Hypothermic cardiopulmonary bypass without exchange transfusion in sickle-cell patients: a matched-pair analysis

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Abstract

OBJECTIVES: Sickle-cell patients undergo cardiopulmonary bypass (CPB) surgery in our institution without perioperative exchange transfusion. We sought to determine whether this protocol increased mortality or important sickle-cell-related complications.

METHODS: We adopted a 1:1 matched-pair case-control methodology to evaluate the safety of our protocol. Sickle-cell patients who underwent CPB between January 1995 and January 2014 were matched with haemoglobin AA (HbAA) controls according to sex, age, weight and type of cardiac procedure.

RESULTS: Thirty-three sickle-cell patients (21 HbAS, 7 HbSS and 5 HbSC) underwent CPB surgery using our institutional protocol. Sickle-cell patients and controls were similar according to the matching criteria. Preoperatively, haemoglobin SS (HbSS) and haemoglobin SC (HbSC) patients were anaemic (8.5 ± 1.4 vs 13.5 ± 1.9 g/dl; P <0.01 and 11.0 ± 0.6 vs 12.7 ± 0.9 g/dl; P = 0.01, respectively). Operative procedures included valve repair and replacement (12) as well as repair of congenital cardiac malformations (21). The duration of CPB and lowest CPB temperatures was similar for sickle-cell patients and controls. Systemic hypothermia (23.8–33.5°C), aortic cross-clamping, cold crystalloid antegrade cardioplegia and topical hypothermia were used in sickle-cell patients without complications. There was no acidosis, hypoxia or low cardiac output state. No mortality or important sickle-cell-related complications occurred. Although blood loss was similar between sickle-cell patients and controls, HbSS (unlike HbAS and HbSC) patients required more blood transfusion than controls (30.0 ± 13.3 vs 10.8 ± 14.2 ml/kg; P = 0.02) to counter haemodilution and replace blood loss. In-patient stay was similar for sickle-cell patients and controls.

CONCLUSIONS: Perioperative exchange transfusion is not essential for a good outcome in sickle-cell patients undergoing CPB. A simple transfusion regimen to replace blood loss is safe in HbSS patients; blood transfusion requirements for HbSC and HbAS patients undergoing CPB are similar to those of matched HbAA controls. The use of systemic hypothermia during CPB does not increase sickle-cell-related complications. Cold crystalloid cardioplegia and topical hypothermia provide safe myocardial protection without the need for more sophisticated measures.

Keywords: Haemoglobinopathy • Sickle-cell anaemia • Exchange transfusion • Cardiopulmonary bypass • Hypothermia • Surgery

INTRODUCTION

Sickle-cell haemoglobinopathy is a group of genetic disorders characterized by the presence of haemoglobin (Hb)S, an abnormal variant of HbA, in red cells of affected individuals. Red cells of sickle-cell patients contain HbAS, haemoglobin SS (HbSS), haemoglobin SC (HbSC) or combinations of rarer variant Hbs.

Individuals with HbAS have the sickle-cell trait; those with HbSS or HbSC have sickle-cell disease. Sickle-cell disease is characterized by chronic haemolytic anaemia, recurrent painful vaso-occlusive crises with progressive multisystem damage and reduced survival. Under extreme conditions, such can occur during cardiopulmonary bypass (CPB), patients with the sickle-cell trait can manifest the risk profile of sickle-cell disease [1].

Sickle-cell patients undergoing CPB are at risk of potentially fatal sickle-cell-related complications, which can be induced by hypoxia, hypothermia, acidosis or low-flow states [2]. Most studies on sickle-cell patients undergoing CPB are case reports or small case series. Consequently, optimal management of these patients is surrounded by much controversy. Current perioperative protocols emphasize reducing the blood concentration of HbS through exchange transfusion to diminish the likelihood of sickle-cell-related complications. Even though no definitive control data have been reported, exchange transfusion to reduce the HbS fraction to less than 30% is generally recommended [2] for sickle-cell patients undergoing CPB procedures. We reported earlier [3, 4] that hypothermic CPB could be performed safely in sickle-cell patients without perioperative exchange transfusion. We have since used the same approach in all sickle-cell patients undergoing CPB in our institution.

