Role of Diagnostic Testing in Schistosomiasis Control Programs in Rural Ghana

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Abstract

Background: Schistosomiasis affects an estimated 200-300 million people worldwide. Construction of dams has contributed to the high prevalence of urinary schistosomiasis in Ghana. To assist rural villages downstream from the Barekese dam in schistosomiasis control programs, this study evaluated possible detection methods of schistosomiasis.

Methods: A cross-sectional survey of volunteers was conducted in a rural setting of Ghana. Five hundred and thirty four (534) volunteers provided symptom information and urine samples for urinalysis. Microscopic egg count of 341 random samples was used to determine prevalence of disease and to analyze effectiveness of urinalysis and symptom information for diagnosing schistosomiasis.

Results: Schistosomiasis prevalence was 41.1 % for the village. The highest prevalence was in the 10-14 age groups (71.1 %). Sensitivity and specificity for hematuria were 76.1 and 77.7 % respectively, and proteinuria was 58.2 & 68.7 % respectively. The positive predictive value was highest for hematuria (71.1 %). The highest negative predictive value was among positive proteinuria or hematuria (84.0 %). From urinary symptom information, reporting pain and dark urine yielded the highest positive predictive value (72.0 %). Reporting pain, difficulty, or dark urine yielded the highest negative predictive value (75.8 %).

Discussion: The positive and negative predictive values of urine analysis and symptom information may be an inexpensive tool for diagnosing schistosomiasis in areas of high prevalence.

Introduction

Schistosomiasis is one of the world’s most prevalent neglected infectious diseases. There are an estimated 200-300 million people living with schistosomiasis and 650 million people living in endemic areas [1]. The burden of this disease causes an estimated 8-60 million Disability Adjusted Life Year (DALY) every year [2]. Urinary schistosomiasis is especially a burden in Sub-Saharan Africa where Schistosoma haematobium is the most prevalent schistosoma in this region [1]. World eradication of urinary schistosomiasis has been a challenge for multiple reasons: female schistosoma can produce 200 to 2000 eggs daily, difficult access to clean water, and water contact activities in endemic areas are a part of daily life. The burden of urinary schistosomiasis can cause glomerulonephritis, pulmonary hypertension, squamous cell carcinoma of the bladder, anemia and under nutrition [3-5]. Schistosomiasis and anemia in children has also been known to contribute to poor growth and reduced school performance [7]. Schistosomiasis as co morbidity is associated with worse outcomes with urinary tract infections and with higher HIV shedding [6,9].

In Ghana, communities have reported prevalence of S. haematobium infection as high as 60 percent [10]. Problems of schistosomiasis have been attributed to creation of habitat for Bulinus. Globus snails from damming of Lake Volta [11]. Because of the effect of the creation of Lake Volta, many studies on urinary schistosomiasis have been focused in this part of the country [10]. However, urinary schistosomiasis is also a problem among other regions in Ghana [10]. The village of Barekuma is located in the Ashanti region and receives water from the Offin River. The village is approximately 7 kilometres downstream from the Barekese dam. A previous assessment estimated that fifty-eight percent (58%) of school children in the Barekuma community had schistosomiasis [12]. The purpose of this study was to assess the prevalence of disease in Barekuma and evaluate inexpensive methods of urine analysis and symptom information to aid in intervention efforts in schistosomiasis control.

Materials and Methods

Health and economic problems in Barekuma are being evaluated through a Community Based Participatory Research (CBPR) method. CBPR involves an equal partnership between investigators and the community. Power, resources, results, and knowledge from the project are shared with all involved. Community members and investigators are involved in the research design process, interpretation of results, and determining the action of the results [13]. The CBPR research provides the foundation theory of the collaboration of the Barekuma Community Collaborative Development Project (BCCDP). The BCCDP is a partnership of village members, medical professionals at the Komfo Anokye Teaching Hospital (KATH), Kwame Nkrumah University of Science and Technology, School of Medical Sciences, Atwima Nwabiagya District Assembly and researchers at the University of Utah from the United States. The BCCDP is currently gathering data to aid the CBPR process with the village to help determining intervention

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strategies for schistosomiasis control. The BCCDP received approval for this study from the Kwame Nkrumah University of Science and Technology, School of Medical Sciences and the University of Utah Institutional Review Boards.

