

Echocardiographic screening for rheumatic heart disease in 4 515 Sudanese school children: marked disparity between two communities

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Abstract

Introduction: Echocardiographic (echo) screening has unmasked a high prevalence of subclinical rheumatic heart disease (RHD) in many countries, and it can be used as a surveillance tool to control the disease.

Methods: School children of 10 to 15 years of age were selected in two areas of Sudan, Khartoum, the capital, and Niyala in western Sudan. Echo screening using a hand-held echo (HHE) was conducted in Khartoum using a three-view protocol, and in Niyala, a one-view protocol, both modified from the World Heart Federation protocol. Suspected cases were referred for standard echo study. Training of health personnel was conducted and health education sessions were delivered to the public.

Results: In Khartoum, a total of 3 000 school children were screened; seven cases were positive for RHD using HHE and one case was confirmed by standard echocardiography. The prevalence of RHD using echocardiography was 0.3 per 1 000 children. In Niyala, a total of 1 515 school children were screened. Using HHE, 59 cases were positive for RHD; 44 had definite and 15 borderline disease. Out of 34 who underwent standard echocardiography, 29 (85.2%) were found to have RHD; 22 had definite and seven borderline disease. The prevalence using echocardiography was 19 per 1 000 children. A total of 779 health workers were trained in South Darfur and 50 000 posters and pamphlets were distributed.

Conclusion: Using echocardiography, there was a significant disparity in RHD prevalence between the two communities in Sudan. Efforts to control RHD should be directed to this area, and other rural communities should be investigated.

Keywords: rheumatic heart disease, echocardiography, Sudan

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Rheumatic heart disease (RHD) is an immune response to group A beta-haemolytic streptococcal infection and is considered a leading cause of acquired heart disease in young people globally.¹ Sudan is the third largest country in Africa with a population of 34 million, poverty rate of 46.4%, per capita income of US\$1 270, and human development index of 0.414. Political conflict has resulted in social divides that caused internal displacement of thousands of families in the Darfur area.²

In Sudan, the last epidemiological study on RHD was conducted in 1992 and showed a clinical prevalence of 11 per 1 000 in Khartoum's school children.³ In recent years, echocardiographic (echo) screening has documented a prevalence of RHD that is several fold higher than clinical auscultation.^{4,5} The availability from the World Heart Federation (WHF) of defined echo criteria for diagnosing subclinical RHD has enabled many investigators to objectively study subclinical carditis in different settings.⁶ Hand-held echo (HHE), a small and less costly machine, was proven to have a sensitivity of up to 97% for definite RHD, therefore it can be used as a surveillance tool in resource-limited settings.⁷

In Sudan, a World Health Organisation-based RHD control programme ended in 1998 and since then, there has been no active programme until 2012, when a national programme was established.^{8,9} A hospital-based register has shown that most RHD patients come from a belt localised to Kordofan, Darfur, White Nile and Gezira states in western and central Sudan.¹⁰ This study aimed to measure the prevalence of RHD in Khartoum using echo for diagnosis, compare it to that of South Darfur, and initiate a sentinel site for RHD control in the latter area.

Methods

Phase 1 of the study was conducted in Khartoum inner city, Mayo area, from September 2015 to February 2016, and phase 2 in Niyala city, South Darfur state from July to September 2016. The gap of four months was due to the school holidays. Schools

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were chosen from inside the camps of people who were internally displaced because of Darfur political conflict. Table 1 details the features of the communities in Khartoum and Niyala (data obtained from local authorities).

The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the research ethics committee of the University of Khartoum. Approval was obtained from the school health department of the Ministry of Health as well as the school and camp authorities. Informed consent forms were given to the children's families and only those who consented were screened.

A sample size of 3 000 subjects was calculated for each site based on an estimated echo prevalence of 3%¹⁰ and non-respondent rate of 5%. In both study areas, all the primary schools were listed. Fifteen schools were selected randomly in Khartoum and eight in Niyala, Darfur, with equal numbers of girls' and boys' schools. In both areas, school grades four to eight were chosen (age 10 to 15 years). All the pupils were invited to participate.

Two HHE machines (V scan, General Electric) were used. This machine has a single probe with a frequency of 1.7 to 3.4 MHz. It has storage capacity and a battery that lasts about 2.5 hours.

For the Khartoum study, four paediatric cardiology fellows were trained in using the V scans based on the WHF guidelines, with the exception of continuous-wave Doppler, which is not available in the HHE.⁶ Three views were used (parasternal long-axis, four-chamber and four-chamber with aorta), all done without and then with colour Doppler. The fellows took the measurements and recorded abnormal echo studies for offline review by another cardiologist.

