CYSTICERCOSIS
IMAGING RESULTS IN VARIABLE PRESENTATIONS

Ashton Lehmann, Harvard Medical School Year III
Gillian Lieberman, MD
Our patient presents to ED with acute onset, worsening headache: “worst headache of my life”

Evaluation for subarachnoid hemorrhage with non-contrast computed tomography (CT)

### Clinical Condition: Headache

**Variant 3:** Sudden onset of severe headache (“Worst headache of one’s life”, “thunderclap headache”).

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
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<tbody>
<tr>
<td>CT head without contrast</td>
<td>9</td>
<td>Usage of CT vs MRI depends on local preference and availability.</td>
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<tr>
<td>CTA head with contrast</td>
<td>8</td>
<td>Usage of CT vs MRI depends on local preference and availability.</td>
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<tr>
<td>MRA head with or without contrast</td>
<td>8</td>
<td>Usage of CT vs MRI depends on local preference and availability.</td>
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<tr>
<td>Arteriography cervicocerebral</td>
<td>7</td>
<td>May be helpful after CT depending on CT findings.</td>
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<td>MRI head without contrast</td>
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<td>MRI head without and with contrast</td>
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**Rating Scale:** 1, 2, 3 Usually not appropriate; 4, 5, 6 May be appropriate; 7, 8, 9 Usually appropriate

**RRL:** Relative Radiation Level

ACR Appropriateness Criteria; reviewed 2009.
Non-contrast computed tomography (CT) scan

Enlargement of lateral, 3\textsuperscript{rd}, and 4\textsuperscript{th} ventricles

Consistent with communicating hydrocephalus

Bilateral scattered calcifications throughout white matter

No acute intracranial hemorrhage, edema, or major infarct

Axial head CT (-C):

Enlarged lateral ventricles
Calcifications
Index Patient: CT Findings (2)

- Non-contrast computed tomography (CT) scan
- Enlargement of lateral, 3rd, and 4th ventricles
- Consistent with communicating hydrocephalus
- Bilateral scattered calcifications throughout white matter
- No acute intracranial hemorrhage, edema, or major infarct

Sagittal head CT (-C)
Enlarged ventricles: lateral, 3rd, 4th
Lumbar puncture (LP) showed lymphocytosis, concerning for viral infection

MR +/- contrast & HSV labs ordered

Headache now intermittent with movement; reports dizziness and blurred vision
Index Patient: MR Findings

- Magnetic Resonance (MR) imaging with and without contrast
- 1.3 cm cystic lesion in 4th ventricle causing obstructive hydrocephalus; seen here on T2 weighted

Image: PACS, BIDMC
Flow study indicated CSF flow into the 4th ventricle but no CSF flow into the foramina of Luschke and Magendie

Index Patient: Points

- Neurocysticercosis is highly suspected
  - Multiple calcifications seen on CT
  - Cyst seen on MR
- In the setting of obstructive hydrocephalus causing increased intracranial pressure, lumbar puncture (LP) is contraindicated
  - LP should not have been performed!
  - LP had been ordered when hydrocephalus appeared to be communicating (non-obstructive) on CT
  - Had obstructive hydrocephalus been identified earlier, LP would not have been performed

White et al., 2009b; Kimura-Hayama et al., 2010.
Taenia solium & Cysticercosis

Variable Patients & Presentations

Choice of Imaging Modality

Appearance on Different Imaging Modalities

Imaging Findings in Variable Presentations

Differential Diagnoses

Criteria for Definitive Diagnosis

Further Workup & Management

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Further Workup & Management
Ingestion of cysts (in infected pork) → tapeworm infection ("taeniasis")

- Tapeworm eggs shed in stool of infected hosts → ingested (by same or different person) → tapeworm eggs hatch & cross intestinal mucosa → cyst deposition in tissues (3-8wks; "cysticercosis")
- Cysts: fluid within membranous walls; each contains scolex (rudimentary tapeworm)
- Viable cyst with intact wall: no immune response
- Natural death or therapy-induce death → inflammatory response no longer controlled → inflammation
- Most commonly involve CNS, eye, muscles

White et al., 2009a; White et al., 2009b; Kimura-Hayama et al., 2010 (also image).
Taenia solium & Cysticercosis

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Epidemiology

- >50 million worldwide with cysticercosis
- Endemic in areas of Central & South America, Sub-Saharan Africa, India, and Asia

Figure: Kimura-Hayama et al., 2010.
Variable Patients

- Higher in rural & peri-urban areas near pigs

Patients:
- Inhabitants of endemic areas
- Travelers to endemic areas
- Spread to other areas through globalization
  (e.g., cases in Orthodox Jewish communities)

