J Neurol Sci.[44] © 1996 Elsevier Science B.V.

[b] Operational definitions. Cystic lesions: rounded, well-defined lesions with liquid contents of signal similar to that of CSF on CT or MRI; enhancing lesions: single or multiple, ring- or nodular-enhancing lesions of 10 mm to 20 mm in diameter, with or without surrounding edema, but not displacing midline structures; typical parenchymal brain calcifications: single or multiple, solid, and most usually <10 mm in diameter; migration of ventricular cyst: demonstration of a different location of ventricular cystic lesions on sequential CTs or MRIs; well-standardized immunodiagnostic tests: so far, antibody detection by enzyme-linked immunoelectrotransfer blot assay using lentil lectin-purified *T. solium* antigens, and detection of cysticercal antigens by monoclonal antibody-based enzyme-linked immunosorbent assay (ELISA); cysticercosis outside the central nervous system: demonstration of cysticerci from biopsy of subcutaneous nodules, x-ray films or CT showing cigar-shaped calcifications in soft tissues, or visualization of the parasite in the anterior chamber of the eye; suggestive clinical manifestations: mainly seizures (often starting in individuals aged 20 to 49 years; the diagnosis of seizures in this context is not excluded if patients are outside of the typical age range), but other manifestations include chronic headaches, focal neurologic deficits, intracranial hypertension and cognitive decline; cysticercosis-endemic area: a place where active transmission is documented.

[c] The use of corticosteroids makes this criterion invalid.

Neurocysticercosis

- **Tissue biopsy/diagnosis**
- **Cysticercosis in other organs**
  - Skin/muscle
  - Subretinal cysticercus

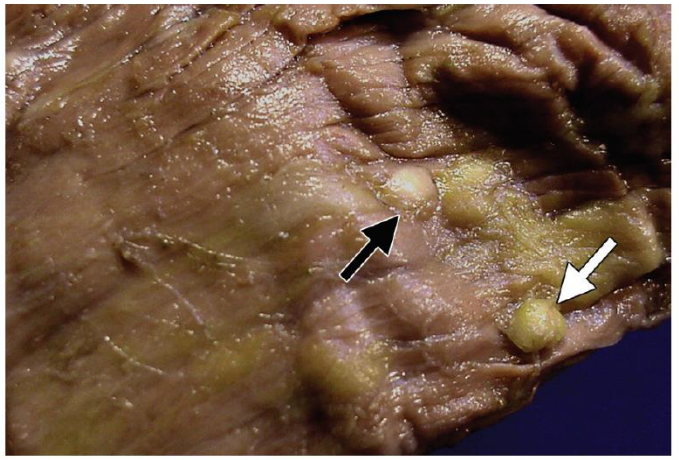
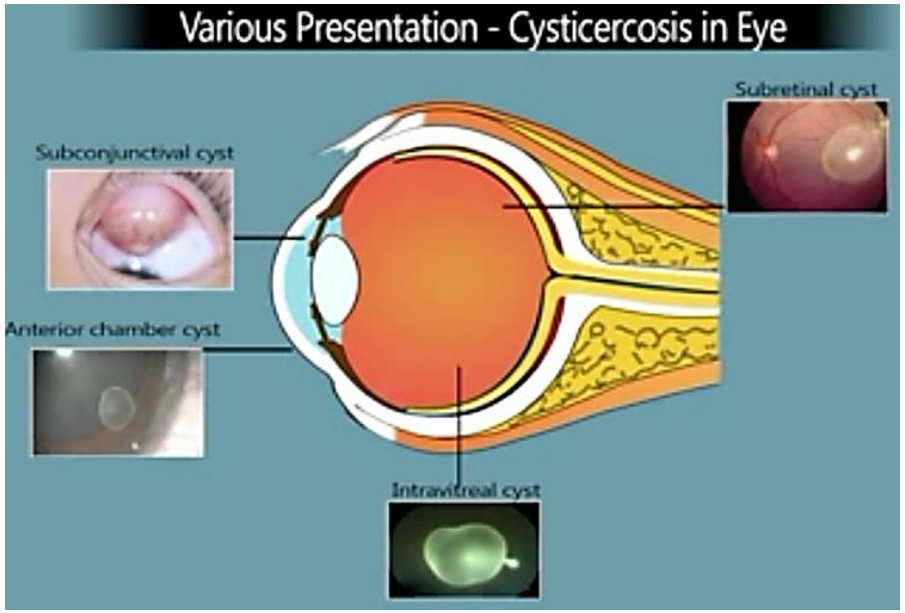


Fig. 15.9. Numerous subcutaneous nodules representing intramuscular cyst of *T. solium*.