For the Niyala, Darfur study, two medical officers were trained in using the V scan. A simplified 'one-view' protocol utilising the parasternal long-axis view was adopted following the publication of an article that showed its high diagnostic ability.¹¹ Four images were recorded, two without and two with colour Doppler. All the studies were recorded and stored to be reviewed offline by two paediatric cardiologists.

An abnormal result was defined by the modified WHF criteria as follows:

- Definite RHD:
 - If there is pathological regurgitation plus two morphological criteria

- If there is borderline disease of both mitral and aortic valves
- Pathological regurgitation is defined as:
 - mitral regurgitation (MR) jet ≥ 2 cm
 - aortic regurgitation (AR) jet ≥ 1 cm
- Morphological criteria are defined as:
 - For the mitral valve: anterior mitral valve leaflet > 3 mm, chordal thickening, restricted leaflet motion and excessive leaflet tip motion in systole
 - For the aortic valve the morphological criteria include irregular thickening, coaptation defect, restricted leaflet motion and prolapse.

The main difference between this method and the original WHF criteria is that we do not use continuous Doppler as the HHE does not have this feature.

- Borderline RHD:
 - Pathological regurgitation without morphological criteria
 - Two of the above morphological criteria without pathological regurgitation.

School children with abnormal results were called through their school administrators and the families were informed. Transportation was arranged to the hospital where a standard echo (SE) study was performed for each child. Echo machines used for SE were the Esaote My Lab 50 in Khartoum and the Mandray machine in Darfur.

Two paediatricians from Niyala Hospital were trained in RHD prevention, according to the national guidelines.¹² Lectures were integrated into the routine training activities of the primary healthcare personnel. Posters and pamphlets were distributed to the health workers. Local radio and television programmes were provided with a promotional video.¹³

Statistical analysis

Data were analysed using percentages. Bias-adjusted kappa = 2 (Agreement 1) was used to assess agreement between HHE and SE. The same test was used to determine the inter-observer variation on a randomly selected sample of 28 echo studies.¹⁴ Data were analysed using Stata version 14.¹⁵

Results

In Khartoum, 3 000 school children were screened using HHE. Seven cases were found to have RHD, six were borderline and one was definite (ratio of definite-to-borderline RHD of 0.16:1). Using SE, two cases were found to have congenital heart disease (partial atrioventricular septal defect in both), one had mitral valve prolapse, one physiological MR and two were normal. One was found to have definite RHD (pathological MR plus two morphological criteria). The prevalence of RHD in Khartoum was 0.3/1 000 children. The average time to complete the HHE study was 10 minutes.

In Niyala, Darfur, due to technical problems with electricity supply (see limitations), we managed to screen only 1 515 school children. On reviewing the echo studies, 17 were excluded because of inadequate imaging quality. Out of the remaining 1 498 studies, 59 cases were positive for RHD; 44 had definite and 15 borderline RHD. The ratio of definite-to-borderline RHD was 2.9:1. The average time to complete the echo study was four minutes.

Table 1. Demographic features of the two sites

Demographic features	Khartoum site	Niyala site
Location	Mayo area 9 km south of Khartoum	Ottash and Deraig camps for displaced people, 6 km south of Niyala, South Darfur
Population	37 000	128 460
Average income (US\$/month)	66	30
Type of work	Marginal business	Seasonal farmers
Average number of family members	11	10
Type of house	50% non-brick	100% non-brick
Piped water	Available	Not available
Electricity	Available	Not available
Number of health facilities	20 units	6 units
Population/health facility ratio	1 850:1	21 410:1

Out of 59 children with positive HHE results, 34 were available for a SE study while 15 were unable to attend due to social reasons and 10 were travelling. Of the 34 children who underwent SE, 29 were found to have RHD (85.2%); 22 had definite and seven borderline disease. The ratio of definite-to-borderline RHD by SE was 3.1:1, with females representing 72% of the definite cases. The echo prevalence was 19/1 000 children.

The bias-adjusted kappa test showed good agreement between the two echo readers of 92.9% (= 2, Agreement 1 = 2 × 0.9643 – 1).

All the cases with definite and borderline RHD were asked to come for a follow-up study by SE after six months. Definite RHD cases were started on benzathine penicillin prophylaxis. Table 2 and Figs 1 and 2 summarise these findings.