- Most symptomatic patients 15-40y/o
  - Peak: 25-35y/o
  - With infection likely occurring at 5-15 y/o

White et al., 2009a; White et al., 2009b; Kimura-Hayama et al., 2010.
Symptoms dictated by location and stage of cysts

- Seizures (due to perilesional inflammation or calcifications)
- Altered consciousness
- Visual loss or disturbances
- Symptoms of increased intracranial pressure: headache, vomiting/nausea/dizziness, papilledema
- Symptoms of TIA/infarction (due to vascular complications – e.g., vasculitis)

Kimura-Hayama et al., 2010.
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Criteria for Definitive Diagnosis

Further Workup & Management
• **CT for initial evaluation**
  - Visualization of calcified cysts/lesions
  - Often sufficient for diagnosis
  - If inconclusive, MR may be necessary

• **MR for follow-up evaluation**
  - Evaluation of intraventricular or small lesions
  - Scolex visualization (even possible in some calcified lesions)
  - Follow-up after therapy
  - Evaluation of degenerative changes and perilesional inflammation (best with T2-weighted)
  - Drawbacks: expensive, scarce availability in endemic areas, poor sensitivity for detection of calcified lesions

Garcia & Del Brutto, 2003; White et al., 2009b.
Other Imaging Modalities

- **Ultrasound**
  - Ocular cysts
  - See cyst wall against vitreous humor
  - Requires scolex visualization for specificity

- **Plain film**
  - Extraneural cysticercosis
  - Cigar-shaped calcifications in muscle or subcutaneous tissue
  - Less sensitive: plain film catches ~1/2 of muscular calcifications that CT picks up

Khosla, 2011; Bustos et al., 2005.
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Criteria for Definitive Diagnosis

Further Workup & Management

Agenda
Appearance on CT

- CT with contrast for Companion Patient #1
- Ring-enhancing pericystic inflammation
- Minimally enhancing cystic wall
- Hyperattenuating scolex
- Scolex not reliably visible on CT

Degenerating cysts with hypointense wall and hyperintense surrounding edema

Edema often best visualized on T2-weighted MRI

Companion Patient #2

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Variable Patients & Presentations

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Criteria for Definitive Diagnosis

Further Workup & Management
3 main mechanisms of disease:
- Direct: Mass effect/obstruction due to parasite
- Indirect: Inflammatory response (e.g., edema, gliosis, arachnoiditis)
- Scarring: fibrosis, granulomas, calcifications

Above mechanisms combine $\Rightarrow$ highly pleomorphic appearance of cysticercosis on imaging

Further variable appearances dependent upon:
- location of cyst(s)
- stage in life-cycle (can vary by lesion)

Sotelo et al., 1985; Kimura-Hayama et al., 2010.
Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

Parenchymal

Extraparenchymal

Intraventricular

Subarachnoid

Intraocular

Extraneural Cysticercosis

Any tissue, but most often:
- muscular
- subcutaneous

White et al., 2009b
Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

Extraneural Cysticercosis

Parenchymal

Extraparenchymal

Intraventricular

Subarachnoid

Intraocular

Spinal

Any tissue, but most often:
- muscular
- subcutaneous

White et al., 2009b
>60% of neurocysticercosis

Cysts in cerebral cortex or brainstem

Appear as cysts, enhancing lesions, or calcifications

Present as seizures, or encephalitic symptoms if many cysts

Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

- Parenchymal
- Extraparenchymal
  - Intraventricular
  - Subarachnoid
  - Intraocular
  - Spinal

Extraneural Cysticercosis

Any tissue, but most often:
- muscular
- subcutaneous

White et al., 2009b
10-20% of symptomatic cases
- Free floating in ventricles or attached to choroid plexus
- Trap in foramina or aqueduct → obstructive hydrocephalus
  - 50% of cases in 4th ventricle
  - Intermittent obstruction → intermittent symptoms associated with movement (Brun’s syndrome)
- CSF and cyst fluid = similar attenuation, so difficult to see with CT
- Hints: Obstructing hydrocephalus, CSF flow abnormalities, ventricular distortions
- Usually seen on MR due to cyst fluid and CSF having slightly different signal intensity on T1 or T2

White et al., 2009b; Teitelbaum et al., 1989; gross image: Kimura-Hayama et al., 2010; MR image: PACS, BIDMC.
Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

- Parenchymal
- Extraparenchymal
  - Intraventricular
  - Subarachnoid
  - Intraocular

