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Original Research Article

Perioperative anesthesia management in patients with sickle cell hemoglobinopathies for open heart surgery: Retrospective analysis of 15 cases

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Abstract

Introduction: Sickle cell hemoglobinopathies spectrum varies from benign sickle cell trait to fatal sickle cell disease. It is recessively inherited genetic disorder, results from mutation chromosome 11 which further ends up matching with valine rather than glutamine at ß-globin gene. Occurance is common in india specifically in central india. Hypoxia, hypercarbia, hypothermia, dehydration increases sickling and these events are not uncommon in intra and postoperative periods in patients undergoing cardiac surgery on cardiopulmonary bypass. Timely and proper interventions by anesthesiologist are needed to avoid these events and improve outcome of patients.

Methodology: We here analyzed successful outcome of 15 cases done in 2 years at Achary Vinoba Bhave Rural Hospital Sawangi meghe, Wardha and discussed in details interventions for better outcome of patients undergoing cardiac surgery on cardiopulmonary bypass.

Conclusion: By following multidisciplinary approach, intra and post operative course was uneventful and with sickle levels such as those presented here, we feel that this technique has significant benefits.

Keywords: Sickle cell Trait, Open Heart Surgery, Cardiopulmonary Bypass, Anesthesia Management in sickle cell trait

1. Introduction

Sickle cell hemoglobinopathies are inherited disorders, ranging from the benign sickle cell trait (SCT) to the fatal sickle cell anemia. Sickle cell disease (SCD) is a homozygous genotype (HbSS), with the fractional concentration of HbS varying from 70-98%. Sickle cell disease (SCD) is commonly encountered in African population and also found in Indians.[1] Patients with Sickle cell hemoglobinopathies who undergoing cardiac surgery are at risk of a fatal sickle cell crisis, which may be induced by acidosis, low-flow states or hypothermia hypoxia.[2] Hence, the special considerations are required, and modification of routine perioperative management, for better outcome and good prognosis in patients with Sickle cell hemoglobinopathies who undergo open cardiac surgery.

Nevertheless, literature on the evaluation and specific management of these patients remains limited, and further studies are strongly recommended. The aim of our study was to retrospectively analyze outcome of 15 patients with sickle cell hemoglobinopathy who have underwent open heart surgery at our institution, Acharya vinoba bhave rural hospital, Sawangi(Meghe), Wardha.

2. Materials and methods

2.1 Study design: Retrospective study

2.2 Sample size: Fifteen patients

2.3 Inclusion criteria:

A total of 15 patients with sickle cell trait who underwent cardiac surgery during the years 2013 & 2014 and required cardiopulmonary bypass at our institute were reviewed from the hospital record, retrospective manner.

2.4 Parameters:

In this study we recorded parameters, like duration of cardiopulmonary bypass, duration of aortic cross clamp time, hemoglobin level, blood pH, base excess and fluid balance during preoperative, intraoperative and postoperative period. In intraoperative period, we record the hemoglobin level in blood ABG before induction of anesthesia, on cardiopulmonary bypass and after cardiopulmonary bypass. In postoperative period, hemoglobin level, blood pH and base excess in post extubation and 24 hrs after shifting the patient. Overall fluid balance was recorded on postoperative day one morning.

2.5 Anesthesia management

Detailed history about all patients received their cardiac medications until the morning of surgery. Oral solid intake was stopped 6 hrs before surgery. Oral clear fluid like water and lemon juice was allowed till 2 hrs before shifting patients to operating room. Routine premedication in the form of Tab. Pantoprazole 40mg orally was given 2 hours before surgery, in adult patients. In pediatric patients, Inj. Midazolam 0.05 mg/kg IV was given 15 mins prior to induction. Arterial and central venous cannulation was done under local anesthesia before induction of anesthesia in adult patients and after induction of anesthesia in pediatrics patients.

