British Journal of Anaesthesia **113** (5): 847–54 (2014)
Advance Access publication 10 July 2014 · doi:10.1093/bja/aeu194

BJA

Platelet count and function in paediatric cardiac surgery: a prospective observational study

B. S. Romlin[1]*, F. Söderlund[1], H. Wåhlander[2], B. Nilsson[1], F. Baghaei[3] and A. Jeppsson[4,5]

[1] Department of Paediatric Anaesthesia and Intensive Care and [2] Department of Paediatric Cardiology, Queen Silvia Children's Hospital, SE-416 85 Gothenburg, Sweden
[3] Department of Medicine/Haematology and Coagulation Disorders and [4] Department of Cardiothoracic Surgery, Sahlgrenska University Hospital, Gothenburg, Sweden
[5] Department of Molecular and Clinical Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

* Corresponding author. E-mail: birgitta.romlin@vgregion.se

Editor's key points

- Thrombocytopenia and platelet dysfunction occur after cardiac surgery, but data in children or neonates are conflicting.
- This small study found marked reductions in intraoperative platelet count and aggregation, especially in neonates.
- These persisted into the first postoperative day and were associated with increased intraoperative transfusion requirements.
- There was no significant correlation between intraoperative platelet dysfunction and postoperative bleeding or transfusions.

Background. Platelet deficiency, impaired platelet function, or both increase the risk of bleeding complications. We assessed platelet count and function during and after paediatric cardiac surgery. Secondary aims included the effect of modified ultrafiltration, identification of factors associated with platelet dysfunction, and to assess associations between platelet function and transfusion requirements.

Methods. Fifty-seven patients were included in a prospective observational study. Platelet count and platelet function (multiple-electrode impedance aggregometry) were analysed before and during cardiopulmonary bypass (CPB), after modified ultrafiltration, on arrival at the intensive care unit, and on the first postoperative day. Intraoperative transfusions of blood products were registered.

Results. Both platelet count and platelet aggregation were markedly reduced during surgery with the greatest reduction at the end of CPB. On postoperative day 1, platelet count was still reduced by 50%, while platelet aggregation had returned to—or above—preoperative levels. There were only moderate correlations between platelet count and platelet aggregation. Modified ultrafiltration had no significant influence on platelet count or aggregation. Young age, low weight, and long operation time were associated with poor platelet aggregation during surgery, while young age, low weight, high preoperative haemoglobin levels, and low preoperative platelet count were associated with poor aggregation after operation. Patients with impaired platelet function during CPB had markedly increased intraoperative transfusion requirements.

Conclusions. Platelet count and platelet aggregation are markedly reduced during and immediately after paediatric cardiac surgery, especially in neonates. The recovery in aggregation is faster than that in platelet count. Intraoperative platelet dysfunction is associated with increased transfusion requirements.

Keywords: blood, platelets; complications, haemorrhage; heart, congenital defects; surgery, cardiovascular; transfusion

Accepted for publication: 13 March 2014

Platelet deficiency, impaired platelet function, or both increase the risk of bleeding complications and transfusion requirements in cardiac surgery.[1–3] During surgery, a number of different factors influence platelet count and function, including the use of cardiopulmonary bypass (CPB), haemodilution, hypothermia, and preoperative treatment with platelet-inhibiting agents.[4–7]

Monitoring of perioperative platelet function increases the possibility of identifying clinically important platelet disturbances during and after cardiac surgery and can also help to guide haemostatic therapy.[8–10] However, classical methods of assessing platelet function, such as light-transmission aggregometry, are time-consuming and require large sample volumes,[9 11] making them less suitable in paediatric patients. New whole blood-based point-of-care instruments evaluate platelet function considerably more rapidly. One of these instruments is multiple-electrode aggregometry (MEA), which measures adhesion and aggregation of platelets to metal wires. The method allows analysis within 10 min after sampling.[12] The method has been used previously in adult and paediatric cardiac surgery patients for monitoring platelet-inhibiting agents[11 13 14] and to follow the effects of CPB on platelet function.[10 15 16]

In the present study, we investigated platelet count and function in paediatric cardiac surgery. Five prospectively defined aims were established: (i) to determine changes in platelet count and platelet function during and after paediatric cardiac surgery; (ii) to determine possible associations between platelet count and platelet function; (iii) to determine how modified ultrafiltration influences platelet count and platelet function; (iv) to identify factors associated with impaired platelet function during and after surgery; and (v) to determine the relation between intraoperative platelet function and transfusion requirements.