Extraneural Cysticercosis

Any tissue, but most often:
- muscular
- subcutaneous

White et al., 2009b
In gyri, fissures, or cisterns

- Mass effect or arachnoiditis
  - Meningeal enhancement (focal or diffuse) with meningitis → chronic meningeal thickening → entrapped cranial nerve palsies
    - Usually without fever or signs of meningeal irritation
  - Vasculitis → ischemia
  - Communicating or obstructive hydrocephalus

- Growth not limited by brain parenchyma → grow up to 10 cm (esp. in Sylvian fissure)

Axial head T1-weighted MR of Companion Patient #5: subarachnoid cysts (arrows)

White et al., 2009b; image: Kimura-Hayama et al., 2010.
Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

Parenchymal

Extraparenchymal

Intraventricular

Subarachnoid

Spinal

Any tissue, but most often:

- muscular
- subcutaneous

Intraocular

White et al., 2009b
1-3% of cases

Impaired vision, recurrent eye pain, diplopia

Inflammation around degenerating cysts → chorioretinitis, retinal detachment, vasculitis → impaired vision

Evaluate pre-pharmacologic treatment with CT or ultrasound


Axial head CT (+C) of Companion Patient #6: Calcified cyst in right orbit subretinal space
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Gillian Lieberman, MD

Locations of Cysts: Overview

Cysticercosis

- Neurocysticercosis
  - Parenchymal
  - Extraparenchymal
    - Intraventricular
    - Subarachnoid
    - Intraocular
    - Spinal

- Extraneural Cysticercosis
  - Any tissue, but most often:
    - muscular
    - subcutaneous

White et al., 2009b
1.5% of cases:
Rarity likely due to “sieve effect” of narrow foramina of Luschke and Magendie

Usually in subarachnoid space → inflammatory and demyelinating changes in nerve roots →
radicular pain, paresthesias, sphincter disturbances

MR is superior to CT; myelography may show filling defect

White et al., 2009b; Kimura-Hayama et al., 2010; image: Neurology: Teaching NeuroImages:
http://www.neurology.org/content/77/23/e138/F1.expansion.html.
Locations of Cysts: Overview

Cysticercosis

Neurocysticercosis

Parenchymal

Intraventricular

Subarachnoid

Intraocular

Extraparenchymal

Spinal

Extraneural Cysticercosis

Any tissue, but most often:

- muscular
- subcutaneous

White et al., 2009b
- Found in ~1/2 of neurocysticercosis cases
- Subcutaneous and intramuscular cysts are usually asymptomatic, “cigar-shaped” calcifications
- If muscle involvement is extensive → myopathy
- Any tissue can be affected (e.g., liver, tongue, cardiac)

White et al., 2009b; gross: Kimura-Hayama et al., 2010; CT: Bustos et al., 2005.
- **Noncystic stage**: asymptomatic, no imaging findings

- **Vesicular stage**: viable cysts are associated with minimal inflammation
  - Nonenhancing, hypodense lesions (5-20mm)
  - 50% of cases show scolex/scolices (2-4mm)
  - Encysted T. solium usually die 2-6yrs post-infection → vigorous symptomatic inflammatory reaction

- **Colloidal stage**: lymphocytic infiltration of cyst wall & fluid
  - Inflammatory response around cysts → ring enhancing lesions with contrast enhancement
  - Scolex degenerates

- **Granular-nodular stage**: cyst retracts to form granulomatous nodule; fibrosis encompasses cyst; cavity collapses

- **Calcific stage**: calcification of necrotic (nonactive) larva → calcified nodule
  - Solid, nodular lesions (1-10mm, usually 2-4mm)

## Imaging Findings in Life-Cycle Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>CT Findings</th>
<th>MR Imaging Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noncystic</td>
<td>Often invisible</td>
<td>Often invisible</td>
</tr>
<tr>
<td>Vesicular*</td>
<td>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)</td>
<td>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</td>
</tr>
<tr>
<td>Colloidal vesicular†</td>
<td>Cyst may be hyperattenuating, pericystic enhancement on contrast-enhanced images, edema may be seen</td>
<td>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</td>
</tr>
<tr>
<td>Granular nodular</td>
<td>Similar to colloidal vesicular stage but with more edema, thicker ring enhancement</td>
<td>Similar to colloidal vesicular stage but with more edema, thicker ring enhancement</td>
</tr>
<tr>
<td>Calcified nodular</td>
<td>Hyperattenuating calcific nodules, no edema, no enhancement</td>
<td>Hypointense nodules, no edema, no enhancement</td>
</tr>
</tbody>
</table>

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

Kimura-Hayama et al., 2010.
Taenia solium & Cysticercosis

Variable Patients & Presentations

Choice of Imaging Modality

Appearance on Different Imaging Modalities

Imaging Findings in Variable Presentations

Differential Diagnoses

Criteria for Definitive Diagnosis

Further Workup & Management
Multiple intracranial calcifications:
- Metabolic disorders, vascular malformations, intracranial neoplasms, idiopathic, physiologic (e.g., choroid, dura), parasitic (cysticercosis, paragonimiasis)

