

MANAGEMENT OF SICKLE CELL DISEASE DURING CABG SURGERY

- A Case Report -

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Abstract

Elective Coronary Artery Bypass Graft (CABG) surgery using cardiopulmonary bypass techniques following preoperative transfusions to increase the hemoglobin A levels to above 60%, in a male patient with sickle cell disease [SCD] is described. Avoidance of hypoxia and acidosis lead to an uneventful perioperative period. Our institutional protocol for preoperative transfusions is highlighted.

Key Words: Blood: Sickle cell disease, Hemoglobin. Surgery: CABG, Cardiopulmonary bypass.

Introduction

Sickle cell hemoglobinopathies are inherited disorders ranging from the usually benign sickle cell trait [SCT] to the potentially fatal sickle cell anemia. Sickle cell disease [SCD] is a homozygous genotype [HbSS], with the fractional concentration of HbS varying from 70-98%.

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SCD in patients undergoing open-heart procedures presents a multitude of challenges to the treating medical staff. A major concern in these patients is the development of an intraoperative sickle cell crisis. Cardiopulmonary bypass [CPB] techniques, which can possibly lead to hypoxia and acidosis can trigger off the sickling process.

Case Report

We report the case of a 40-year-old man with SCD who required elective Coronary Artery Bypass Graft [CABG] surgery. He had history of chronic stable angina [NYHA class II] of one-year duration. The coronary angiogram revealed critical lesions of LAD, OM₂ & RCA, and was advised CABG surgery. His preoperative complete blood counts [CBC] revealed hemoglobin levels of 10.7 g/dl [normal: 14-18.1], hematocrit of 31.4% [normal: 35-53], with normal platelets and WBC counts. He tested positive for sickling and SCD was diagnosed on subsequent hemoglobinopathy screening (Table-1).

Table 1
Hemoglobinopathy screening

	Initial	Preoperative [After transfusions]	1st P.O.D	2nd P.O.D
Hemoglobin [Normal: 14-18.1 g/dl]	10.7	12	11.2 g/dl	10.9 g/dl
Hemoglobin A (Adult)	21.9%	70%	74.1%	78.5%
Hb A ₂	5.6%	3%	3.2%	3.4%
Hb F	3.6%	1%	1.1%	2%
Hb S	68.9%	26%	21.6%	16.1%
Other variant of hemoglobin	0%	0%	0%	0%

4 units of blood were transfused preoperatively to raise the Hb A level to >60% 48 hrs prior to surgery as per our institutional protocol [Table-1].

Anesthesia was induced with fentanyl, midazolam, thiopentone, and

pancuronium and maintained with fentanyl, isoflurane and propofol infusion throughout the surgical procedure. Propofol and fentanyl infusions were continued postoperatively for sedation and analgesia.

Monitoring techniques were standard: ECG with ST segments analysis, SpO₂, EtCO₂, nasal/skin temperature, invasive arterial and central venous pressure and urine output. CPB parameters for good tissue perfusion like arterial inflow line pressure, cardiac index, and temperature gradients were monitored, as well as arterial and venous blood gas status. Venous oxygen saturation was kept above 75% and perfusion pressures equal to or >60 mmHg were maintained at all times. All residual pump blood was discarded.

During CPB the patient received vasodilators as needed (Inj Nitroglycerine or Inj. Phentolamine) to improve peripheral perfusion and to reduce stasis.

The patient received 4 grafts [left internal mammary artery to LAD and 3 saphenous venous grafts to OM₂, D₁ and distal RCA] on CPB with cold antegrade cardioplegia [St. Thomas solution] and moderate hypothermia. The total CPB time was 75 mins and with an aortic cross clamp time of 57 mins. A blood prime was used and 3 units of blood were transfused perioperatively.

After an uneventful postoperative course, the patient was extubated after 8 hrs of artificial ventilation. The hemoglobin screening on the 1st and 2nd postoperative days showed Hb A levels above 70% [Table-1]. Early anticoagulation was initiated with IV heparin 6 hrs after surgery, which was overlapped with oral warfarin on the third day. Heparin was withdrawn on the 6th postoperative day.

A 12 lead ECG was recorded immediately on reaching the PSCU, and every day thereafter until discharge from PCSU, for early identification of myocardial ischemia.

Discussion

Hypoxia or acidosis initiates the sickling phenomenon, which is

initially reversible but then becomes irreversible. The danger of sickling provoked by CPB has been emphasized¹⁻⁶. CPB by causing hypoxia or acidosis or both can initiate a vicious cycle leading to increased viscosity resulting in capillary stasis, thrombosis, ischemia and necrosis. Sickle cells are mechanically more fragile and are prone for hemolysis^{2,6}. In addition, hypothermia used during CPB augments sickling^{2,6}.

