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URINARY TRACT LESIONS DUE TO *SCHISTOSOMA HAEMATOBIUM* INFECTION ASSESSED BY ULTRASONOGRAPHY IN A COMMUNITY BASED STUDY IN NIGER

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Abstract. The comparative prevalences of urinary tract lesions in 2 villages where urinary schistosomiasis was endemic and in a control village free from infection were assessed by ultrasonography. Of the 822 residents >4 years of age in the first village (Sébéri) where the prevalence of infection was 57%, 279 were examined by ultrasonography. The prevalence of bladder lesions was 71% in those 5–14 years of age, 57% among adult men, and 24% among women in this endemic village, compared to 10%, 16%, and 6%, respectively, in the control village.

Renal lesions were infrequent among adults and there was no significant difference in the rates between Sébéri and the control village. Among children, moderate hydronephrosis was absent in the control village, but was observed in 19% of the boys 5–14 years of age and 2% of the girls 5–14 years of age in Sébéri.

Sixty schoolchildren of the second endemic village with urinary egg counts ≥100 eggs/10 ml of urine were examined by ultrasonography.

The overall prevalence and the severity of bladder lesions in the 2 endemic villages were significantly related to the urinary egg count.

The significance of urinary tract lesions in patients infected with *Schistosoma haematobium* has been demonstrated by numerous studies using radiological techniques,[1,2] cystoscopy,[1,3,4] surgical or postmortem examinations[5–7] and, more recently, using ultrasonography.[8–10] Few community based studies have been carried out. A high prevalence of urinary tract lesions has been observed in apparently healthy schoolchildren[11,12] and village residents[13,14] in endemic areas.

As a noninvasive, innocuous technique, ultrasonography is suited to mass surveys and permits the study of control populations. Degremont et al.[8] assessed the specificity and sensitivity of ultrasonography in comparison with intravenous pyelography (IVP) and cystoscopy for the detection of urinary tract lesions due to *S. haematobium*. Ultrasonography was found to be highly sensitive except in the detection of bladder calcifications.

This study assessed the comparative prevalence of urinary tract lesions by ultrasonography between Sébéri, a village where urinary schistosomiasis is endemic, and Fataboki, a village free from infection, as well as the relationship between the urinary egg count and the frequency and severity of urinary tract lesions. For this last point only, the data from Saga, the second endemic village, were also included.

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MATERIALS AND METHODS

Study area

This study was completed between December 1984 and June 1985 in 3 villages in the vicinity of Niamey: Sébéri, Saga, and Fataboki. The first 2 villages are in the Niger Valley, next to irrigated fields where *S. haematobium* is transmitted by *Bulinus truncatus rohlfsi*. In Fataboki, domestic water is obtained solely from wells and no surface water or schistosomiasis transmission is present. Intestinal schistosomiasis is not found in the vicinity of Niamey where the snail intermediate host is absent.

TABLE 1

Prevalence and mean S. haematobium *egg counts/10 ml of urine in Sébéri in the whole population and in those subjected to ultrasound examinations*

		Parasitologically examined				Subjected to ultrasonography			
				S. haematobium eggs/10 ml				*S. haematobium* eggs/10 ml	
Age	Sex	No.	Prevalence	Arith. mean	Geom. mean log(x + 1)	No.	Prevalence	Arith. mean	Geom. mean log(x + 1)
5–14 yr	M	151	73%	51	8.9	75	66%	68	9.1
	F	122	72%	56	9.9	54	73%	54	9.5
	M + F	273	73%	54	9.4	129	69%	62	9.2
≥15 yr	M	136	50%	20	3.3	82	57%	27	3.5
	F	147	35%	4	2	68	37%	4	2.1
	M + F	283	42%	13	2.5	150	48%	17	2.8
Total	M + F	556	57%	32	4.8	279	58%	38	4.9

Parasitologic examination

The population of Sébéri was 1,030 (529 men, 501 women) and that of Fataboki 293 (151 men, 142 women) at the time of the study. Among those >4 years of age, 556 persons in Sébéri and 167 in Fataboki submitted specimens for parasitologic examination by urine filtration using paper filters,[15] representing 68% and 69% of the populations, respectively. In Saga, parasitologic examinations were made on 510 schoolchildren aged 7 to 15 years (252 boys, 258 girls). Because of the circadian variation of ova output, urine samples were collected between 0900 and 1300 hours.