A village school was temporarily used as a research and laboratory facility where data and urine samples were obtained from participants. 534 participants from the village were first administered a questionnaire to obtain information about urinary symptoms such as pain, colour and difficulty and exposure to the river by frequency and activity. The survey was developed in English and administered in Twi by bilingual interviewers. Sterile urine cups were provided for samples. Urine analyses for proteinuria and hematuria were performed using Clinichek (Bayer Corp. Leverkusen, Germany) dipssticks on site. Following urine analyses, all participants were seen by physicians from the Komfo Anokye Teaching Hospital and received specific instruction depending on the findings of urinalysis. Those with positive urine blood on dipssticks as well as positive egg count were given Praazinquantel at the Barekese health post.

A sample population of 341 urine specimens was randomly selected for microscopy for the presence of *S. haematobium* eggs and subsequent filtration and egg count at the Komfo Anokye Teaching Hospital parasitology laboratory. A positive egg count was considered the standard for a positive diagnosis of schistosomiasis.

**Statistical methods**

All data were entered into EpilInfo October 2004 version 3.3 (Centre for Disease Control and Prevention) and exported to Excel spreadsheet (Microsoft Corporation, Redmond, WA) and population characteristics and frequencies were determined using STATA 10 statistical software (Stata Corp., College Station, TX.). The frequency of schistosomiasis was stratified by age and sex. Sensitivity, specificity, positive predictive values and negative predictive values was calculated for hematuria, proteinuria, either hematuria or proteinuria and different combinations of symptom information of dark, pain, or difficulty urinating compared to microscopy.

**Results**

More than half of the participants (56.3%) were females (Table 1 & Figure 1). Age distribution ranged from 10.9 to 23.5 % between the different age groups.

The highest prevalence of schistosomiasis was in the age group of 10-14 (71.1 %). The lowest prevalence was among the 30-54 age groups (19.2 %). The crude prevalence for the population was 41.9 %.

Sensitivity and specificity of the urine analysis with a positive hematuria was 76.1 & 77% respectively (Table 2). The sensitivity and specificity of urine analysis for proteinuria was 58.2 & 68.7 % respectively. The sensitivity and specificity among those who had a positive hematuria or proteinuria were 85.2 & 78.9 respectively. The positive predictive value was highest for hematuria (71.1%). The highest negative predictive value was for testing for proteinuria or hematuria (84.0 %).

The positive predictive values of symptoms reported by participants are also reported in Table 3. The highest positive predictive value was among those who reported pain and dark urine (72.0). The highest negative predictive value was among those who reported no pain, no difficulty, and no dark urine (75.8 %).

**Discussion**

Schistosomiasis continues to be a health concern in communities in developing countries. Using the Community Based Participatory

| Characteristic | N | Frequency |
|----------------|---|-----------|
| Sex            |   |           |
| Male           | 149 | 0.443     |
| Female         | 192 | 0.557     |
| Age            |   |           |
| 5-9            | 80  | 0.235     |
| 10-14          | 76  | 0.223     |
| 15-29          | 75  | 0.220     |
| 30-54          | 73  | 0.214     |
| 55+            | 37  | 0.109     |

Table 1: Characteristics of participants, Schistosomiasis Urine Analysis and Egg Count, Barekuma, Ghana, 2007.

| Symptom Combination | Positive | Negative | Sensitivity | Specificity | PPV | NPV |
|---------------------|----------|----------|-------------|-------------|-----|-----|
| Painful, Difficult and Dark Urine | 87 | 45 | 0.617 | 0.774 | 0.659 | 0.740 |
| Painful and Dark Urine | 60 | 32 | 0.606 | 0.789 | 0.720 | 0.755 |
| No Painful, Difficult and Dark Urine | 39 | 120 | 0.532 | 0.823 | 0.627 | 0.758 |

