Neurocysticercosis
(Taenia solium Infection)

Feasibility and Strategy of Eradication

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- Imaging
- Immunoblots
- Immigration

Global Emergence of *Taenia solium*
Clinical manifestations of cysticercosis in humans
TAENIA SOLIUM LIFE CYCLE

Egg → Cysticercus → Adult Worm in Small Intestine → Pig
World Distribution of *Taenia solium*
Ecologic settings conducive to *Taenia solium* transmission
La Neurocisticercosis es “un testimonio al sub-dessarrollo”
H.M. Canelas, 1962
Seropositive persons often clustered in households in association with taenia carriers
Prevalence of Human and Porcine Cysticercosis Infection and Human Taeniasis in 8 Villages in the Central Sierra of Peru.

From Garcia et al., 2002
### Calculation of Disease Burden Associated with Neurocysticercosis in Peru

<table>
<thead>
<tr>
<th>Variable</th>
<th>Calculated value (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population of Peru (1993)</td>
<td>22,704,204</td>
</tr>
<tr>
<td>Population in area of endemicity</td>
<td>10,449,649</td>
</tr>
<tr>
<td>Population aged &gt; 15 years in areas of endemicity</td>
<td>6,269,789</td>
</tr>
<tr>
<td>Estimated range of cysticercosis seroprevalence, %</td>
<td>6</td>
</tr>
<tr>
<td>No. of seropositive persons aged &gt; 15 years</td>
<td>376,187</td>
</tr>
<tr>
<td>with NCC-associated seizure disorders</td>
<td>18,809</td>
</tr>
<tr>
<td>with other clinical manifestations of NCC</td>
<td>4702</td>
</tr>
<tr>
<td>Total with symptomatic NCC</td>
<td>23,512</td>
</tr>
</tbody>
</table>

Source: Bern et al., 1999
Neurocysticercosis in the U. S. A. is Primarily an Imported Disease

Current husbandry practices for pigs in the U. S. are not conducive to transmission of *Taenia solium*
Clinical and Epidemiologic Experiences with Neurocysticercosis in Non-Endemic Countries

• **Imported Disease** – In Los Angeles Co., epidemic of diagnoses began in the 1970s

• **Introduced infection/disease**
  - Cluster of “endemic” cases in Brooklyn community
  - Continuous isolated cases

![Annual Incidence of Diagnosed NCC](Richards et al., 1985)

![Cluster of cases](Schantz et al., 1994)
Driving force of continuing emergence of neurocysticercosis in North America is Hispanic immigration.

During decade 1991-2000, Hispanic population in USA increased by 58% to 35.3 million.

Factors Associated With Migrations
* scarcities of land, water, food
* overcrowding
* widening disparities of income
* poverty
* lack of employment

Source: Kane H: World Watch, 1994
Eradicability of *Taenia solium* Infection

- The International Task Force for Disease Eradication (1992) determined that *Taenia solium* was potentially eradicable based on the following considerations:
  - Life cycle requires humans as definitive hosts
  - Tapeworm infections in humans are the only source of infection for pigs, the natural intermediate host
  - Swineherds can be managed
  - No reservoirs of infection exist in wildlife.
Eradicability of *Taenia solium* Infection

- However, *T. solium* has not been eliminated from any region by a designed program and no national programs are yet in place.
Strategies for Intervention

Cook meat
Control slaughter
Meat inspection

Mass taeniacidal treatment
Improve sanitation

Restrain pigs
Vaccinate pigs*
Treat pigs*

TAENIA SOLIUM LIFE CYCLE
Proposed Control Measures

• Improved living conditions
• Control of pig slaughter
• Health education
• Mass taeniacidal Rx of humans
• Mass cysticercicidal treatment of pigs
• Vaccination of pigs
Effectiveness of Intervention Combining Taeniacidal Treatment in humans and Cysticercicidal Treatment of Pigs in Hyperendemic Villages in Peruvian Highlands

- **Interventions**
  - Mass treatment of pigs
    - Two rounds of oxfendazole (30 mg/kg)
  - Mass treatment of humans
    - One round of praziquantel (5mg/kg)

- **Effect**
  - Reduced prevalence and incidence of cysticercosis in pigs, however, the magnitude of the effect was lower than expected.

Garcia H and the Cysticercosis Working Group in Peru, 2002
**Cysticercosis/Taeniasis: Elimination progress**

- Categorized as ‘potentially eradicable’
  - International Task Force for Disease Eradication (1993)
- **Operational research to define optimal strategy**
- Developing political/social constituencies
  - World Health Assembly 2002
Questions?
Prevalence and Morbidity Caused by Neurocysticercosis in Latin America

- **Seizures**
  - Peru - 24-39 thousand cases
  - Latin America - 400 thousand cases

Some assumptions:

- Nearly 10% of people will be infected by the time they reach adulthood
- 1 in 200 will develop seizures

Source: Bern et al. 1999
Prevalence of Human and Porcine Cysticercosis Infection and Human Taeniasis in 8 Villages in the Central Sierra of Peru.

