ANESTHETIC MANAGEMENT OF SICKLE CELL DISEASE

Essay
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List of Abbreviations

2,3 DPG	*2,3 diphosphoglycerate*
ACS	*Acute chest syndrome*
ANF	*Avascular necrosis of head of femur*
BNP	*Biomarker pro-brain natriuretic peptide*
EDRF	*Endothelium derived relaxing factor*
EPO	*Erythropoietin*
ET-1	*Endothelin-1*
FDA	*Food and Drug Administration*
Fe^{+2}	*Ferrous*
Fe^{+3}	*Ferric*
FRC	*Functional residual capacity*
HbA	*Adult hemoglobin*
HBAs	*Heterozygous type of sickle cell disease (sickle cell trait)*
Hbf	*Fetal hemoglobin*
HbS	*Sickle cell hemoglobin*
HBS/B+	*Sickle beta plus thalassaemia*
HBS/B^{o}	*Sickle betazero thalassaemia*
HbSc	*Heterozygous type of sickle cell disease with one sickle gene and another encoding hemoglobin (C) (sickle hemoglobin c disease)*
Hbss	*Homozygous type of sickle cell disease (sickle cell anemia)*

HPLC	*High performance liquid chromatography*
HSCT	*Hematopoietic stem cell transplantation*
Hu	*Hydroxyurea*
IUGR	*Intrauterine growth fretardation*
Kpa	*Kilo pascal*
MgSo4	*Magnesium sulphate*
NO	*Nitric oxide*
NOS	*Nitric oxide synthetase*
NSAIDS	*Nonsteroidal anti-inflammatory drugs*
OSA	*Obstructive sleep apnea*
P50	*Partial pressure of oxygen in arterial blood at which hemoglobin is 50 % saturated*
PAH	*Pulmonary artery hypertension*
PAo2	*Partial press use of alveolar oxygen*
Pao2	*Partial pressure of oxygen in arterial blood*
SCD	*Sickle cell disease*
SO2	*Oxygen saturation*
TCD	*Transcranial Doppler*
Vo2	*Oxygen consumption*
VOC	*Vasoocclusive crisis*

Introduction

Sickle Cell disease is congenital hemoglobinopathy characterized by deformed red blood cells, acute episodic attacks of pain and pulmonary compromise, wide spread organ damage, and early death . The central pathological event has traditionally been assumed to be an increase in sickling or deformation of erythrocytes as a result of the insolubility of the deoxygenated mutant sickle hemoglobin (hemoglobin S), while acute pain and pulmonary complications often have no clear identifiable causes. The preoperative period is a well recognized and predictable time of disease exacerbations.

Sickle Cell disease have high incidence of preoperative complication. Traditional anesthetic management depend largely on avoidance of red cell sickling to prevent exacerbation of the disease by pre-emptive erythrocyte transfusion, aggressive hydration and avoidance of hypoxia, hypothermia and acidosis ***(Steinberg, 1999).***

A contemporary publication of series of 604 cases noted a rate of acute sickle cell disease exacerbation of approximately 15% with morality rate of 0.3% was mostly due to preoperative hypoxia, hypo- perfusion and acidosis

which cause erythrocyte to sickle which precipitate vascular occlusion and organ dysfunction ***(Vinchinsky et al., 1995).***

Also patient of sickle cell disease complaining from psychological distress due to effect of chronic, incurable, incompletely understood lethal disease ***(Vinchinsky et al., 1999).***

Aim of the Work

Is to discuss the pathophysiology of sickle cell disease including signs, symptoms, Anesthetic management including preoperative – intraoperative and postoperative management and management of its complications.

Physiology of Oxygen Transport

In order to survive humans have to be able to extract oxygen from the atmosphere and transport it to their cells where it is utilized for essential metabolic processes. Some cells can produce energy without oxygen (anaerobic metabolism) for a short time, although it is inefficient. Other organs (e.g. brain) are made up of cells that can only make the energy necessary for survival in the presence of a continual supply of oxygen (aerobic metabolism). Tissues differ in their ability to withstand anoxia (lack of oxygen). The brain and the heart are the most sensitive. Initially a lack of oxygen affects organ function but with time irreversible damage is done (within minutes in the case of the brain) and revival is impossible.

Oxygen transport from Alveolus to blood

Blood returning to the heart from the tissues has a low PO2 (40 mmHg) and travels to the lungs via the pulmonary arteries. The pulmonary arteries form pulmonary capillaries, which surround alveoli. Oxygen diffuses (moves through the membrane separating the air and the blood) from the high pressure in the alveoli (100 mmHg) to the area of lower pressure of the blood in the pulmonary capillaries (40 mmHg). After oxygenation blood

moves into the pulmonary veins which return to the left side of the heart to be pumped to the systemic tissues. In a 'perfect lung' the PO2 of pulmonary venous blood would be equal to the PO2 (partial pressure of oxygen) in the alveolus. Three factors may cause the PO2 in the pulmonary veins to be less than the PAO2 (alveolar partial pressure of oxygen) ventilation/perfusion mismatch, shunt and slow diffusion ***(Treacher et al., 1998)***.