In Sébéri, the prevalence of *S. haematobium* infection was 74% in the 10–14 years age group. In Saga, 79% of the schoolchildren between 10 and 14 years of age were infected. In Fataboki, urinary schistosomiasis was detected in only 9 individuals who resided outside the village; they were excluded from our study.

At the end of the investigation, all infected patients were treated with praziquantel 40 mg/kg body weight, in a single dose. Post-treatment control will be done at 6 and 12 months with ultrasonography.

Ultrasound examination

The comparative ultrasonography study was completed in Sébéri and Fataboki. Family groups, except for children <5, regardless of the result of the urine examination, were taken to the hospital in Niamey in groups of 10 to 15 persons for ultrasound examination.

The ultrasonography equipment was a 3.5 MHz real-time sectorial scanner (Sonnel 202 CGR). Reproductions were done by REPRO-Son 4 (CGR) with Kodak N.M.B. films. Every patient drank 600 ml of liquid ½ hr before examination. The radiologist was not aware of the parasitological status of the patients he examined.

Prevalence of infection according to age group is not significantly different from the entire study population. The mean urinary egg counts were also similar (Table 1).

In a separate study at Saga, 60 schoolchildren (36 boys, 24 girls) who had urinary egg counts ≥100 eggs/10 ml of urine were examined by ultrasonography. They were examined under the supervision of their teacher, after oral parental consent.

Under normal conditions, whenever moderately or completely filled, the bladder shows a transsonic zone with a thin wall which is sometimes difficult to discern. Vesical wall thickness was assessed at the dorsal part of the bladder. Ureteral dilatation has not been studied systematically because the diameter of the ureter is very difficult to discern and measurements are hard to reproduce.

Confirmatory examinations

Seven patients who had severe renal lesions detected by ultrasound were also subjected to IVP, which was performed by intravenous injection of a contrast medium (Telebrix 38) at a dose of 1 mg/kg body weight. Radiographs were taken without compression 5, 15, and 30 min

