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Transfusion of blood products in off-pump coronary artery bypass and conventional coronary artery revascularization. A prospective randomized study

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Abstract

Introduction: There has been a growing interest in off-pump coronary artery bypass (OPCAB) grafting in recent years. Beating-heart surgery is believed to be less invasive as it allows the side effects of extracorporeal circulation to be avoided.

The aim of the study was to compare blood product transfusion rates between two groups of patients undergoing surgery for ischemic heart disease with either the off-pump technique or using cardiopulmonary bypass (CPB).

Material and methods: There were 152 patients enrolled in the prospective randomized study. All procedures were elective. There were 84 patients (62 men and 20 women) at the mean age of 63.74 ± 7 years who underwent OPCAB (group I), and 68 patients (54 men and 14 women) at the mean age of 63.51 ± 6 years who underwent cardiopulmonary bypass (group II).

Results: There were no perioperative deaths. The mean number of grafts was 2.27 ± 0.3 (OPCAB group) and 2.63 ± 0.6 (CPB group) ($p < 0.05$). The mean number of packed red blood cells transfused in the OPCAB group was 2.31 ± 0.18 units/patient and 3.94 ± 0.30 units/patient in the CPB group ($p < 0.05$). The mean number of fresh frozen plasma units transfused was 1.13 ± 0.13 in the OPCAB group vs. 1.57 ± 0.15 in the CPB group ($p < 0.05$). There were 12 patients (14%) in the OPCAB group who had no transfusion.

Conclusions: One of the most important advantages of the OPCAB technique is that it makes it possible to reduce the rate of blood product transfusions.

Key words: myocardial revascularization, OPCAB, CPB, CABG, blood products, transfusion.

Streszczenie

Wstęp: W ostatnich latach coraz częściej wprowadza się do leczenia chirurgicznego choroby wieńcowej zabieg pomostowania aortalno-wieńcowego bez użycia krążenia pozaustrojowego (*off-pump coronary artery bypass* – OPCAB). Zabieg przeprowadzany na bijącym sercu uważa się za mniej inwazyjny, ponieważ pozwala uniknąć efektów ubocznych związanych ze stosowaniem krążenia pozaustrojowego.

Celem badania było porównanie ilości przetaczanych preparatów krwi w dwóch grupach pacjentów operowanych z powodu choroby niedokrwiennej serca przy użyciu techniki pomostowania aortalno-wieńcowego bez użycia krążenia pozaustrojowego lub z użyciem krążenia pozaustrojowego (*cardiopulmonary bypass* – CPB).

Materiał i metody: Do prospektywnego badania z randomizacją zakwalifikowano 152 pacjentów. Wszystkie zabiegi przeprowadzono w trybie elektywnym. Grupa I składała się z 84 osób (64 mężczyzn i 20 kobiet), w średnim wieku 63,74 ± 7 lat, które poddano zabiegowi z użyciem techniki OPCAB, a grupę II tworzyło 60 osób (54 mężczyzn i 14 kobiet), w średnim wieku 63,51 ± 6 lat, które poddano zabiegowi z użyciem płucoserca (CPB).

Wyniki: Śródoperacyjnie i we wczesnym okresie pooperacyjnym nie obserwowano przypadków śmiertelnych. Średnia liczba wykonanych pomostów wyniosła 2,27 ± 0,3 (grupa OPCAB) i 2,63 ± 0,6 (grupa operacji w krążeniu pozaustrojowym/grupa CPB) ($p < 0,05$). Średnia liczba jednostek koncentratu krwinek czerwonych podanych w grupie OPCAB wyniosła 2,31 ± 0,18 jednostek na pacjenta, a w grupie CPB – 3,94 ± 0,30 jednostek na pacjenta ($p < 0,05$). Średnia liczba jednostek świeżo mrożonego osocza wyniosła 1,13 ± 0,13 w grupie OPCAB i 1,57 ± 0,15 w grupie CPB ($p < 0,05$). U 12 pacjentów (14%) w grupie OPCAB nie wykonano transfuzji.

Wnioski: Istotną zaletą techniki OPCAB jest związana z nią możliwość zmniejszenia częstości transfuzji preparatów krwi.

Słowa kluczowe: rewaskularyzacja mięśnia sercowego, OPCAB, CPB, CABG, preparaty krwi, transfuzja.

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Introduction

Cardiovascular diseases are the leading cause of death in Poland. Among them, ischemic heart disease poses one of the largest challenges [1].

Recent years have seen a growing interest in off-pump coronary artery bypass surgery. The majority of cardiac procedures are performed on cardiopulmonary bypass, with blood transfusions being part of the procedure [2]. As the extracorporeal circulation causes many side effects involving blood components, the restoration of hemoglobin concentration by means of transfusion is almost always essential [3]. The majority of heart surgery complications are reported to be related to cardiopulmonary bypass [4]. Systemic inflammatory response syndrome (SIRS) is usually self-limiting and may involve most organs [5, 6].

