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ORIGINAL ARTICLE

Equal Blood Conservation In On- And Off-Pump Coronary Bypass Operation With The Routine Use Of Cell Saver

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ABSTRACT

Background: The limitations of recent studies comparing usage of blood products in on and off- pump coronary artery bypass grafting (CABG) have been the routine use of cell saver in the former but not in the latter group. We routinely use cell savers in both on- and off-pump coronary bypasses. We analysed our prospectively collected data to get a more balanced comparison of the two methods.
Methods: Data were prospectively collected on all patients undergoing isolated CABG from January 2003 to December 2004. One hundred and seventy-four patients operated on using off-pump technique (OPCAB) were compared with 1125 on-pump cases (ONCAB). They were well matched in terms of age, sex, disease severity, and priority of surgery.
Results: There were no significant differences between OPCAB and ONCAB groups in terms of usage of red cells (18% vs. 21%, *p* not significant (NS)), platelet (6% vs. 7%, *p* NS), fresh frozen plasma (6% vs. 10%, *p* NS), chest drain output at 12 hours (mean 802 vs. 856 ml, *p* NS), or pre-discharge haemoglobin (10 $\pm$ 1 vs. 9 $\pm$ 1 g/dl, *p* NS).
Conclusion: The routine use of cell saver can achieve the same blood conservation in both on- and off-pump CABG.

Key words: CABG, blood transfusion, cell saver

Introduction

Out of 2.2 million units of blood issued by National Blood Service in England 10% are used in cardiac surgery [1]. Despite institutional efforts to minimize the use of blood transfusions in cardiac surgery the frequency of blood transfusions still remains high ranging from 30 to 80% [2],[3]. Coronary artery bypass grafting (CABG) is the commonest cardiac operation which leads to blood transfusion to patients. Blood is an expensive and scarce resource. Its use has been proven to be associated with higher incidence of bacterial infection [4], pneumonia, renal dysfunction, severe sepsis, hospital mortality and poorer long-term survival [5]. Need of transfusion in conventional on pump coronary artery bypass grafting (ONCAB) is perceived to be due to the association of the cardiopulmonary bypass with haemodilution and consumptive coagualopathy of clotting factors. Recent studies [6,7] have suggested off pump coronoary artery bypass grafting (OPCAB) results in less blood transfusion. However the limitations of those studies were that the cell saver was used in the off-pump group and not in the on-pump group.

To minimise blood usage a variety of pharmacological, mechanical, and operative

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strategies have been in use. The cell saver is an established mechanical device to reduce blood loss in cardiac surgery [8]. They wash the salvaged blood and permit re-infusion of concentrated erythrocytes free from substances like soluble activated clotting factors [9], anticoagulants, white cells, platelets, soluble haemoglobin, intracellular enzymes, etc. The safety and cost effectiveness [10–12] of these devices are well established in cardiac surgery. We hypothesised that the cell saver is the essential variable for blood conservation and not the elimination of CPB. If we use cell savers in both the groups of patients, there is no real difference between the two groups. We use a high-quality prospective database to collect data on all patients undergoing cardiac surgery at our institute, which is filled in at each successive stage of patient care by the relevant health-care professional and then verified by a dedicated audit officer. To test this hypothesis we analysed the data from this database.

Materials and Methods

Patients

Between January 2003 and December 2004, a total of 1299 consecutive isolated coronary bypass operations were carried out. Off-pump approach was used in 174 patients (OPCAB) whereas on-pump approach (ONCAB) was used in 1125 patients. Selection of surgical technique was based on surgeon preference and expertise. A single surgeon operated on all of OPCAB patients, whereas four surgeons operated on ONCAB patients. The surgeon performing off-pump operations chose all cases to be performed off pump, except a small number of cases given away to the trainees.

Anaesthesia and operative techniques

The anaesthetic techniques were standardised for both groups. We used Medtronic cell savers (Medtronic Limited, UK) in both the groups. A continuous flow of heparinised saline brought the blood to cell saver. In the OPCAB group, all patients were operated using suction-based mechanical stabilisers for positioning. Heparin was used at 2 mg/kg to achieve a target-activated clotting time (ACT) of 400 seconds before first anastomosis or division of internal mammary artery. At the end of operation, it was reversed fully with protamine. The cell saver was used throughout the operation to salvage blood.

In the on-pump group, heparin was administered at 3 mg/kg either at the time of division of the internal mammary artery or at the time of cannulation. A target ACT of more than 480 seconds was achieved. Medtronic Biomedicus centrifugal pump (Medtronic Limited, UK) was used along with a membrane oxygenator. Cold blood cardioplegia or intermittent fibrillation techniques were used for myocardial preservation, along with moderate systemic hypothermia of 28–32°C, depending on surgeon preference. Some patients (9.7%), mainly during re-operations, received aprotonin on the pump. The cell savers were used from the time of incision till full heparinization and then from the time of protamine reversal to the end of the operation. At the end, the pump contents were emptied into the cell savers.

