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Research Article

STUDY ON EVALUATION OF ARTERIAL OXYGEN SATURATION LEVELS USING PULSE OXIMETRY IN SUBJECTS WITH SICKLE CELL DISEASE

Sushma Bhopalam Jagannatha and Shrikant Chandrakar

Dept. of Biochemistry Chandulal Chandrakar Medical College & Hospital Kachandur, Durg, Chhattisgarh

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A B S T R A C T

Background: Pulse oximeters are cheap, rapid and widely used non-invasive, point-of care testing devices widely used in clinical practice for estimating arterial oxyhemoglobin saturation, denoted by SpO2. SCD is a common hereditary hemoglobinpathy that occurs primarily in individuals of African Americans, Arabian and Indian descent. Sickle Cell Disease (SCD) is the major health problem in Chhattisgarh Population. Many studies showed haemoglobin desaturation to be common in patient with sickle cell anaemia (SCA) even at steady state. **Objectives of the study:** To measure SpO2 levels, liver function tests in steady state sickle cell disease subjects both homozygous and heterozygous (HbSS and HbAS) and to compare SpO2 levels between sickle cell disease subjects and healthy controls and to measure the prevalence of hypoxemia in sickle cell disease subjects.**Methods:**100 diagnosed and HPLC confirmed cases of SCD (HbSS and HbAS) along with 100 age and gender matched controls were involved in the study. In the subjects when seated, a semi-disposable oximeter sensor was applied to the index finger of the non-dominant hand, after ensuring that nail polish was not present, and was then attached to the oximeter and 5mL of random blood sample was drawn for biochemical analysis (liver function tests) after taking consent from the patients**. Results:** In the present study, we found low oxygen saturation and high prevalence of hypoxemia (SpO2 <96%) in sickle cell disease subjects as compared to healthy controls. The serum total bilirubin, direct bilirubin, indirect bilirubin, aspartate transaminase (AST) and alanine transaminase (ALT) levels were significantly higher in SCD patients (P <0.001) than in controls. **Conclusion:** It is recommended that a simple, rapid, non-invasive pulse oximetry measurement of SpO2 in these subjects could be highly useful to detect early the chances of hypoxemia and hence therapy can be instituted and it is advisable that liver function tests be interpreted with caution in these patients. SCD patients require serial monitoring of these parameters during their routine visits to the hospital.

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INTRODUCTION

Pulse oximeters are cheap, rapid and widely used non-invasive, point-of care testing devices widely used in clinical practice for estimating arterial oxyhemoglobin saturation, denoted by SpO2. Blood oxygen saturation level (SpO2) represents, the maximum amount of oxygen carried in the hemoglobin, expressed in percentage. In healthy subjects, the normal oxygen saturation ranges from 95% to 100%. Low SpO_2/hypoxemia have been associated with conditions or diseases causing ventilation–perfusion mismatch in the lungs, hypoventilation, right-to-left shunts, reduced diffusion capacity, and reduced oxygen partial pressure in inspired air [1].

Sickle Cell Disease (SCD) is a monogenic autosomal recessive genetic disorder resulting from a single base A to T mutation in the triplet encoding the sixth residue of the β-globin chain, leading to a substitution of valine for glutamic acid resulting in abnormal hemoglobin S (HbS). It is a common hereditary hemoglobinpathy that occurs primarily in individuals of African Americans, Arabian and Indian descent.Sickle Cell Disease (SCD) is the major health problem in Chhattisgarh Population. Recent statistical data reveals that, the prevalence of SCD among the screened population in Chhattisgarh is about 2.1% and sickle cell trait is 10% among the different tribes. [2,3]. The primary pathophysiology is based on the polymerization of deoxy HbS with formation of long fibers within the RBCs causing a distorted sickle shape which eventually leads to increased hemolysis and vaso-occlusive crisis [4,5].