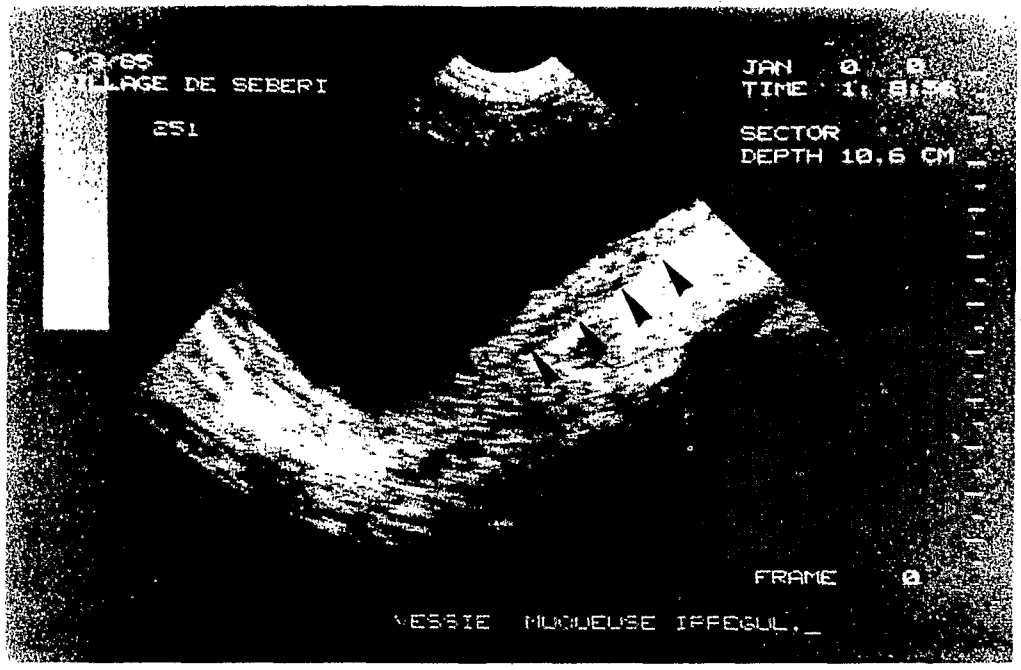

FIGURE 1. Thickened (8 mm) and irregular wall (arrows indicate the thickness of the wall).

after injections. In cases of very distinct stasis, additional radiographs were taken 45 min after injection of the medium.

Eleven adult men (14 to 49 years of age) who had bladder lesions detected by ultrasound were also subjected to cystoscopy. None of them received IVP.

RESULTS

Ultrasound characteristics of urinary tract lesions

Bladder lesions. Three types of bladder lesions were observed: thickened wall, regular with thickness ≥6 mm; irregular wall, showing a pattern of thick and thin areas, producing an irregular image (Fig. 1); and localized hypertrophy (single or multiple), common pattern showing a "large based" polypoid image in the bladder (Figs. 2 and 3) ranging from several mm to large tumors.

Lesions were classified as minor or major according to the following criteria: minor: slightly irregular wall and/or thickness 6–10 mm and/or a single localized hypertrophy; and major: very irregular wall and/or a thickness >10 mm and/or several localized hypertrophies.

In general, bladder calcifications are very difficult to demonstrate[8] using a 3.5 MHz transducer since the most anterior part of the bladder, where calcifications usually occur, cannot be seen well. It is, however, always possible to recognize the calcification of large localized hypertrophies; these lesions appear as a "brilliant" spot of echogenicity followed by a conical shadow.[16]

Eleven men with bladder lesions detected by ultrasound were subjected to cystoscopy; this revealed specific lesions for schistosomiasis in 8 cases, nonspecific lesions in 2 cases, and a normal bladder wall with an ureteric orifice abnormality ("golf hole") in 1 case.

The specific lesions, bilharzial tubercles, bilharzial nodules, and sandy patches[3] are frequently observed in association with nonspecific lesions such as hyperemia and inflamed congested mucosa. These nonspecific lesions were seen in 2 cases.

Renal lesions. Three grades of hydronephrosis were used according to the classification of Weill et al.[17] and that of Doehring:[10] mild hydronephrosis (initial stage); moderate hydronephrosis, with marked pyelocalyceal dilatation, corre-