Hemostatic disturbances secondary to CPB may cause such serious complications as disseminated intravascular coagulation (DIC) [7, 8].

Material and methods

There were 152 patients (118 men and 34 women) at the mean age of 63 ± 14 years enrolled in the study. The patients were divided into the OPCAB group and the CPB group. The OPCAB group included 84 patients (64 men and 20 women) at the mean age of 64 ± 7 years and the CPB group included 68 patients (54 men and 14 women) at the mean age of 63 ± 6 years. The mean preoperative left ventricular ejection fraction was 53 ± 9% and 51 ± 8%, respectively. Demographic and clinical data are presented in Table I. All procedures were performed as a result of stable angina pectoris. Concomitant valvular pathology was the exclusion criterion. Preoperative laboratory tests showed no statistically significant difference between the groups. The serum hemoglobin concentration was 8.70 ± 1.03 mmol/L in the OPCAB group vs. 8.78 ± 0.70 in the CPB group. The mean hematocrit values were 0.41 ± 0.05 in the OPCAB group vs. 0.42 ± 0.03 in the CPB group, ns. There was no difference in serum platelet concentration, which was 251.42 ± 74.01 G/L in the OPCAB group vs. 228.04 ± 59.78 G/L in the CPB group.

Tab. I. Demographical and perioperative data

Data	OPCAB group $n = 84$	CABG group $n = 68$	
Demographical			
Age	64 ± 7	63 ± 6	ns
Gender (M/F)	64/20	54/14	ns
Risk factors			
DM	14 (17%)	11 (16%)	ns
Stroke	2 (2%)	2 (3%)	ns
Peripheral disease	4 (5%)	4 (6%)	ns
COPD	7 (8%)	5 (7%)	ns
Smoking history	16 (19%)	12 (17%)	ns
Arterial hypertension	42 (50%)	31 (45%)	ns
Clinical			
Vessel disease			ns
LMCA	10 (12%)	8 (12%)	ns
2 vessels disease	22 (26%)	24 (34%)	$p < 0.05$
3 vessel disease	52 (62%)	36 (53%)	$p < 0.05$
LVEF			
preoperatively	57 ± 4%	53 ± 6%	ns
postoperatively	59 ± 6%	54 ± 7%	ns
Surgery			
No of grafts	2.27 ± 0.3%	2.63 ± 0.6%	ns

Heparin was administered at the dose of 2 mg/kg in the OPCAB group and 3 mg/kg in the CPB group, and the desired ACT was 350 s and 480 s, respectively. Postoperatively, heparin was neutralized by protamine administered at the dose of 1 mg per 1 mg of heparin.

The CPB group was subsequently subjected to the procedures of ascending aorta and right atrium cannulation. Cardiopulmonary bypass was conducted in moderate hypothermia (27-29°C) with cold, crystalloid cardioplegia administered antegrade in accordance with the St. Thomas Hospital formula.

In the OPCAB group, the Octopus III® (Medtronic, USA) stabilization system was used and intraluminal shunts were applied during each distal anastomosis.

Red packed cells were transfused whenever serum hemoglobin was lower than 6.5 mmol/L (< 10.5 g/dL).

Statistical analysis

The obtained data were entered and analyzed using the StatView 5.0 software (SAS Institute, Inc., Cary, NC, USA). The normality of data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were described as mean values ± SD and compared using Student's *t*-test or the Mann-Whitney *U*-test. The χ^2 test or Fisher's exact test was chosen to compare categorical variables. To

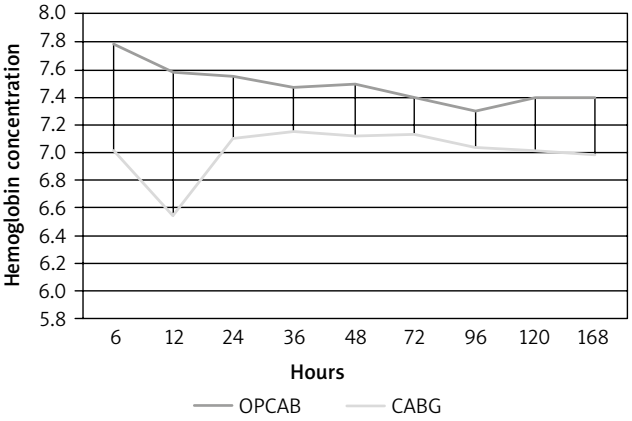

Fig. 1. Hemoglobin concentration after surgery in OPCAB and CPB group

evaluate changes over time, we used repeated measures analysis of variance (ANOVA). Values of $p < 0.05$ were considered significant.

Results

There were no perioperative deaths and no case of postoperative low cardiac syndrome was found in the study groups. There were 12 patients (14%) in the OPCAB who did not require any blood product transfusions. Two reoperations (2.4%) in the OPCAB group and three (4.4%) in the CPB group were performed due to excessive bleeding ($p < 0.05$). The mean cardiopulmonary bypass time was 63 ± 18 minutes and the mean cross clamping time was 43 ± 11 minutes in the CPB group.