The current study was undertaken to evaluate the safety of our protocol. Specifically, we sought to determine whether hypothermic CPB performed in sickle-cell patients without exchange
transfusion increased mortality or important sickle-cell-related complications.

MATERIALS AND METHODS

Ethical approval for the study was waived. A retrospective analysis of all sickle-cell patients who underwent open heart surgery in our institution between January 1995 and January 2014 was carried out. Primary outcomes for the study were early mortality and measures of sickle-cell induced organ injury (painful vaso-occlusive crisis, acute chest syndrome, stroke and acute kidney injury). Secondary outcomes were surrogates for haemolysis (hyperbilirubinaemia and haemoglobinuria), blood loss from mediastinal drains, blood transfusion requirement, intensive care unit stay and hospital length of stay.

Setting

The Korle Bu Teaching Hospital (KBTH) is a 2000-bed tertiary institution in southern Ghana where 20% of the population carry the HbS gene; another 10% carry the HbC gene and 2% of newborns have HbSS or HbSC disease [5]. Over four decades ago, KBTH investigators reported data on the perioperative management of sickle-cell patients exchange transfusion was not used in any of the more than 500 patients being administered a general anaesthetic [6]. The cardiothoracic team of the KBTH reported 3 sickle-cell (2 HbSS and 1 HbSC) patients undergoing CPB without exchange transfusion between 1998 and 2001 [3, 4]. The 3 patients are included in this analysis to create a substantive database for the current study.

Patient selection

Between January 1995 and January 2014, all sickle-cell patients who underwent CPB surgery in our institution were enlisted. Of 1038 CPB patients, 33 (3.2%) had sickle-cell haemoglobinopathy on electrophoretic testing as defined by standard criteria [7]. There were 21 HbAS, 7 HbSS and 5 HbSC patients. All HbSS and HbSC patients had past histories of repeated painful sickle-cell crises, whereas this feature was absent in the HbAS patients.

Design

To counter the major prognostic factors, a 1:1 matched-pair case-control methodology was adopted for evaluating the safety of performing CPB without perioperative exchange transfusion in sickle-cell patients. During the study period, patients in the institutional database with haemoglobin AA (HbAA) who underwent CPB surgery were chosen as controls. For each sickle-cell patient, an HbAA patient was matched for sex, age (within 5 years), weight (within 5 kg for patients <12 years; within 10 kg for older patients) and type of intracardiac procedure (identical or nearly identical). When more than 1 control case qualified for selection, the closest match was selected. When no control case met the strict criteria, selection was based on the closest match outside the range. In 5 cases, extensions outside the range were required. These extensions did not affect the overall matching of either group in a statistically significant manner. The EuroSCORE system was used to stratify and compare the operative risk among the groups.

Medical records were reviewed for age, sex, weight, Hb genotype, preoperative steady-state Hb concentration (for HbSS and HbSC patients), anaesthesia, intracardiac procedure performed, aortic cross-clamp time, total CPB time, perioperative blood transfusion, duration of intensive care unit (ICU) and hospital stays, complications and early mortality. Factors that were not matched were evaluated for statistical significance.

Definitions

‘Sickle-cell trait’ (HbAS) patients have red cells with HbS fraction less than 50% [2]. ‘Sickle-cell disease’ patients have red cells with HbS ranging 70–98% [2] in HbSS disease and approximately 50% each of HbS and HbC in HbSC disease [8].

‘Steady state’ in sickle-cell disease patients was defined as a period without blood transfusions within the previous 4 months and the absence of acute episodes (vaso-occlusive crisis, infection, acute chest syndrome, stroke, priapism or acute splenic sequestration) for at least 1 month [9].

