SCHISTOSOMIASIS

epidemiology, control and prevention
Framework

1. The disease in a few words…
2. General epidemiology
3. Epidemiology of transmission & life cycle
   i. Parasites
   ii. Molluscs
   iii. Reservoir of parasites
   iv. Parasitic cycle
   v. Susceptibility to schistosomiasis
      - Host factors
      - Parasitic factors
Framework (continued)

3. Control and prevention
   – Fight against molluscs
   – Hygiene & Sanitary development
   – Mass treatment: drug & targets
   – Prevention programmes

4. Basic points
1. THE DISEASE IN A FEW WORDS...

- Parasitic disease linked to direct cutaneous contacts with freshwater

- **Chronic** disease
  - Digestive and splenohepatic
  - Urinary depending on parasitic species
• Public health model in D.C.
  – linked to development
    • dams & canals (hydroelectricity, irrigation…)
      Ex: Aswan, Akosombo, Mangoky…

  – linked to hygiene & socioeconomic level
    • Africa
    • Japan
2. GENERAL EPIDEMIOLOGY

i. Target population

- Anybody with cutaneous contacts with water: children (epidemiological indicators ++)
  women, fishermen, workers in ricefields...

- 200 million (300 ?)
  - 74 endemic countries
  - Africa 85%

- 500 million living in risk areas
• Children +++

– epidemiological indicators

– highest prevalence (up to 90%)
– highest parasite burden
  → eggs count

due to lack of immunity
& high level of contacts with freshwater
ii. Clinical epidemiology

- Digestive & splenohepatic disease

→ morbidity: cirrhosis & portal hypertension

→ mortality: digestive bleeding (esophageal varicose)
- Urinary & genital disease

➔ morbidity > mortality:

✓ chronic urinary infections

(bladder fibrosis ➔ ‘encapsulated’ bladder)

✓ renal insufficiency

✓ sterility

Global mortality rate (digestive disease ++):

: 1/2 to 1 million/ year
- ‘morbidity’ course:

chronic disease with ~ daily infections

Symptomless but haematuria / bloody diarrhea

Clinical consequences of bladder fibrosis / liver fibrosis
• Geographical repartition

- 3 major parasites pathogenic in humans with specific geographical distribution (map)
  + a less pathogenic \((S.\text{intercalatum})\) & \(S.\text{mekongi}\)

- in an endemic zone: heterogeneous transmission

  in \textit{focus} + ++

  • infected hosts
    + contacts with freshwater
    + specific snails

  ➔ macro & micro epidemiology ex: China
EGYPT
Praziquantel chemotherapy coupled with a vigorous media campaign has resulted in a significant decrease in the morbidity and prevalence of schistosomiasis infection.

IRAN, MOROCCO and SAUDI ARABIA
Schistosomiasis control has been successful in these areas with eradication of the disease planned.

CHINA
Schistosoma continues to be a major public health problem in lake and marshy regions despite successful control in other endemic areas.

LAO PEOPLE’S DEMOCRATIC REPUBLIC
S. mekongi control has been successful around Khong Island with prevalence reduced from 42% to less than 2%.

DJIBOUTI and SOMALIA
Displacement of people by war and instability has introduced intestinal schistosomiasis to these countries.

NORTH-EAST BRAZIL
Urban schistosomiasis now presents in and around many major cities.

GHANA
Intestinal schistosomiasis has increased due to the construction of Akosombo Dam and other much smaller dams.

SUB-SAHARAN AFRICA
More than 85% of the estimated 200 million people globally infected with schistosomiasis and the majority of patients with severe disease live on this continent.

INDONESIA
Schistosomiasis has been controlled in the Lindu region of Sulawesi to such an extent that the prevalence of infection is lower than 2%.
3. EPIDEMIOLOGY OF TRANSMISSION
LIFE CYCLE

i. Parasites

- Schistosomes (helminth\trematoda)
  - S. haematobium \(\rightarrow\) urinary disease
  - S. mansoni \(\rightarrow\) digestive & spenohepatic disease
  - S. japonicum \(\rightarrow\) digestive & spenohepatic disease
  - S. mekongi
  - S. intercalatum \(\rightarrow\) not a public health pb
Adult worms:

- 1 cm,
- longevity: 8 to 15 years,
- capillary blood vessels in specific egg-laying sites
- male
  + female (genital canal)
  (model of faithfulness!)

