

The Role of Ultrasound in the Diagnosis of Urinary Schistosomiasis: A Systematic Review

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Abstract

Urinary schistosomiasis is one of the most neglected endemic tropical diseases in Africa. More than 207 million people are affected worldwide and about 85% live in sub-saharan Africa. Globally, 200,000 deaths are attributed to schistosomiasis annually. The study is aimed at reviewing the available literatures on the prevalence and pattern of sonographic bladder abnormalities in patients diagnosed for urinary schistosomiasis. Studies reveal the prevalence of schistosomiasis in Africa, children also had more urinary tract diseases than adults and there is a higher prevalence of urinary tract morbidity in males than females. The most common urinary tract abnormalities detected on ultrasound from the reviewed articles from various parts of the African continent were found to be bladder wall thickening and hydronephrosis while the least frequent abnormality was abnormal bladder shape. The ultrasound features reported indicate the prevalence of bladder wall thickening and hydronephrosis as the most common urinary tract morbidities.

Keywords: Schistosomiasis, Ultrasound, Urinary bladder, Systematic review

INTRODUCTION

Schistosomiasis is a parasitic disease caused by flukes of the genus *Schistosoma*. There are two major forms of schistosomiasis; Urinary schistosomiasis – which mainly affects the urinary bladder, ureters and kidneys. Symptom includes hematuria, and Intestinal schistosomiasis – which mainly affects the liver, spleen and the intestines. Symptoms include abdominal pain, diarrhoea and bloody stool. Schistosomiasis is the third most devastating tropical disease in the world, being a major source of morbidity and mortality for developing countries in Africa, South America, the Caribbean, the Middle East, and Asia (WHO, 2010). More than 207 million people are infected worldwide, about 85% live in subsaharan Africa and an estimated 700 million people are at risk of infection in 76 countries where the disease is considered

endemic(WHO, 2010). Globally, 200,000 deaths are attributed to schistosomiasis annually (Chistulo *et al.*, 2004). Those who have been infected for a long time may experience liver damage, kidney failure, infertility or bladder cancer. In

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children, it may cause poor growth and learning difficulty. Urinary schistosomiasis is among the chronic diseases affecting the urinary bladder, and the infection is caused by *Schistosoma haematobium* (King *et al.*, 2011). Microscopy of the urine is gold standard for the diagnosis of urinary schistosomiasis but requires the adult worms to be producing eggs; serological test can also diagnose less advanced infections. However, the urinary bladder can be evaluated using ultrasonography, computed tomography, cystography, magnetic resonance imaging, and cystoscopy. Ultrasonography has been extensively used because it is non-invasive, readily accessible, affordable and not associated with ionizing radiation. It has also been extensively investigated as a possible substitution for some of the more common invasive modalities used to evaluate the urinary bladder (Stephanie *et al.*, 2010). Ultrasound study is considered a valuable tool in assessing the urinary system, its related pathology and complications associated with schistosomiasis, as well as the therapy's follow-up (Ferrara *et al.*, 2018).

The missing gap identified by this review from the previous published articles in the subject area are not using Doppler ultrasound in the studies and not correlating the sonographic findings with the histopathological features in all the studies. If further studies consider using Doppler ultrasound and correlating the sonographic findings with the histopathological features will enhance the role of ultrasound in the diagnosis of urinary schistosomiasis. The study is aimed at reviewing the available literatures on the prevalence and pattern of sonographic bladder abnormalities in patients diagnosed for urinary schistosomiasis.

A prospective study was conducted by Remppis *et al.* (2019) on focused assessment with sonography for urinary schistosomiasis (FASUS) – pilot evaluation of a simple point-of-care ultrasound protocol and short training program for detecting urinary tract morbidity in highly endemic settings in Lambaréné, Gabon from December 2015 to June 2016. Among 85 cases assessed by both transverse and longitudinal bladder scan, pathology compatible with urogenital schistosomiasis (UGS) was detected in 35 (41%) cases by transverse scan alone compared with 38 (45%) by a combination of both scans. In five cases, renal pelvis and/or ureter dilation was present without bladder wall thickening of ≥ 5 mm. All five were positive for *S. haematobium* in urine microscopy. During follow-up, pathology compatible with UGS was present in 15/46 (33%) cases at follow-up visits 1 (M1) and in 16/49 (33%) cases at after treatment visits 3 (M3) among scans of sufficient quality. Hydronephrosis was present in 3/51 (6%) and 3/54 (6%) cases at follow-up visits 1 (M1) and after treatment visits 3 (M3) respectively. As criteria for follow-up were not consistent, these rates cannot be used to measure treatment success.