Definitions and diagnostic criteria of the phenotypic manifestations of sickle-cell disease used in this study are in keeping with those recently recommended by the Comprehensive Sickle Cell Centers Group [10].

MANAGEMENT PROTOCOL

Patients with HbAS were managed differently from HbSS and HbSC patients; the protocol for HbAS patients undergoing CPB was almost identical to those with HbAA.

Anaesthesia

General anaesthesia is induced with midazolam, fentanyl and propofol (or etomidate in patients with low cardiac output). Muscle relaxation is achieved with pancuronium. All invasive procedures (insertion of central venous and arterial lines) are performed after induction of anaesthesia. Full invasive monitoring is instituted. Anaesthesia on CPB is maintained with a propofol infusion, fentanyl and boluses of pancuronium. After completion of the procedure, patients are transferred to the ICU still under full anaesthesia. Tranexamic acid is given to limit postoperative bleeding. Mechanical ventilation is weaned when optimal postoperative haemodynamic and respiratory functions are achieved. Postoperatively, pain control is maintained with continuous infusion of standard doses of morphine and acetaminophen.

Cardiopulmonary bypass

A blood or crystalloid prime is used according to the desired on-pump haematocrit. In HbSS and HbSC patients, an on-pump haematocrit of 15–20% is targeted. In HbAS patients, a target haematocrit of 30% is used. Patients are cooled to the desired core temperature after CPB is instituted. During bypass, flow is kept between 80 and 150 ml/kg/min with a perfusion pressure of at least 55 mmHg. The arterial pO2 is kept close to 300 mmHg, and the pH between 7.40 and 7.45 in HbSS and HbSC patients.
patients prior to separation from CPB. We aim to get the post-bypass haematocrit between
nasopharyngeal temperatures not less than 36°C before terminating CPB: cardiopulmonary bypass; Hb: haemoglobin; ICU: intensive care unit; Δ—change in serum levels, i.e. postoperative minus preoperative.

### RESULTS

#### Statistical analysis

The patients were separated into three groups for data analysis: HbAS, HbSS, and HbSC patients. For differences in categorical variables, the groups were compared using the chi-squared test assuming equal variance; a p-value of <0.05 was considered statistically significant. Statistical analysis was performed using the Microsoft Excel 2007 software.

There was no statistically significant difference in terms of sex, age, weight, and total CPB time (Table 2). Systemic hypothermia ranged from 23.8 to 33.5°C. The risk profiles of cases and controls were comparable according to the EuroSCORE risk profile (Table 1).

#### Postoperative transfusion triggers/targets

Postoperatively, a Hb concentration close to the preoperative steady-state value (preferably not exceeding 10 g/dl) is targeted for HbAS patients. A HbSC patients is targeted to avoid undue hyperviscosity; a Hb concentration of at least 10 g/dl is targeted for HbAS patients.