Table 3 details the echo findings of 29 cases found positive using SE. MR was present in all the cases detected by SE and in 58/59 of those by HHE (Fig. 3). AR was present in seven cases using HHE (11.8%) and in four with SE. Of those with AR detected by HHE, only four came for SE. Two children had aortic valve morphological abnormalities detected by HHE but did not come for SE. These included irregular thickening in one, and in another case it was associated with leaflet prolapse and asymmetry (Fig. 4). No cases of mitral or aortic stenosis were identified.

The agreement between HHE and SE on the assessment of mitral valve morphological criteria as well as the diagnosis of RHD were calculated. Bias-adjusted kappa showed a fair agreement of anterior mitral valve leaflet thickness > 3 mm, chordal thickening and excessive leaflet tip motion in systole (28, 28 and 32%, respectively) and good agreement (66%) with the diagnosis of definite versus borderline RHD.

Table 2. Summary of the clinical and echo findings of children in Khartoum and Niyala, Darfur

Characteristics	Khartoum	Niyala, Darfur
Number of school children	3 000	1 515
Number of echo studies analysed	3 000	1 498
Mean age in years (± SD)	10.5 (0.4)	10.8 (0.2)
Female gender (%)	50	51
Echo findings		
Positive by HHE	7	59
Positive by SE	1	29/34
Definite-to-borderline ratio using HHE	0.16/1	2.9/1
RHD prevalence using echo	0.3/1 000	19/1 000

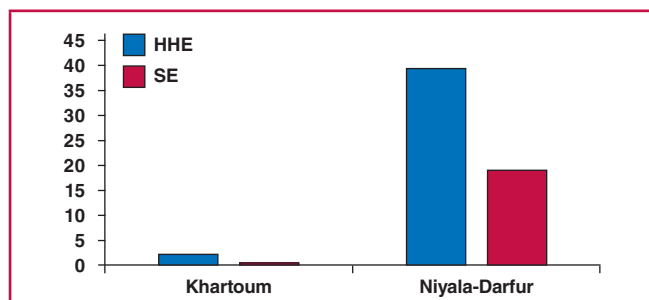


Fig. 1. Prevalence of RHD in Khartoum and Niyala, Darfur (per 1 000 population) by hand-held echo (HHE) and standard echo (SE).

Discussion

This is the first study that has measured the echo-diagnosed prevalence of RHD in Sudan. This was coupled with the initiation of a control programme based on training of health personnel, and raising public awareness in South Darfur.

Compared with the 1992 clinical prevalence of 11 per 1 000,³ RHD prevalence in Khartoum has dropped significantly, which could be attributed to the relative improvement of health services and living conditions in urban areas. On the other hand, this study unmasked a huge burden of asymptomatic patients living in a poor rural community. In sharp contrast to Khartoum, the prevalence in South Darfur camps was over 60 times higher. This prevalence may have been underestimated due to the smaller sample size and the high number of children who could not attend the SE study in Niyala.

The Khartoum study was conducted by paediatric cardiology fellows who were experienced in echo and were using three echo views as per the modified WHF protocol, therefore the accuracy of the echo studies was expected to be high. Moreover, the inter-observer agreement was 92%, indicating the reliability of echo interpretation. This disparity in prevalence could be attributed to many factors, including the availability of more health centres within Khartoum compared to the Darfur area, and a relatively better socio-economic status and more secure living conditions in the Mayo area, which is only 9 km from the Khartoum centre.

The ratio of definite-to-borderline RHD cases of 3:1 further supports the notion that the disease is well established in Darfur

Table 3. Features of patients who were found to have RHD by standard echo (total = 29)

Patient characteristics	No (%)	
Type of RHD		
Definite	22	(76)
Borderline	7	(24)
Female:male ratio	3:1	
Echo features	Definite	Borderline
Pathological MR	22 (100)	7 (100)
AML thickening	18 (81)	4 (57)
Chordal thickening	22 (100)	4 (57)
Restricted leaflet motion	1 (0.04)	0
Excessive anterior leaflet tip motion	13 (59)	0
Pathological AR	4 (18)	0
Morphological aortic valve criteria	0	0
Borderline disease in both mitral and aortic valves	3 (14)	0

MR: mitral regurgitation, AML: anterior mitral valve leaflet, AR: aortic regurgitation.