Transfusion protocol

Postoperative blood loss was measured as chest drain output from the time patients left the theatre. A strict transfusion protocol was formulated and adhered to. Excessive bleeding was defined as bleeding in excess of 250 ml/hr over 2 consecutive hours. Prolongation of ACT for more that 30 seconds of base line was treated with extra dose of protamine. They were transfused with blood (suspended in saline–adenine–glucose–mannitol – SAGM) if haemoglobin was less the 8 gm/dl or PCV <24%. Platelets were transfused if the patients were bleeding because of aspirin intake till surgery or had low platelet count (80,000 platelets/ml). Fresh frozen plasma (FFP) was transfused in the presence of a deranged clotting, shown by international normalised ratio (INR) greater than 1.5. The patients were reopened if they were bleeding in excess of 500 ml over the first hour, 300 ml/hr for 2 consecutive hours or 200 ml/hr for 3 consecutive hours, despite correction of coagulopathy.

Data collection and statistical Methods

Data were promptly entered at each stage into a database (Patient Analysis and Tracking Systems: Dendrite Clinical Systems, London, UK), which has five sections to be filled in by the surgeon, anaesthetist, perfusionist, and intensive care and ward staff. The resident doctor collected the transfusion data prospectively on all patients, on the first postoperative day. An audit officer verified all data by periodically matching it with the case notes.

All statistical analyses were performed using Minitab version 13 statistical package using a personal computer. All continuous data were expressed as mean ± standard deviation for normally distributed data and as median (interquartile range) for skewed data. Parametric data were analysed with the two-sample *t*-test, and non-parametric data were analysed with the Mann–Whitney U-test. Categorical data were analysed using the chi-square test or the Fisher exact test where appropriate. A *p* value of less than 0.05 was considered significant.

Results

Analysis of preoperative variables [Table/Fig 1] showed that both the groups were fairly well matched in terms of age, gender, urgency of operation, severity of disease, and respiratory and neurological co-morbidity.

Table/Fig 1: Preoperative and intraoperative variables

Variables	Off pump (*n* = 174)	On pump (*n* = 1125)	*p* Value
Age (years)	63 ± 9	62 ± 9	NS
Female	24.0%	18.5%	NS
Previous cerebrovascular accidents	12.0%	8.5%	NS
Left main stem stenosis	17.0%	18.6%	NS
Urgent/emergent	27.0%	31.5%	NS
Unstable angina	29.3%	28.0%	NS
Chronic obstructive airway disease	13.0%	10.8%	NS
Body mass index (kg/m^2)	29 ± 4	27 ± 4	<0.01
Median Parsonnet score	5.5	4.0	NS
Diabetes	17.0%	10.9%	NS
Left ventricular impairment	33.0%	26.0%	NS
Number of grafts	2.9 ± 1.0	3.1 ± 0.8	NS

Non-significant *p* values are shown as NS.

However, the OPCAB group had more obesity (mean BMI 29 ± 4 vs. 27 ± 4 kg/m^2, $p < 0.01$) and a tendency towards higher mortality risk score (Parsonnet score) (median of 5.5 vs. 4.0), diabetes (17% vs. 10%), and impaired left ventricular function (33% vs. 26%), though they failed to reach statistical significance. The mortality and morbidity, however, were similar between the two groups [Table/Fig 2]. Postoperative hospital stay was significantly shorter in the OPCAB group, with only 36% staying more that a week compared to 65% staying more than a week in the ONCAB group (p= 0.01).

Table/Fig 2: Postoperative variables

Variables	Off pump (*n* = 174) (%)	On pump (*n* = 1125) (%)	*p* Value
Postoperative stay >7 days	36	65	0.01
Died	1.1	2.4	NS
Reintubation	1.7	1.9	NS
Any complication	52.8	55.0	NS
Ventilation >48 hours	0.5	1.33	NS
Neurological complication	0.0	1.33	NS
Sternal wound infection	0.5	0.6	NS
Renal impairment	3.4	3.2	NS

Non-significant *p* values are shown as NS.

Further analysis [Table/Fig 3] revealed that there was no significant difference between the groups in terms of requirements of transfusion of red cells (18% vs. 21%, *p* NS), platelet (6% vs. 7%, *p* NS), and FFP (6 vs. 10, *p* NS) in the first 24 hours.