#### Table 1: EuroSCORE risk profile of sickle-cell patients and controls

<table>
<thead>
<tr>
<th>EuroSCORE</th>
<th>HbAS (n = 21)</th>
<th>HbAA (n = 21)</th>
<th>P-value</th>
<th>HbSS (n = 7)</th>
<th>HbAA (n = 7)</th>
<th>P-value</th>
<th>HbSC (n = 5)</th>
<th>HbAA (n = 5)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>7</td>
<td>21</td>
<td></td>
<td>5</td>
<td>5</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>15.8 ± 11.9</td>
<td>16.9 ± 13.6</td>
<td>0.8</td>
<td>13.6 ± 8.0</td>
<td>14.9 ± 10.1</td>
<td>0.8</td>
<td>13.2 ± 5.4</td>
<td>12.6 ± 5.4</td>
<td>0.87</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>38.7 ± 20.6</td>
<td>37.9 ± 21.7</td>
<td>0.92</td>
<td>36.6 ± 28.2</td>
<td>34.4 ± 21.7</td>
<td>0.88</td>
<td>38.2 ± 14.0</td>
<td>37.0 ± 16.4</td>
<td>0.90</td>
</tr>
<tr>
<td>Preoperative Hb (g/dl)</td>
<td>13.2 ± 1.5</td>
<td>12.3 ± 1.9</td>
<td>0.14</td>
<td>8.5 ± 1.4</td>
<td>13.5 ± 1.9</td>
<td>&lt;0.01</td>
<td>11.0 ± 0.6</td>
<td>12.7 ± 0.9</td>
<td>0.01</td>
</tr>
<tr>
<td>Aortic cross-clamp time (min)</td>
<td>58.5 ± 22.1</td>
<td>54.2 ± 18.5</td>
<td>0.53</td>
<td>56.0 ± 23.1</td>
<td>57.9 ± 34.6</td>
<td>0.91</td>
<td>39.0 ± 14.0</td>
<td>50.2 ± 18.6</td>
<td>0.31</td>
</tr>
<tr>
<td>Total bypass time (min)</td>
<td>100.6 ± 33.4</td>
<td>92.5 ± 24.9</td>
<td>0.38</td>
<td>92.3 ± 29.1</td>
<td>94.6 ± 31.9</td>
<td>0.09</td>
<td>74.4 ± 18.8</td>
<td>92.6 ± 25.4</td>
<td>0.23</td>
</tr>
<tr>
<td>Lowest CPB temperature (°C)</td>
<td>28.4 ± 2.6</td>
<td>28.9 ± 2.3</td>
<td>0.54</td>
<td>27.9 ± 2.8</td>
<td>29.3 ± 2.0</td>
<td>0.3</td>
<td>30.4 ± 2.6</td>
<td>28.7 ± 1.8</td>
<td>0.28</td>
</tr>
<tr>
<td>Mediastinal bleeding (ml)</td>
<td>739 ± 497</td>
<td>1009 ± 878</td>
<td>0.24</td>
<td>727 ± 332</td>
<td>663 ± 524</td>
<td>0.79</td>
<td>493 ± 190</td>
<td>827 ± 561</td>
<td>0.24</td>
</tr>
<tr>
<td>Postoperative Hb (g/dl)</td>
<td>9.8 ± 1.5</td>
<td>9.1 ± 1.4</td>
<td>0.14</td>
<td>7.3 ± 2.0</td>
<td>9.8 ± 2.0</td>
<td>0.04</td>
<td>9.7 ± 2.5</td>
<td>9.8 ± 1.1</td>
<td>0.95</td>
</tr>
<tr>
<td>Total blood transfused (ml)</td>
<td>429 ± 465</td>
<td>664 ± 803</td>
<td>0.21</td>
<td>854 ± 265</td>
<td>357 ± 520</td>
<td>0.04</td>
<td>490 ± 407</td>
<td>450 ± 318</td>
<td>0.87</td>
</tr>
<tr>
<td>Blood transfused (mg/dl)</td>
<td>13.9 ± 13.7</td>
<td>16.5 ± 13.4</td>
<td>0.52</td>
<td>30.0 ± 13.3</td>
<td>19.8 ± 14.2</td>
<td>0.02</td>
<td>131 ± 9.9</td>
<td>181 ± 135</td>
<td>0.53</td>
</tr>
<tr>
<td>Inotropic support (days)</td>
<td>22.2 ± 1.8</td>
<td>21.1 ± 1.7</td>
<td>0.8</td>
<td>19.1 ± 1.6</td>
<td>2.0 ± 2.6</td>
<td>0.9</td>
<td>1.6 ± 0.5</td>
<td>1.8 ± 0.8</td>
<td>0.72</td>
</tr>
<tr>
<td>ICU stay (days)</td>
<td>43.1 ± 18.8</td>
<td>38.1 ± 13.3</td>
<td>0.34</td>
<td>5.9 ± 2.9</td>
<td>4.0 ± 1.9</td>
<td>0.18</td>
<td>3.2 ± 1.1</td>
<td>4.4 ± 2.1</td>
<td>0.29</td>
</tr>
<tr>
<td>Hospital stay (days)</td>
<td>11.8 ± 5.4</td>
<td>11.2 ± 2.9</td>
<td>0.71</td>
<td>15.3 ± 5.3</td>
<td>11.9 ± 3.7</td>
<td>0.18</td>
<td>10.6 ± 3.6</td>
<td>11.6 ± 3.6</td>
<td>0.67</td>
</tr>
<tr>
<td>Δ Creatinine (µmol/l)</td>
<td>62.7 ± 25.6</td>
<td>66.1 ± 23.9</td>
<td>-</td>
<td>56.7 ± 15.6</td>
<td>82.3 ± 44.3</td>
<td>-</td>
<td>50.2 ± 9.8</td>
<td>58.8 ± 16.9</td>
<td>-</td>
</tr>
<tr>
<td>Δ Bilirubin (µmol/l)</td>
<td>69.2 ± 31.5</td>
<td>991 ± 103.6</td>
<td>P = 0.17</td>
<td>64.4 ± 13.3</td>
<td>83.4 ± 45.2</td>
<td>P = 0.96</td>
<td>520 ± 18.1</td>
<td>753 ± 38.6</td>
<td>P = 0.41</td>
</tr>
</tbody>
</table>
| Δ—change in serum levels, i.e. postoperative minus preoperative.
Primary outcomes