Table 2: Sensitivity and Specificity of Urinalysis.

| Microscopy Results | Positive | Negative | Sensitivity | Specificity | PPV | NPV |
|---------------------|----------|----------|-------------|-------------|-----|-----|
| Painful Urination   | 76 | 66 | 0.535 | 0.668 | 0.535 | 0.668 |
| No Painful Urination| 66 | 133 | 0.535 | 0.668 | 0.535 | 0.668 |
| Difficulty Urinating| 57 | 51 | 0.401 | 0.744 | 0.528 | 0.635 |
| No Difficulty Urinating| 85 | 148 | 0.401 | 0.744 | 0.528 | 0.635 |
| Dark or Bloody Urine| 87 | 45 | 0.617 | 0.774 | 0.659 | 0.740 |
| No Dark or Bloody Urine| 54 | 154 | 0.617 | 0.774 | 0.659 | 0.740 |

Table 3: Sensitivity, Specificity, Positive Predictive Values, and Negative Predictive Values of Reported Symptoms.
Research method in schistosomiasis control, investigators from the Barekuma Community Collaborative Development Project have collected information on schistosomiasis prevalence and diagnostic testing to help the village of Barekuma discuss interventions strategies. The crude prevalence in the village was 41.9 percent. The most affected were adolescents ages 10-15 (71.1 percent) and lowest were among adults 30-54 (19.2 percent). This distribution of schistosomiasis in Barekuma based on age and sex is similar to what other prevalence studies have shown in other areas of the world. [10,14]. The decrease in prevalence as people age may be attributed to less exposure or increased immune response as shown in other studies [15] The short term and long term complication associated with this disease makes these findings of high prevalence an important public health disease [16-18].

To determine possible economic diagnostic strategies for future intervention programs, urine analysis and symptoms for detecting urinary schistosomiasis were evaluated. Urinalysis for schistosomiasis detection showed that hematuria and proteinuria have a low sensitivity (76.1 & 58.2 % respectively) and low specificity (77.78 & 68.7 %respectively) compared to egg counts from filtration and microscopy. These results for sensitivity and specificity of hematuria and proteinuria were similar to other studies [19,20]. Although these tests may not be useful in communities with low prevalence, the negative predictive value of either hematuria or proteinuria is 84.0 % and positive predictive value for hematuria is 71.1 percent suggesting that it may be useful in Barekuma for detection for schistosomiasis. Similar to urine analysis, urinary symptom information sensitivity was low (highest was 61.7 % for reporting dark and painful urination.) Specificity for dark, painful or difficulty urine, however, was 82.3%. Urinary symptom information from patients in Barekuma, specifically reporting dark and painful urine or reporting normal urination can be useful for diagnosis because of the relatively high positive predictive values and high negative predictive values (72.0 & 75.8).

This study has some limitations. Because samples were taken from volunteers, people concerned about schistosomiasis might be oversampled in the population and those who were working not be able to participate. There is also a potential source of information bias because of the humid environment where the urine analysis was preformed which may introduce some error into the results of the urine analysis. This information was presented to village leaders, educators, and community members of Barekuma, Ghana to stimulate discussion preformed which may introduce some error into the results of the urine analysis. This information was presented to village leaders, educators, and community members of Barekuma, Ghana to stimulate discussion and community members of Barekuma, Ghana to stimulate discussion of possible intervention strategies and the roles of the community, government, and BCCDP in these interventions. Subsequently all the study participant with schistosomiasis were treated at the Barekese Health Centre.