The possible dangers of CPB in sickle cell hemoglobin states led to many recommendations:

Sickling may occur in the heterozygous state at a PO₂ of 20-25 mmHg, whereas in the homozygous form it occurs at a higher PO₂ of 40 mmHg⁴. Hence optimal oxygenation with avoidance of acidosis throughout is an important measure during cardiac operations to avoid sickling.

To decrease the risk of sickling reduction of HbS% by preoperative transfusions⁴ or by partial exchange transfusion immediately before bypass, has been suggested^{1,6,7}. This might necessitate the use of blood in the priming solution^{1,2,3,4,6}, which alone would be sufficient to decrease the percentage of HbS%².

Systemic hypothermia has not been recommended on theoretical basis since it can lead to sickling^{2,4}. Contrary to this, there is experimental evidence that hypothermia may actually be beneficial, as it slows the polymerization of HbS and delays the onset of sickling. Maintenance of peripheral perfusion during cooling by hemodilution decreases capillary transit time below that required for deoxygenation and sickling, and hence hypothermia is safe in these patients⁸. From the formation of deoxygenated Hb to the onset of aggregation of the deoxygenated Hb into a gel, there is a delay time, which is inversely proportional to the temperature. The presence of significant amounts of polymerized HbS does not invariably produce a sickle cell. As the cell returns to less hypoxic environment, there is reversal of the polymerization⁹. It has been postulated¹⁰ that sickling occurs if the capillary transit time is lengthened to exceed delay time.

This would suggest that hypothermia, hemodilution and vasodilation should to some extent have a protective effect in preventing sickling as

the red cells pass through an hypoxic environment. The proviso being a capillary transit time of the shortest possible duration. This would involve administration of vasodilator drugs, control of packed cell volume [hemodilution], and optimization of oxygenation.

Aortic cross clamping and topical hypothermia have been used successfully recently^{7,10} though they were not recommended initially for the fear of precipitating in situ sickling^{2,4}.

In our part of the world, the prevalence of SCT is 6% and SCD is about 0.2%¹¹. Since Middle Eastern countries are known for the increased incidence of SCD, every patient undergoing open-heart surgery is routinely screened for sickle cell and other hemoglobinopathies, if not known already.

The following is the protocol followed in our institution for simple and exchange transfusion in SCD patients: This applies to HbSS, HbS beta thalassaemia, HbSC-disease and HbS with high Hb F. The algorithm expresses goals based on Hb A levels.

- For urgent surgery, 4 units of compatible, packed RBCs are administered as soon as possible with the intent to complete the last transfusion at least 48-72 hrs prior to any surgery. CBC & HPLC are repeated to see the effect of transfusions. If the post transfusion Hb is less than 12 gms% or the Hb A is less than 40%, 1 unit of packed RBCs is transfused for each gram of Hb less than 12 gms%. CBC and HPLC are repeated to see the effect of the transfusions. If the final Hb A does not meet the transfusion goals, exchange transfusion may be indicated.

- For elective surgery (>3 weeks before elective surgery), 10-15 ml/kg of compatible blood is transfused each week. The procedure is repeated for a total of three times. CBC and HPLC are checked to see the effect of the transfusions. If the final Hb A does not meet the transfusion goals [i.e.] Hb A <40%, exchange transfusion is considered.

We consider preoperative transfusion if the Hb A is <40% for minor surgical procedures and if Hb A is <50% for major surgeries.

There have been several reports of vaso-occlusive events and sudden death in subjects with sickle cell trait. However, the precise mechanism

underlying these episodes remains unclear. Sickle cell disorders, such as Hb SS and Hb SC, are associated with a hypercoagulable state that may contribute to the vaso-occlusive episodes observed in the disorders. Westerman et al reported that the d-dimers, TAT, F1.2, and monocyte count showed significant increasing trends through groups of increasing severity (Hb AA, Hb AS, Hb SC, and Hb SS). The measures of coagulation activity in SCT were lower than in patients with Hb SC and SCD¹² suggesting that patients with SCD may be at risk for developing catastrophic vaso-occlusive complications such as pulmonary infarction or stroke. Keeping in view the possibility of a hypercoagulable state in SCD patients, we commenced anticoagulation quite early in the postoperative period. There was no ischemia detected in the ECG recordings.

In our patient, standard CPB using moderate hypothermia, aortic cross clamping and topical hypothermia was used. The patient had an uneventful recovery and was discharged home on 6th postoperative day.

In conclusion, though theoretically CPB has been feared in sickle disease patients, increasing Hb A and reducing the HbS% to acceptable levels by perioperative blood transfusions, makes CPB associated procedures like aortic cross clamping and hypothermia safe.

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