CARDIOPULMONARY BYPASS SURGERY IN SICKLE CELL DISEASE: AN UPDATE

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SUMMARY
We share our experience of two cases of successful mitral valve replacement and one tricuspid anuloplasty in patients with sickle cell disease and a history of repeated sickling crises. This was done with cardiopulmonary bypass and moderate hypothermia. By avoiding acidosis, dehydration and hypoxia, successful cardiopulmonary bypass was effected without pre or intra-operative exchange transfusion.

Keywords: Cardiopulmonary bypass, sickle cell disease, exchange transfusion, haemoglobinopathy.

INTRODUCTION
Cardiopulmonary bypass in sickle cell disease can be safely performed without exchange transfusion but certain precautions need to be taken during surgery[1]. There is a relatively high frequency of the haemoglobin S and C gene in West Africa. In Ghana the frequency of the S and C gene are 20% and 10% respectively[12]. The homozygous SS and heterozygous SC are characterised by haemolytic anaemia, thrombotic, aplastic and hyperhaemolytic crises[12].

Thrombotic crises following general anaesthesia and with surgical procedures is frequent. It is therefore generally recommended that the haemoglobin S content of the blood be reduced to less than 30% by exchange transfusion of red cells containing AA haemoglobin before surgery[8]. The majority of cases of successful cardiopulmonary bypass surgery in subjects with sickle cell haemoglobinopathy have accordingly employed exchange transfusion pre- and peri-operatively to reduce the circulating concentration of HbS[2-8]. It must be noted however that the majority of such patients have been those with the sickle cell trait or sickle cell disease without significant history of crises[9]. We believe that avoidance of events that are likely to induce crises such as acidosis, hypoxia, hypotension and decreases in blood flow can enable successful cardiopulmonary bypass without exchange transfusion. The National Cardiothoracic Centre (NCTC), Accra, is the only tertiary centre for cardiothoracic disorders in Ghana. We report our experience at the NCTC with three cases (2 homozygous SS, 1 heterozygous SC) who had successful open heart surgery involving the use of cardiopulmonary bypass and hypothemia.

CASE 1
A.B a 12 year Nigeria boy homizygous for HB S gene (father AS; mother AS) with several hospital admissions for sickling crises, four of which necessitated blood transfusions presented with heart failure. He was found on Doppler echocardiography with colour flow mapping, to have severe rheumatic mitral regurgitation with increased left ventricular end diastolic and systolic volumes. His haemoglobin and haematocrit before surgery were 8.0g% and 23.3g% respectively.

CASE 2
R. O was a 12-year-old Ghanaian girl with sickle cell disease (SS genotype; father AS; mother AS) and several episodes of sickling crises and four previous blood transfusions. She presented with congestive cardiac failure from rheumatic heart disease. Evaluation with Doppler echocardiography with colour flow showed an enlarged left atrium, increased Left Venticullar(LV) end diastolic dimension and severe rheumatic mitral regurgitation. Laboratory investigations revealed a haemoglobin and haemoatocrit of 7.8% and 24.1% respectively.

CASE 3
V.T a 17 year old Ghanaian girl with sickle cell disease (genotype SC: father AC; mother AS) with

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several hospital admissions for pain crises and many previous blood transfusions. Diagnosis of severe tricuspid regurgitation and a dilated right atrium was found on Doppler echocardiography. The cause of the tricuspid incompetence was not known. Her haemoglobin and haemotocrit preoperatively were 10.1g% and 31% respectively.

Anaesthesia, cardiopulmonary bypass and surgery
In all cases, general anaesthesia was induced with fentanyl, midazolam, etomidate and neuromuscular paralysis with pancuronium. Prebypass anaesthesia was maintained with isoflurane, fentanyl, oxygen (2L) and nitrous oxide (2L). Fentanyl, vecuronium and midazolam were used during surgery for the first two cases, with pancuronium replacing vecuronium for the third case.

The cardiopulmonary bypass circuit was constructed with a MASTERFLOW bubble oxygenator, cardiotomy reservoir, tubing sets, and other accessories from DEDICO S.P.A. The heart-lung machine (HLM) was primed with, 500-1000mls of Ringers Lactate, 500,mls of 5% dextrose, 1 unit of blood and 40ml of 8.4% sodium bicarbonate. 300iu/kg heparin was used for systemic heparinization before the start of bypass. The subjects were connected to the HLM through an aortic and bicaval cannulation. Cold ST. Thomas cardioplegic solution (NaCL–147mmol/L, KCL-20mmol/l. MgCL-167mml/L, CaCL–2mmol/L and procaine HCL-1mmol/L) was infused into the root of the cross clamped aorta to achieve cardiac arrest and myocardial protection. Systemic hypothermia was maintained at nasopharygeal and rectal temperatures of 28.4C and 25.6C (case 1), 28.0C and 25.0C (case 2) and 30.4C and 28.4C (case 3) respectively.

The average haemoglobin (HB) and haematocrit (Hct) during bypass were 5.2g/dl (Hct 15.2%), 5.2g% (Hct 15.4g%), 7.33g% (Hct 22.0%) for cases 1, 2 and 3 respectively. The mean arterial pressures for the three cases were between 50-70mmHg and the partial pressure of oxygen (PO2) ranged between 378 and 512 mmHg with a mean saturation of 99.9%. The PH was kept between 7.43 and 7.48 and the bicarbonate(HCO3) level 21, 1mmol/L and 22.9mmol/L.