Anesthesia was induced with intravenous midazolam (0.05-0.1mg/kg), fentanyl (2-3µg/kg) and thiopental (1-2mg/kg) after preoxygenation. Vecuronium (0.1mg/kg) was used for muscle relaxation. After intubation, all patients were ventilated with 100% oxygen. Anesthesia was maintained with isoflurane in adult patients, and sevoflurane in pediatric patients, in oxygen and air. Further incremental doses of fentanyl up to 10-15µg/kg were administered during the operation. Arterial blood pressure, central venous pressure, electrocardiogram, saturation with pulseoxymetry, and rectal temperature were monitored during and after surgery.

All patients were transferred to the intensive care unit while still under full anesthesia. Patients were extubated when optimal cognitive, hemodynamic, and respiratory functions were achieved. For postoperative pain management, paracetamol 15 mg/kg every 6 hourly were administered in adult patient and fentanyl 0.5µg/kg/min was administered in pediatrics patients. Tranexamic acid (10 mg/kg bolus) was given after induction of anesthesia, to prevent bleeding complications.

2.6 Cardiopulmonary bypass:

All patients underwent open heart surgery requiring cardiopulmonary bypass. The bypass circuit volume was arranged to be 3 times the patient's circulating volume. In priming solution we used volulyte, ringer's lactate, mannitol (1g/kg), sodium bicarbonate (1ml/kg). These volumes were adjusted according to the age, weight, and body surface area of each individual patient to reach a minimum hematocrit value of 25 - 30% during CPB. Additional crystalloid, colloid, or red blood cells were added to the CPB circuit as needed according to the desired hematocrit levels (25 – 30%) as indicated in ABG's.

Modifications done from routine protocol were as follows. During CPB, active cooling of patients was avoided. Temperature was maintained approximately 35°C monitored by rectal probe. pH of the blood during CBP was maintained between 7.40 and 7.44. The flow was adjusted as body surface area times cardiac index (2.4 to 2.6 L/m^2 of body surface area for the adult patients; 2.4 to 2.8 L/m^2 of body surface area for the pediatric patients). There is a potential risk of sickling within the coronary arteries with the administration of cold cardioplegia under the cross clamp, so we administered normothermic blood cardioplegia.

3. Results

All patients were belonging to sickle cell trait. Out of 15 patients, 11 patients were female and 4 patients were male. Age range from 3 yr to 52 yrs. Only 3 patients were pediatrics. Nine patients were for mitral valve replacement, one patient for double valve replacement (aortic and mitral), four patients for ventricular septal defect closure and one for atrial septal defect closure.

Cardiopulmonary bypass time ranged from 48 mins to 134 mins (mean 79.2 ± 23.3 min). maximum time of CPB was 134 mins for double valve replacement. Cross clamp time ranged from 18 mins to 64 mins (41.66 ± 11.43 mins). None of the patients received preoperatively blood transfusion. Preoperative hemoglobin were range from 8.7 to 14.2 gm% (avg 12.16 ± 1.6). pH of blood range from 7.31 to 7.44 (7.37 ± 0.04). During CPB pH ranged from 7.35 to 7.46 (7.39 ± 0.02). Correction was done with sodium bicarbonate done to keep pH near 7.4 or slightly above.

Post cardiopulmonary bypass, pH ranged from 7.37 to 7.46 (7.4 ± 0.03). Hemoglobin was range from 8 to 10.4 gm% (9.4 ± 1.3). Hemoglobin was corrected with blood transfusion if hemoglobin level falls below 10 gm%.

In post extubation and next 24 hours we tried to keep the pH near 7.4. If it is less than 7.4, corrected with sodium bicarbonate solution. Special attention was given to fluid balance. It was kept purposely on positive side in preoperative and postoperative period.

No mortality or complication from sickle cell seen during observation period. Average number of blood transfusion required in these patients was 0.13. Patients were given oxygen on mask after extubation for 2 days.