The mean packed red blood cells, fresh frozen plasma and platelet units transfused in the OPCAB group were 2.31 ± 0.18, 1.13 ± 0.13 and 0.28 ± 0.16, respectively. The mean packed red blood cells, fresh frozen plasma and platelet units transfused in the CPB group were 3.94 ± 0.30, 1.57 ± 0.15 and 0.23 ± 0.16, respectively. There was a statistically significant difference in the mean packed red blood cells (2.31 ± 0.18 vs. 3.94 ± 0.30, $p < 0.05$) and fresh frozen plasma (1.13 ± 0.13 vs. 1.57 ± 0.15, $p < 0.05$) transfusion rate between the groups.

There was a difference in the mean serum hemoglobin concentration between the groups (OPCAB 7.79 ± 0.91 mmol/L vs. CPB 7.03 ± 0.88 mmol/L six hours after surgery, $p < 0.05$ and OPCAB 7.47 ± 1.10 mmol/L vs. CPB 7.17 ± 0.99 mmol/L one day after surgery). Figure 1 presents the differences in the serum hemoglobin concentration between the groups after surgery. The platelet count was comparable before the procedure (199 ± 61 10^3/L vs. 178 ± 41 10^3/L in the OPCAB and CPB group, respectively). The platelet count after surgery decreased progressively from 205 ± 56 10^3/L, 192 ± 53 10^3/L one day after surgery to 169 ± 57 10^3/L on the 7th postoperative day. On the other hand, the platelet count after surgery increased progressively in the CPB group from the initial 155 ± 41 10^3/L, 165 ± 43 10^3/L one day after surgery to 369 ± 72 10^3/L on the 7th postoperative day.

There was also a statistically significant difference in postoperative drainage between the two groups (OPCAB: 755.54 ± 42.82 mL vs. CPB: 895.74 ± 47.35 mL, $p < 0.05$).

Discussion

The first successful use of the heart-lung machine on humans occurred in 1953, when John Gibbon performed surgery on a 15-month-old girl, Celia Bavolek, at Jefferson Hospital in Philadelphia [9].

Eleven years later, in 1964, the Russian surgeon Kolessov performed the first successful heart bypass surgery on a beating heart [10]. Surgical revascularization was soon demonstrated to provide excellent survival results and relief of symptoms [11, 12].

Renewed interest in beating-heart bypass grafting in the mid-1990s resulted from the option of revascularization without the potential complications of extracorporeal support. Although the theoretical advantages of OPCAB procedures are generally accepted, the use of this technique still remains sporadic. For example, off-pump surgery constitutes only 20 to 25% of all coronary artery bypass procedures performed in the United States [13].

Tab. II. Blood products transfusions

Blood products	OPCAB group	CABG group	
Red cells (units)	2.31 ± 0.2	3.94 ± 0.3	< 0.05
Fresh frozen plasma (units)	1.13 ± 0.13	1.57 ± 0.15	< 0.05
Platelets (units)	0.28 ± 0.16	0.23 ± 0.16	ns

A debatable issue is that of graft patency rates, which seem to be at least equivalent to those observed in the case of conventional techniques. The advantage of off-pump coronary artery bypass can be supported by such important factors as reduced morbidity and mortality, rapid return to usual functional capacity, and economic benefits. Unfortunately, a lot of data reported in the literature concerning the outcomes of off-pump bypass grafting have been inconclusive as to the overall benefit of the technique. Most studies have suffered from the fact that they have been retrospective reviews. Although the OPCAB technique eliminates cardiopulmonary bypass and hypothermic cardiac arrest, the manipulation of the ascending aorta by partial clamping has for the most part not been eliminated.

So far, there have been 37 randomized clinical trials published, comparing OPCAB versus conventional CABG. No randomized trials have shown a significant reduction in the occurrence of stroke or myocardial infarction, acute renal failure, intra-aortic balloon pump (IABP) requirement, mediastinitis or wound infection, the recurrence of angina, or the need for reintervention within 30 days of OPCAB, in comparison with conventional CABG [14]. Similar results were obtained at 1 and 3 years after surgery [15].

In the present study, there was a reduction of blood cell product transfusions in the OPCAB group, as compared to the CPB group (Table II). OPCAB procedures make it possible not only to limit the number of transfusions but to eliminate transfusions altogether [16, 17]. The elimination of blood product transfusion can be essential in the case of patients with religious restrictions, such as Jehovah witnesses [18].

The serum hemoglobin concentration in the OPCAB group remains stable throughout the postoperative period, as presented in Table I. At the same time, we can observe a decline in the hemoglobin concentration in conventional CABG patients until the 12th postoperative hour. The restitution of the hematocrit level was achieved by administering packed red cell transfusions thereafter.

Conclusions

Off-pump surgery allows for reducing the rate of blood product transfusions or eliminating them altogether. The hematocrit level remained more stable during the postoperative period in the OPCAB group. Patients undergoing

conventional CABG surgery were characterized by higher postoperative drainage, presumably due to more serious coagulation disturbances.

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