From Garcia et al., 2002
## Prevalence Estimates of *Taenia solium* Cysticercosis and Taeniasis in People and Pigs in Latin American Communities

<table>
<thead>
<tr>
<th>Country</th>
<th>Community</th>
<th>Sample Size</th>
<th>Prevalence Cysticercosis (Immunoblot) (%)</th>
<th>Prevalence Taeniasis (%)</th>
<th>Prevalence Cysticercosis in pigs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>Angahuan</td>
<td>1552</td>
<td>10.8</td>
<td>0.3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Xoxocotla</td>
<td>1005</td>
<td>4.9</td>
<td>0.2</td>
<td>7</td>
</tr>
<tr>
<td>Guatemala</td>
<td>Quesada</td>
<td>862</td>
<td>11</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>El Jocote</td>
<td>955</td>
<td>20</td>
<td>2.8</td>
<td>14</td>
</tr>
<tr>
<td>Bolivia</td>
<td>“rural community”</td>
<td>159</td>
<td>22.6</td>
<td>n.d.</td>
<td>39</td>
</tr>
<tr>
<td>Ecuador</td>
<td>San Pablo del Lago</td>
<td>118</td>
<td>10.4</td>
<td>n.d.</td>
<td>8</td>
</tr>
<tr>
<td>Peru</td>
<td>Lima (urban)</td>
<td>250</td>
<td>0</td>
<td>n.d.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Maceda</td>
<td>371</td>
<td>8</td>
<td>0.3</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Churusapa</td>
<td>134</td>
<td>7</td>
<td>n.d.</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Haparquilla</td>
<td>108</td>
<td>13</td>
<td>n.d.</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Monterredonda</td>
<td>489</td>
<td>16</td>
<td>n.d.</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Quilcas</td>
<td>18</td>
<td>n.d.</td>
<td>60-70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saylla</td>
<td>99</td>
<td>24</td>
<td>8.6</td>
<td>36</td>
</tr>
</tbody>
</table>

From: Schantz, Wilkins and Tsang, 1998
Cysticercosis/ Taeniasis: Elimination Strategy

- **Interrupt transmission**
  - health/sanitary education
  - modernize swine husbandry
  - mass-treat populational foci of infection

- **Surveillance**
  - identify infected populations

- **Operational research**
  - explore alternative elimination approaches
Praziquantel for taeniasis can provoke neurologic symptoms in patients with occult neurocysticercosis

12 y.o. girl developed severe headaches persisting for 10 days after receiving praziquantel (5mg/kg). MRI revealed 7 intracerebral cysticerci.
Neurocysticercosis in the U. S. A. is Primarily an Imported Disease

- Published clinical reports through 1986 totaling >900 cases documented that >90% of patients were born outside of U.S. (most frequently in Mexico)
  - only 15 cases were diagnosed in patients born in the U.S. with no foreign travel history to countries with endemic *T. solium* infection.

Current husbandry practices for pigs in the U.S. are not conducive to transmission of *Taenia solium*
Cysticercosis/Taeniasis: Elimination strategy

- **Interrupt transmission**
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Criteria for Assessing Eradicability of Diseases

**Political Will/Popular Support**

- Perceived burden of disease
- Expected cost of eradication
- Synergy of eradication efforts with other interventions
- Necessity for eradication rather than control

ERADICATION OF Taenia solium INFECTIONS IN EUROPE
DUE TO: (Pawlowski, 1987)

- Improvement in general sanitation
- Improvement in economy status
- Change into in-door husbandry
- Rigorous meat inspection

NONE OF THESE FACTORS OPERATIVE IN THE ENDEMIC COUNTRIES NOW

CYSTICERCOSIS IN SWINE

BERLIN, GERMANY, 1885–1910

Rate per 1000

Rate in 1988: 1.3 per million

Hinz, 1991

SOURCE: Official slaughterhouse records (Ostertag, 1932)
Symptomatic disease

Asymptomatic infection

EITB + CT -

EITB - CT -
Symptomatic disease

CT + EITB -

CT +

EITB + CT +

EITB +

resolved

Bern et al., 1999
Pig Population in Eastern & Southern Africa 1961 - 2000*

*excludes South Africa
Hispanic Population in the United States

- 1990 total population: 249 million
  - 22.4 million Hispanics
  - 9% of total population
- 2000 total population: 281 million
  - 35.3 million Hispanics
  - 12.5% of total population
- 1990 to 2000 Hispanic change:
  - 13.0 million
  - 58% increase since 1990