Methods

Patients

Fifty-seven patients undergoing paediatric cardiac surgery with CPB were included in a prospective observational study between September 2008 and November 2012. During this period, a total of 839 children underwent open cardiac surgery at our institution. Patients were included when the platelet test device and research assistants were available. Twenty-seven patients were included during 2008–2010 and 30 during 2011–2. The study was approved by the Regional Medical Research Ethics Committee and conducted in accordance with the Declaration of Helsinki. Informed written consent was given by all parents. All patients were operated on and anaesthetized by the same group of surgeons and anaesthetists. Patients with a known bleeding disorder, or severe renal or hepatic disorder, were excluded. Two patients were on acetylsalicylic acid treatment and seven on prostaglandin treatment. The patient characteristics and the types of congenital heart defects are given in Table 1.

Table 1 Patient characteristics, operative variables, and preoperative laboratory analyses. Mean (SD), median (range), or number (%). AS, aortic stenosis; ASD, atrial septal defect; AVSD, atrial-ventricular septal defect; CPB, cardiopulmonary bypass, DORV, double outlet right ventricle; HLHS, hypoplastic left heart syndrome; INR, international normalized ratio; SD, standard deviation; TGA, transposition of the great arteries; VSD, ventricular septal defect

Age (months)	5 (0.1–90)
Weight (kg)	5.8 (2.4–23)
Girls [*n* (%)]	24 (42%)
Diagnosis	
ASD	1
VSD	13
AVSD	11
Tetralogy of Fallot	8
TGA	3
AS	3
HLHS, DORV, hypoplastic aortic arc	7
Truncus arteriosus	2
Others	9
CPB time (min)	124 (69)
Aortic clamp time (min)	67 (48)
Hb (g litre^{-1})	130 (22)
Prothrombin time (INR)	1.2 (0.2)

Anaesthesia

Midazolam and ketamine were used for induction of anaesthesia. Maintenance of anaesthesia included isoflurane, fentanyl (25–75 μg kg^{-1}), midazolam (0.1–0.3 mg kg^{-1}), and atracurium (0.5–0.7 mg kg^{-1}), supplemented with propofol if indicated during CPB. The anaesthesia procedure was unaltered during the study period.

Anti-coagulation and reversal

An initial i.v. bolus of unfractionated heparin (Leo Pharma A/S, Ballerup, Denmark), 350 U kg^{-1} body weight, was administered before CPB cannulation. The level of anti-coagulation was repeatedly controlled during bypass with activated clotting time (ACT) (Hemocron Jr II; ITC, Edison, NY, USA) with kaolin as initiator. Reversal of heparin was achieved with protamine (Leo Pharma A/S), 1 mg per 100 U of the total heparin dose. Additional doses of protamine were administered on clinical indication in combination with excessive post-bypass ACT.

Bypass technique

CPB was conducted with a hard-shell reservoir and a patient size-adapted membrane oxygenator (Terumo, Tokyo, Japan). Target rectal temperature (28–36°C) was decided by the surgeon depending on the type of surgery. The total pump prime volume ranged from 350 to 700 ml, depending on the tubing and the oxygenator. The priming solution consisted of crystalloid fluid and allogenic blood, mannitol (5 ml kg^{-1}), and 100 ml Tribonat® (Fresenius Kabi AB, Uppsala, Sweden) and heparin. Packed red blood cells (RBC) were added to the prime aiming at a target haematocrit (Hct) of 27–30% during CPB. Forty-nine out of 57 patients (86%) received RBC in the prime. During bypass, heparin was administered whenever ACT was <480 s. Myocardial protection was achieved with cold intermittent blood cardioplegia. Modified ultrafiltration was performed after weaning from CPB with cannulae in place, aiming at an Hct of 35–40%. In children <3 kg, or children planned for complex surgical procedures or elective re-operations, tranexamic acid was administered before initiation of CPB (50 mg kg^{-1}) and after CPB (30 mg kg^{-1}); aprotinin was not used in any of the patients.

Transfusions

The decision to transfuse patients with blood products intraoperatively was made jointly by the anaesthetist and surgeon responsible. According to the institutional protocol, RBC should be transfused during CPB when Hct is <25%. After CPB, RBC should be transfused when haemoglobin (Hb) levels are <110 g litre^{-1} except in children with cyanotic lesions and shunts where the limit is 130 g litre^{-1}. Plasma, platelets, and fibrinogen concentrate were transfused in patients with ongoing bleeding, haemodynamic derangement, or both,