Ventilation/perfusion mismatch

In a 'perfect lung' all alveoli would receive an equal share of alveolar ventilation and the pulmonary capillaries that surround different alveoli would receive an equal share of cardiac output ie. Ventilation and perfusion would be perfectly matched. Diseased lungs may have marked mismatch between ventilation and perfusion. Some alveoli are relatively overventilated while others are relatively overperfused (the most extreme form of this is shunt where blood flows past alveoli with no gas exchange taking place. Well ventilated alveoli (high PO2 in capillary blood) cannot make up for the oxygen not transferred in the underventilated alveoli with a low PO2 in the capillary blood. This is because there is a maximum amount of oxygen which can combine with hemoglobin. The pulmonary venous blood (mixture of pulmonary capillary

blood from all alveoli) will therefore have a lower PO2 than the PO2 in the alveoli (PAO2). Even normal lungs have some degree of ventilation/perfusion mismatch; the upper zones are relatively overventilated while the lower zones are relatively overperfused and underventilated ***(Hameed et al., 2003).***

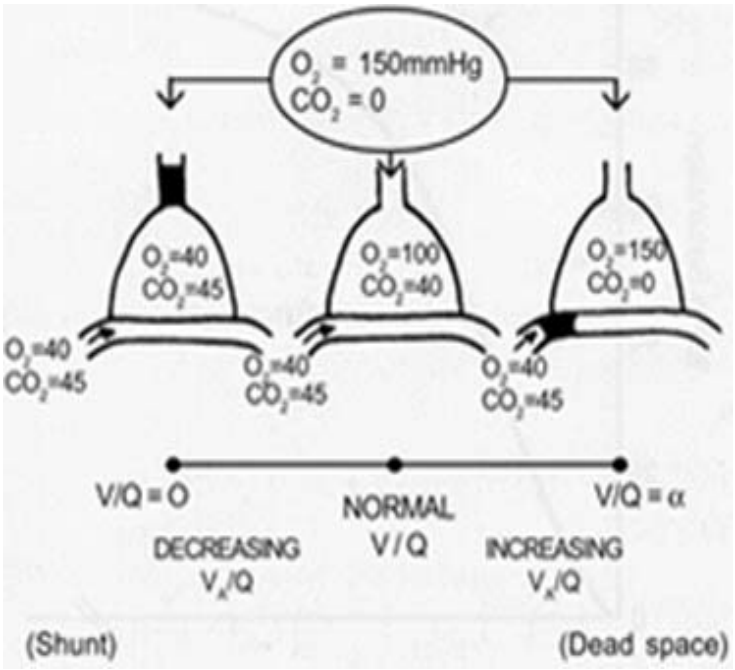

Fig. (1): Shunt occurs when deoxygenated venous blood from the body passes unventilated alveoli to enter the pulmonary veins and the systemic arterial system with an unchanged PO2 (40 mmHg). Atelectasis (collapsed alveoli), consolidation of the lung, pulmonary oedema or small airway closure will cause shunt ***(West et al., 1990)***.

O2= oxygen. Co2=Carbon dioxide.
V= ventilation. Q= perfusion.

Oxygen carriage in blood

The oxygen-hemoglobin dissociation curve:

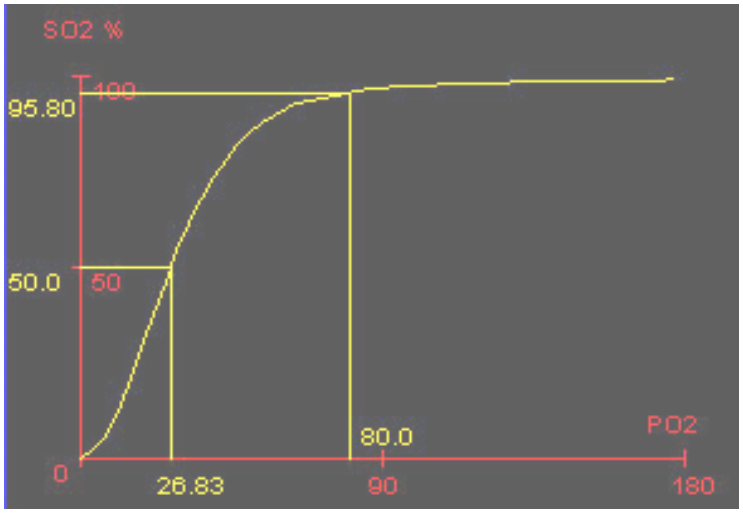

Fig. (2): The sigmoid shape of hemoglobin's oxygen-dissociation curve results from cooperative binding of oxygen to hemoglobin ***(Guyton et al., 2006).***

Oxygen-hemoglobin dissociation curve, is an important tool for understanding how our blood carries and releases oxygen. Specifically, the oxy-hemoglobin dissociation curve relates oxygen saturation (SO_2) and partial pressure of oxygen in the blood (PaO_2), and is determined by what is called "hemoglobin's affinity for oxygen"; that is, how readily hemoglobin acquires and releases oxygen molecules into the fluid that surrounds it.

Hemoglobin, globular protein, is the primary vehicle for transporting oxygen in the blood. Oxygen is also carried