Garcia *et al.* (2018) conducted a prospective study on ultrasound findings and associated factors to morbidity in *Schistosoma haematobium* infection in a highly endemic setting in Cubal, Angola from August to December 2013. A simple random sampling method was employed

and 157 subjects were evaluated. A portable ultrasonography device (myLab 25 ESAOTE) was used as an instrument for data collection. Eighty six (54.8%) were females while 71 (45.2%) were males, and the mean age was 8.7 ± 3.2 years (i.e. age range \leq and >10 years). Ultrasound examination showed pathological changes in 134 of 157 (85.4%) children. The bladder was the most common site of alteration and was abnormal in 133 of 157 (84.7%) children. Some type of ureteral dilatation was seen in 54 of 157 (34.4%), and 10 of 157 (6.3%) had kidney pathology, 67 (42.6%) out of 157 had abnormal bladder shape, 71 (45.2%) had bladder wall thickening, 51 (32.4%) had bladder mass, 6 (3.7%) had pseudopolyp and 74 (47%) had bladder wall irregularities.

Another prospective study was conducted by Oyeyemi *et al.* (2018) on urinary bladder thickness, tumor antigen, and lower urinary tract symptoms in a low *Schistosoma haematobium* endemic rural community in Ogun State, Nigeria. A simple random sampling method was used and 56 individuals were recruited for the study. A Mindray, DP2200 portable ultrasound apparatus with a 3.5 MHz curvilinear probe was used to obtain the data. The prevalence of urogenital schistosomiasis in the area was 3.6%. Bladder wall thickening (BWT) (35.7%) was the most prevalent bladder pathology while bladder wall contracture (1.8%) was the least. The overall prevalence of lower urinary tract symptoms (LUTS) was 64.3%. Urgency, dysuria (16.1% each), and frequency (3.6%) were the most and least reported lower urinary tract symptoms, respectively.

A prospective study was also conducted by Barda *et al.* (2017) on ultrasonographic evaluation of urinary tract morbidity in school-aged and preschool-aged children infected with *Schistosoma haematobium* and its evolution after praziquantel treatment: a randomized controlled in Adzopè region of Cote d'Ivoire from November 2015 to May 2016. A stratified random sampling method was employed and 303 preschool aged children (PSAC) and school aged children (SAC) were recruited for the study. The instrument for data collection was a Sonosite 180 Plus ultrasound machine, with a 3.5 MHz convex probe. One hundred and sixty two of the 303 children were PSAC with a mean age of 3.8 (2-5) years, 46% of the preschoolers were males while 54% were females. One hundred and forty one of the participants were SAC, 44% were males while 56% were females, the mean age was 8.9 years and the range was (6-15) years. Thirty percent of PSAC (48/162) and 1.4% of SAC (2/141) did not reach an adequate fill of the bladder to be analyzed with sonography. At baseline 43% (70/162) of PSAC had urinary tract (UT) morbidity. The vast majority had light/ moderate bladder morbidity (40%), such as focal wall thickening or bladder heterogeneously echoic, 2% (3/162) had polyps or masses on their bladder and 7% (11/162) had hydronephrosis. 67% (94/141) of SAC presented urinary tract pathology. The majority had light/moderate pathology (47%), such as heterogenous wall or focal thickening of the bladder, 4% (6/141) presented polyps or masses on the bladder wall or dilated ureter and 6% (9/141) had pyelectasis.

A prospective study was conducted by Onile *et al.* (2016) on detection of urinary tract pathology in some *Schistosoma haematobium* infected Nigerian adults in Eggua community Ogun state, Nigeria between August 2012 and May 2013. A stratified sampling method was employed and a total of 257 (79 male and 178 female) participants aged 30-90 years were screened for *S.haematobium* infection and associated bladder pathologies. A portable B mode ultrasound apparatus was used as instrument of data collection. The mean age of participants was 48 ± 12.2 years. Statistical analysis of data obtained was done using SPSS version 20.0 ($P < 0.05$). The overall prevalence of *S.haematobium* in the sampled population was 25.68% (66/257), 21 (31.8%) in males and 45 (68.2%) in females. The highest prevalence of infection was observed in participants over 60 years old. Bladder pathologies were observed in 33.9% (87/257) of the sampled population and included abnormal bladder wall thickness (39/66) (59%), abnormal bladder shape (10/66) (15.2%), bladder wall irregularities (15.2%), bladder masses (1.5%), and bladder calcification (1.5%). Bladder wall thickness, the most common

abnormality, was recorded in 46/79 (58.2%) males and 90/178 (50.6%) females. Among the participants, 56 (84.8%) with bladder pathologies also had an existing schistosomiasis infection, 48 (87.3%) of which were light intensity and 8 (72.7%) of which were heavy intensity: $\chi^2 = 267.5, P = 0.001$. Thus, there was an association between urinary tract pathology and the intensity of *S. haematobium* infection ($\chi^2 = 375.4, P = 0.001$). Among the participants with light and heavy intensity of *S. haematobium* infections, bladder wall thickness was the most common bladder structural pathology identified in 33/56 (58.9%)

and 6 (60.0%) participants with light and heavy *S. haematobium* infections, respectively. Abnormal bladder shape and bladder wall irregularity were seen in 8/56 (14.3%) and 2 (20%) participants with light and heavy infections, respectively. Hydronephrosis was present in only one participant with light infection, while calcification was identified in only one participant with heavy infection. No bladder polyp was detected. Mild bladder pathology was more common than severe bladder pathology in this study and was found in 48 of the participants. There was a higher incidence of bladder pathologies among female participants; bladder mass and hydronephrosis were also seen only in female participants.