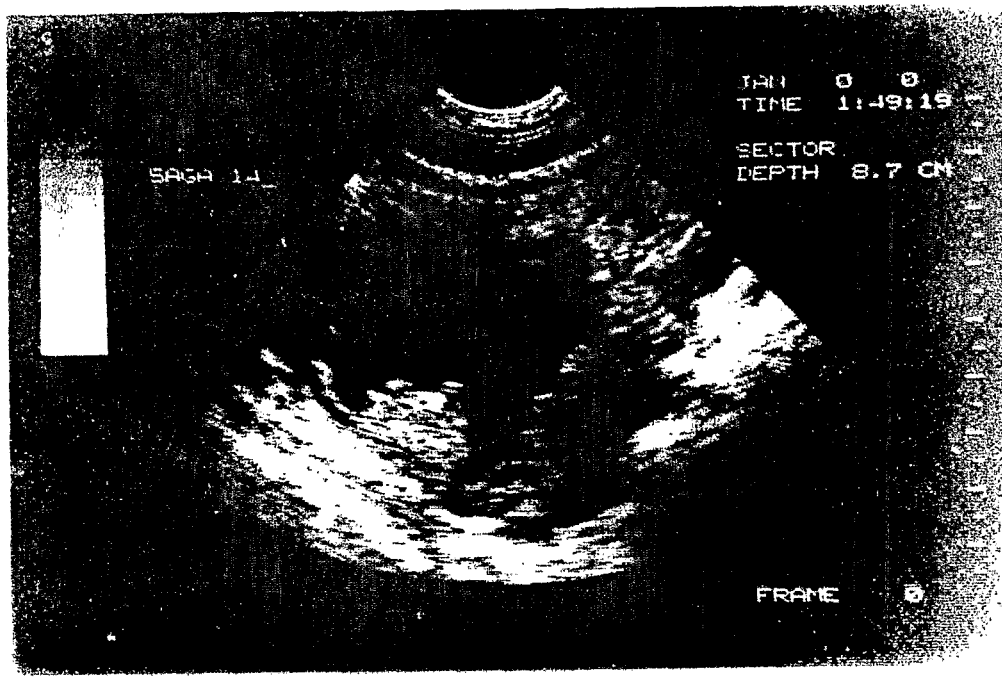

FIGURE 2. Localized hypertrophy with a large base.

sponding to conventional urographic pictures; and major hydronephrosis, with lack of functional parenchyma (not observed in this study).

Seven of the patients showing moderate hydronephrosis by ultrasonography were also subjected to IVP. A perfect correlation of the lesions was found with the 2 methods.

Comparison between the endemic (Sébéri) and control (Fataboki) villages

Bladder lesions (Table 2). Bladder lesions were significantly more frequent among children between 5 and 14 years of age in the endemic village (71%) than in the control village (10%) ($\chi^2 = 43.7$, $P < 10^{-9}$).

In Sébéri the prevalence and distribution of lesions did not differ significantly between the sexes ($\chi^2 = 1.40$, $P < 0.30$) nor between the 5–9 and 10–14 years age groups ($\chi^2 = 0.18$, $P < 0.8$).

In the adult population (≥15 years), bladder lesions were significantly more frequent in the endemic village than in the control village, both in men (57% vs. 16%) ($\chi^2 = 15.5$, $P < 10^{-4}$) and in women (24% vs. 6%) ($\chi^2 = 4.09$, $P < 0.05$). In the endemic village prevalence of bladder lesions was higher in men than in women (57% vs. 24%) ($\chi^2 = 17.52$, $P < 10^{-4}$).

Renal lesions (Table 3). Among children, renal lesions were more frequent in the endemic village (Sébéri) than in the control village ($\chi^2 = 12.60$, $P < 10^{-3}$), where moderate hydronephrosis was absent. In Sébéri, moderate hydronephrosis was significantly more frequent in boys (19%) than in girls (2%) ($\chi^2 = 6.8$, $P < 0.01$). Of the 14 boys from Sébéri with moderate hydronephrosis, 3 were bilaterally affected and 1 had a dilatation of the upper left ureter of 11 mm. In 12 of 14 cases, renal lesions were associated with bladder lesions.

In adults, renal lesions were not frequent in our study and there was no significant difference in the rate between the villages.

Among men from Sébéri, unilateral moderate hydronephrosis was found in 1 person aged 26 years who also had a single bladder lesion. His egg count was 10 eggs/10 ml of urine. The confirmatory IVP showed homolateral renal calculi.

Moderate hydronephrosis was also present in 2 adult women, both of whom were pregnant. One had neither *S. haematobium* eggs in the urine nor a bladder lesion; the second had a negative urinary egg count and a minor lesion.