Table 1: Showing demograohic and opearive data

Demographic Data		
Age	**Gender**	**Diagnosis**
14	F	MS
45	F	MS
40	F	VSD
30	F	MS
50	F	MS
3	F	VSD
3	M	VSD
42	F	MS
46	M	MS
15	M	MS
2	F	VSD
38	F	AS with MS
52	F	MS
24	M	ASD
27	F	MS

MS= Mitral stenosis, AS= Aortic stenosis, ASD= Atrial septal defect, VSD= Ventricular septal defect

Table 2: Showing preoperative, intraoperative and postoperative Cardiopulmonary bypass (CPB) Hb & acid-base balance

Preoperative			During CPB			Post CPB			Postextubation			After 24 hrs		
pH	Hb	BE	pH	Hb	BE	pH	Hb	BE	pH	Hb	BE	pH	Hb	BE
7.34	12.3	1.2	7.35	8.1	2.4	7.40	10.3	1.4	7.39	10.5	1.6	7.42	10.1	0.6
7.42	11.8	1.1	7.44	7.6	2.4	7.38	9.5	1.3	7.42	10.1	1.2	7.40	9.6	1
7.36	10.2	0.8	7.38	6.3	3.1	7.39	8.4	0.9	7.44	9.6	-0.4	7.46	9.3	2.1
7.38	11.5	-0.9	7.36	7.1	2.3	7.37	9	-2.1	7.40	9.4	-0.1	7.38	9	-1.2
7.40	10.8	-1.2	7.37	6.8	2.5	7.41	8.9	-0.7	7.43	9.7	2.1	7.44	9.1	1.5
7.39	12.7	2.1	7.41	8	2.8	7.45	10.4	1.5	7.35	11.3	1.8	7.40	10.9	1.1
7.41	13.2	-1.6	7.38	7.9	3.2	7.43	10.1	2.4	7.39	11.6	1.6	7.42	10.7	-0.8
7.33	10.6	1.4	7.37	6.8	2.9	7.38	8.2	-2	7.43	9.8	0.4	7.41	10	-1.6
7.32	13.5	3.2	7.39	8.2	2.9	7.45	10.4	2.1	7.41	11.1	1.5	7.45	10.4	2.2
7.30	12.2	-0.7	7.42	6.3	2.8	7.46	8	0.5	7.41	10.2	-1.2	7.38	9.8	1.3
7.40	14.2	-4.4	7.41	8.2	3	7.38	11.1	-2.4	7.42	12.7	-1	7.46	11.8	-1.7
7.31	14	-0.1	7.39	9.1	2.3	7.37	10.8	1.3	7.45	11.8	2.1	7.39	11.2	1.2
7.44	8.7	-0.1	7.40	5.4	2.7	7.42	6.2	-1.7	7.38	7.5	-0.7	7.45	9.2	1.1
7.42	12.3	1.2	7.46	8.1	2.4	7.41	10.3	1.4	7.45	10.9	2.5	7.39	9.8	0.8
7.43	11.8	1.1	7.41	7.6	2.4	7.43	9.5	1.3	7.46	10.3	-0.5	7.44	9.1	-0.9

HB= hemoglobin (g/dl), BE= Base excess (mmol/L), CPB= cardiopulmonary bypass

Table 3: Showing fluid balance (hydration status)

Fluid Balance (ml)		
Preoperative	Intraoperative	Postoperative
+ 180	- 200	+ 210
+ 220	- 240	+ 270
+ 240	+ 160	+ 300
+ 270	- 210	+ 220
+ 300	- 180	+ 250
+ 150	+ 90	+ 110
+ 130	+ 110	+ 130
+ 260	- 230	+ 280
+ 240	- 300	+ 200
+ 180	- 190	+ 260
+ 90	+ 80	+ 100
+ 120	- 350	+ 190
+ 350	- 150	+ 280
+ 250	+ 120	+ 320
+ 240	- 220	+ 230

Table 4: Showing operative data

CPB Time (mins)	CCT (mins)	Procedure
78	40	MVR
86	44	MVR
48	28	VSD Closure
91	48	MVR
85	46	MVR
54	34	VSD Closure
66	41	VSD Closure
88	46	MVR
84	42	MVR
102	58	MVR
50	29	VSD Closure
134	64	DVR
90	42	MVR
40	18	ASD Closure
92	45	MVR

CPB= Cardiopulmonary bypass, CCT= Cross clamp time, MVR= Mitral valve replacement, ASD= Atrial septal defect, VSD= Ventricular septal defect, DVR= Double valve replacement.