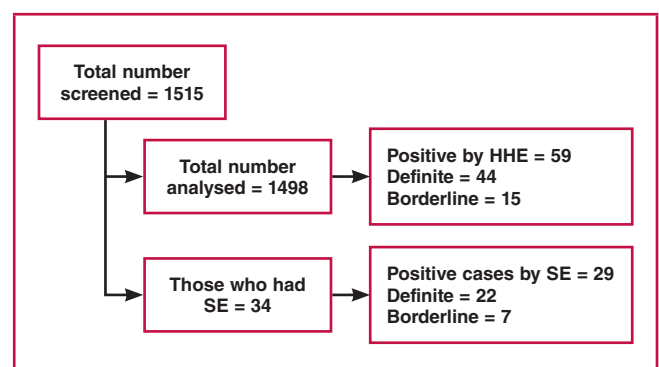


Fig. 2. Total subjects screened in Darfur and their results.

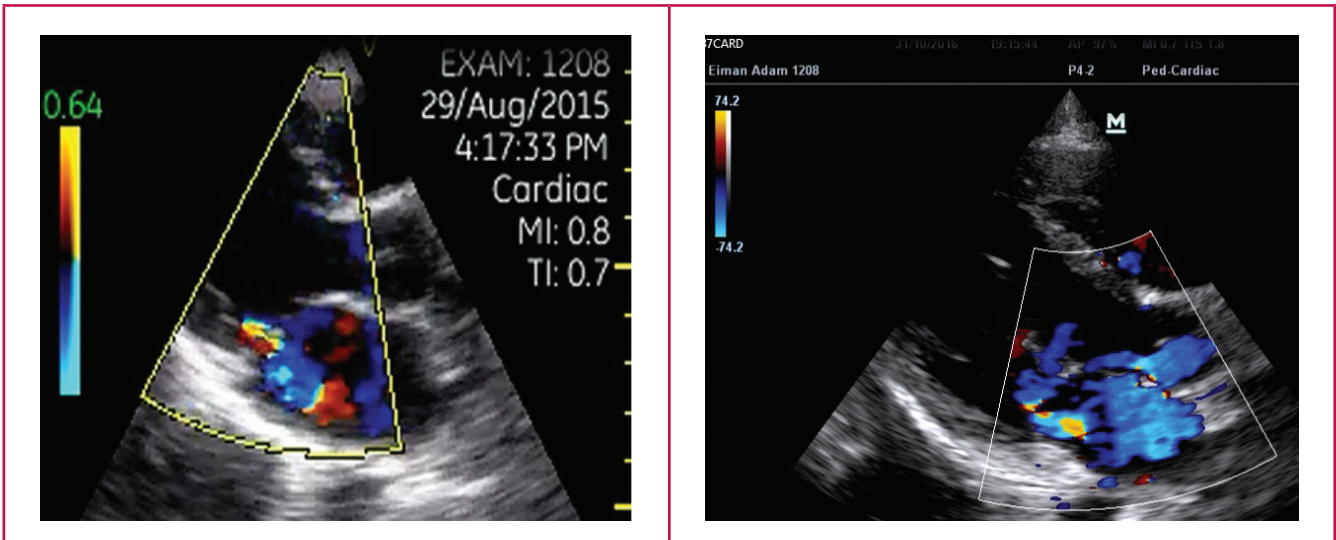


Fig. 3. A: Hand-held echo in parasternal long-axis view with colour Doppler showing mitral regurgitation. B: Standard echo in parasternal long-axis view with colour Doppler of the same patient, showing mitral regurgitation.

school children. By contrast, in Khartoum the definite-to-borderline ratio was 0.16:1, in accordance with other studies done in urban communities.^{4,16-18} The definite-to-borderline ratio in Darfur was much higher than the 1.2:1 that was reported in Ethiopia.¹⁸

The high RHD prevalence in Darfur is comparable to that found in Cambodia and South Africa but less than that found in Ethiopia and Mozambique.^{16,18} Similar to our findings, Engel *et al.* found a disparity between two areas within South Africa, which was attributed to lower socio-economic status.¹⁸ These findings emphasise the importance of improving medical services in the most vulnerable rural communities within the same country and call for effort to be directed to RHD control programmes in these areas.

It is desirable to have a simplified approach to RHD screening

in remote areas. In this study we documented that the 'one-view' protocol decreased screening time, as has been reported by Zühlke *et al.*¹¹ We have shown that HHE identified 85.2% of cases of RHD that were detected by SE, with a good agreement between HHE and SE in diagnosing definite versus borderline RHD.

These findings support the usefulness of HHE in resource-limited areas in order to improve RHD surveillance, as well as being a potential mode for early diagnosis and management of patients in remote, high-risk settings when SE is not immediately available. Although there is no consensus regarding the management of echo-diagnosed borderline RHD, there is preliminary agreement to start prophylaxis for definite cases and arrange follow-up echo for both definite and borderline cases.