A prospective study was conducted by Santos *et al.* (2015) on comparison of findings using ultrasonography and cystoscopy in urogenital Schistosomiasis in a public health centre in Luanda Angola between December 2011 and September 2012. Eighty people were recruited into the study. A portable ultrasound apparatus (Siemens portable ultrasound with a 3.5 mHz curvilinear probe, WA 980297002, USA) was used as instrument of data collection. The median age of the patients was 41 years (range 3 - 75); 62 (77.5%) were males while 18 (12.4%) were females. Sixty (75.0%) of the participants had distortion of the bladder shape and 29 (36.3%) had bladder masses. Patients with lesions in the bladder mucosa such as neoplasms, ulcers or granulomas detected by CE also had changes in bladder thickness. On ultrasound (US) residual urine was observed in 17 patients (21.3%), and bilateral hydronephrosis was found in 3 (3.8%). One patient had an associated kidney neoplasm. The outcomes achieved by the two diagnostic approaches supported an acceptable correlation for the detection of bladder changes by ultrasound and Cystoscopic examination (CE) while bladder wall distortion or bladder masses in urogenital Schistosomiasis were detected by ultrasound, it was not possible to obtain meaningful information about bladder thickness. A prospective study was conducted by Magak *et al.* (2015) on case-control study of post treatment regression of urinary tract morbidity among adults in *Schistosoma haematobium*-endemic communities in Kwale County, Kenya from the year 2000-2003. A total of 154 subjects were used for the investigation. A portable ultrasound unit (Sonosite 180, Bothell, WA) was used to obtain the required data. Of the affected adults, 63% were males while 37% were females, and the mean age was 27 ± 16.5 years. Upon standardized urinary tract sonography, *S. haematobium*-related urinary tract abnormalities were present in 17% with bladder inflammation present in 16%, and evidence of hydronephrosis or hydroureter in 2%. Also 172 adults (10%) had abnormal intake ultrasounds, that is, exams manifesting significant moderate-to-severe pathology detected in bladder, ureters, or kidneys.

A prospective study was also conducted by Ma`aji & Adamu, (2015) on pattern of urinary bladder sonographic findings in patients evaluated for urinary Schistosomiasis at Usmanu Danfodiyo University, Teaching Hospital Sokoto and Federal Medical Centre Birnin Kebbi. A total of 107 consecutive patients were evaluated. The instruments for data collection were Apogee 800 plus (Japan 2002) and Concept D (Dynamic Imaging Scotland) ultrasound scanners with a variable frequency probes at 3.5-5 mHz. The mean age of the patients was

42.9 ± 16.8 years, with a range between 7 and 86 years. There were 84 (78.5%) males and 23 (21.5%). The majority of the patients are fish farmers making 40 (24.3%), followed by plants farmers with 26 (24.3%). All the 16 (15.0%) of the female patients were married. Civil servants, teachers, and traders account for 7 (6.5%), 5 (4.5%), and 3 (2.8%), respectively. Urinary bladder stone with wall thickening was the most common finding accounting for 37 (36.4%), followed by bladder wall thickening with internal echoes accounting for 32 (21.5%) of the patients. A gray scale ultrasound image shows bladder wall thickening. The incidence of irregular bladder mass was 15 (14.0%) while polypoidal mass accounted for 4 (3.7%). A gray scale ultrasound image shows an irregular mass with wall thickening. Contracted bladder with wall calcification was seen in 7 (6.5%) while no abnormalities were seen in the urinary bladder in 6 (5.6%) of the patients. A Doppler ultrasound image shows a vascular bladder mass.