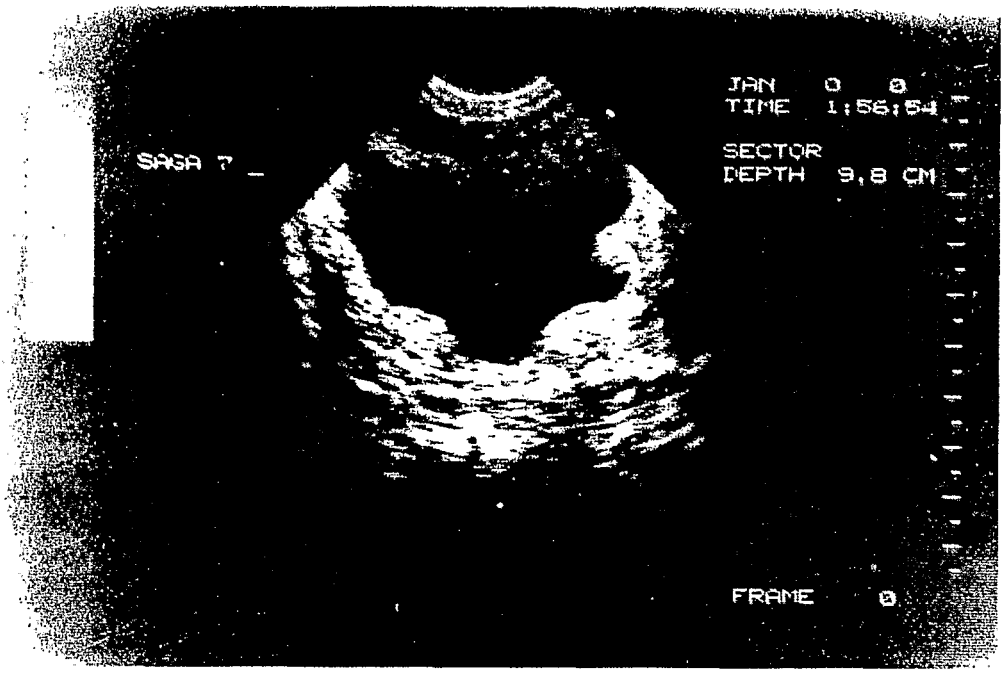

FIGURE 3. Characteristics of multiple localized hypertrophies.

Relation between urinary egg count and urinary tract lesions

Bladder lesions in children. In the endemic village, boys and girls with bladder lesions had urinary egg counts significantly higher than those without bladder lesions (Table 4).

The prevalence of bladder lesions according to urinary egg counts among the individuals from Fataboki and Sébéri is shown in Table 5; 60

TABLE 2

Prevalence of the different types of bladder lesions in the Sébéri and Fataboki villages

	Sébéri						Fataboki					
	Male (n = 157)		Female (n = 122)		Total (n = 279)		Male (n = 54)		Female (n = 48)		Total (n = 102)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
5–14 years												
Normal bladder	24	32%	14	26%	38	29%	20	87%	16	94%	36	90%
Minor lesions	33	44%	26	48%	59	46%	3	13%	1	6%	4	10%
Major lesions	17	23%	15	28%	32	25%	0	—	0	—	0	—
Total number examined	75	—	54	—	129	—	23	—	17	—	40	—
Total number of bladder lesions	50	67%	41	76%	91	71%	3	13%	1	6%	4	10%
≥15 years												
Normal bladder	35	43%	52	76%	87	58%	26	84%	29	94%	55	89%
Minor lesions	30	36%	12	18%	42	28%	5	16%	2	6%	7	11%
Major lesions	17	21%	4	6%	21	14%	0	—	0	—	0	—
Total number examined	82	—	68	—	150	—	31	—	31	—	62	—
Total number of bladder lesions	47	57%	16	24%	63	42%	5	16%	2	6%	7	11%

Minor lesions: slightly irregular wall, thickness ≥6 mm–≥10 mm, single localized hypertrophy.
Major lesions: very irregular wall, thickness >10 mm, several localized hypertrophies.