For mitral valve morphological criteria, HHE showed only a fair agreement with SE. Lu *et al.*¹⁹ reported similar findings

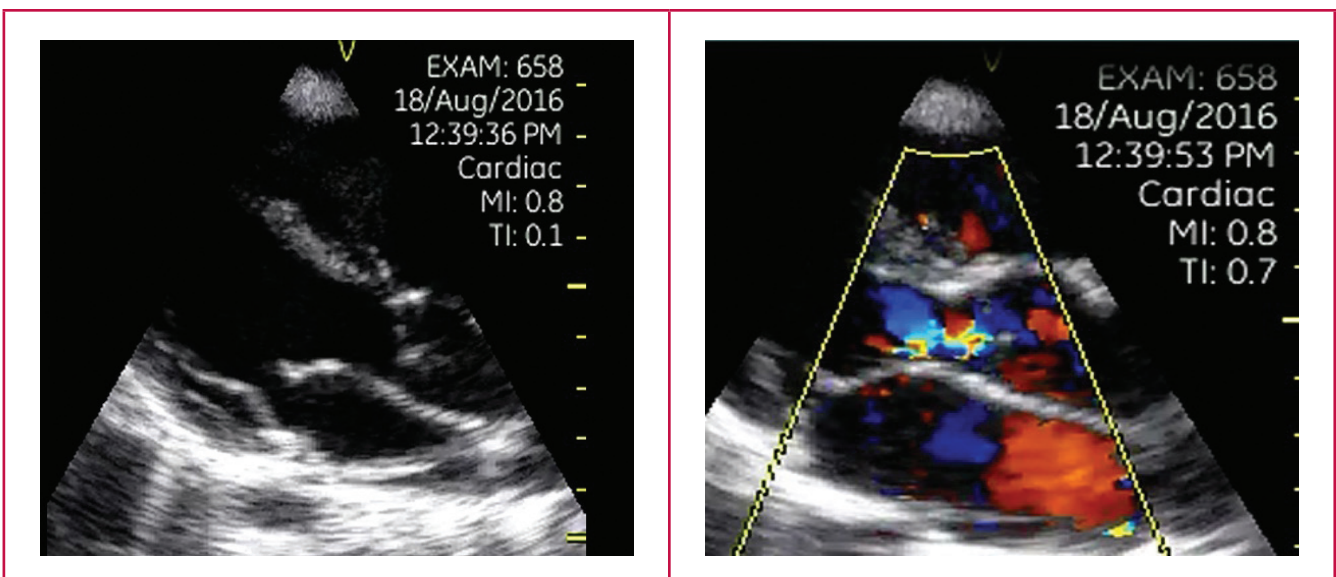


Fig. 4. A: Hand-held echo in parasternal long-axis view showing irregularity and prolapse of the aortic valve cusp. B: Hand-held echo in parasternal long-axis view with colour Doppler for the same patient, showing aortic regurgitation.

that morphological criteria diagnosed by HHE had poor sensitivity for definite RHD, therefore these parameters should be interpreted with caution when diagnosed with HHE.

A prevention programme for RHD was initiated in South Darfur using scanty resources. Training and raising the awareness of a large number of health workers can be achieved. A regional register for RHD as well as an echo clinic were established, which serves South Darfur and nearby states.

There were some limitations to this study. Electricity was not available in most of the schools so we had to use generators. In Darfur, the generator electricity was unstable and the chargers of the V scans were damaged, which led to a premature ending of the study. When asked to come for the SE, many families were not available, but we are in contact with those who did not attend as we realise that there are probably many cases of RHD among them. Lastly, the roads to the camps were not paved in an area experiencing heavy rains, which led to the cancellation of many trips.

Conclusion

RHD prevalence in Khartoum has dropped significantly in the last 23 years. However we found a high prevalence of RHD in Niyala, Darfur camps, reflecting the vulnerability of this community. HHE using a single view was reliable and performed well in screening for RHD. We initiated a control programme despite limited resources, which needs to be consolidated in this area and in similarly affected rural Sudanese communities.

In order to have an impact on clinical practice, mapping of RHD cases within the country must be carried out. HHE screening is a cheap and fast tool to identify hot spots of RHD and this study will be replicated in other areas. Control programmes must be implemented in high-prevalence areas. The reliability of HHE obviates the need to do an SE, therefore definite cases can immediately be started on penicillin prophylaxis.

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