A prospective study was conducted by Elmadani *et al.* (2013) on ultrasound findings in urinary Schistosomiasis infection in school children in the Gezira state central Sudan from the year 2009–2010. A total of 73 school boys were recruited for the cross sectional study. Data was collected using an ultrasound apparatus (Aloka SSD-500 portable ultrasound with a 3.5-mHz curvilinear probe; Aloka, Tokyo, Japan). A total of 73/103 (71%) children were positive for *S. haematobium*. All positive subjects were examined by ultrasound. The mean age of all the positive subjects was 11.3 ± 2.9 years, with age ranged 7 - 20 years. Ultrasound of the urinary bladder revealed that 66/73 (90.4%) patients had some degree of wall thickening, ranging from mild to severe, as follows: 35/66 (53%) mild, 12/66 (18.2%) moderate and 14/66 (21.2%) severe. There was no significant difference between the different age groups ($P > 0.05$). Twenty-seven out of 66 (40.9%) patients had multiple polyps and 22/66 (33.3%) had a single polyp. The ultrasound findings of ureters showed that 38/73 (52%) patients had different degrees of ureteric dilatation. However, no patient had a severe degree of ureteric dilatation, and there were no significant differences between the different age groups. Ultrasound showed that 19/73 (31.2%) patients had different degrees of hydronephrosis; 18 patients had a mild hydronephrosis and only one patient showed a moderate degree of hydronephrosis. However, there were no significant differences between the different age groups. The result showed that 32/66 (48.5%) patients had bladder and ureter abnormalities, while 16/66 (24.4%) showed bladder, ureter and kidney abnormalities and 3/66 (4.5%) had both bladder and kidney abnormalities.

A prospective study was conducted by Ekwunife *et al.* (2009) on ultrasonographic screening of urinary schistosomiasis infected patients in Agulu Community, Anambra state, Nigeria. A total of 60 primary school students were involved in the study. The ultrasonographic examination was carried out using an Aloka SSD-500 sector scanner with a convex probe (5 mHz). The age groups of the participants include 5-9 years, 10-14 years and > 15 years respectively. Ultrasound examination showed pathological changes in the urinary tract of 23 (38.3%) out of the 60 children examined. Irregularities of the bladder inner surface were the most common changes identified in 25% of the pupils. Other changes included congestive changes in 6.7% of the individuals at the right pelvis and 1.7% at the left pelvis. These kidney changes were moderate. The urinary bladder intermediate score was 69 and upper urinary tract intermediate score was 30, thus giving a final *S. haematobium* score of 99. Irregularities of the bladder wall were higher among male (60%) pupils when compared with females' pupils (40%). Also 4 (66.7%) of the pupils with bladder thickness, were males while 2 (33.3%) were females. The two mass cases were males. Moderate kidney dilation was also observed in 4 males out of the 5 positive cases. Of the 23 individuals associated with bladder wall lesion among which 5 were associated with kidney dilation, 19 (67.9%) belong to the age group 10-14. Others comprising of 21.4% and 10.7% belong to the age groups > 15 and 5-9 respectively. The differences observed in lesion distribution among males and females was found to be significant ($df = 6, p < 0.05$) at 5% level.

Another prospective study was conducted by Nmorsi *et al.* (2007) on urinary tract pathology in *Schistosoma haematobium* infected individuals in Ekpoma, Edo state, Nigeria. Sample sizes of 43 volunteers were the subjects of the investigation. The examinations were done using a Fukuda Denshi UF 4000 (Japan) ultrasound machine with a 3.5 MHz frequency curvilinear real time probe. The abnormalities were classified according to WHO standards (WHO, 1996). A pathologically rounded (distorted) bladder was given a score of 1 (compared to the normal rectangular shape of the bladder). If the wall thickness was >5 mm, a score of 1 was given if it was focal and a score of 2 was given if it was multifocal or diffuse. A mass was considered a localized thickening of the bladder wall protruding into the lumen (>10 mm) and was given a score of 2. Multiple masses (n) were given a score of n+2. A pseudopolyp was defined as an outgrowth of the wall, attached by a slender base (narrower than the mass). A single pseudopolyp was given a score of 2. A hydroureter was given a score of 3 when the ureter was dilated and 4 when it was markedly dilated. Hydronephrosis was given a score of 6 when the kidney was moderately dilated. A normal non-pathological state was given a score of 0. The data obtained in this study were evaluated statistically using Microsoft Excel. Ten pathological conditions were observed: wall thickness 24 (55.8%), abnormal shape 30 (69.8%), irregular bladder wall 12 (27.9%), masses 10 (27.9%), pseudopolyps 2 (4.7%), significant residual volume 12 (27.9%), echogenic particles 30 (69.8%), calcifications 24 (55.8%), hydroureter 10 (23.3%) and hydronephrosis 8 (18.6%). Amongst the volunteers with light infection the most common pathological conditions, abnormal bladder shape and echogenic particles, were observed in 18 (66.7%). The volunteers with heavy infections and calcified bladders 14 (87.7%) had the most prevalent pathological conditions. The structural urinary tract diseases found in volunteers with heavy infection were more prevalent than in those with light infection, however, this difference was not statistically significant ($t = -2.19$, $p < 0.02$). Children had more urinary tract diseases than adults. This difference was statistically significant ($t = 3.23$, $p < 0.03$). Hydronephrosis and hydroureter were absent in the volunteers with light infection. The highest prevalence of abnormal bladder shape with echogenic particles occurred in children 22 (73.3%). Amongst adults, abnormal bladder shape and echogenic particles were most prevalent (61.5%).