No mortality occurred among sickle-cell patients. No episode of painful vaso-occlusive crisis, acute chest syndrome, acute kidney injury or stroke occurred in any sickle-cell patient. A 4-year old HbSS patient was returned to the operating theatre 3 h after a ventricular septal defect (VSD) repair for closure of a residual VSD not detected intraoperatively. He underwent a second CPB run for correction of the residual defect at a systemic temperature of 32° C, aortic cross-clamp time of 32 min and total CPB time of 55 min. His postoperative recovery was uneventful with an ICU stay of 4 days and overall hospitalization of 9 days. A 10-year old male HbSS patient developed a left lower lobar opacity, hypoxaemia (SpO2 of 85–94%) and leucocytosis (24 × 10⁹/l) 4 days after an otherwise uneventful atrial septal defect repair. He was kept in the ICU on suspicion of acute chest syndrome but, on haematological consultation, criteria for acute chest syndrome were not fulfilled: the peak temperature recorded was 38°C, with minimal constitutional symptoms and complete resolution in 6 days on conservative measures (hydration, chest physiotherapy, oxygen inhalation and antibiotics). Blood cultures yielded no isolates; he was considered to have suffered atelectasis.

Acute kidney injury did not occur in any sickle-cell patient as determined by pre- and postoperative serum creatinine estimations (Table 2). One HbAA patient who underwent mitral valve replacement developed low cardiac output postoperatively and died from postoperative acute kidney injury on the 8th postoperative day despite renal replacement therapy.

Secondary outcomes

Blood loss. Postoperative bleeding assessed by total mediastinal drainage was similar between sickle-cell patients and controls. Two patients (1 HbSS and 1 HbSC) developed traumatic nasal mucosal bleeding during upper airway intubation after induction of anaesthesia. In the postoperative period, blood transfusion and intervention (adrenaline-soaked sponges in the nasopharynx) by the otorhinolaryngology team was required. Moderate gnathopathy was present in both patients.

Blood transfusion requirements. Blood transfusion requirement was significantly higher in HbSS patients compared with matched controls. This was not the case in HbAS or HbSC patients (Table 2).

Haemolysis. Haemoglobinuria was not observed in any patient. The lowest postoperative Hb concentration was significantly lower for HbSS patients than controls, but similar between HbAS and SC patients and controls. Compared with preoperative levels, serum bilirubin was not significantly raised postoperatively in sickle-cell patients (Table 2).

In-patient stay. The duration of ICU stay and hospital length of stay was similar in sickle-cell patients and controls (Table 2).

