Neurocysticercosis in North Carolina: An Emerging Infectious Disease Associated with Immigration

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2007 One Medicine Symposium
December 12, 2007
Migrant Public Health

- “Hot” topic of immigration
- Migrant
  - a person who moves from one place to another
- 191 million migrants in 2005
- Changing global epidemiology

Why Cysticercosis?

- Zoonotic disease
- Treatable
- Preventable
- Potentially eradicable
- “One Medicine” approach needed for control and prevention
Topics for Today

- Cysticercosis and neurocysticercosis overview
- Methods
- Results
- Conclusions
- Future directions
Cysticercosis

- Pork tapeworm (*Taenia solium*)
- Worldwide
- Primarily rural, developing countries
- Most common parasite of central nervous system
  - Leading cause of acquired epilepsy
- Affects 50 million people worldwide

Figure: WHO, 55th World Health Assembly, April 2002
Life Cycle of *Taenia solium*

- 19th C. discovery of cysticercosis and adult tapeworm connection
- **Definitive hosts** = human (carriers)
- **Intermediate hosts** = human or pig
- **2 forms of disease**
  - Taeniasis (adult tapeworm)
  - Cysticercosis (larvae)

Figure: Garcia HH and Evans CA. *The Lancet.* 2003.
Human Cysticercosis

- Muscular, subcutaneous tissue
  - Asymptomatic
  - +/- Nodules

- Ocular
  - Blurry vision
  - Swelling
  - Detached retina

Neurocysticercosis

- Presence of 1 or more cysts in central nervous system
- Pathology
  - Space-occupying lesion
  - When parasite dies
- Dying parasite causes intense inflammatory reaction
  - Can initiate a seizure
- Former cyst calcifies
  - Can serve as focus for recurrent seizures

Neurocysticercosis: Clinical Signs and Symptoms

- Seizures
  - 50% - 70% cases
- Chronic headache
- Mental deterioration
- Focal neurological deficits
- Severe complications associated if obstruction of cerebrospinal fluid

Photo: Dr. Theodore Nash
Clinical Evaluation

- Presumptive diagnosis
  - History, clinical signs, imaging study
- Additional tests
- Treatment
  - Depends on location, number, stage, and clinical symptoms
  - +/- antiparasitics, steroids, anti-seizure meds, surgery

Photo: Pareja RR et al. Medifam. 2002
Porcine Cysticercosis

- Cysts in muscle, subcutaneous fat
- Rarely associated with symptoms
- Diagnosis
  - Examination of tongue
  - Carcass inspection
- Treatment (oxfendazole)
- Vaccine

Control and Prevention

LET’S BREAK THE PORK TAPEWORM CYCLE
with these 6 easy steps

1. Always use a toilet.
   Use a toilet to use when appropriating pits and other
   methods.

2. Wash your hands.
   Handwashing is an important step to prevent
   spreading the disease, which helps to stop the
   disease from spreading.

3. Go to the clinic.
   Each time you have tapeworms, go to the doctor
   to get treatment and other symptoms are
   prevented.

4. Stop pigs from roaming.
   Pigs that roam in infected areas can spread
   the disease to humans, so keep your pigs
   to prevent them from spreading.

5. Check meat is safe.
   Check meat to make sure it is cooked
   thoroughly before eating. Meat should
   not be eaten raw or undercooked.

6. Cook meat well.
   It is safer to eat the meat well. Meat must be cooked
   thoroughly no food to see pink meat and no blood
   remains. This will kill any organisms that can cause
   infection.

This child has a tapeworm growing inside him.

Thousands of tapeworm eggs can live in the intestines.
They move through the intestines via the bloodstream.

The eggs spread orally.
Worm eggs can contaminate the ground and wash away.
They enter our hands, enter the drinking water.

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Worm eggs can contaminate the ground and wash away.
They enter our hands, enter the drinking water.

Pigs get infected.
Fluke eggs are ingested by eating human tissue containing tapeworm eggs.

Swallowing tapeworm eggs is dangerous.
Tapeworm eggs grow inside the body, cause infection.
They can cause several symptoms and other people.

Figure: International Livestock Research Institute, 2006
Cysticercosis in the U.S.

- Nationally
  - Increase in number of diagnoses
    - Global travel of residents
    - Arrival of migrants from endemic areas
    - Availability and use of CT and MRI
  - Not nationally reportable
    - Reportable in California, Arizona, New Mexico, Texas, Oregon

- State-wide
  - Investigations of morbidity and mortality in Oregon, California, Texas
  - Limited information available in North Carolina
Study Objectives

- Determine morbidity and mortality associated with neurocysticercosis
- Describe and characterize distribution and economic impact on health care system
Methods

- Identified all individuals with cysticercosis discharge diagnosis or deaths in North Carolina from 1995 - 2004
  - ICD-9CM, ICD-9, ICD-10 codes

- Reviewed medical records and death certificate information

- Collected data
  - Demographic
  - Clinical
  - Other
Definitions

- Incident case
  - No prior diagnosis in lifetime at least one month prior to the first hospital visit

- Denominator for rates
  - U.S. Census Bureau data and bridged population estimates

- Ethnicity: Hispanic
  - Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race
Results
351 discharges with cysticercosis diagnosis

262 unique patients identified

253 (97%) patients with records available

250 (99%) patients with records supporting diagnosis

246 (98%) patients survived

4 (2%) patients with cysticercosis-related deaths
Annual Distribution of Discharges

n = 351 discharges

Frequency

Population (millions)

Total
Non-hispanic
43 different hospital facilities

5 facilities accounted for 55% of all discharges

- University of North Carolina, Chapel Hill (16%)
- Carolinas Health Care System, Charlotte (14%)
- North Carolina Baptist Hospital, Winston-Salem (10%)
- Duke University Health System, Durham (8%)
- Pitt County Memorial Hospital, Greensville (7%)
## Demographics of Study Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>%</th>
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<tbody>
<tr>
<td>Sex</td>
<td>64 (males)</td>
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<tr>
<td>Median age</td>
<td>27 years (range 3-83)</td>
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</table>
Geographical Distribution

- Mecklenburg: 14%
- Wake: 10%
- Forsyth: 7%
- Durham: 7%
- Alamance: 5%
Country of Origin

n=213/250 (85%) with available data
$X^2=226.3$, df=3, $p<0.0001$ by Fisher’s exact test
Travel Outside the U.S.