≠ stages:
Eggs:
- spine,
- 50/day up to 3,000/day,
- 50% die ➔ granuloma
Granuloma

elementary lesion in the pathological mechanism
• Digestive disease

granuloma

→ liver fibrosis
→ cirrhosis

→ portal hypertension
  → spleno/hepatomegaly
  → rupture of esophageal varicoses → bleeding
• **Urinary disease**

  - granuloma
  - fibrosis
  - encapsulated bladder
  - ureteral stenosis
    - urinary infections
    - renal insufficiency
  - Fallopian tubes stenosis
    - sterility
Eggs (continued)

50% die

✓ 50% pass through the walls of

- bladder
- biliary duct; colon

→ excreted in urine

haematuria

faeces

bloody diarrhea

= mild manifestations of the disease
- Miracidium:
  - ciliary movements
  - specific snails

- Cercariae:
  - infecting forms
  - swim around midday
  - penetrate skin
Schistosomula

- lymphatic & venous channels
  - right heart – lungs – left heart
  - digestive capillary network

then maturation in adults

- mating
- migration of the couple to specific egg-laying sites
  - urinary tract capillary vessels
  - liver & bowels capillary vessels
ii. Snails

✓ No snails, no transmission
  ➔ weak point

✓ Specific of parasitic species

- *S. haematobium*: bulinus
- *S. mansoni*: biomphalaria
- *S. japonicum*: oncomelania (amphibious)
iii. Reservoirs of parasites

- People!
- Animals
  - Important impact for *S. japonicum* & *mekongi*
dogs, cows, pigs, rats
  - Limited impact for *S. mansoni*
  - No animal hosts for *S. haematobium*

⇒ to be considered in control programs
iv. Life cycle
v. Susceptibility to infection

1. Host factors

– Environmental factors
  • intensity of exposure,
  • number of snails…

– Acquired immunity
  • primary infection in childhood and daily ‘superinfections’
  • slow development and poor efficacy
  • can reduce the number of surviving schistosomula

– Genetic factors
  • protective factors (Brazil)
2. Parasitic factors

- linked to species

  ‘global’ severity of infection

  \[ S. \text{ Japonicum} > S. \text{ mansoni} > S. \text{ haematobium} \]

  (3,000 eggs/d) \quad (200 eggs/d) \quad (50 eggs/d)

- genetic factors of ‘virulence’ intraspecies

  Ex: \textit{S mansoni} in Congo in 2 focus
4. CONTROL & PREVENTION

- Control program

  3 complementary targets to cut the transmission chain

  - intermediate hosts (snails)
  - contacts of people with freshwater
  - reduction of the number of excreted eggs
• **Fight against snails**

– **Mollusciciding**
  
  • chemical product: niclosamide
  
  • 2 opposite ways for use
    – large applications: main irrigation canal or…by plane!
      but ecological impact, cost, no cooperation of the community
    
    – focused application
      » localization of all water contact-areas
      » cercarial research
      » focused mollusciciding

• frequency of application: every 3 or 6 months?
mollusciciding
• Other:

  – Competitors
    • sophisticated & « ecologically » correct but still an experimental tool
    • unexpected side effects
      (invasion of water point with consequences on plants or fish)

  – Collection:
    • picking up then burying (China)
Hygiene & sanitary development

to avoid contacts with ‘wild’ water

2 ways
– health education
  • modification of behaviour linked to educational level and socioeconomic necessities
  • poor impact \ takes a (very) long time

– provision of sanitary facilities
  • washing-places
  • latrines
  • water supplies
1 example of poor impact in the short term for sanitary facilities

- Philippines, children at school
  - 1975 incidence 22.2%
  Only sanitary facilities program
  - 1979 incidence 28.4%
  + praziquantel
  - 1983 incidence 6.8%
Mass chemotherapy

- praziquantel
  - single oral dose of 40 to 60 mg/kg
  - well tolerated

- definition of a strategy for the delivery system & population coverage ++
  - depending of initial epidemiological assessment
  - depending of financial resources
• **Who?**
  - targeted treatment? : children, fishermen…
  - whole population?