Ring enhancing lesion(s):
- If single: abscess (bacterial, fungal, toxoplasmosis), cysticercus cyst, glioblastoma multiforme, resolving hematoma, lymphoma, metastasis
- If multiple: metastases, multifocal infections disease (TB, histoplasmosis), demyelinating plaques of MS, parasitic (cysticercosis, toxoplasmosis, paragonimiasis, neurotrichinosis)

Obstructive hydrocephalus:
- Neoplasm, cyst (arachnoid, parasitic: cysticercus or paragonimus), abscess, tuberous sclerosis, hematoma, encephalitis, abscess, congenital

Cystic spinal lesion:
- Congenital, parasitic, posttraumatic syrinx

Reeder & Felson, 2003; White et al, 2009b; Kimura-Hayama et al., 2010.
Taenia solium & Cysticercosis

Variable Patients & Presentations

Choice of Imaging Modality

Appearance on Different Imaging Modalities

Imaging Findings in Variable Presentations

Differential Diagnoses

Criteria for Definitive Diagnosis

Further Workup & Management
Narrowing the Diagnosis

- Diagnosis largely based on radiographic imaging along with clinical presentation
  - CT usually sufficient
- Serologic tests can help (but may be falsely negative)
- Lumbar puncture (LP) for CSF assay can help
  - Contraindicated if elevated intracranial pressure (ICP)
  - Mildly elevated WBC, normal glucose and protein
  - +/- eosinophilic CSF
- Biopsy
  - Rarely necessary for CNS cysts
  - Useful for skin & muscle cysts

Serpa et al., 2006, White et al., 2009b.
Definitive Diagnosis

- Absolute criteria for cysticercosis:
  - Cystic lesion showing scolex on CT or MR
    - Scolex is pathognomonic for cysticercosis
  - Histologic demonstration of parasite from biopsy
  - Direct visualization of subretinal parasite by fundoscopic exam

- Any 1 of the above absolute criteria is sufficient for definitive diagnosis

Serpa et al., 2006, White et al., 2009b.
Definitive Diagnosis (2)

- Definitive diagnosis also achieved when:

  Lesions highly suggestive of neurocysticercosis on neuroimaging studies occur in the context of…
  - Clinical presentation suggestive of neurocysticercosis

  AND
  - Epidemiologic factor: household contact OR contact with endemic area

  AND
  - EITHER
  - Positive serology
  - Resolution of lesions following antihelminthic therapy

Serpa et al., 2006, White et al., 2009b.
Taenia Solium & Cysticercosis

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Criteria for Definitive Diagnosis

Further Workup & Management
Evaluate for spinal and ocular cysts
- Inflammation around treated, degenerating cysts can cause previously asymptomatic cysts to become symptomatic
- Can lead to pain/paralysis/paresthesias (spinal) and blindness (ocular)

Treatment
- If incidental finding in asymptomatic patient: may do nothing
- Medical management:
  - Antiparasitics: albendazole, praziquantel
    - Cyst fluid becomes more proteinaceous and gelatinous: increased signal intensity on T1-weighted MR
  - Symptom control: anticonvulsants
  - Anti-inflammatory agents: corticosteroids
- Interventions:
  - Hydrocephalus: ventriculoperitoneal shunt for decompression
  - Cyst resection may be necessary (in acute setting or if nonresponsive to therapy)

White et al., 2009b; Kimura-Hayama et al., 2010.
Successful treatment is complicated by:

- Effectiveness of drugs → recurrence
- Undiagnosed cysts in various life stages → new symptoms with induced inflammation
- Large cysts burden → therapy inducing degeneration can produce massive inflammatory response → diffuse brain edema resembling encephalitis (with seizure, HA, N/V, altered consciousness, impaired vision, occasionally fever)

Follow-up

- Monitor post treatment/intervention with imaging
- Test of choice: MR with and without contrast

White et al., 2009b; Kimura-Hayama et al., 2010.
1 day later: Ventriculoperitoneal shunt placed to decompress obstructive hydrocephalus; shunt placement confirmed with CT (-C; top)

2 days later: MR of C, T, and L spines (+&1C) to evaluate for spinal cysticercosis: no cystic lesions found

The following week: serology confirms diagnosis

The following month: resection of cyst; post-operative evaluation with CT (bottom)

In subsequent months: monitoring with MR will occur

Images: PACS, BIDMC
References

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Thank you to all of you for making this a great month!