Non-U.S. Born
- n = 62
- $X^2=3.6$, df=1, p=0.1

U.S. Born
- n = 10
- $X^2=2.3$, df=1, p=0.1
Type of Brain Lesion By Time Since Moving to the U.S.

n=154 (80%) non-U.S. born residents with classifiable lesions and date of move
Diet

Ever Eat Meat
n=44
$X^2=40.1$, df=1, p<0.0001
by Fisher’s exact test

Ever consumed raw or undercooked pork
n=25, $X^2=0.4$, df=1, p =0.5
by Fisher’s exact test
Total Hospitalization Duration

- Median duration per patient: 4 days (1-101)
- Total hospital duration: 1,810 days
- Median direct cost per patient: $9,024 ($611-212,539)
- Total direct costs: $4.4 million
*190/250 (76%) with available insurance type (54 Hispanics and 6 non-Hispanics missing data)
Mortality

- 4 (2%) cysticercosis-related deaths
  - 3 males, 1 female
- Ages at death ranged from 20 - 46 years old
- Race and ethnicity
  - 1 black, non-Hispanic (born in U.S.)
  - 3 white, Hispanics (not born in U.S.)
- Complications
  - 3 with ventricular obstruction
  - 1 with aspiration pneumonia
- Mortality rate for total population
  - 0.05 per 1 million population, 95% CI (0.0-0.1 per 1 million population)
## Cysticercosis Rates For 1995 - 2004

<table>
<thead>
<tr>
<th>Population</th>
<th>Incidence Rate per 1 million person-years (95% CI)</th>
<th>Prevalence Rate per 1 million people (95% CI)</th>
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<tbody>
<tr>
<td><strong>Total</strong></td>
<td>2.6 (2.2 - 2.9)</td>
<td>3.1 (2.7 - 3.5)</td>
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<tr>
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<td>~1 out of 400,000 person-years</td>
<td>~1 out of 320,000</td>
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<tr>
<td><strong>Hispanic</strong></td>
<td>55.9 (48.0 – 63.8)</td>
<td>66.9 (58.3 – 75.6)</td>
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<td>~1 out of 18,000 person-years</td>
<td>~1 out of 15,000</td>
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<td><strong>Non-Hispanic</strong></td>
<td>0.2 (0.1 - 0.3)</td>
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<td>~1 out of 5,900,000 person-years</td>
<td>~1 out of 3,800,000</td>
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Summary of Findings

- Disproportionate impact among Hispanics
- Majority of patients not born in U.S.
  - Mexico, Central or South America
  - Some continue to travel outside U.S.
  - U.S.-born patients travel to endemic areas
- Majority were young, males, living in or near large cities
- Relatively low mortality rate
- Majority do not have health insurance
- Median total direct costs per patient = $9000
Limitations

- Incomplete medical record information and missing data
  - Country of origin, diet, travel, animal exposure
- Underestimated Hispanic population
- Did not address *where* transmission occurred
Future Directions

- Increase in number of immigrants in North Carolina
- Conduct patient interviews
  - To better understand transmission and risk factors
- Increase surveillance
  - Locate additional cases of taeniasis and cysticercosis
  - Stool and serologic testing
  - Reportable disease?
- Provide education
Acknowledgements

- Medical record department staff
- North Carolina Department of Health and Human Services
  - Paul Buescher
  - Jeff Engel
  - Brenda Horne
  - Pedro Luna-Orea
  - Jean-Marie Maillard
  - Greg Smith
- North Carolina State University College of Veterinary Medicine
  - Maria Correa
- University of North Carolina-Chapel Hill
  - Emily Sickbert-Bennett
  - Charlie Poole
  - J Richard Seed
  - The Graduate School
- Others
  - Pablo Destefanis
  - Sara Forhan
  - John Hubbell
  - Cathryn Jirlds

The findings and conclusions in this presentation are those of the author(s) and do not necessarily represent the views of the North Carolina Department of Health
Questions?
Additional References (Websites)

Additional References (Journal Articles)

Extra Slides
Deaths from Cysticercosis
1990-2002

FJ Sorvillo et al. Deaths from Cysticercosis, United States. EID. 2007
# Race:
**Medical record review vs. Hospital discharge database**

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<td><strong>107</strong></td>
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Weighted kappa 0.06 (95% CI 0.02-0.11), p<0.0001
Source of Admission

Referrals: HMO, clinical, and general referral
n=351 discharges
$X^2=156.0$, $df=2$, $p<0.0001$
Animal or Farm Exposure

Data available for 47/250 (19%)

$X^2=2.6$, df=1, p=0.1 by Fisher’s exact test
Occupation

210/250 (84%) with available occupation type
*Food Industry includes industrial (e.g. food processing plants, n=18) and/or restaurants (n=21)