

Oxyhemoglobin Saturation in Sickle Cell Anaemic Children (Steady State) Using Pulse Oxymetry In Jos University Teaching Hospital, Jos, Nigeria

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Abstract: Comparing the oxyhemoglobin saturation in stable sickle cell anaemic children with those of healthy Hemoglobin AA controls in Jos. A review of 141 cases and 141 controls was undertaken. Hypoxemia is a common event in SCA and has been associated with sickling, cellular damage, reduced longevity. The causes of hypoxaemia include infections, dehydration, cold and high altitude (these are peculiar features of Jos, a town in Nigeria). Hence the avoidance or detection and correction of hypoxaemia are of major importance in the management of SCA. The study was carried out with the aim of assessing the difference in oxyhemoglobin saturation between healthy SCA and Hemoglobin AA children in Jos using pulse oximetry and also the relevance in clinical practice of routinely monitoring oxyhemoglobin saturation in healthy SCA children in the clinic, Descriptive study. The cases were recruited from the sickle cell clinic at the Jos University Teaching Hospital while the Controls were age and sex matched non-sickle cell volunteers in the surrounding communities in Jos town. Oxygen saturation was determined using pulse oxymetry. Anthropometry was also done. Prevalence of hypoxemia (PO₂<95%) was 51% in the cases and 16% in the controls (p<0.0005). Mean oxyhemoglobin saturation in the cases was 93.5%±5.4 and that for the controls was 96.5%±5.3 (p<0.0005). Mode of oxygen saturation for both cases and controls was 98%. The mean oxygen saturation was lowest among the school and the preschool age groups in the SCA and control groups respectively and lower in the older age groups than in the younger age groups. The SCA boys generally had the lowest mean oxygen saturation (92.68%). Their nutritional status had no significant effect on their oxygen saturation (p-values 0.28). The mean oxyhemoglobin saturation in stable SCA children was significantly low. This was particularly true for the boys in the school age group. Hence there is need to routinely monitor the oxyhemoglobin saturation of stable SCA patients, in the clinic, paying closer attention to the school age boys, in order to improve the morbidity and mortality rates in SCA children.

Keywords: JUTH, Nigeria, oxygen saturation, pulse oximetry, sickle cell anaemia, stable state

INTRODUCTION

Sickle Cell Anaemia (HbSS) is the most severe form of the sickle cell diseases and the commonest sickle cell genotype in Jos (Honig, 1996; Olanrewaju, 2001). This disease is characterised by recurrent sickling and anaemia with subsequent significant morbidity and mortality (Honig, 1996; Comber and Lopez, 1996).

Pulmonary complications and hypoxemia are common in Sickle Cell Anaemia (SCA) and may exacerbate microvascular occlusive phenomena. Thus, detecting hypoxemia is of particular importance in SCA (Olanrewaju, 2001). Since hypoxia is a trigger for sickling of Hbs, its avoidance and correction are of major importance in the management of SCA. The causes of the initial hypoxia that triggers sickling are environment dependent like infections, dehydration, cold and high altitude (Ortiz *et al.*, 1999; Attah and Ekere, 1975; Plateau

State Govt. Org, 2004) and these are peculiar features of Jos, a town in Nigeria. Alveolar hypoxia has been shown to be associated with entrapment of sickle cells in the pulmonary microcirculation, which may propagate a cycle of further hypoxemia and sickling (Online Nigerian Communication, 2004; Kendrick, 2000). The recognition of the presence of hypoxemia by the human eye is rather poor. In some studies, it was observed that 47% of observers could not detect hypoxemia until oxygen saturation fell below 80% (Blaisdell *et al.*, 2000). Even when the oxygen saturation had fallen to 71-75%, 25% of observers did not detect hypoxemia (Kendrick, 2000; Ahmed *et al.*, 2005). The detrimental effects of hypoxemia have been recognised for a long time and were summarised succinctly by JS Haldane: "Anoxaemia not only stops the machine, but wrecks the machinery (Kendrick, 2000)." Hypoxaemia has an adverse effect on longevity, but this can be reversed to some extent by

administration of oxygen. It is known that episodic hypoxaemia is more common than suspected and that, where hypoxaemia (less than 90%) lasts for more than 5 min in 24 h, the long term prognosis is 3.3 time worse than when there are no hypoxaemic events (Kendrick, 2000). Factors that trigger hypoxaemia or sickling are very common in this our environment and results in significant morbidity and mortality among our sicklers, therefore provision of more efficient ways of close monitoring in their steady states and prevention of the acute phases is important. In Jos University Teaching Hospital (JUTH), SCA takes 13% of all our Paediatric Emergency admissions and 25% of paediatric out patient visit. Hence we now seek to answer this question: Should oxygen saturation be routinely monitored even in the steady state of SCA in the clinic?

