The emergent use of Cardiopulmonary bypass and extracorporeal membrane oxygenator in a child with sickle cell disease

Le recours urgent à la circulation extracorporelle et à l'oxygénation extracorporelle par membrane chez un enfant drépanocytaire

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RÉSUMÉ

L'utilisation de la circulation extracorporelle (CEC) et de l'oxygénation extracorporelle par membrane (ECMO) chez les patients drépanocytaires nécessite des précautions particulières. Cependant, aucun protocole consensuel n'a été établi.

Cas Clinique : Un garçon âgé de 7 ans a été admis à l'hôpital pour chirurgie urgente d'une endocardite avancée. L'examen physique a noté une fièvre, une dyspnée majeure associée à une altération de l'état hémodynamique. Les tests biologiques explorant une anémie ont révélé un taux d'hémoglobine S (HbS) à 39,1%. L'échocardiographie a montré une importante dilatation des cavités droites avec de multiples végétations aortiques. Dix minutes après l'induction anesthésique, une aggravation brutale de l'état hémodynamique est apparue nécessitant l'assistance urgente par une CEC normothermique avec transfusion par 4 culots globulaires. Après la chirurgie, le patient a été assisté par ECMO pendant 2 jours puis il a succombé.

Conclusion: La chirurgie cardiaque urgente chez les patients drépanocytaires pose un dilemme thérapeutique majeur. Des études prospectives dans le but de définir la bonne place de l'assistance cardio-pulmonaire dans des protocoles thérapeutiques consensuels paraissent indispensables pour une meilleure prise en charge.

Mots-clés

Circulation extracorporelle, drépanocytose, insuffisance cardiaque, anémie, oxygénation extracorporelle par membrane.

SUMMARY

The use of Cardiopulmonary bypass (CPB) and extracorporeal membrane oxygenator (ECMO) in patients suffering from Sickle cell disease (SCD) needs specific precautions. Whereas, no consensual protocols have been established to clarify therapeutic management.

Case Report: A 7-year-old boy was admitted to the hospital for surgery of advanced endocarditis. Major dyspnea, hemodynamic distress and fever were noted on physical examination. Biological tests exploring anaemia revealed Haemoglobin (Hb) S levels of 39.1%. Echocardiography showed important right heart cavities dilation with multiple aortic vegetations. The child was accepted for emergent surgery. Ten minutes after anesthetic induction, serious hemodynamic distress was established. The patient was put on normothermic CPB when he received four packed red-blood-cell. After surgery, he was placed on ECMO support for 2 days than he succumbed.

Conclusion: Urgent cardiac surgery in patients suffering from SCD poses a major therapeutic dilemma. Multiplying case reports and encouraging prospective studies are necessary to define the right place of cardio-pulmonary assistance in treatment protocols for better management.

Key-words

Cardiopulmonary bypass, sickle cell disease, heart failure, anaemia,extracorporeal membrane oxygenator.

Sickle cell disease (SCD) is an inherited disorder that usually needs specific precautions especially in the peri-operative period (1). Cardiopulmonary bypass (CPB) in patients suffering from SCD may trigger a crisis of profound magnitude. Actually, there is a big lack of consensus that could clarify therapeutic management in such cases (2,3). Herein, we report the case of a patient who had SCD and required urgent double valve replacement.

CASE REPORT

A 7-year-old boy operated at the age of 2 months of percutaneous dilation of congenital aortic stenosis, was admitted to the hospital for persistent fever, worsening dyspnea and consciousness disorders complicating community bronchitidis. There was no prior history of any sickle-cell crisis or blood transfusions. Preoperative exploration of moderate anemia (Haemoglobin(Hb) =8.9g/dL) revealed on electrophoresis HbS level of 39.1% along with HbA level of 57.3%, and HbA2 of 3.6%. Diagnosis of SCD in its minor form was maintained since no further clinical symptoms were noted. Physical examination demonstrated apparent distress, major polypnea (respiratory rate: 60 cycles/min), dizziness and shortness of breath at rest. Diffuse crackles were present on pulmonary auscultation with systolic murmur on aortic valve area. Electrocardiogram showed supraventricular tachycardia (170 cpm) with no ST or T wave abnormalities. Echocardiography done in emergency found multiple aortic and mitral vegetations associated with severe regurgitation in each valve (grade 3). It revealed also important dilation of the right cavities, intensive tricuspid regurgitation with pulmonary hypertension of 65mmHg, and a 3 cm diameter patent ductus arterious. Left ventricular systolic function was relatively conserved (LVEF= 73 %).