The arterial PO2, PCO2, HCO3, Base excess (BE), PH and the HB during bypass are displayed in tables 1, 2 and 3 below)

For the first two cases, the mitral valve was approached through the atrial septum. The thickened and retracted or redundant valve tissue was excised and 29mm, 27mm Sorin bicarbon bileaflet mechanical prosthesis implanted in the mitral area using 2-0 cardiofil mattress sutures for cases 1 and 2 respectively. For the case 3 the tricuspid valve was approached through the right atrium and tricuspid reconstruction was performed.

All the three cases were weaned off cardiopulmonary bypass without difficulty. Exanguinated blood in the oxygenator was discarded. All the three patients were transfused with two units of packed cells after coming off bypass. The fluid management included the use of gelofusine and crystalloids to maintain a CVP of between 7-10mmHg and a urine output of 1ml/kg/hour.

Blood results during bypass

Table 1
Case 1 (Duration of bypass - 79 mins)

Time Mins.	PO2 (mmHg)	PCO2 (mmHg)	HCO3 (mmol/L)	BE	PH	HB g%
Prebyass	250.6	35.1	21.3	-3.2	7.38	8.0
On bypass						
+10	450.5	39.5	21.5	-5.7	7.35	5.4
+40	580.1	35.1	22.9	-3.5	7.39	5.3
+70	456.3	38.3	23.2	-2.3	7.38	5.1
Prebypass	290.9	34.3	22.5	-2.8	7.42	9.3

Table 2
Case 2 (Duration of bypass - 85 mins)

Time Mins.	PO2 (mmHg)	PCO2 (mmHg)	HCO3 (mmol/L)	BE	PH	HB g%
Prebyass	190.1	40.1	21.9	-4.0	7.34	7.8
On bypass						
+10	397.7	38.3	22.8	-2.8	7.36	5.3
+40	463.4	33.5	21.7	-5.1	7.35	5.1
+70	409.0	36.1	23.9	-1.4	7.41	5.1
Prebypass	188.8	38.9	22.5	-2.2	7.37	9.9

Table 3
Case 3 (Duration of bypass - 71 mins)

Time Mins.	PO2 (mmHg)	PCO2 (mmHg)	HCO3 (mmol/L)	BE	PH	HB g%
Prebyass	175.1	40.6	24.2	0.8	7.40	10.1
On bypass						
+10	420.3	29.5	22.4	-4.3	7.41	7.5
+40	501.9	30.0	21.8	-1.6	7.46	7.2
+70	382.4	26.7	23.2	-1.7	7.48	7.4
Prebypass	215.6	40.3	22.5	-2.2	7.37	10.6

Nasogastric feeding was started in the first postoperative day. The postoperative course for all the three patients were normal. The first two cases who had mitral valve replacement were discharged home on life long anticoagulation with warfarin. Monthly benzathine penicillin injections were recommended. After follow-up for four years there has been no incidence of sickle cell crises or the need for transfusion. The third patient who had tricuspid valve repair did not require anticoagulation. She has had one episode of crises in the past two years.

DISCUSSION

The majority of cardiac patients undergoing cardiopulmonary bypass have received preoperative or intra-operative exchange transfusion[2-8]. In the case of the three patients reported in this communication, no pre-or intra-bypass exchange transfusions were performed and no adverse sequelae ensued in all the three cases. Meticulous care was however taken to avoid dehydration, hypoxia and acidosis during bypass. This was done by maintaining a good flow rate through the bypass machine, a high flow of oxygen through the oxygenator and correction of acidosis by the use of 8.4% sodium bicarbonate infusions. Metras and co-workers also performed cardiopulmonary bypass in sickle-cell haemoglobinopathy patients without preoperative exchange transfusions[9]. In their series however, thirteen subjects had only sickle cell traits and none the SS genotype. There is no consensus regarding hypothermia during bypass in subjects with sickle cell haemoglobinopathy. Potential dangers of hypothermia include vasoconstriction, slugging of red cells and increased capillary transit time and risk of sickling of red cells. Some workers have therefore avoided using hypothermia during cardiopulmonary bypass in sickle cell disease[10]. There is some evidence that hypothermia appears to slow in vitro polymerisation of Hb S and delay the onset of sickling of the red cells.

Indeed, a number of studies have successfully employed hypothermia in patients with sickle cell trait and sickle disease undergoing cardiopulmonary bypass during cardiac surgery[2,6,7]. Moderate hypothermia did not adversely affect our patients.

In order to avoid prosthetic-valve associated haemolysis, the use of prolonged anticoagulant therapy in chronically anaemic patients, and reoperation for degenerated bioprosthesis, some workers hae advvocated the use of valve repair instead of valve replacement in sickle cell disease[10]. We opted for prosthetic valve replacement in the two cases with mitral regurgitation for the following reasons. Bioprosthesis have a faster rate of degeneration in younger people[13]. Secondly, our subjects with rheumatic heart disease usually had advanced disease even at a young age with degeneration of the subvalvular mitral apparatus making repair of the valve difficult. Finally the cost of cardiac surgery is relatively prohibitive and reoperation later for degenerated bio prossthesis may be impossible to fund. On review four years after surgery for the first two cases, they were well on anticoagulant therapy. Only the last case, who was not on anticoagulanta had one episode of crises in the last two years requiring a blood transfusion. She was not on any warfarin since she had only an anulopasty done. It is worthy to note that in the first reported case of mitral valve replacement in sickle cell anaemia by Craenen et al[11], the patient had experienced no sickling crisis on coumadin two years after operation. It appears that anticogulation may protect against haemolysis and vaso-occlusive crises. Increased cardiac performance and improved oxygenation may, however, be partly responsible for the absence of sickling crises in these patients. Furthermore, the frequency of sickling crises is known to decrease with age.

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