Aim:

- To assess the difference in oxyhemoglobin saturation between healthy SCA and Hemoglobin AA children in Jos using pulse oximetry
- To assess the relevance in clinical practice of routinely monitoring oxyhemoglobin saturation in healthy SCA children in the clinic.

SUBJECT AND METHODOLOGY

Jos town (Plateau State Govt. Org, 2004; Online Nigerian Communication, 2004) is situated on a Plateau and has one of the coolest environmental temperature (sometimes well below 20°C) in the country. Jos is a miniature Nigeria, in which virtually all the tribes in Nigeria are fairly represented. JUTH is the only Teaching Hospital, largest and the cheapest in Plateau state. It is located in the centre of the town, where the population density is most concentrated and also serves as a referral centre for neighbouring states like Bauchi, Nassarawa, Abuja. The most common SCD genotype in Jos town was Hb SS.

This study was descriptive, aimed at determining the prevalence of hypoxaemia in stable SCA children and also to document the relevance of routine monitoring of oxygen saturation in SCA children in the clinic. This study was conducted in Jos over a period of three months between October and December 2006. Subjects were consecutively 141 stable SCA patients attending sickle cell clinics in JUTH, while the controls were age and sex matched 141 children chosen among volunteers from Jos communities. Approval from the JUTH Ethical Committee and the Hospital Authorities was obtained. Consent was obtained from the child and/or parents/guardians.

The studied population were already confirmed SCA patients (by electrophoresis) in steady state, attending the Sickle Cell clinic. Their stability was based on normal

hematocrit (20-30%) without any complaint or abnormality on brief physical examination. Controls were healthy children with genotype AA. There are three ways of measuring oxygen saturation. They are pulse oximetry and blood gas analysis (Olanrewaju, 2001). Blood gas can also be analysed using calculations (which many studies claim that it overestimate the true oxygen saturation) and co-oximetry (which many agree is the most accurate). Blood gas analysis is beyond our reach in this part of low income countries (Rackoff *et al.*, 1993). The pulse oximetry have been found not to be too accurate at the extremes of oxygen saturation (75-95%), but can be used reliably in most clinical settings (Pianosi *et al.*, 1994). Pulse oxymetry is what is available here. Oxygen saturation was determined using pulse oxymetry in this study.

Anthropometry was also done. Weight was taken to the nearest 0.05 kg and height or length to the nearest 0.01 cm. Their nutritional status was determined by Waterlow's classification of malnutrition (Paynter and Parkin, 1991).

The data were entered into the EPI Info version 2003 and the means and prevalence of the variables were determined. The significance between the variables were determined using Chi-square and Student t test where necessary. p-value less than 0.05 was considered significant.

RESULTS

One hundred and forty-one stable SCA patients with 141 age and sex-matched controls were recruited over the period of three months. They were classified into age-groups. The infant (1-18 months), toddler (>18 months-3 years), preschool (>3-6 years), school (>6-12 years), adolescents (>12-18 years). The school age group was the largest in number constituting 34.8% of the study population, followed by the adolescent age group (32%) (Table 1). There were only 2 (1.4%) infants in each group. The boys were 51.1%, while the girls were 48.9% (Ratio: 1.05:1) of the study population (Table 1). The nutritional status of the cases and controls did not differ significantly ($p = 0.92$), Table 1. SCA children were generally taller and weighed lesser than their controls but not statistically significantly so (Table 1). Their height, weight and nutritional status had no significant effect on oxygen saturation (p -values 0.4, 0.35 and 0.11, respectively). Hence they were matched for sex and age alone. The prevalence of hypoxaemia was statistically significantly higher in the SCA (51%) than in the controls (16%), p -value <0.0005 (Fig. 1). The cases had significantly lower mean Oxygen saturation ($93.49 \pm 5.40\%$) than the controls ($96.55 \pm 5.28\%$), Table 2, p -values <0.0005 . The most occurring Oxygen saturation was 98% in both stable SCA and normal children, Table 2. In Fig. 2, showing the mean

Table 1: Characteristics of healthy-sickle cell anaemic children and non-sickle cell controls

Characteristics	SCA	Controls	p value
1 Number	141	141	
2 Age groups:			
Infant	2 (1.4%)	2 (1.4%)	
Toddler	17 (12.1%)	17 (12.1%)	
Preschool	28 (19.9%)	28 (19.9%)	
School	49 (34.8%)	49 (34.8%)	
Adolescent	45 (31.9%)	45 (31.9%)	
3 Gender:			
Female	69 (48.9%)	69 (48.9%)	
Male	72 (51.1%)	72 (51.1%)	
4 Mean weight	23.1 kg	23.4 kg	0.93
5 Mean height	121.4 cm	119.8 cm	0.06
6 Nutritional status:			
Normal	84 (60%)	73 (51.8%)	
Malnourished	57 (40%)	68 (48.2%)	0.92