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References
1. World Health Organization (1993) The control of schistosomiasis: Second report of the WHO Expert Committee. Geneva: WHO, WHO Technical Report Series 830
2. van der Werf MJ, de Vlas SJ, Brooker S, Looman CW, Nagelkerke NJ (2003) Quantification of Clinical Morbidity Associated with Schistosomiasis in Sub-Saharan Africa. Acta Trop 86: 125-139.
3. Bourée P, Piveteau J, Gerbal JL, Halpen G (1990) Pulmonary arterial hypertension due to bilharziasis. Apropos of a case due to Schistosoma haematobium having been cured by praziquantel. Bull Soc Pathol Exot 83: 66-71.
4. Greenharn R, Cameron AH (1980) Schistosoma haematobiumand the nephrotic syndrome. Trans R Soc Trop Med Hyg 74: 609-613.
5. Murta-Nascimento C, Schmitz-Dräger BJ, Zeegers MP, Steineck G, Kogevinas M, et al. (2007) Epidemiology of urinary bladder cancer: from tumor development to patient’s death. World J Urol 25: 285-95.
6. Salvana EM, King CH (2008) Schistosomiasis in travelers and immigrants. Curr Infect Dis Rep 10: 42-49.
7. Stephenson L (1993) The impact of schistosomiasis on human nutrition. Parasitology 107: 107-123.
8. Helling-Giese G, Kjetland EF, Gundersen SG, Poggensee G, Richter J, et al. (1996) Schistosomiasis in women: manifestations in the upper reproductive tract. Acta Trop 62: 225-238.
9. Leutscher PD, Pedersen M, Raharisolo C, Jensen JS, Hoffmann S, et al. (2005) Increased Prevalence of Leukocytes and Elevated Cytokine Levels in Semen from Schistosoma haematobium-Infected Individuals. J Infect Dis 191: 1639-1647.
10. Aryeeley ME, Wagatsuma Y, Yeboah G, Asante M, Mensah G, et al. (2000) Urinary schistosomiasis in southern Ghana: 1. Prevalence and morbidity assessment in three (defined) rural areas drained by the Densu river. Parasitol Int 49: 155-163
11. Wen ST, Chu KY (1984) Preliminary schistosomiasis survey in the lower Volta River below Akosombo Dam, Ghana. Ann Trop Med Parasitol 78: 129-133.
12. Akoto A (2007) Schistosoma haematobium infection in School children in a rural community in Ashanti Region of Ghana. Submitted to the West African College of Physicians (WACP) in partial fulfillment for the requirement of WACP Part 2 Fellowship Examination.
13. Faridi Z, Grunbaum JA, Gray BS, Franks A, Simoes E (2007) Community-based par-ticipatory research: necessary next steps. Prev Chronic Dis 4: A70.
14. Tetteh IK, Adjei RO, Sasu S, Appiah-Kwakye L (2004) Index of potential contamination: Schistosoma haematobium infections in school children in the Ashanti Region of Ghana. East Afr Med J 81: 520-4.
15. Mutapi F, Winborn G, Midzi N, Taylor M, Mdluzula T, et al. (2007) Cytokine responses to Schistosoma haematobium in a Zimbabwean population: contrasting profiles for IFN-γ, IL-4, IL-5 and IL-10 with age. BMC Infect Dis 7: 139.
16. Geelhoed D, Agadzi F, Visser L, Ablordepepy E, Asare K, et al. (2006) Severe anemia in pregnancy in rural Ghana: a case-control study of causes and management Actost Gynecol Scand 85: 1165-1171.
17. Renaud R, Bretteis P, Castanier C, Loubiere R (1972) Placental bilharzias. Int J Gynecol Obstet 10: 29-30.
18. Siegrist D, Siegrist-Obimpeh P (1992) Schistosoma haematobium infection in pregnancy. Acta Trop 50: 317-321.
19. Takougau I, Meili J, Fotsi S, Angwafo F 3rd, Kameju E, et al. (2004) Hematuria and dysuria in the self-diagnosis of urinary schistosomiasis among school-children in Northern Cameroon. Afr J Health Sci 11: 121-127.
20. Bosompem KM, Owusu O, Okanla EO, Kojima S (2004) Applicability of a monoclonal antibody-based dipstick in diagnosis of urinary schistosomiasis in the Central Region of Ghana. Trop Med Int Health 9: 951-966.