• **With or without parasitological screening?**
  » eggs count?
    / 10 mL urine
    / 1 g stool (standardized Kato technique)
  » rapid tests in urine (circulating antigens)?
  » reagent strips (*S. haematobium*) to detect blood

• **When?**
  - every 3 ? 6 ? months
<table>
<thead>
<tr>
<th></th>
<th>Cul de sac valley mollusciding</th>
<th>Marquis Valley chemotherapy</th>
<th>Riche Fond Valley sanitary facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial incidence</td>
<td>22 %</td>
<td>18.8 %</td>
<td>22.7 %</td>
</tr>
<tr>
<td>Incidence &gt; 2 years</td>
<td>9.8 %</td>
<td>4 %</td>
<td>11.3 %</td>
</tr>
<tr>
<td>Cost / 1 person</td>
<td>3.7 $</td>
<td>1.1 $</td>
<td>4 $</td>
</tr>
</tbody>
</table>
Don’t conclude sanitary improvement has no impact !!!
→ Brazil, urban area, results after 3 courses of oxamniquine

<table>
<thead>
<tr>
<th>zone</th>
<th>sanitary level</th>
<th>prevalence</th>
<th>eggs count</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>medium</td>
<td>47 %</td>
<td>204 / 1 g stool</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>18 %</td>
<td>48 / 1 g stool</td>
</tr>
<tr>
<td>C</td>
<td>medium</td>
<td>46 %</td>
<td>122 / 1 g stool</td>
</tr>
<tr>
<td>D</td>
<td>high</td>
<td>20 %</td>
<td>24 / 1 g stool</td>
</tr>
<tr>
<td>E</td>
<td>high</td>
<td>24 %</td>
<td>56 / 1 g stool</td>
</tr>
<tr>
<td>F</td>
<td>poor (no sanitary facilities)</td>
<td>71 %</td>
<td>314 / 1 g stool</td>
</tr>
</tbody>
</table>
• 4 conditions for a successful control program

– 1/ **Long term** program
  • financial resources
  • political stability
  • community based & accepted

– 2/ Definition of **Objectives**
  ‘Eradication’ is banned!
  • reduction of transmission?
  • reduction of mortality? morbidity?
  • reduction of parasitological indicators

 ➔ definition of **indicators**
3/ Definition of a strategy

- Based on the initial assessment
  - epidemiological indicators

- Adapted according to permanent assessment

Ex.: focused mollusciciding every 6 months
+ targeted chemotherapy in children every 6 months without parasitological screening
+ water supplies & sanitary facilities
4/ Assessment

- Initial: ‘pilot’ zone or on samples
  - clinical indicators
  - parasitological indicators
  - malacologic and cercarial indicators

→ To determine the initial strategy

- Permanent: to follow indicators

- + selective “external” assessments (“expert”)
  - systematically
  - in case of problem

→ adaptation of the strategy
Schistosomiasis control program

‘vertical’ team

‘attack’ phasis  maintenance phasis  long term phasis

1 to 5 years  2 to 5 years  Indefinite?

‘horizontal’ team

Initial assessment
¬samples/pilot zone
¬strategy

Permanent assessment
### Pragmatical approach for objectives & strategy

1. Classification of the initial situation: 4 levels

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prevalence</strong></td>
<td>low</td>
<td>high</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td><strong>Parasitological load</strong></td>
<td>low</td>
<td>low / high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td><strong>Reinfection rate</strong></td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>
## 2 / definition of objectives & strategy

<table>
<thead>
<tr>
<th>objectives</th>
<th>strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>integrated program children ++</td>
</tr>
<tr>
<td>prevalence</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>3 years « attack » then L1</td>
</tr>
<tr>
<td>prevalence &lt; 2O %</td>
<td></td>
</tr>
<tr>
<td>75% prevalence &lt; 2O %</td>
<td></td>
</tr>
<tr>
<td>Parasitological load</td>
<td></td>
</tr>
<tr>
<td>75% parasitological load</td>
<td></td>
</tr>
<tr>
<td>Morbidity</td>
<td>5 years « attack » then L1</td>
</tr>
<tr>
<td>nothing regarding prevalence</td>
<td></td>
</tr>
<tr>
<td>L4</td>
<td>international cooperation</td>
</tr>
<tr>
<td>Hard work</td>
<td></td>
</tr>
<tr>
<td>Morbidity</td>
<td></td>
</tr>
</tbody>
</table>
• Prevention

– Prevention program before any agricultural or energy development project linked to freshwater

⇒ to avoid introduction of the disease
⇒ same principles as control programs

– In the future: vaccine
Prevention is profitable!