Table 2: Mean and mode of O₂ saturation

	Subjects (SCA)	Controls	p-value
1 Mean	93.49±5.40%	96.55±5.28%	<0.0005
2 Mode	98%	98%	

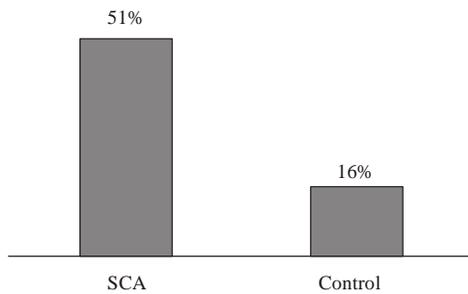


Fig 1: Prevalence of hypoxaemia amongst sickle cell and non-sickle cell children. P.val=<0.0005.

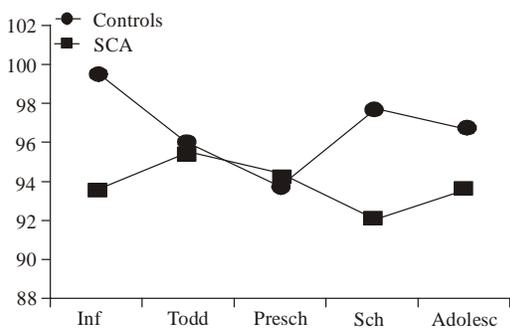


Fig 2: Mean Oxygen saturation across age groups amongst Cases and Controls

oxygen saturation across the age groups in the Cases and Controls, the mean oxygen saturation was lowest among school and the preschool age groups respectively and lower in the older age groups than in the younger age groups. The SCA boys generally had the lowest mean oxygen saturation (92.68%) in Fig. 3. In the control group, the boys had a higher mean oxygen saturation

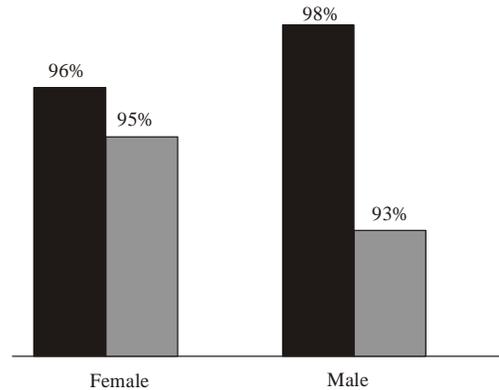


Fig 3: Mean oxygen saturation across the gender groups amongst the Cases and Controls.

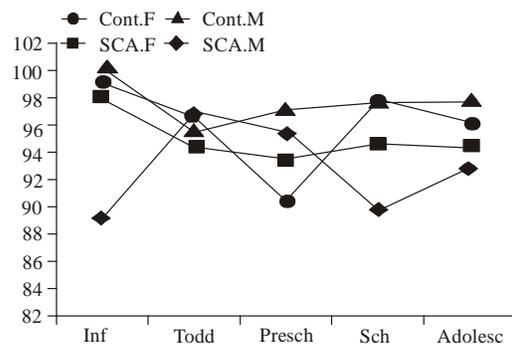


Fig 4: Mean oxygen saturation across the age groups and gender amongst the Cases and Controls.

(97.5 vs 95.9%) than their female counterparts, but this relationship is the reverse in the SCA group, where the girls measured higher than the boys (94.9 vs 92.68%), Fig. 3. In each age group, the highest and the lowest mean oxygen saturation measured were among the: infants-the control boys (100%) and SCA boys (89%); toddlers-SCA boys (96.6%) and SCA girls (94.3%); preschool age group-the control boys (97%) and control girls (90.4%); the school age group-the control girls (97.7%) and the SCA boys (89.7%); adolescents-the control boys (97.5%) and the SCA boys (92.8%). The difference in the mean oxygen saturation across the boys and the girls was most significant at the school age, in the SCA group, p = <0.0005. Also, the SCA boys had the most dramatic trend in their mean oxygen saturation as they grow older, p = 0.003, Fig. 4.

DISCUSSION

It is expected that the blood oxygen saturation in SCA tends towards hypoxaemia in all age group especially in older children with chronic disease due to their lower haematocrit (compared to those with Hb AA)

and pulmonary function abnormality (Kendrick, 2000). Their lower hematocrit is due to severe, chronic, haemolytic anaemia from premature destruction of the brittle, poorly deformable (RBC). The pulmonary function abnormality is as a result of membrane diffusion defects, intra pulmonary right-left shunts and shift of Hb oxygen dissociation curve to the right of normal (Rodgers, 1997).