A prospective study was conducted by Koukounari *et al.* (2006) on assessment of ultrasound morbidity indicators of Schistosomiasis in the context of large-scale programs in Mali from March 2004 to June 2004. A systematic random sampling method was employed to a sample size of 2,841 subjects. Ultrasonographic assessments were performed with a portable ultrasound device (SSD-500; Aloka, Tokyo, Japan) with a convex 3.5-MHz transducer as an instrument for data collection. All examinations were performed by the same clinician, who was blind to Schistosome infections status of the individual children. Ultrasonographic examinations were performed according to current WHO guidelines. Females accounted for 53% (i.e. 1506) while males accounted for 47% (i.e. 1335) of children in the survey and approximately equal numbers of children were recruited in each year group from 7 to 14 years of age. Bladder wall thickening 43 (1.5%), irregularities 43 (1.5%), bladder masses 42 (1.4%), hydronephrosis 105 (3.7) and pseudo-polyps 42 (1.4%), were found in 9.5% of the children. The prevalence of upper urinary tract (kidney) pathology was estimated to be 3.7%. The prevalence of positive global scores was estimated to be 10.1%, and this prevalence at the school level ranged from 1.0% to 61.4%. Children with either light or heavy *S. haematobium* infection intensities were more likely to have a positive ultrasonographic global score than uninfected children (light: OR 2.6, $P 0.013$ and heavy: OR 5.7, $P < 0.001$). Boys showed significantly higher ultrasonographic morbidity global scores than girls (OR 2.0, $P < 0.001$).

Another retrospective study was conducted by King, (2002) on ultrasound monitoring of structural urinary tract disease in *Schistosoma haematobium* infection in Kwale District of Kenya from 1984 to 2002. A stratified random sampling method was employed. Portable ultrasound machines powered by generator (initially Toshiba Sonolayer SL, later Shimadzu model SDU-350A) or a rechargeable battery pack (Sonosite 180) were used to collect the data. Urinary tract pathology was detected by sector scanning and scored according to standardized protocols (Subramanian *et al.* 1999, Richter *et al.* 2000). The age groups of the participants include < 8 years, 8-11 years, 12-15 years, 16-19 years, 20-24 years respectively. Ultrasonography in endemic villages in coastal Kenya indicate a 15-22% overall prevalence of bladder thickening and granulomata, with peak prevalence (36%) between the ages of 16 and 20 yrs, one to five years after the peak of infection intensity. Hydronephrosis is found in 5% of residents, with peak prevalence of 10% among adolescents aged 12-15, with a second peak (6%) among subjects older than 49 yrs. It appears from longitudinal treatment studies that “acute” polypoid-granulomatous lesions, more common in younger individuals, are first to regress after therapy, and may disappear within weeks after treatment (King *et al.* 1992, Hatz *et al.* 1998). “Late” complications, such as hydronephrosis, may take a longer time (1-2 yrs) to show improvement, particularly in males (King *et al.* 1992). In high transmission areas, reinfection with *S. haematobium* may occur in 1-2 yrs, with resulting recrudescence of urinary tract abnormalities detected by ultrasound (Hatz *et al.* 1998).

A prospective study was conducted by Richter *et al.* (1996) on sonographic screening for urinary tract abnormalities in patients with *Schistosoma haematobium* infection: pitfalls in examining pregnant women in Accra region of southern Ghana from July to August 1993. A sample size of 73 females (median age: 17 years; range: 6-61 years) were included of which 34 women were of childbearing age and five of the women (age range: 17-38 years) were pregnant (gestational age: 4-34 weeks). A portable general purpose ultrasound scanner that conformed to WHO specifications (Aloka model SSD-500; Aloka, Tokyo, Japan) with a convex 3.5 MHz transducer connected to a portable generator (Honda, Tokyo, Japan) and Photo documentation was carried out using an echocopier (Aloka model SSZ305; Aloka, Tokyo, Japan) on printing paper (Sony type II, Sony Corporation, Tokyo, Japan) was used to obtain the required data. Ultrasound findings on Non-pregnant women revealed bladder wall irregularities in 30, focal irregularities in 23, and diffuse bladder wall thickening in 5 of the 68 women in this category; intra-luminal masses occurred in 2 of these women and polyps in 1 of them. Dilatation of one or both ureters at the renal end, the ostium, both extremities, or entirely was detectable by ultrasound in 6/68 patients. Dilatation of the renal pelvis (from fissure to moderate degree) was observed in 5/68 cases. Abnormality of the ureters and/or the kidneys was always associated with bladder wall alterations. Findings on pregnant women reported 3 women in the second and third trimesters had difficulties in retaining enough urine for a reliable examination to be performed. Thus, no information on bladder wall alterations could be obtained. Bilateral dilatation above the pelvic brim was found in one of the five pregnant women and there were three cases of mono- or bilateral fissures of the renal pelvis, while moderate hydronephrosis, which was associated with ureteral dilatation, was observed in one case.