Table/Fig 3: Transfusion and haematological data

Variables	Off pump (*n* = 174)	On pump (*n* = 1125)	*p* Value
Red cells	18%	21%	NS
FFP	6%	10%	NS
Platelet	6%	7%	NS
No blood and blood products	78%	76%	NS
Drain output (ml)	857 ± 411	834 ± 524	NS
Reopening for bleeding	2%	3%	NS
Preoperative Hb (g/dl)	13 ± 1	13 ± 1	NS
Pre-discharge Hb (g/dl)	10 ± 1	9 ± 1	NS

Non-significant *p* values are shown as NS.

Not surprisingly, the chest drain output at 12 hours (mean 802 vs. 856 ml, *p* NS), pre-operative haemoglobin (13 ± 1 vs. 13 ± 1,g/dl *p* NS), pre-discharge haemoglobin (10 ± 1 vs. 9 ± 1g/dl, *p* NS), and reopening for bleeding (2% vs 3%, *p* NS) were also not significantly different. There appeared to be a significantly greater volume of blood salvaged in on-pump group (595 ± 137 vs. 288 ± 143 ml). This merely reflected the fact that on average about 300 ml of blood is salvaged from bypass circuit at the end of the operation, and once this was omitted the difference was insignificant.

Discussion

In a recent randomised controlled trial, McGill and associates [1] confirmed the benefit of using cell saver in the on-pump group compared to the control group, but they did not include the off-pump group in their study. Our data confirm their findings; however, these contrast with findings of Ascione et al., who showed reduced postoperative blood loss and transfusion requirement after beating-heart coronary operations [6]. In a prospective randomised trial, they used the cell savers only in the off-pump group and not in the on-pump group. As evidenced by previous reports of Cosgrove et al. [13] and others, cell savers salvage on average about 250–300 ml of blood. So this volume of blood gets wasted in the on-pump group without the use of cell savers, which, at least to some extent, must have contributed to the difference in blood usage between the two groups. This drawback invalidates the conclusion from this study. It has been proved that a very low transfusion rate can be achieved even with the use of CPB, as highlighted by Helm and associates' report [14] of 100 consecutive CABG operations without blood transfusion and Ovrum and associates' [15] report of 97% transfusion-free operations, which included re-operations as well. The median postoperative haematocrit values in the aforementioned study [6] are nearly identical in both on- and off-pump groups and fail to account for more than double the rate of transfusion reported in the on-pump group. The use of FFP and platelets in the on-pump group seems to be much more liberal compared to other published reports in literature.

Nader and associates [16] have used the cell savers in both the groups, but they have failed to identify that about 250–300 ml of blood comes from the CPB circuit and, once this is taken into consideration, the volume of intraoperative loss remains similar between the two groups. Though these authors have mentioned that the off-pump group needed on average 2.25 units less of RBC, 1.75 units less of FFP, and 3.75 units less of platelets, they have failed to clarify what percentage of patients in each group required transfusion. Average transfusion of more than five units of red cells per patient in the on-pump group seems to be much higher than expected, according to our data and also similar data reported from other centres [13]. This drawback, coupled with lack of clearly defined transfusion criteria, renders the comparison in this study inconclusive.

Our series is the first comparative study where a balanced comparison has been made by using the cell savers in both the groups, along with clear predefined transfusion criteria. Our transfusion rate is higher than reports of Helm et al [14] and Ovrum et al [15]. However, our transfusion rates in both the groups are substantially lower than most of other reported series in literature, including those reported by Ascione and associates [6]. A bigger and more balanced randomised controlled trial is indicated to answer this question properly.

Cell savers are not in routine use in all ONCAB cases in UK. Some earlier studies raised concern about the cost effectiveness of routine use of cell savers [17]. These studies were from an earlier era, and the picture has changed considerably with several-fold increase in the cost of blood and blood products, as well as realization of greater potential dangers of blood transfusion [4],[5]. In cardiac theatres, perfusionists and operating room assistants can easily be trained to run the cell saver machine, with no significant added labour cost.

Our study had some important limitations. It is non-randomised study and the sample size is relatively small. Transfusion data included transfusion only in the first 24 hours. There are numerous factors that can influence the blood loss intra- and postoperatively, and this study cannot take into account all those factors. Only one surgeon did all the OPCAB cases, whereas three other surgeons contributed to most of ONCAB cases (off-pump surgeon also contributed a small fraction of cases). Nevertheless, this study does

add significantly to our knowledge in the ongoing debate of off- versus on-pump bypass grafting.

Conclusion

Several blood conservation techniques are currently available, which can be used in combination according to clinical circumstances to minimise the blood transfusion rate. Cell saver is an important part of an integrated, comprehensive blood conservation strategy. Routine use of this method leads to similar degree of blood conservation in on- and off-pump CABG.

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