

Transfusion practices among patients who did and did not predonate autologous blood before elective cardiac surgery

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Abstract

Background: Preoperative autologous blood donation is commonly used to reduce exposure to allogeneic transfusions among patients undergoing elective cardiac surgery. However, this technique is associated with an overall increase in transfusions (allogeneic or autologous). The authors assessed the impact of transfusion decision-making on the effectiveness of preoperative autologous donation in reducing the frequency of allogeneic transfusions, and its impact on the increased transfusion rate associated with preoperative autologous donation in cardiac surgery.

Methods: This retrospective analysis compared transfusion practices among 176 patients who predonated autologous blood before elective cardiac surgery and 176 matched cardiac surgery patients who did not predonate blood. The impact of decision-making on transfusion exposure was determined using multivariate analyses to account for major perioperative interventions and complications. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for exposure to allogeneic blood transfusion or any transfusion, before and after exclusion of transfusions not conforming with selected transfusion criteria.

Results: Exposure to allogeneic transfusion was more likely among patients who did not predonate blood than among those who did predonate blood (OR 14.0, 95% CI 5.8–33.8). This finding was still true after exclusion of transfusions not meeting the transfusion criteria (OR 19.3, 95% CI 6.7–55.7). The autologous blood donors were more likely than the nondonors to receive any transfusion (OR 10.8, 95% CI 5.7–20.3). However, this association was substantially attenuated after exclusion of transfusions not meeting the transfusion criteria (OR 1.9, 95% CI 1.1–3.2).

Interpretation: Patients who predonated blood before elective cardiac surgery were at lower risk of receiving allogeneic transfusions than the nondonors. This was not because of a deliberate withholding of allogeneic transfusions from autologous donors. However, more liberal transfusion criteria for autologous blood were largely responsible for the increased transfusion rate among the autologous donors.

In response to the concern of transmitting viral infections through blood products, preoperative autologous blood donation has been proposed to reduce the frequency of allogeneic blood transfusion in cardiac surgery.¹⁻⁵ However, the efficacy of this technique in cardiac surgery is unproven, and consequently 2 major concerns regarding its use have arisen. First, its reported effectiveness may depend on decisions to withhold allogeneic transfusion from autologous blood donors. This practice has been observed in noncardiac surgery.⁶ Second, preoperative autologous donation is associated with an overall increase in exposure to any transfusion (allogeneic or autologous).^{1-4,7} This association may outweigh the potential benefit of autologous donation by increasing the risk of other transfusion-related complications such as bacterial contamination and transfusion reactions owing to laboratory or clerical errors.⁸⁻¹¹ More liberal criteria for transfusing autologous blood may be largely responsible for the increased transfusion rate observed among autologous donors.^{6,12,13} However, the impact of decision-making on transfusion exposure, when autologous blood is available, is unknown.



Evidence

Études

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Using models proposed to evaluate transfusion practice,^{14,15} we analysed transfusion decisions in a cohort of patients who predonated autologous blood before elective cardiac surgery. The objectives were to determine whether withholding allogeneic transfusions from autologous donors occurred and contributed to the decreased rate of allogeneic transfusion in this population, and whether more liberal criteria for transfusing autologous blood contributed significantly to the increased transfusion rate among patients who predonated blood.

Methods

This retrospective cohort study was approved by the University of Ottawa Heart Institute Human Research Ethics Committee. Data were retrieved from patient charts and the blood bank database. All patients who were referred to the preoperative autologous donation program and underwent cardiac surgery at the University of Ottawa Heart Institute between Jan. 1, 1994, and Dec. 31, 1995, were eligible. For comparison, we obtained data for a matched group of patients who underwent elective cardiac surgery during the same period but did not predonate blood. Matching criteria to account for most predictors of transfusion in cardiac surgery were selected:^{16,17} patients were within 5 years' age difference, were within 5 kg weight difference, had the same number of previous cardiac procedures and were within one operative risk category of the multifactorial risk index of Tuman and associates.¹⁸ The last criterion is a multifactorial outcome predictor separating patients into 5 risk categories according to their preoperative health status and the complexity of their surgery. We excluded patients undergoing urgent procedures and those who were unmatched.