The child was accepted for urgent surgery of advanced endocarditis without preoperative exchange transfusion.

General anesthesia was induced with etomidate (0,3mg/kg), sufentanyl (0.3γ/kg) and cisatracurium (0,15mg/kg). We take meticulous care to avoid hypoxia, acidosis, hypotension and dehydration in this patient. The circuit was primed with Ringer's lactate solution, 250 ml of 5% human serum albumin, 11.2% sodium bicarbonate, and 1 unit of blood. Ten minutes after the induction course, severe hypotension, hypoxemia, and bradycardia have suddenly appeared leading to cardiac arrest. Cardiopulmonary resuscitation led to hemodynamic improvement after 15 minutes and a total of 12.5 mg of Adrenaline. The patient's chest was emergently explored and urgent CPB was instituted with normothermic bypass conducted using aortic and bicaval cannulas with high inspiratory fraction of oxygen on the oxygenator (FiO2=100%) and a pump flow about 2,8 round/min (to maintain venous oxygen saturations above 75 %). Heparinization was achieved with 300 units·kg-1. Tranexamic acid was given as an antifibrinolytic drug. Myocardial protection was achieved with delivery of continuous antegrade warm blood cardioplegia every 20 minutes. Then, the aortic and mitral valve were excised, and replaced by prosthesis.

While on CPB, the patient received four packed red-blood-cell transfusions in order to decrease HbS levels and increase total Hb. Biological tests and CPB data are showed on table 1.

Table 1 : Summary of bypass data

	Before surgery	After CA Before CBP	At the end of CBP
Arterial pH		7.18	7.14
Arterial PaCO2 (mmHg)		27	24
Arterial PaO2 (mmHg)		415	419
Arterial SaO2 (%)		99.9	100
Arterial HCO3 (mEq/l)		10.1	6.3
Haemoglobin (g/dL)	8.9	6.5	11.2
Arterial blood pressure (mmHg)	110/55	50-75	60-75
Adrenaline dose (mg/h)	0.1	12	5
Temperature (°C)	37.2	36.5	37.4

Coming over CPB, the heart was incapable to restore sufficient cardiac output capable of perfusion besides high doses of catecholamines. The right atrium, the pulmonary artery and the ascending aorta were cannulated, and the patient was placed on extracorporeal membrane oxygenation (ECMO) support.

The patient was transferred to the intensive care unit, kept warm with a warming blanket and high inspiratory fraction of oxygen. The evolution was marked by persistent acidosis, the need of progressive doses of catecholamines and the appearance of multi-organ failure. He succumbed two days after surgery.

DISCUSSION

SCD is one of the most common genetic disorders world-wide. It concerns 10-30% of people in Equatorial Africa but it is infrequent in North and South Africa (4,5).It results from inheritance of a mutant version of the β-globin gene on chromosome 11 which codes for assembly of the β-globin chains of the haemoglobin A (HbA). The mutant β-allele codes for the production of the variant haemoglobin: haemoglobin S (HbS) (4,6,7).

Deoxygenation of erythrocytes containing high amounts of HbS (PaO2< 25 mmHg in the heterozygous state, or PaO2< 40 mmHg in the homozygous form) induces potassium efflux, which increases cell density and the tendency of HbS to polymerize(8,9). Then, sickle cells, normally discshaped, become crescent-shaped, causing small blood clots that give rise to recurrent episodes of vaso-occlusive crisis, hemolytic anaemia, narcotic abuse

and multisystem disease (5,10,11). The classic precipitating factors for sickling include stress, exposure to cold, dehydration, infections, hypoxia, inflammatory cascades, and acidosis making major surgery with prolonged anesthesia a greater risk in this population (4,12).