4. Discussion

Sickle cell hemoglobinopathy is a recessively inherited genetic disorder which results from the mutation of the substitution of adenine for thymidine, which further ends up matching with valine rather than glutamine at the 6th codon of chromosome 11, i.e., the ß-globin gene.[2-4] Sickle cell hemoglobinopathies may present with SCD, the severe form of which is the homozygous genotype (HbSS), in which the fractional concentration of HbS ranges from 70 – 98% or it can be manifested as SCT, in which the fractional concentration of HbS is <50%.[3]

The solubility characteristics of HbS are severely affected, and after dispersal of oxygen to tissues, the molecule adopts its characteristic sickle shape. Erythrocytes containing high amounts of HbS undergo multiple sickling and desickling events, deforming their conformation and eventually resulting in autolysis and anemia.[3,4] Furthermore, these deformed cells have an increased tendency to adhere to the vascular endothelium, frequently leading to occlusion of small-caliber vessels and causing organ damage. Although regarded as benign, the literature contains information about an increased rate of sudden death during high-stress activities among SCT patients.[3]

The classic precipitating factors for sickling include stress, exposure to cold, dehydration, infections, hypoxia, inflammatory cascades, and acidosis.[1-4] Such conditions lead to potassium efflux, causing formation of insoluble globinpolymers. These molecules increase the viscosity of blood and lead to vasoocclusive phenomena, which include cell sickling, adherence of sickle cells to the endothelium and vasoocclusion.[3-6] Although the risks accompanying sickle cell pathology before high-risk surgery, including orthopaedic and cholecystectomy, have been well stated,[3] the literature contains only small series or case reports on sickle cell patients having cardiac surgery.[1-6]

It should be noted that above-mentioned predisposing conditions are more common in patients undergoing cardiac surgery. Especially during the operation, CPB itself, as well as aortic cross-clamping, low-flow states, topical or whole-body hypothermia, cold cardioplegia, and use of vasoconstrictive agents, may predispose to the crisis state. Hence, special care should be taken in sickle cell patients who require cardiac surgery to avoid or at least to minimize those risk factors.

In managing the cases as we described, we felt that it would be safe to avoid pre-operative exchange transfusion by using the cardiopulmonary bypass machine to decrease sickle load. We were concerned about the potential for precipitation of sickling before cardiopulmonary bypass and therefore meticulous in optimizing circulating volume, avoiding hypothermia and acidosis.

Intravascular dehydration plays important role in precipitantion of SCD complications, as the intracellular dehydration increases haemoglobin concentration, and consequently the rate of sickling.[7,8] Increased plasma osmolarity from a reduced plasma volume can worsen a vaso-occlusive crisis by causing intracellular dehydration, hemoglobin polymerization and further sickling. During hyponatremia, the affinity of hemoglobin S for oxygen is increased. Therefore, at any given PaO_2, less oxygen is in the deoxygenated state, which is the form most susceptible to polymerization. Patients with sickle cell disease have isosthenuria, which leads to difficulty in excreting a sodium load.[9]

Hypothermia has been suggested as a perioperative trigger of SCD complications. [10,11] The mechanisms of the apparent hypothermia induced crisis are unknown, although aberrant vasoconstriction has been suggested as a contributing factor. Iatrogenic hypothermia may be indicated during cardiac and neurosurgical procedures, and there is no direct clinical evidence to demonstrate that this should be avoided in SCD patients.[12]

Therefore, we avoided hypothermia in these patients by taking following steps. 1) We kept operation room temperature to 25° C. 2) We also used forced hot air warmer. 3) Fluid warmer during intraoperative period. 4) In post-operative intensive care unit, we continued the use of fluid warmer, forced hot air warmer and brought operating room temperature to 25° C as early as possible.