– 1 / Cost of prevention can be recovered

Ex: Tanzania, sugar cane plantation
Loss of 5 % productivity due to schistosomiasis

Ex: Mangoky, sugar cane & coton plantation
Work disability = 41 % of the control program yearly cost
Control programs are expensive

- 6 million $ in Mali for 6 years

- Egypt: in 1984: 8% of the national health budget

- Madagascar (Mangoky) «local» control program 150,000 $ / year
5. BASIC POINTS

• Contacts with freshwater

• 2 diseases:
  – Urinary: *S. haematobium*: Africa
  – Splenohepatic: more severe
    • *S. mansoni*: Africa & South America
    • *S. japonicum* & *mekongi*: Asia
• Transmission in focus with necessity of intermediate hosts (snails)

• Pathogenesis linked to non-excreted eggs (granuloma)

« auto-induced » disease
• 3 targets to interrupt transmission in control programs:

  – Snails → mollusciciding

  – Reduction of contacts with water → sanitary facilities

  – Reduction of excreted eggs → mass chemotherapy
• 4 conditions in control programs
  – Long term
  – Definition of objectives
  – Definition of strategy
  – Initial and permanent assessment
THANK YOU
List epidemiological indicators

- Clinical / Morbidity indicators
- Transmission indicators
Non exhaustive list

1/ morbidity indicators

• Urinary disease
  – Haematuria (nber, %)
  – Number of hospitalizations (nber, %)
  – Positivity of reagent strip (nber, %)
  – Positivity of circulating Antigen rapid test (urine) (nber, %)
  – Echographical features (quantitative, qualitative)

• Digestive disease
  – Bloody diarrhea / abdominal pain
  – Splenohepatomegaly, ascitis
  – Digestive bleeding
  – Hospitalizations
  – Positivity of circulating Antigen rapid test (urine)
  – Echographical features
2/ transmission indicators

- ‘level’ of infection parameters
  - Prevalence, incidence, reinfection rate
  - Parasitological load (number of eggs/10 mL or 1 g)

- Malacological parameters
  - Density of snails
  - Rate/number of infected snails
  - Number of cercariae (cercariometry) / L

- ‘Population-related’ parameters
  - Number of water-points
  - Number of contacts host-water
  - Ratio infected children / population
  - Rate of participation in the chemotherapy program
  - Rate of participation in the health education sessions
  - Rate of the use of sanitary facilities

- Reservoir of parasites: number/% of infected animals
Ex 1: China, control program initiated in 1956

<table>
<thead>
<tr>
<th></th>
<th>1956</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence (number of infected persons)</td>
<td>12 millions</td>
<td>870,000</td>
</tr>
<tr>
<td>Areas with snails (m²)</td>
<td>14 billions</td>
<td>3 billions</td>
</tr>
<tr>
<td>Number of infected water buffalos</td>
<td>1.2 million</td>
<td>100,000</td>
</tr>
<tr>
<td>Number of counties with schisto.</td>
<td>372</td>
<td>eradication n = 125, control n = 141, failure n = 106</td>
</tr>
</tbody>
</table>
• Why such a success?
• Long term program (34 years at the time of these results and still on going)

• Political stability
Ex 2 : Maniema – former Zaïre (D R Congo)

• Initial assessment:
  – prevalence:
    • 80 to 100 % (~ 100 % in children)
  – Mean parasitological load : 500 eggs / 1 g
  – Reinfection rate 80 %

• Assessment after a 8 years program
  – prevalence / parasitological load / reinf. rate = idem

  – Why such a failure?
  – Is it currently a failure?
  – Other indicator(s) to assess?
• Level 4 epidemiological situation

➤ prevalence & reinfection rate illusory

➤ morbidity only possible

Ex: ➤ rate of hepatosplenomegaly

Not so bad for the infected persons !!!
Ex 3 : Tunisia

• Initial assessment:
  – prevalence:
    • 10 to 15 % (~ 70 % in children)
  – low parasitological load
  – Reinfection rate < 10 %