Pulse Oximetry is often used in the evaluation of arterial oxygen saturation in sickle cell disease patients.The lungs are a major organ involved patients with sickle cell disease (SCD), with both acute and chronic pulmonary complications and is

Corresponding author:* **Sushma Bhopalam Jagannatha
Dept. of Biochemistry Chandulal Chandrakar Medical College & Hospital Kachandur, Durg, Chhattisgarh

associated with increased mortality [6,7]. Sickle cell chronic lung disease presumably results from recurrent episodes of pulmonary infarction and infection [8]. Moderate to severe pulmonary function impairment can results in hypoxemia, which may initiate or exacerbate vasculopathy [9]. There are reports of increased risk for central nervous system events with hypoxemia [10,11]. Many studies showed haemoglobin desaturation to be common in patient with sickle cell anaemia (SCA) even at steady state [12,13]. In the present study, we aimed to measure arterial oxygen saturation (SpO2) levels in steady state sickle cell disease subjects (HbSS and HbAS) using pulse oximetry. Low oxygen saturation (hypoxemia) was defined as SpO_2 less than 96%, which predicts a PaO_2 of less than 70 mm Hg based on a normal oxyhemoglobin curve [14]. Liver dysfunction is very common in sickle cell disease subjects due to various pathophysiological factors such as multiple blood transfusions associated with risk of hepatitis, excessive iron stores, intrahepatic sinusoidal sickling and bilirubin gallstones. Hence serial monitoring of liver function parameters is required in these patients to detect the liver dysfunction at the earliest and hence the treatment.

Objectives

1. To measure SpO2 levels in steady state sickle cell disease subjects both homozygous and heterozygous (HbSS and HbAS).
2. To compare SpO2 levels between sickle cell disease subjects and healthy controls.
3. To measure the prevalence of hypoxemia in sickle cell disease subjects.
4. To study the liver function tests in sickle cell disease subjects

MATERIALS AND METHODS

1. ***Source of data:*** Study on Evaluation of Arterial Oxygen Saturation Levels Using Pulse Oximetry in Subjects with Sickle Cell Disease was conducted in Chandulal Chandrakar Memorial Medical College, Kacahndur, Durg between August-December 2018. Written informed consent was taken from the study subjects. All these subjects participatedvoluntarily in the study. Detailed medical history and relevant clinical examinations were carried out in these subjects.
2. ***Inclusion Criteria:***100 proven cases of Sickle Cell Disease both HbSS (Number 26)and HbAS (number 64) aged 10-40 years who were on regular follow-ups along with newly diagnosed cases of Sickle Cell Disease and 100 age and gender matched healthy controls were included in the study. All the patients suffering from Sickle Cell Disease was diagnosed and confirmed by High Performance Liquid Chromatography (HPLC), Hemoglobin Electrophoresis were included in the study.
3. ***Procedure for Measurement of SpO_2:*** While the subject was seated, a semi-disposable oximeter sensor was applied to the index finger of the non-dominant hand, after ensuring that nail polish was not present, and was then attached to the oximeter. After verification of good perfusion, the values for SpO2 and pulse rate were recorded.
4. ***Sample Collection and Analysis:*** A general examination was done on all the subjects before blood samples were taken for hematological and biochemical analysis. 5 mL of whole blood sample was collected into plain tube for biochemical analysis (Liver function tests: Total Bilirubin, Indirect Bilirubin, Alanine Transaminase and Aspartate Transaminase). These parameters are estimated in Automated Biochemistry Analyzer MISPA nano.
5. ***Statistical Analysis:*** Students t-test was used to compare means of variables between sickle cell disease patients and controls. P value <0.05 was considered as statistically significant. Prevalence of hypoxemia in sickle cell disease was calculated and was compared between controls.

RESULTS

In this study, we included 100 patients with sickle cell disease both homozygous (HbAS) and heterozygous (HbSS) and 100 age and gender matched healthy controls. Of the 100 sickle cell disease subjects 26 were homozygous (HbSS) and 64 were heterozygous (HbAS). Out of 26homozygous15 were males and 11 were females and of the 64 heterozygous35 were males and 29 were females. Out of 100 controls 58 were males and 42 were females. The mean age in sickle cell disease subjects (AS+SS) were 23.7±12.5 and in controls is 24.8±10.2.