Because acidosis hastens red blood cells deformation on exposure to hypoxia,[13,14] acidemia has widely been suggested to be a precipitant of perioperative SCD-complications. Hence, we played keen attention to acid base regulation during and post-operative period.

We also concerned about two additional risks relating to bypass: the cooling effect and the potential for sickling within the coronary vessels during cardioplegia administration. The use of hypothermia is controversial in these cases as it can result in vasoconstriction and sludging with the potential for sickling. We used moderate hypothermia, avoiding cooling before and on bypass, and only cooling to 35°C whilst on cardiopulmonary bypass. All the haemoglobin concentration and acid base balance were monitored on single standard arterial blood gas machine. In this study, we transfused blood to two patients as their haemoglobin levels were below the trigger point of our institute protocol.

5. Conclusion

Our plan i.e. good preoperative hydration, maintain temperature approx 35°C, allowed us to avoid any of the recognised complications of sickle cell hemoglobinopathy in cardiac surgery. All above precautions avoided intraoperative hypoxia, hypovolemia, hypothermia, vasoconstriction and ultimately the crisis. By following multidisciplinary approach, intra and post operative course was uneventful and with sickle levels such as those presented here, we feel that this technique has significant benefits.

References

[1] Firth PG. Anaesthesia for peculiar cells: a century of sickle cell disease. *Br J Anaesth*. 2005; 95: 287–299.
[2] Sachithanandan A, Nanjaiah P, Wright CJ, Rooney SJ. Mitral and tricuspid valve surgery in homozygous sickle cell disease: perioperative considerations for a successful outcome. *J Card Surg*. 2008; 23: 167–168.
[3] Hemming AE. Pro: exchange transfusion is required for sickle cell trait patients undergoing cardiopulmonary bypass. *J Cardiothorac Vasc Anesth*. 2004; 18: 663– 665.
[4] Messent M. Con: exchange transfusion is not required for sickle cell trait patients undergoing cardiopulmonary bypass. *J Cardiothorac Vasc Anesth*. 2004; 18: 666–667.
[5] Heiner M, Teasdale SJ, David T, Scott AA, Glynn MF. Aorta-coronary bypass in a patient with sickle cell trait. *Can Anaesth Soc J*. 1979; 26: 428–434.
[6] Djaiani GN, Cheng DC, Carroll JA, Yudin M, Karski JM. Fast-track cardiac anesthesia in patients with sickle cell abnormalities. *Anesth Analg*. 1999; 89: 598–603.
[7] Bunn HF. Pathogenesis and treatment of sickle cell disease. *N Eng J Med* 1997; 337: 762–69.
[8] Eaton WA, Hofrichter J. Hemoglobin S gelation and sickle celldisease. *Blood* 1987; 70: 1245–66.
[9] Okpala I. The management of crisis in sickle cell disease. *Eur J Haematol*. 1998; 60: 1–6.
[10] Rubenstein E. Studies on the relationship of temperature tosickle-cell anemia. *Am J Med* 1961; 30: 95–8.
[11] Serjeant GR, Ceulaer CD, Lethbridge R, Morris J, Singhal A, Thomas PW. The painful crisis of homozygous sickle cell disease:clinical features. *Br J Haematol* 1994; 87: 586–91.
[12] Firth PG, Head CA. Sickle cell disease and anesthesia. *Anesthesiology*2004; 101: 766–85.
[13] Hahn EV, Gillespie EB: Sickle cell anemia. Arch Intern Med 1927; 39: 233–54.
[14] Bookchin RM, Balazs T, Landau LC: Determinants of red cell sickling:Effects of varying pH and of increasing intracellular hemoglobin concentration byosmotic shrinkage. *J Lab Clin Med* 1976; 87: 597–616.