A cross sectional study was conducted by Abdel-wahab *et al.* (1992) on ultrasound for detecting *Schistosoma haematobium* urinary tract complications: comparison with radiographic procedures at Kasr El Aini Hospital Cairo, Egypt. A sample size of 40 subjects was recruited for the study. Serial ultrasonic scans through the longitudinal and transverse planes of the kidneys were performed with the patient in the supine position to measure kidney size, shape,

texture and parenchymal thickness, and to detect the presence of calculi. The ureters were

of pub- lication	design	location	method	size	Abnormal Shape	Wall thickening	Pseudopo- Mass	Calcification lyp	Irregularities	Hydro nephrosis	Hydro ureter
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scanned for evidence of congestive changes and calculi. The bladder was scanned in the transverse and longitudinal planes. The wall was observed for regularity, thickness, masses and calcification. The presence of calculi in the bladder was recorded. All ultrasound examinations were done by a single investigator who was aware of the results of the other procedures, since patients were selected because of the presence of lesions. The 40 patients were all 15 years old or older and the majority were male subjects, ultrasound as able to detect bladder wall calcification in 13 of the 20 patients who had calcification detected by a plain x-ray. Bladder masses were visualized by an IVP in 9 patients and by ultrasound in 8 of the 10 in whom they were detected by cystoscopy, hydronephrosis and hydroureter were detected in many patients by an IVP and/or ultrasound. Renal and bladder stones were visualized by x-ray and ultrasound. However, ultrasound had considerable difficulty in detecting ureteral stones. Bladder Calcification: A total of 20 patients had bladder wall calcification detected by an x-ray. Of these patients 7 had no visualization with ultrasound, for a sensitivity and specificity of 65% and 100% for the procedure. When visualized, ultrasound provided an excellent means of diagnosing bladder wall calcification. A total of 9 patients had a bladder mass detected by an IVP. One patient had a small mass seen only during cystoscopy, which was incorrectly diagnosed as senile enlargement of the prostate by an IVP. Ultrasound had a sensitivity of 89% and a specificity of 100% when compared with an IVP for detecting bladder wall masses, which in this case were all malignancies. There were 19 patients with changes of hydronephrosis detected by an IVP, 17 of who were also detected by ultrasound. Therefore, ultrasound had a sensitivity of 89% in comparison with an IVP for detecting hydronephrosis. However, ultrasound detected hydronephrosis in 4 of 5 patients whose kidneys did not visualize on an IVP. Thus, ultrasound was more sensitive than an IVP for diagnosing hydronephrosis, being able to demonstrate the lesion in 21 patients. Hydroureter was detectable in 16 of the 30 patients studied by an IVP. Dilated ureters were sonographically detected in 10 of these 16 patients (sensitivity 62.5%). 14 patients without lesions seen by an IVP 3 had positive ultrasound examinations. Each of these individuals had non-visualization following injection of the radio-contrast material. Renal, Ureteral and Bladder Stones: Of the 40 subjects 10 had renal stones seen on an abdominal x-ray, including 7 (sensitivity 70%) with stones detected by abdominal ultrasound. Of the 30 patients with negative x-ray studies 3 had ultrasound findings compatible with renal stones. Each procedure was able to detect kidney stones in 10 patients. Ureteral stones were noted by abdominal x-ray in 8 of the 40 subjects. In only 1 patient was a stone also seen by ultrasound (sensitivity 12.5%). Bladder stones were noted on abdominal x-rays in 3 of the 40 subjects. Abdominal ultrasound visualized the bladder stones in these 3 patients and in 1 who had a negative x-ray (sensitivity 100%). The ultrasonographic pattern suggesting debris or sediment in the bladder was detected in 6 patients who had bladder, ureteral or renal calculi.