TABLE 3

Prevalence of the different types of renal lesions in the Sébéri and Fataboki villages*

	Sébéri						Fataboki					
	Male (n = 157)		Female (n = 122)		Total (n = 279)		Male (n = 54)		Female (n = 48)		Total (n = 102)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
5–14 years												
Mild hydronephrosis	28 (8)**	37%	26 (9)	48%	54 (17)	41%	3 (1)	13%	4 (1)	24%	7 (2)	17%
Moderate hydronephrosis	14 (3)	19%	1 (0)	2%	15 (3)	12%	0	—	0	—	0	—
Major hydronephrosis	0	—	0	—	0	—	0	—	0	—	0	—
Total number examined	75	—	54	—	129	—	23	—	17	—	40	—
Total number of renal lesions	42 (11)	56%	27 (9)	50%	69 (20)	53%	3 (1)	13%	4 (1)	24%	7 (2)	17%
≥15 years												
Mild hydronephrosis	12 (5)	15%	13 (1)	19%	25 (6)	17%	3 (1)	10%	4 (0)	13%	7 (1)	11%
Moderate hydronephrosis	1 (0)	1%	2 (1)	3%	3 (1)	2%	0	—	0	—	0	—
Major hydronephrosis	0	—	0	—	0	—	0	—	0	—	0	—
Total number examined	82	—	68	—	150	—	31	—	31	—	62	—
Total number of renal lesions	13 (5)	16%	15 (2)	22%	28 (7)	19%	3 (1)	10%	4 (0)	13%	7 (1)	11%

* Other abnormalities not due to schistosomiasis are not included.
** Numbers in parentheses indicate number of bilateral lesions.

schoolchildren from Saga whose egg counts were ≥100 eggs/10 ml were also included in this study. It was found that overall prevalence of bladder lesions increased significantly in relation to increased urinary egg count.

In Fataboki, 10% of the children had minor bladder lesions. In Sébéri, 50% of the children with a negative urinary egg count had bladder lesions. However, of the 20 children having bladder lesions without *S. haematobium* eggs in the urine at the time of examination, 9 were subjected to a second urine filtration which revealed in all cases a positive urinary count. The other 11 children were not subjected to a second urine filtration, but 4 of them had antischistosomal antibodies ≥1/640.

Bladder lesions in adults. Adults in Sébéri who had bladder lesions had a significantly higher mean urinary egg count than those without bladder lesions (Table 4). The prevalence of bladder lesions increased in relation to the urinary egg counts (Table 5). The rate of bladder lesions among adults with a negative urinary examination was higher in the endemic village than in the control village but the difference was not significant ($\chi^2 = 3.26$, $P = 0.07$). A significantly higher prevalence of bladder lesions in men over women was found in the negative ($\chi^2 = 7/09$. $P < 0.01$) and slightly positive egg count classes (1–9 eggs/10 ml urine) ($\chi^2 = 7.73$, $P < 0.01$).

Relation between urinary egg count and significance of bladder lesions

In this study we attempted to quantify the significance of the bladder lesions detected by ultrasonography and to relate them to the urinary egg count.

Among children having urinary egg count <100, 18% had major lesions vs. 54% in those having an egg count ≥100. This difference is significant ($\chi^2 = 16.23$, $P < 10^{-4}$). The prevalence of major lesions was 34% in the population of men between 15 and 30 years of age, 5% in men >30 years old, and 6% among all adult women. Major lesions were not found in the control village.

Five adults with major lesions were subjected to cystoscopy; they all had either bilharzial tubercles or bilharzial nodules or sandy patches, i.e., specific lesions of schistosomiasis.