Neurocysticercosis

- **CBC**
  - Eosinophilia of patients (37%)
- **CSF** – depend on stage (active vs inactive); cyst intraventricular
  - Increased ICP
  - Pleocytosis usually < 100 cell (sometimes > 1000)
    - Monocyte predominate
    - Eosinophils (50%)
  - Protein elevation < 100 mg/dl (rare > 300)
  - Normal sugar (low sugar ratio 25%)
- **Stool**
  - Usually **normal** in cysticercosis condition; Found in taeniasis

Neurocysticercosis

- **Serology**
  - EITB (Enzyme immunotransfer blot) – serum or CSF
  - ELISA - sensitivity of 40.0% and a specificity of 100%
- **Plain film**
  - Calcification of cyst intramuscular (most common at thigh)

Weerayut Nunrungroj. Neurocysticercosis : Clinical Manifestations and Assessments. *Siriraj Medical Journal*, *54*(7), 394–402.

Neurocysticercosis

- **Combination of management**
  - **Antiparasitic drugs** (often with steroids) **if viable or degenerating cysts** are present.
    - may temporarily **worsen neurologic symptoms** – inflammation around a damaged cyst.
    - **Contraindication** – uncontrolled elevated ICP

    Single parenchymal cyst – choose ONE antiparasitic
    - **Albendazole** 15 mg/kg/day x 7-15 days divided in 2-3 times
    - **Praziquantel** 100 mg/kg/day x 4 wks divided in 3 times (Textbook of clinical neurology TH)

    Multiple parenchymal cyst – choose combination therapy
    - **Albendazole** 15 mg/kg/day x 7-15 days divided in 2-3 times
      - Longer duration (extended to 1 month) if large or several number of cysts

    PLUS
    - **Praziquantel** at 50 mg/kg/d for 10 days

  - **Steroid**

    Indication
    - Developed high ICP during antiparasitic treatment
    - Encephalitis form – priming with steroid + delayed antiparasitic drug
      - Repeat CT brain + closed monitoring

Follow-up imaging in parenchymal form

Repeat CT brain after 3 months of complete treatment ->
see stage change + confirm diagnosis

Neuroparasitology and Tropical Neurology Edited by Hector H. Garcia, Herbert B. Tanowitz, Oscar H. Del Brutto Volume 114,Pages 2-414 (2013)
Textbook of Clinical Neurology. Thai Neurological Society. 2014
CONTINUUM (MINNEAP MINN) 2021;27(4, NEUROINFECTIOUS DISEASE):943–962

Neurocysticercosis

- **Combination of management**
  - **Anti-seizure drug**
    - Active form – consider during initial treatment of antiparasitic -> could cessation later
    - Calcification – Rx as epilepsy patient
  - **Elevated intracranial pressure, if present**
  - **Surgery**
    - Large parenchymal cyst >> removal
    - Ventricle and spinal cyst refractory to treatment >> removal
    - Ventricular shunt in case of hydrocephalus
- **Prognosis**
  - Active parenchymal form – usually good response to treatment
    - Observe seizure in long term due to calcification
  - High load of cyst -> poor prognosis
  - Hydrocephalus response to surgery

Neuroparasitology and Tropical Neurology Edited by Hector H. Garcia, Herbert B. Tanowitz, Oscar H. Del Brutto Volume 114,Pages 2-414 (2013)
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CONTINUUM (MINNEAP MINN) 2021;27(4, NEUROINFECTIOUS DISEASE):943–962

Neurocysticercosis

ตารางที่ 4 แสดงการรักษา neurocyticercosis

ลักษณะของโรค	การรักษา
Active disease	
Parenchymal cyst ขนาดเล็ก	ยาฆ่าพยาธิ
Parenchymal cyst ขนาดใหญ่	ยาฆ่าพยาธิ หรือ การผ่าตัดเอา cyst ออก
Meningitis/arachnoiditis without hydrocephalus	ยาฆ่าพยาธิและเฝ้าระวังการเกิด hydrocephalus
Meningitis/arachnoiditis with hydrocephalus	ยาฆ่าพยาธิร่วมกับ ventricular shunt
Intraventricular cyst	การผ่าตัดเอา cyst ออก หรือยาฆ่าพยาธิร่วมกับ ventricular shunt ถ้ามี hydrocephalus ร่วมด้วย
Spinal cord cyst	ยาฆ่าพยาธิ หรือ การผ่าตัดเอา cyst ออก
Inactive disease	
Calcified granuloma	รักษาตามอาการ เช่น ยากันชัก
Hydrocephalus without meningitis/arachnoiditis	Ventricular shunt

Textbook of Clinical Neurology. Thai Neurological Society. 2014