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Red blood cell storage time and the outcome after coronary surgery

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ABSTRACT

Background: The impact of transfusion of aged red blood cells (RBCs) on the outcome after coronary artery bypass grafting (CABG) is controversial. This issue has been investigated in the present study.
Materials and methods: Data on perioperative blood transfusion, storage time of RBCs, and adverse events were available for 819 consecutive patients who underwent isolated CABG and received two to four units of RBCs. The maximum RBC storage time was 35 d.
Results: Repeated-measure test showed that transfusion of all RBC units >14 d and at least one RBC unit >14 d was associated with similar postoperative C-reactive protein ($P = 0.245$ and $P = 0.103$, respectively) or creatinine levels ($P = 0.414$ and $P = 0.259$, respectively) compared with newer RBC units. Propensity score–adjusted analysis showed similar immediate and late outcome in patients receiving only newer RBCs compared with those who received only older RBCs. Similar findings were observed in patients receiving only newer RBCs compared with patients who received at least one unit of older RBCs. Logistic and proportional hazards analyses adjusted for the number of RBC units showed that the median storage duration of RBCs was not associated with either any of the immediate outcome end points or late mortality.
Conclusions: These findings suggest that, when the maximum RBC storage time is 35 d, the duration of storage of transfused RBCs does not affect the immediate and late outcome of patients with moderate bleeding after CABG.

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1. Introduction

Perioperative red blood cell (RBC) transfusion is known to be associated with adverse outcome after cardiac surgery [1–6]. Of particular concern is the influence of RBCs with long storage time on the outcome as RBCs undergo progressive structural and functional changes when stored for prolonged time [7–11]. A number of studies indicated that these changes occur after 2–3 wk of storage time [11,12]. Indeed, a number of studies showed an association between transfusion of older RBCs and increased mortality and morbidity after cardiac surgery [13–16]. However, other studies failed to show an association between RBC storage time and postoperative adverse events [17–21]. We sought to investigate this controversial issue in patients undergoing isolated coronary artery bypass grafting (CABG).

2. Materials and methods

2.1. Patient population and data collection

The present study included 819 consecutive patients who underwent isolated CABG from June 2006 to December 2013 at the Oulu University Hospital, Oulu, Finland. The study includes elective, urgent, and emergency operations carried out either with off-pump or on-pump technique. The main inclusion criterion of this study was transfusion of two to four units of RBCs during or immediately after isolated CABG. Patients who did not receive RBC transfusion and those who received only one or more than four units of RBCs were excluded from this analysis. The decision to evaluate only this patient population was based on the findings that patients with universal definition of perioperative bleeding class 2 [22,23] have an intermediate risk of adverse events. Indeed, patients who received two to four units of RBCs were not exposed to significant blood loss and its related ischemic effects as well as the potential adverse effect of massive blood transfusion. This may allow a more reliable analysis of the possible adverse impact of RBC storage duration in patients with moderate perioperative blood loss.

Complete preoperative, intraoperative, and postoperative data were available in all these patients as obtained from institutional electronic cardiac surgery database collecting baseline and operative data as well as data on immediate postoperative adverse events. The amount of transfused blood products such as RBCs, platelets, and solvent/detergent-treated plasma (Octaplas; Octapharma AG, Lachen, Switzerland) as well as data on storage time of transfused RBCs were retrieved from a prospective electronic hospital registry collecting data on any transfusion of blood products. Transfused blood product units were counted from the operation day to the discharge of the patient or to a maximum of 1 mo after the operation if the length of in-hospital stay was >1 mo. Data on the amount of postoperative blood losses were retrieved from a prospective electronic registry of the intensive care unit (ICU). Patients' characteristics are summarized in Tables 1 and 2.

Estimated glomerular filtration rate was estimated by the Modification of Diet in Renal Disease formula [24]. Clinical variables were defined according to the EuroSCORE II definition criteria [25]. Data on patients' death were retrieved from the Central Statistical Office of Finland (Tilastokeskus), which collects the certificates of death of all inhabitants of

Table 1 – Baseline characteristics and operative data of patients according to different RBC storage time.					
Variables	All newer RBCs (n = 311)	All older RBCs (n = 286)	P-value	At least one unit of older RBCs (n = 508)	P-value
Age (y)	68.3 ± 9.0	68.5 ± 9.1	0.689	68.4 ± 9.0	0.758
Female	95 (30.5)	78 (27.3)	0.378	161 (31.7)	0.731
Hemoglobin (mg/L)	132 ± 14	132 ± 15	0.400	131 ± 15	0.604
Pulmonary disease	33 (10.6)	25 (8.7)	0.441	46 (9.1)	0.464
Diabetes	79 (25.4)	83 (29.0)	0.320	154 (30.3)	0.130
Hypertension	189 (60.8)	171 (59.8)	0.807	302 (59.4)	0.708
Stroke	7 (2.3)	8 (2.8)	0.670	14 (2.8)	0.657
Neurologic dysfunction	7 (2.3)	5 (1.7)	0.662	7 (1.4)	0.350
Extracardiac arteriopathy	31 (10.0)	25 (8.7)	0.608	41 (8.1)	0.352
eGFR (mL/min/1.73 m^2)	84 ± 25	85 ± 23	0.466	84 ± 25	0.937
eGFR < 60 mL/min/1.73 m^2	48 (15.5)	37 (12.9)	0.366	78 (15.4)	0.954
Recent myocardial infarction	175 (56.3)	151 (52.8)	0.395	281 (55.3)	0.789
Previous PCI	18 (5.8)	24 (8.4)	0.214	36 (7.1)	0.467
Previous cardiac surgery	3 (1.0)	5 (1.7)	0.489	10 (2.0)	0.390
Left ventricular ejection fraction (%)			0.050		0.035
30–50	83 (27.4)	66 (24.4)		115 (24.0)	
<30	16 (5.3)	5 (1.8)		11 (2.3)	
Critical preoperative status	24 (7.7)	21 (7.3)	0.863	43 (8.5)	0.705
Operative data					
Type of operation			0.579		0.625
Elective	115 (37.0)	115 (40.2)		188 (37.0)	
Urgent	171 (55.0)	153 (53.5)		288 (56.7)	
Emergency	25 (8.0)	18 (6.3)		32 (6.3)	
Off-pump coronary surgery	140 (45.0)	131 (45.8)	0.847	230 (45.3)	0.942
Number of distal anastomoses	4.0 ± 1.1	3.8 ± 1.0	0.156	3.9 ± 1.1	0.630
Used blood products					
RBC units	2.7 ± 0.8	2.6 ± 0.8	0.269	2.9 ± 0.8	0.007
Octaplas units	0.8 ± 1.5	0.6 ± 1.3	0.021	0.6 ± 1.3	0.029
Platelet units	2.6 ± 3.9	2.2 ± 3.8	0.140	2.3 ± 3.9	0.187

eGFR = estimated glomerular filtration rate; PCI = percutaneous coronary intervention.

P-values are for comparison with all newer RBCs. Definition criteria are according to EuroSCORE II. Continuous variables are reported as mean and standard deviation; nominal variables are reported as absolute number and percentages; all P-values are for unadjusted analyses. The storage time was ≤14 d for newer RBC and >14 d for older RBC.