Table 1 Shows the comparison of Hemoglobin, SpO2 and liver function tests between sickle cell disease subjects and controls

	Sickle Cell Disease Subjects	**Controls**	**p Value**
Hemoglobin (Hb gm/dL)	11.5±1.369	12.8±1.68	S
SpO2	94.6±3.13	98.9±1.87	HS
Total Bilirubin (mg/dL)	3.46± 1.58	0.69± 0.23	HS
Indirect Bilirubin (mg/dL)	3.08± 1.565	0.49± 0.17	HS
ALT (U/L)	45.3± 19	23.2±18.2	HS
AST (U/L)	63.2± 22.5	24.6± 16.8	HS

S = Significant (p = <0.05), HS = Highly Significant (p = <0.001)

From the table 1: it is evident that the Hemoglobin and SpO2 levels were decreased whereas total bilirubin, indirect bilirubin, ALT and AST levels were significantly elevated in Sickle Cell Disease patients compared to controls.

Table 2 Shows comparison of Hb, HbF, SpO2 and liver function tests between Sickle Cell Disease Subjects (HbSS vs HbAS)

	Sickle Cell Disease Subjects (n = 26)	**Controls (n = 64)**	**p Value**
Age (in Years)	23.6±12.4	24.5±12.7	NS
Hemoglobin (Hb gm/dL)	11.5±1.3	11.6±1.27	S
Fetal Hemoglobin (HbF in gm/dL)	14.5±1.4	14.4±1.05	NS
SpO2	94.5±3.17	96±1.21	NS
Total Bilirubin (mg/dL)	3.46± 1.58	3.39± 1.24	NS
Indirect Bilirubin (mg/dL)	3.02±1.57	2.88±1.23	NS
ALT (U/L)	44.29± 19.6	46.1±15.29	NS
AST (U/L)	62.88± 22.7	65.3± 16.25	NS

NS = Nothing Significant (p = >0.05)

From the table 2: It is evident that the SpO2 levels were decreased significantly in HbSS compared to HbAS subjects. There was no significant difference in hemoglobin, fetal hemoglobin, total bilirubin, indirect bilirubin, ALT and AST levels between HbSS and HbAS.

Table 3 Shows the Distribution of SpO2 in (HbSS &HbAS) and control group

	Sickle Cell Disease Subjects				Controls (n = 100)	
	HbSS (26)		HbAS (64)			
SpO2	No of Subjects	Percentage	No of Subjects	Percentage	No of Subjects	Percentage
<90%	6	23	0	0	0	0
90-95%	20	76.9	22	34.3	3	3
96-100%	0	0	42	65.6	97	97

From the table 3: It is evident that the prevalence of hypoxemia in HbSS is 76.9% and in HbAS 34.3%. Severe hypoxemia subjects were 6%.

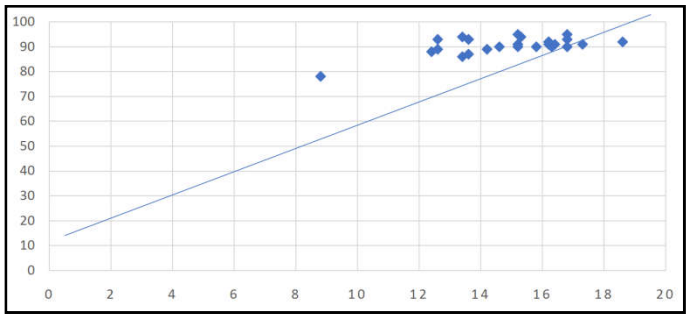

Figure 1 Shows the correlation between Hb and SpO2 in Sickle Cell Disease Subjects