Table 1 shows the summary of findings of the reviewed articles

Table 1: Summary of findings of the reviewed articles

Author & year	Study	Study	Sampling	Sample	Findings (Bladder & Upper Urinary Tract) Scores (n & %)							
Remppis <i>et al.</i> , 2019	Prospective	Gabon	Convenience	118	-	46 (38.9%)	-	-	-	-	7 (5.9%)	20 <i>et al.</i> (16.9%)
Garcia <i>et al.</i> , 2018	Prospective	Angola	Random sampling	157	67 (42.6%)	71 (45.2%)	51 (32.4%)	6 (3.7%)	-	74 (47%)	10 (6.3%)	54 (34.4%)
Oyeyemi <i>et al.</i> , 2018	Prospective	Nigeria	Random sampling	56	-	20 (35.7%)	-	-	1 (1.8%)	-	-	36 (64.3%)
Barda <i>et al.</i> 2017	Prospective	Cote d'Ivoire	Stratified sampling	303	-	98 (32.3%)	4 (1.3%)	3 (0.9%)	-	-	20 (6.6%)	2 <i>al.</i> , (0.6%)
Onile <i>et al.</i> 2016	Prospective	Nigeria	Stratified sampling	257	10 (3.9%)	39 (15.2%)	1 (0.4%)	-	1 (0.4%)	39 (15.2%)	6 (2.3%)	- <i>al.</i> ,
Santos <i>et al.</i> 2015	Prospective	Angola	-	80	60 (75%)	-	29 (36.3%)	6 (7.5%)	75 (93.7%)	79 (98.7%)	3 (3.8%)	- <i>al.</i> ,
Magak <i>et al.</i> 2015	Prospective	Kenya	-	157	-	25 (16%)	-	-	-	-	3 (2%)	- <i>al.</i> ,
Ma`aji & Adamu, 2015	Prospective	Nigeria	-	107	-	69 (57.9%)	15 (14%)	4 (3.7%)	7 (6.5%)	-	-	-
Elmadani <i>et al.</i> , 2013	Prospective	Sudan	-	73	-	66 (90.4%)	-	49 (82%)	-	-	19 (31.2%)	38 <i>et al.</i> (52%)
Ekwunife <i>et al.</i> , 2009	Prospective	Nigeria	-	60	-	6 (10%)	2 (3.3%)	-	-	15 (25%)	5 (8.4%)	- <i>et al.</i>
Nmorsi <i>et al.</i> , 2007 (18.6%)	Prospective	Nigeria	-	43	30 (69.8%)	24 (55.8%)	10 (23.3%)	2 (4.7%)	24 (55.8%)	12 (27.9%)	10 (23.3%)	9
Koukounari <i>et al.</i> , 2006	Prospective	Mali	Systematic sampling	2841	-	43 (1.6%)	42 (1.5%)	42 (1.5%)	-	43 (1.6%)	105 (3.7%)	-
King, 2002	Retrospective sampling	Kenya	Stratified	-	36%	-	-	-	-	-	16%	-
Richter <i>et al.</i> , 1996	Prospective	Ghana	-	174	-	5 (2.9%)	-	-	-	30 (17.2%)	5 (2.9%)	6 (3.4%)
Abdel-wahab <i>et al.</i> , 1992	Prospective	Egypt	-	40	-	-	8 (20%)	-	13 (32.5%)	-	4 (10%)	13 (32.5%)

Discussion

Ultrasound examination can be useful in identifying urinary bladder pathologies such as abnormal bladder shape, bladder wall thickening, bladder masses, pseudopolyps, calcifications, bladder wall irregularities, diverticula, bladder cancer and renal abnormalities such as hydronephrosis and hydroureter as well as uteroceles amongst others. To have an accurate results using ultrasound in the diagnosis of urinary schistosomiasis is to ensure sufficient bladder filling (i.e. complete distention of the bladder) so that the shape of the urinary bladder, bladder wall morphology as well as the diameters of the ureter and renal pelvis can be assessed to determine pathologic changes caused by *Schistosoma haematobium*.

