Hematological Profile in Patients of Sickle Cell Anemia and Sickle Cell Trait in Relation to Blood Gas Analysis—Revisited

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Research Article

Abstract: Several works in different parts of the world have contributed to the etiological and hematological aspects of sickling disorders. The work in this study was planned to correlate hematological profile with blood gas analysis in cases of sickle cell anemia and sickle cell trait .Sickling disorders are associated with an abnormal hemoglobin, vascular obstruction by sickled cells and a resultant shunting of blood across the pulmonary circulation without access to ventilation. An important aspect of the pathophysiology of sickling disorders lies in the maintenance of adequate oxygen delivery in the face of anemia and vascular obstruction, confounded by compensated pulmonary function. Some of the contemporary works on pulse oximetry have thrown light on various other parameters that need to be considered.

Key words: sickle cell anemia(SCA), sickle cell trait(SCT),partial pressure of oxygen(pO2), pulse oximetry, sickle cell disease(SCD), hemoglobin S(HbS)

Introduction

Sickling disorders were initially recognized in the African countries as far back as 1670,as recurrent painful crises. Much later in the 20th century several works on cases and groups in different parts of the world have been done, elaborating the etiological and hematological aspects of these disorders. The western scientific community was first introduced to this disorder in the year 1910, when a cardiologist, Dr J B Herrick, detailed the clinical manifestations and described the occurrence of peculiar sickle shaped red blood cells in the peripheral blood during the investigations of severe anemia in one of his West Indian patients. Herrick's report led to a series of studies that resulted not only in the identification of structural abnormalities of hemoglobin underlying this condition but also to the discovery of homozygous and heterozygous states, and other correlates like pH ,temperature and fixatives that affected sickle cell formation in vitro.[4,5,15,17] Hemoglobin S differs from normal hemoglobin in the substitution of valine for glutamic acid in the sixth position from the N-terminal of the beta globin chain .Exclusion of oxygen is a major prerequisite to sickling and the phenomenon is reversed on re-exposure to the gas.[20] The heterozygous state is called sickle cell trait with AS hemoglobin, while the homozygous state is called sickle cell anemia with SS hemoglobin .Doubly heterozygous states have also been reported.[20] The present study was planned to study the hematological profile in patients of SCA and SCT in relation to blood gas analysis.[22]

Material and methods [12,19,20]

The study was carried out in the department of Pathology, MGIMS, Sewagram over a three year period. 98 cases including 48 cases of SCA and 50 cases of SCT were studied. All the cases were subject to haematological investigations which included hemoglobin, total leucocyte count, differential leucocyte count, peripheral blood smear examination, reticulocyte count, total red cell count, sickling test, hemoglobin electrophoresis and blood gas analysis for pH, pCO_2 and pO_2. Capillary blood was used for blood gas analysis. The SCA was further grouped according to type of clinical crisis namely hemolytic, vaso-occlusive, sequestration and hypoplastic crisis. The remaining patients of SCA were said to be in the steady state.

Observations

1. Maximum number of cases from SCT group was in the age group of 21 -30 years while cases of SCA were mostly seen in the age group of 0-10 years.
2. A female predisposition was noted in SCT whereas SCA showed a male predisposition.
3. Vaso-occlusive crisis was the commonest type (72.9%) followed by hemolytic crisis(23.25%).
4. Both SCA and SCT showed decrease in the hemoglobin values(9 gms% and 8.8 gms% respectively). The values in SCA showed decline in crisis.

5. Leucocytosis was observed in patients of SCA in crisis but not in steady state.
6. The red blood cell counts were lower than normal in SCT as well as SCA.
7. The reticulocyte counts were slightly raised in steady state of the disease and markedly raised in cases of crisis.
8. The mean pH value as observed by capillary blood gas analysis was within physiological range in patients of SCA as well as SCT(7.458 and 7.428 respectively).
9. With a decrease in the hemoglobin percentage, lowering of pH was observed.
10. With higher total leucocyte count, there was a decrease in pH.
11. A rise in the reticulocyte count also showed a rise in pH.
12. The PCO_2 values were in physiological limits except in a case of hypoplastic crisis.
13. The patients of SCT had lower mean PO2 values as compared to steady state. The values declined in crises.
14. The mean blood PO_2 values showed correlation with increase or decrease in total leucocyte count and reticulocyte count.

Discussion

The haematological parameters studied were in conformity with most other studies.[1,8,9,16] The Blood gas parameters however require more studies to be able to draw reasonable data for analysis. An important aspect of the pathophysiology of sickling disorders lies in the maintenance of adequate oxygen delivery in the face of anemia and vascular obstruction. Peculiarities in this regard found in sickling disorders are:

The cardiac output is higher than in anemias of comparable severity.The oxygen pressure and saturation of venous blood are higher with a resultant decrease in arterio-venous saturation difference, thus impairing oxygen unloading to the tissues.A widened alveolar-arteriolar PO_2 difference was attributed to shunt of blood across the pulmonary circulation without access to ventilation. This veno-arterial shunting associated with ventilation-perfusion disproportion is further confounded by lowered oxygen affinity on the hemoglobin. This results in arterial hypoxaemia more severe than that in most other anemias. The infarctive damage to lung tissues of SCA patients could also decrease the oxygen loading in lungs [6,7,14,18,21]

An increase in 2,3-DPG and decrease in pH following hypoxia causes decrease in affinity of HbS for oxygen ,thus enhancing gelation.[10]

At blood pH 7.4 and above,the oxygen affinity was moderately lower than normal. As the pH w as reduced below 7.4, the oxygen affinity of SS blood fell much more steeply than normal. The results of this fall in oxygen affinity are:

a) Increased release of oxygen to tissues, thus trying to compensate for low hemoglobin concentration in SCA.
b) At the same time, an effect of deoxygenation being enhanced intracellular sickling of red cells with greater risk of hemolysis and occlusion- a self damaging effect which overshadows the benefits of lowered oxygen affinity.[21]

Acidification of urine as well as concentration of urine which is an active energy requiring process and which is accomplished primarily in the medulla, is compromised in SCD due to medullary ischemia. Thus acidosis develops more readily in SCD in the setting of mild renal insufficiency.[2,3]

When hypoxic intravascular sickling was prevented, persons with 70% HbS in their red cell hemolysates displayed no evidence of anemia or disease and the life span of their erythrocytes was normal.[11]

The present study was aimed at correlating hematological and blood gas parameters in SCA and SCT However, no studies from available literature showed such correlation .Further analysis to show the impact and importance of the less studied pulmonary aspects of sickle cell disease would be required. A need was felt to develop hematological reference values in individual laboratories for optimal patient care. When the study was revisited, data on contemporary works elaborating the pros and cons of pulse oximetry in sickle cell disease were available. The authors emphasized the reliability of arterial oxygen saturation measurement, rather than PO_2, in assessing gas exchange abnormalities.[23,24,25] Prevention of hypoxia ,still remains the mainstay of management[11] – a point to ponder for those interested in treks field sports ,water sports ,heavy exercises and also those requiring anaesthesia.

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