Overall, there were no statistically significant differences in either primary or secondary outcomes favouring the HbAA group.

DISCUSSION

To the best of our knowledge, this study represents the largest cohort of HbSS and HbSC patients in whom CPB surgery has been performed successfully without perioperative exchange transfusion. The study demonstrates that perioperative exchange transfusion is not essential for a good outcome in these patients if a simple transfusion regimen to replace blood loss and counter haemodilutional anaemia is adopted. With such a protocol, neither mortality nor sickle-cell-related complications are increased. Systemic hypothermia and cold crystalloid cardioplegia appear safe in these patients. In HbAS patients, our findings endorse those of previous investigators that CPB can be performed safely with little alteration to the standard protocol. Our method!ological approach provides a more robust confirmatory dataset on hypothermic CPB surgery in HbAS patients.

Cardiopulmonary bypass for sickle-cell trait patients

Data from early case reports suggested that CPB posed a considerable risk of sickle-cell-related complications in sickle-cell trait patients. A 1967 study reported fatal systemic sickle-cell thrombi in multiple organs of a sickle-cell trait patient after aortic valve replacement [11]. This position was further strengthened in 1989 when Hasleton et al. [1] reported what was thought to be sickling-induced acute respiratory distress syndrome mortality in a 54-year old patient following coronary artery bypass. From such reports, ‘full precautionary measures’ were recommended for sickle-cell trait patients undergoing CPB. However, in 1982, Metras et al. [12] had reported 13 sickle-cell trait patients who tolerated CPB without exchange transfusion. The selection criteria for the control group in that report [12] were not indicated. In 1999, Djiani et al. [13] reported 10 sickle-cell trait patients who underwent coronary artery bypass without exchange transfusion with excellent outcomes similar to those of age, weight and procedure-matched controls. However, in that study, active systemic cooling on CPB was avoided (the minimum nasal temperature achieved was 33°C), and topical cooling to augment myocardial protection was not used. More recently (in 2006), Maddali et al. [14] have reported excellent results in 43 sickle-cell trait patients who underwent CPB without exchange transfusion. Notably, their selection criteria and data for the control group were not reported. In line with these studies [12–14], our data show comparable outcomes between 21 sickle-cell trait patients and age, sex, weight and procedure-matched HbAA controls undergoing CPB. Our study provides a more robust dataset on the safety of hypothermic CPB in sickle-cell trait patients using standard protocols.

Cardiopulmonary bypass for sickle-cell disease patients

Possibly, the first report of CPB in HbSS disease was the 1964 report of Harris et al. [15]. In that report, the authors reasoned that dilution of HbS to very low levels using HbA blood eliminated the possibility of sickling-induced complications. Their successful outcome [15] and that of others [16] who followed their recommendation ostensibly justified the necessity of exchange transfusion in such settings. However, no control data support such a recommendation. The Preoperative Transfusion in Sickle Cell Disease Study Group conducted a multicentre prospective randomized trial to assess preoperative transfusion regimens for sickle-cell disease patients undergoing 604 surgical procedures [17]. They found that...
using a conservative transfusion regimen to achieve a target Hb of 10 g/dl regardless of HbS concentration was as effective in preventing perioperative sickle-cell complications as exchange transfusion to reduce the HbS concentration to less than 30% [17]. In another study involving 85 sickle-cell disease patients undergoing general, orthopaedic and otorhinolaryngological surgical procedures, investigators [18] found that postoperative sickle-cell crises occurred in 22.2, 9.5 and 4.3% of the exchange transfusion, simple transfusion and non-transfusion groups, respectively. In specific regard to CPB procedures, Murtuza et al. [19] reported an adult HbSS patient undergoing aortic valve replacement in whom the so-called ‘full precautionary measures’ were followed. Nonetheless, the patient developed life-threatening acute chest syndrome leading to acidosis and type II respiratory failure postoperatively. In their 2010 report involving 43 sickle-cell disease and 4 sickle-cell trait patients, Yousafzai et al. [2] used exchange transfusion to reduce the HbS concentration to a mean of 8.1 ± 2.6% while keeping CPB temperatures above 32°C. There was no sickling or acidosis, but the early mortality rate was 2.1%; stroke occurred in 4.3%, renal failure in 4.3% and prolonged mechanical ventilation in 2.1%. The results of these studies [2, 17–19] indicate that exchange transfusion does not eliminate sickle-cell-related complications as earlier works [15, 16, 20] suggested. We avoided exchange transfusion in our series of 12 sickle-cell disease (and 21 sickle-cell trait) patients and achieved outcomes similar to matched HbAA controls. We used a simple transfusion regimen targeted at maintaining the Hb concentration at a steady-state value in the postoperative period. The blood transfusion requirement using this regimen was approximately 30 ml/kg for HbSS patients and 11 ml/kg for HbSC patients. In comparison, a one-volume total exchange transfusion requires 70–85 ml/kg of blood [21]. A significant reduction in the rate of alloimmunization (5 vs 10%) is an additional benefit of such a regimen [22].