Therefore in this study, we decided to find out the relevance of including routine measurement of blood oxygen saturation using the pulse oximetry in monitoring the clinical state of SCA children in Jos both in the steady and crisis state, in order to prevent and reduce the incidence of crisis states in these children, so that they can live a near-normal life like other children.

The bulk of the subjects were the school and adolescence age groups. SCA is a genetic problem, so it is expected that all the age groups be equally represented. But here we find the patients presenting late and therefore mostly older age groups form the bulk of the study. There was no significant difference in the ratio between the gender since SCA is not a sex-linked disease. The nutritional status of both study groups (SCA and non-SCA) was not significantly different and this reflects the benefits of a Special Clinic that these patients have received over the period of time they had been with us. Also the fact that both the Cases and Controls had the same mode of Oxygen saturation, shows the quality of care received in our SCA clinic.

There was a significant difference in the Oxygen saturation of stable SCA and controls. The SCA had significantly lower mean Oxygen saturation than the controls. Also the prevalence of hypoxaemia was significantly higher in the SCA than in the controls. This result is similar to other studies done in the USA (Needleman *et al.*, 1999), Philadelphia (Rackoff *et al.*, 1993), Jamaica (Homi *et al.*, 1997) and is due to the tendency of SCA towards hypoxaemia in all age group. Unfortunately there is no known published local study to the best of our knowledge. The oxygen saturation was lowest in the preschool and school age groups (Controls and Cases respectively) because, this represents the time when children start school, mix with other children and are exposed to new infections (like ARI, which is commonest in this age group). The SCA children appears to start school later than the controls due to their conditions, hence PO₂ was lowest in older age group (School Vs Preschool, respectively). The boys are more prone to these infections than the girls, hence hypoxaemia was significantly commoner in the preschool and school boys. Pulmonary complications and poor alveolar wall compliance with alveolar hypoxia from recurrent sickling is commoner with increasing age as seen by the lower mean PO₂ obtained in the older age groups than in the younger ones. This also was confirmed in other studies in

which progressively above the age of 5 years, there is considerable reduction in the blood oxygen saturation in SCA children (Rackoff *et al.*, 1993; Needleman *et al.*, 1999). But in contrast to these reports, (Homi *et al.*, 1997) concluded that oxygen saturation was not associated with age and sex but his study was done in older age group of SCA children (9-18 years). Also (McKerrell *et al.*, 2004) found no significant relationship between Oxygen saturation and age, though he documented that the younger ones had more crisis than the older patients but his study was also on much older age group (up to 40 years of age). The mean Oxygen saturation of stable SCA and controls obtained in this study is lower than in some previous foreign studies done in (95.6%-SCA, 99%-AA) Philadelphia (Rackoff *et al.*, 1993), (92.5%-SCA, 97.1%-AA-within 95% confidence interval) West Indies (Homi *et al.*, 1997) and the (94%-SCA) USA (Needleman *et al.*, 1999). This can be explained by the higher prevalence of risk factors for hypoxaemia in this less developed part of the world and the topography of the location of study (Jos is located on a plateau). Some authors believe that the higher level of HbF in older SCA girls than their corresponding boys could also explain this difference in oxygen saturation between the gender (Rackoff *et al.*, 1993; McKerrell *et al.*, 2004). The older the sickler is above the age of 5, the higher the risk of pulmonary complications and hence the less the supply of oxygen (Rackoff *et al.*, 1993). Anthropometry and nutritional status has no significant effect on the Oxygen saturation in this study as in (Homi *et al.*, 1997) who found that greater height and weight were associated with higher Oxygen saturation but not significantly so.

LIMITATIONS

The limitations include the fact that we could not do the genotype of the Controls because of funds. SCA and any chronic illness was ruled out based on history, physical examination and PCV. But this limitation was a minor one as it did not affect the clear difference in PO₂ of the Cases and Controls as seen in the study. Also use of Pulse Oxymetry instead of Blood gas analysis (which is the gold standard) to measure the PO₂. But Blood gas analysis is expensive, painful, technically difficult and not available to us. Pulse oxymetry is non-invasive, cheap, simple to carry out, available and safe within the ranges of PO₂ we got in this study.

RECOMMENDATIONS

Hence there is need to routinely monitor the Oxygen saturation of SCA patients in the sickle cell clinic and to further evaluate those with hypoxaemia. Desaturation is common in steady-state SS disease and knowledge of the

individual's steady-state value may be important in the interpreting low values during acute complications.

Also, there is need to conduct a second phase of this study, where the oxygen saturation of these patients can be determined during the crisis state in order to further establish the benefits of routine pulse oxymetry in preventing the acute phase.

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