  – What are your objectives ?
  – What is your strategy ?
• Level 1 => objectives

  – dramatic ➤ prevalence possible:
      above a public health problem
      < 1 %
  – dramatic ➤ parasitological load possible
      0 egg !!
  – dramatic ➤ reinfection rate
      ~ No reinfection possible

In this situation eradication is possible
• **Strategy**

  – Yearly mollusciciding

  – **TTT:**
    * 1 time after parasitological screening in adults and then if symptomatic
    * Mass TTT in children on a yearly basis

  – Sanitary facilities
Ex 4 : Ghana Akosombo

• dam built between 1964 & 1969
• 70,000 displaced people → new villages around the « new » lake (8,500 Km 2)
• ‘Invasion’ of the banks of the lake by Ceratophyllum (water plants)
• 2 populations:
  – ‘Ewe’ fishermen coming from another area because of the lake
  – ‘Krobo’ farmers (autochthonous inhabitants)

  – ½ of the whole population < 15 year-old
• Initial assessment before dam:
  – prevalence:
    • 30 %
    
    (S. haematobium)
  
  – New assessment 1 year after the construction of the dam:
    – prevalence: 80 to 90 %
    – (very) high parasitological load
    – reinfection rate 80 %
Questions:
- List all the factors able to play a role in the epidemiological evolution
- What would be the target population(s) for the control program?
- Objectives of the program?
- Strategy? (in detail !)
Factors playing a role

- the lake itself (➔ possible water-points)
- ‘locally’ displaced people (Krobo)
- migration of Ewe fishermen coming with their parasites + high level of contacts water / hosts
- high rate of children (high level of contacts water / hosts)
- Ceratophyllum plants: feed snails ➔ multiplication of the snails
• Target populations
  – Ewe fishermen
  – children
• Objectives:
  – Level 4 epidemiological situation
  – main objective: morbidity
  – 50% parasitological load
  – long term objective: 50% prevalence
Strategy

Initially in a ‘pilot’ area: 2 years
  → 26 villages; 3,500 persons

• Attack phase: 3 years
  – Focused mollusciciding
    • inventory of water-points: 230 = 8 or 9 / village
    • niclosamide in each water-point yearly
    • destruction of Ceratophyllum
  – Yearly targeted mass treatment
  – Sanitary facilities: water pumps in villages
– Assessment (including malacologic indicators: cercariometry, infected snails)

– Maintenance phasis: 3 years with the participation of the ‘horizontal’ team (integration in primary health care)
• Results at the end of the attack phasis in the pilot zone:

63 %  prevalence
78 %  parasitological load
85 %  number of snails

but  of the number of infected snails only in 2/3 of the water-points

Considered at this time as a bad result
In fact regarding the initial level of transmission : success !!

High Cost : 3.5 $ / year / person
Ex.5 : Mangoky (Madagascar)

- 10,000 inhabitants in a 10,000 hectare area
- irrigation project for intensive cotton cultivation
- Non endemic zone for schistosomiasis before construction of the irrigation system

1/ Regarding schistosomiasis, what kind of program should be performed before digging canals?
2/ describe the strategy you guess in that situation
• Prevention program
• Strategy = the same as a control program
  – Definition of the objectives: to maintain schistosomiasis at a very low level
  – Organization of the program
    • Choice of a pilot zone
    • Initial assessment:
      - Prevalence, parasitological load in infected persons, reinfection rate
      - Transmission indicators: identification & number of water points
      - Malacological assessment: number of water-points with snails, samples for cercariometry
– Tools & strategy for a 5 years program:
  • Parasitological screening of all the persons living in the area + immigrants
  • Treatment if +
  • Mollusciciding in ‘infected’ water points
  • Health education + water supply
  • Integration to the local health services at the end of the 5 year ‘vertical’ program

– Main results:
  • Initial prevalence : 0 to 2%
  • Prevalence at year 2 : 2 to 15 %
  • Prevalence at year 5 : 4 %
  • Prevalence at year 8 : 15 % !!!!
• So failure !!; main causes were:

  – Difficulties for communication due to the rainy season (road were regularly floaded)
  – No coordination between the different official administrations
  – More immigrants as expected & difficulties in controlling them
  – Control program area floaded 3 times because of rain
  – Difficulties in killing snails because of a high density of plants in water-points
  – Poor participation of the community in the program