Systemic hypothermia for cardiopulmonary bypass in sickle-cell patients

In the present study, the use of systemic hypothermia in sickle-cell patients was not associated with the occurrence of postoperative vaso-occlusive crises. Several reasons might account for this: thermoregulatory vasoconstriction, the presumed mechanism of cold-induced sickling crisis in the non-hospitalized patient, is possibly inactive in the deeply anesthetized sickle-cell patient undergoing CPB; also during hypothermic bypass, red cell sickling might be inhibited because of hypothermia-induced left shift of the oxygen dissociation curve [23]. Prior to termination of bypass, rewarming sickle-cell patients gradually and sufficiently to temperatures not less than 36°C prevents postoperative hypothermia when anaesthesia is reversed (the so-called afterdrop). Exercising similar precautions, others have used systemic hypothermia in sickle-cell patients without provoking sickle-cell crises [12, 14].

Aortic cross-clamping, cold crystalloid cardioplegia and topical hypothermia

Our data do not support the view that intracoronary sickling and myocardial injury are induced by the administration of cold crystalloid cardioplegia or topical hypothermia. We did not observe any episode of myocardial infarction and neither was there any difference in the duration of postoperative inotropic support or the duration of ICU stay between sickle-cell patients and their matched controls. Hudson et al. [24] found no myocardial injury clinically, electrocardiographically or enzymatically following administration of cold crystalloid cardioplegia in 2 sickle-cell patients.

Risk of nasal bleeding during intubation in sickle-cell disease patients

Presumably, narrowing of the nasal passages associated with the maxillary bone marrow expansion, incisor teeth protrusion and associated overbite (gnathopathy) [5] predisposes affected sickle-cell patients to traumatic nasotracheal intubation, as encountered in 2 patients reported here. Therefore, nasotracheal intubation must be performed with caution in sickle-cell patients with gnathopathy. The orotracheal route is a safer alternative.

Study limitations

CPB data in sickle-cell patients are lacking because open heart procedures are not commonly performed in these patients. Consequently, most reports are case studies or based on small sample sizes. Our study, although among the largest reported series of CPB in sickle-cell patients, suffers from small sample size limitations in its ability to determine significant differences between outcome variables. Thus, the findings deserve careful interpretation.

CONCLUSION

HbAS patients tolerate CPB with little alteration to the standard protocol. CPB can be safely performed in HbSS and HbSC patients using a simple transfusion regimen to replace blood loss and counter haemodilutional anaemia. With such a protocol, perioperative exchange transfusion is not essential for a good outcome. The use of systemic hypothermia during CPB does not increase sickle-cell-related complications if patients are fully rewarmed before separation from bypass. Cold crystalloid cardioplegia and topical hypothermia provide adequate and safe myocardial protection without the need for more sophisticated measures.

Conflicts of interest: none declared.

REFERENCES