Furthermore, a recent meta-analysis has demonstrated that Sickle cell patients have an abnormal dilatation of the left ventricular with a lower load-independent systolic function (13). Cardiovascular manifestations include also right ventricular systolic and diastolic dysfunction, myocardial ischaemia and pulmonary hypertension resulting from intravascular haemolysis. The majority of these abnormalities is correlated with age and become impairing over the time (14,15). The cardiac arrest in our situation results mainly from right heart failure resulting from severe valvular dysfunction, septic dysregulation, pulmonary hypertension and positive intra-thoracic pressure due to mechanical ventilation.

The literature contains only small series or case reports on sickle cell patients having cardiac surgery (16,17). During the operation, cardio-pulmonary bypass (CPB), aortic cross-clamping, low-flow states, hypothermia, cold cardioplegia, and use of vasoconstrictive agents, may predispose to the crisis state (5,8,18).

There is no consensus on absolute safe values of HbS in patients undergoing surgery. But, it is generally agreed that the level of HbS should be reduced to 30% for major surgical procedures, or even 5% for cardiac surgery before or at the time of surgery (8,17). Partial exchange transfusion can -at the same time- decrease HbS level and increase the preoperative hematocrit and then oxygen delivery to the organs. In addition, using blood for priming the circuits can reconcile the aim (3,12). In our situation, surgery was extremely urgent and there was no time to exchange transfusion. Nevertheless, this latter might have better effect on prevention of hemodynamic distress with better outcome.

In some series, initial institution of warm cardioplegia; in order to wash out the existing blood in coronary arteries; followed by normothermic bypass is recommended (7,11). In others, systemic hypothermia may be employed together with cold cardioplegic arrest (3,9,19). In fact, it was experimentally demonstrated that hypothermia may 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. 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. This would suggest that hypothermia, hemodilution and vasodilation should to some extent have a protective effect in preventing sickling (7,9). Our team found that normothermic bypass, using warm blood cardioplegia was the safest options in our case.

In general, continuous control of venous oxygen content, keeping the pH alkalotic, using of warming blankets, maintenance of adequate blood flow, and close monitoring of laboratory results are essential in the management of sickle cell patients. The patient's venous blood oxygen saturation on CPB have to be kept above 80% at all times, hematocrit must be kept at 20%-30% and postoperative pain must be meticulously minimized for these patients (5,9,17).

On another hand, the use of ECMO have progressively increased in the last two decades since its indications have been largely expanded (20,21): It remains the main technique used for pediatric extracorporeal life support after cardiac surgery even if there is no encouraging survival statistics (22,23). Till today, there are neither standardized indications nor recommended protocols to manage ECMO cardiac infants (24). Some authors were interested in poor prognosis factors: Kolovos et al (25) found that patients with single ventricle physiology and others who need dialysis during ECMO are less likely to survive. Baslaim et al (26) noted that renal dysfunction, stroke, disseminated intravascular coagulopathy, high levels of lactate, potential need for catecholamines and long duration of ECMO are all limiting prognostic factors. The situation became more complicated with sickle cell patients: Kuo et al (27) found that only 52% of pediatric patients with SCD placed on ECMO were successfully treated; of those only 43% receiving venoarterial (VA) ECMO survived. Our patient initially suffers from right heart dysfunction complicated firstly by cardiac arrest requiring high doses of catecholamines after resuscitation and secondly by renal dysfunction and multi-organ failure.

CONCLUSION

The management of sickle cell patients proposed for emergent cardiac surgery poses a major therapeutic dilemma such as in timing of admission to the operating theatre, the type of CPB and the indication of post-operative cardiac assistance. Our case illustrates an example of management difficulties especially after deterioration of pre-existing right heart dysfunction.

By multiplying case reports and encouraging prospective studies about cardiac surgery in SCD, consensual protocols could be established to pre-define basic recommended attitudes and to clarify different therapeutic options especially in serious complicated situations.

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