To have an effective follow up after treatment with praziquantel, a prospective study design was employed in order to obtain maximum detection rate. In essence, fourteen out of the fifteen reviewed articles were prospective studies, which could be regarded as a major strength of the study in obtaining an accurate detection rate. The studies were conducted in nine African countries which include: Nigeria, Kenya, Mali, Ghana, Egypt, Sudan, Angola, Cote d'Ivoire and Gabon. The highest prevalence base on the review was from Nigeria while the lowest was from Gabon. A prospective study conducted by Garcia *et al.* (2018) reported that 71 (45.2%) out of 157 children evaluated had bladder wall thickening, the result of this study agrees with a prospective study conducted by Onile *et al.* (2016) who reported that 136 (52.9%) out of 257 participants of the study had a prevalence of bladder wall thickening. However a prospective study design and a sample size of 257 subjects from the study by Onile *et al.* (2016) served as strength over the prospective study conducted by Garcia *et al.* (2018) of which a sample size of 157 participants were studied. This indicates that the study conducted by Onile *et al.* (2016) had more strength considering the fact that it had used a higher sample size than that of Garcia *et al.* (2018). A weakness of the study conducted by Onile *et al.* (2016) was that it failed to obtain any data on pseudopolyps and hydroureter while that of Garcia *et al.* (2018) failed to obtain and report any data on bladder calcification. Santos *et al.* (2015) conducted a study on a sample size of 80 subjects, which reported that 75% of its subjects had an abnormally round bladder shape sonographically which when compared to the study conducted by Nmorsi *et al.* (2007) also revealed that 30 (69.8%) out of 43 volunteers had abnormal bladder shape, this had established the fact that the former study had more strength considering the fact that it had used a sample size of 80 which was higher than the sample size of 43 used by the later. Although the study conducted by Nmorsi *et al.* (2007) was able to obtain significant data on abnormal bladder shape, wall thickening, bladder mass, pseudopolyp, bladder calcification, bladder wall irregularities, hydronephrosis and hydroureter which served as its strength of which the study by Garcia *et al.* (2018) was also able to obtain with the exception of data on bladder calcification. The studies conducted by Barda *et al.*, (2017) Garcia *et al.*, (2018) Santos *et al.*, (2015) Ma`aji & Adamu, (2015) Ekwunife *et al.*, (2007) Nmorsi *et al.*, (2007) Koukounari *et al.*, (2006) & Abdelwahab *et al.* (1992) all indicated significant data on bladder wall masses of which the study by Garcia *et al.* (2018) had the highest score of 51 compared to the study by Ekwunife *et al.* (2007) had the lowest score of 2. The studies which had not indicated findings on bladder masses were considered to have had a downside on that aspect. The study which had recorded the highest data on pseudopolyps was Elmadani *et al.*, (2013) with a score of 49 (82%) out of 73 was considered its strength when compared to the study conducted by Nmorsi *et al.* (2007) which had a score of 2 (4.7%) out of a sample size of 43 was considered its weakness therefore making it less reliable. Studies which indicated findings on urinary bladder calcifications were those conducted by Oyeyemi *et al.*, (2018), Santos *et al.*, (2015), Ma`aji & Adamu, (2015), Nmorsi *et al.*, (2007) & Abdel-wahab *et al.*, (1992). These 5 studies were considered to have had an edge over other studies that had failed to obtain any data on bladder calcifications. Findings on bladder wall irregularities were conducted by 6 studies of which Koukounari *et al.* (2006) used a sample size of 2841 volunteers which was considered a major strength of the cross sectional study and obtained data on 43 (1.5%) volunteers having bladder wall irregularities which when compared to the findings

reported by Oyeyemi *et al.* (2018) which had reported only 1 case which represents only 1.8% of a sample size of 56. Koukounari *et al.* (2006) reported that 105 subjects were diagnosed with hydronephrosis which represents just 3.7% of a sample size of 2841. However, Elmadani *et al.* (2013) reported 19 cases representing 31.2% of a sample size of 73; this by comparison had a far smaller sample size which was considered its downside to the study conducted by Koukounari *et al.* (2006) which had the largest sample size amongst all the reviewed articles. Magak *et al.* (2015) indicated 3 cases (2%) from a sample size of 157 which were considered its strength in terms of sample size compared to similar data obtained by Santos *et al.* (2015) which also reported just 3 cases representing 3.8% of a sample size of 80 which is deemed small. Retrospective studies such as King, (2002) only indicated 16% prevalence on hydronephrosis based on reviewed articles. Both studies had failed to indicate the sample sizes used and both study designs were considered unreliable and weak. Garcia *et al.* (2018) reported 54 (34.4%) cases out of 157 subjects on hydroureter findings which were recognized as strength due to its sample size compared to Barda *et al.*, (2017) which had 303 subjects which is an upside but only reported just two cases representing just 1% of the sample size. Remppis *et al.*, . (2019) and Richter *et al.*, (1996) both had findings on hydroureter to be 9 (7.6%) out of 118 and 7 (4%) out of 174 subjects respectively. Both studies were considered to have had strengths based on their sample sizes and study designs, although the study conducted by Remppis *et al.* (2019) used a convenience sampling method which was considered a weakness on its part. Ekwunife *et al.* (2009) also noted that children had more urinary tract diseases than adults and Irregularities of the bladder wall were higher among male (60%) pupils when compared with female pupils (40%). Also 4 (66.7%) of the pupils with bladder thickness, were males while 2 (33.3%) were females and two mass cases were indicated in the male pupils. Moderate kidney dilation was also observed in 4 males out of the 5 positive cases, which was similar to the findings of Magak *et al.* (2015) which also noted that 108 (63%) males out of 154 subjects had urinary tract abnormalities which establishes the higher prevalence of urinary tract morbidity in males than females. The commonest urinary tract abnormalities were found to be bladder wall thickening and hydronephrosis while the least frequent was abnormal bladder shape. However, these abnormalities were independent of the country where the study was conducted, the study design and the sample sizes used.

Conclusion

The ultrasound features as reported by the published articles included in this review indicates the prevalence of bladder wall thickening and hydronephrosis as the most common urinary tract morbidities. Further studies should consider using Doppler ultrasound and correlating the sonographic feature with histopathological features.

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