TABLE 4

Comparison of mean S. haematobium *egg counts by age and by sex according to the presence or absence of bladder lesions in Sébéri*

Sample	Bladder lesions	Number of individuals	*S. haematobium* eggs/10 ml		Comparison of egg counts according to the presence or absence of bladder lesions (Wilcoxon test)
			Arith. mean	Geom. mean log(x + 1)	
Boys	yes*	52	88	12.7	W test $P < 0.04$
5–14 years old	no	24	25	4.4	Individuals having bladder lesions had higher urinary egg counts than the individuals without bladder lesions.
Girls	yes	38	62	14.4	W test $P < 0.01$
5–14 years old	no	15	35	3.4	Same
Men	yes	47	27	5.1	W test $P = 0.002$
≥15 years old	no	35	28	2.1	Same
Women	yes	16	12	6.0	W test $P < 0.002$
≥15 years old	no	52	2	1.5	Same

* Thickened (≥6 mm) or irregular wall or localized hypertrophy of the bladder wall.

Relation between urinary egg count and renal lesions in Sébéri

In the endemic village, boys with moderate hydronephrosis had a mean urinary egg count significantly higher than those with mild hydronephrosis (Table 6). Mean urinary egg counts, however, were not significantly different in the latter group and in the group with normal kidneys.

In girls and in the adult population, no relation was found between the occasional renal lesions and urinary egg counts.

DISCUSSION

Our study has confirmed the use of ultrasonography as a safe noninvasive technique to assess the presence and severity of urinary tract lesions due to *S. haematobium* infection. The prevalence of infection among children was high (73%) in the endemic village despite a low intensity of infection. The rates of urinary tract abnormalities detected by ultrasonography were high. Seventy-one percent of the children and 42% of the adults had bladder lesions associated with *S. haematobium* infection. In a similar community based study in Tanzania where the prevalence was 62% among children, 68% of those infected had bladder abnormalities.[8]

Thickening, irregularity, and localized hypertrophies of the bladder wall were observed to be associated with *S. haematobium* in our study.

Localized hypertrophies have been only recently described.[8–10] These are characteristic of *S. haematobium* infection, especially when large (Figs. 2 and 3). Cystoscopy confirmed ultrasonography in 10 out of 11 cases. However in 1 case, a major lesion seen at ultrasonography was not found again by cystoscopy, which was performed the same day.

A localized hypertrophy with inflamed mucosa occurred mainly in the trigone, associated or not with thickening, inflammatory changes, and fibrosis of the lower ureter. This may cause obstruction at the uretero-vesical junction, thus explaining the close relation between lesions in the lower urinary tract and dilatation of the upper urinary tract, especially in the boys in our study.

Bladder lesions, all of which were minor, were observed in about 10% of the population in the control village. Some of these lesions may be due to diseases other than schistosomiasis. The high frequency of bladder lesions observed in individuals in the endemic village, despite a negative single urine examination, may be due to the lack of sensitivity of such examinations. This is confirmed by the high rate of positive results from second urine examinations on the same individuals. Several consecutive urine examinations would be necessary to properly classify patients;[18, 19] this is, however, not always feasible in population based studies. Therefore the control population was not included in our assessment.

The endemic village's adult men were more heavily infected than the women and were found to have more bladder lesions. Among children,

TABLE 5

Prevalence of bladder lesions according to S. haematobium *egg counts in Sébéri and Saga*