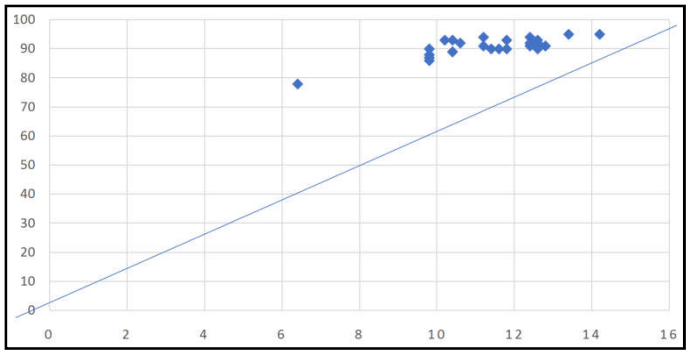

Figure 2 Shows the correlation between HbF and SpO2 in Sickle Cell Disease Subjects

DISCUSSION

In the present study, we found decreased levels of hemoglobin, fetal hemoglobin, arterial oxygen saturation and increased levels of bilirubin (total and indirect), ALT and AST levels in sickle cell disease subjects compared to controls. We found prevalence of 76.9% in HbSS and 34.3% HbAS for hypoxemia and together it was55.6%. The mean levels of SpO2 were significantly lowered in sickle cell disease subjects when compared to controls. This finding was similar to the other studies conducted in the past [15,16].Lung disease (ACS-acute chest syndrome) is the second most common cause for admission to the hospital and common cause of death in children with sickle cell disease. Recurrent episodes of ACS could result in irreversible chronic lung disease. Additionally, sickle cell hemoglobin has an inherent property of causing shift to right in oxygen dissociation curve as a compensatory mechanism to deliver more oxygen to tissues by raising 2,3-diphosphoglycerate (DPG) levels, which is characteristic phenomenon seen in sickle cell anemia.

The prevalence of hypoxemia in steady state HbSS patients is high. This finding highlights the importance of monitoring the sickle cell disease patients for the early detection of hypoxemia and administer the treatment at the earliest. In this study, we found prevalence of 34.3% hypoxemia in sickle cell traits (HbAS), it means that even patients with HbAS irrespective of their symptoms should be monitored for SpO2 levels. However, despite the association of low oxygen saturation with CNS event and other serious complications, there is no agreed treatment modality. In this study, we found positive correlation found between Hb, HbF and SpO2 levels in sickle cell disease subjects. The r values between HbF and SpO2 was 0.68 and r value between Hb and SpO2 was 0.578 shown in figure 1 & 2. Previous reports have shown a strong positive correlation between high HbF and increased SpO2. Pashankar *et al*. reported on the improvement of oxygen saturation following treatment with hydroxyurea (HU). Hydroxyurea increases HbF level (which has a higher an affinity for oxygen than HbS or HbA), and shifts the oxygen dissociation curve to the right which is associated with a high oxygen saturation. These results were quite evident after 6 months' treatment with hydroxyurea, where in the oxygen saturation increased from 95.15% to 98.4% [17].

Even though few authors have reported weak correlation between SpO2 measured by pulse oximetry and arterial blood gas analyzer. Since Pulse oximeter measures oxy- hemoglobin as percentage of functional hemoglobin (oxy- hemoglobin and deoxy-hemoglobin), whereas blood gas analysis for oxygen saturation measures it as a percentage of total hemoglobin including carboxy-hemoglobin and met-hemoglobin. Some other studies have proven strong correlation between the two modes of measurements for SpO2. This is of particularly valuable in low and middle income countries where the burden of SCA is very high, arterial blood gas testing is scarce, hence, pulse oximetry is a reliable method to monitor oxygen saturation [17]. Liver dysfunction is very common in sickle cell disease subjects due to various pathophysiological factors such as multiple blood transfusions associated with risk of hepatitis, excessive iron stores, intrahepatic sinusoidal sickling and bilirubin gallstones.

CONCLUSION

Hypoxemia is a very important and crucial finding in sickle cell disease patients. In this study, we found higher prevalence of hypoxemia as compared to other studies, probably due to the population group that is studied. It is recommended that a simple, rapid, non-invasive pulse oximetry measurement of SpO2 in these subjects could be highly useful to detect early the chances of hypoxemia and hence therapy can be instituted and it is advisable that liver function tests be interpreted with caution in these patients. SCD patients require serial monitoring of these parameters during their routine visits to the hospital.

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