		Nonendemic village	Endemic villages					
			Sébéri				Sébéri + Saga	
		ec = 0 P0	ec = 0 P1	ec = 1–9 P2	ec = 10–99 P3	ec = 1–99 P 2 + 3	ec ≥ 100 P4	Statistical analysis by χ^2 test
Children	Bl+	4	20	15	40	54	71	P0 vs. P1, $\chi^2 = 15.23$, $P < 10^{-4}$
5–14 yr old	%	10%	50%	62%	85%	77%	91%	P1 vs. P2+3, $\chi^2 = 8.45$, $P < 0.01$
	N	40	40	24	47	70	78	P2+3 vs. P4, $\chi^2 = 5.37$, $P < 0.03$
Men	Bl+	5	13	21	10	31	3	P0 vs. P1, $\chi^2 = 3.66$, $P = 0.06$ NS
≥15 yr old	%	16%	37%	68%	83%	72%	75%	P1 vs. P2, $\chi^2 = 6.09$, $P < 0.02$
	N	31	35	31	12	43	4	P2 vs. P3, $\chi^2 = 0.4$, $P < 0.5$ NS
Women	Bl+	2	5	4	7	11	—	P0 vs. P1, $\chi^2 = 0.1$, $P < 0.8$ NS
≥15 yr old	%	6%	12%	25%	78%	44%	—	P1 vs. P2, $\chi^2 = 1$, $P = 0.30$ NS
	N	31	43	16	9	25	0	P2 vs. P3, $\chi^2 = 4.39$, $P < 0.04$
Men + women	Bl+	7	18	25	17	42	3	P0 vs. P1, $\chi^2 = 3.26$, $P < 0.07$ NS
≥15 yr old	%	11%	23%	53%	81%	62%	75%	P1 vs. P2, $\chi^2 = 11.77$, $P < 10^{-3}$
	N	62	78	47	21	68	4	P2 vs. P3, $\chi^2 = 4.71$, $P = 0.03$

Bl+: number of individuals with bladder lesions.
ec: egg count.
N: number of examined individuals.
P(0, 1, 2, 3, 4): urinary egg counts groups.

TABLE 6

Mean S. haematobium *egg counts according to the renal lesions in the population of boys (5–14 years old) of Sébéri*

	Normal kidneys Stage 0	Mild hydronephrosis Stage I	Moderate hydronephrosis Stage II	Comparison of egg counts according to renal lesions (Wilcoxon's rank order test)
Number of individuals	33	28	14	Stage II/Stage I W test $P = 0.01$ significant
Geometric mean of log(x + 1) eggs/10 ml	6.8	7	40	Stage I/Stage 0 W test $P = 0.95$ not significant

the prevalence of infection and the mean urinary egg counts were not significantly different according to sex, and the prevalence of bladder lesions was comparable in the 2 groups. Moderate hydronephrosis was significantly more common in boys (19%) than in girls (2%). In a study utilizing IVP in Tanzania, hydronephrosis was also significantly more frequent in boys than in girls.[20] In neither study could this difference in rate of hydronephrosis be explained solely by differences in urinary egg counts.

As in a previous hospital based study using IVP[21] we observed that obstructive uropathy increased linearly with age, but generally the prevalence of ureterorenal lesions decreased in the group of adolescents or in the group of young adult males.[13–22] This decrease in the prevalence of ureterorenal lesions may be attributed either to a mortality in males with hydronephrosis about the time of adolescence[13] or to a spontaneous resolution of lesions.[23]

In our study the prevalence of renal lesions was particularly low in boys >14 years and, in contrast to previous studies, severe renal lesions were virtually absent in the adult male population. The only cases of moderate hydronephrosis in adults were related: 1 to renal calculi, 2 to pregnancy. The scarcity of renal lesions in adults may be partially related to the lack of exposure to transmission in childhood. In this area the irrigation schemes and high intensity transmission are recent events.

Our study confirms that urinary tract diseases are related to the intensity of infection as measured by urinary egg count.[4, 19, 20, 24] Bladder lesions were already frequent among slightly infected individuals, but the prevalence and the significance of these lesions increased significantly with urinary egg count. The relationship between renal lesions and intensity of infection was less distinct than that between bladder lesions and intensity of infection[20] and could only be demonstrated in boys in our study.

Post-treatment evaluation of urinary tract lesions will be done at 6 and 12 months with ultrasonography. Repeat yearly parasitologic examinations and treatment of all infected persons will be done at Sébéri village to maintain a low prevalence of urinary schistosomiasis. This follow-up will permit evaluation of the effect of praziquantel on morbidity due to *S. haematobium* infection.

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