Patients in the preoperative autologous donation program could not predonate blood if they had one of the following: hematocrit below 0.34 at the first donation, or below 0.32 at subsequent donations; systolic blood pressure below 90 mm Hg or above 180 mm Hg; unstable angina; critical aortic stenosis (valve area less than 0.5 mm² or ventriculo-aortic gradient greater than 70 mm Hg); left main coronary artery stenosis greater than 50%; symptomatic carotid artery disease; recent transient ischemic attack; uncontrolled congestive heart failure; active bacterial infection; dental work within a week before donation; and fever. Blood was collected in standard blood storage bags at the outpatient clinic; donations occurred from 35 days to 5 days before surgery.

All operations were performed under cardiopulmonary bypass using a roller pump and a membrane oxygenator with crystalloids for cardioplegia. Intraoperative harvesting of autologous blood with normovolemic hemodilution was not used in any case. At the end of cardiopulmonary bypass, the blood from the oxygenator was reinfused. Chest-tube drainage after cardiopulmonary bypass accounted for perioperative blood loss.

Decisions to transfuse allogeneic and autologous blood were made according to individual patient's needs by the attending surgeon. Each decision to transfuse 1 or more unit of blood product was classified as conforming or not conforming with selected transfusion criteria. The criteria were meant to identify differences in transfusion patterns between the 2 groups. They were deliberately not selected as markers for the appropriateness of transfusion, a characteristic that remains ill-defined.¹⁹ Transfusions of allogeneic or autologous red blood cells met the transfusion criteria in the presence of one of the following: (a) the pa-

tient's hematocrit value was equal to or less than the median value triggering transfusion of allogeneic red blood cells in all patients (for transfusions during cardiopulmonary bypass, the median value triggering transfusion during that specific period was used because lower hematocrit values are usually tolerated during cardiopulmonary bypass); (b) the patient had a well-documented intraoperative surgical complication leading to rapid blood loss associated with hypotension; (c) there was excessive postoperative chest-tube drainage (more than 1500 mL in 24 hours²⁰); or (d) re-exploration was necessary because of bleeding. Transfusions of platelets, fresh frozen plasma or cryoprecipitates met the selected criteria in the presence of active bleeding and at least one abnormal coagulogram result (platelet count less than $100 \times 10^9/L$, INR [international normalized ratio] greater than 1.5 or partial thromboplastin time more than 50 seconds in the presence of a normal thrombin time¹⁹).

Two end-points were used to compare the allogeneic transfusion practices between the 2 groups: the number of patients in each group who received allogeneic blood transfusions that did not conform with the transfusion criteria; and the number of patients who did not receive allogeneic blood transfusions in the presence of at least one transfusion criterion. For the latter, patients who did not predonate blood could only be compared with autologous donors who had already used all of their units of autologous blood when the transfusion criteria were present.

The groups were compared using the unpaired Student's *t*-test for continuous variables and the 2-tailed χ^2 test or Fisher's exact test for categorical variables. Using receiver operating curves, we tested different cutoff points for continuous variables (e.g., age, weight, hematocrit) to determine the best association with blood transfusions. A univariate analysis identified the perioperative factors associated with autologous and allogeneic transfusions. All significant factors with a *p* value of 0.20 or less were included in forward stepwise multiple logistic regression analyses to determine the most significant factors associated with the various blood transfusions. For each factor, odds ratios (ORs) and 95% confidence intervals (CIs) for exposure to allogeneic transfusion or any transfusion were calculated before and after exclusion of transfusions not meeting the transfusion criteria. In the latter models, patients who would not have received a transfusion had the criteria been met for all decisions were entered as "untransfused." A *p* value of less than 0.05 was considered significant.

Results

During the study period 203 patients scheduled for elective cardiac surgery entered the preoperative autologous blood donation program. Of these, 22 were excluded from our study because of a lack of matched patients for comparison and 5 because of unstable angina leading to urgent surgery. Of the 176 remaining autologous donors, 7 predonated 1 unit of blood, 45 gave 2 units, 104 gave 3 units and 20 gave 4 units. The 2 groups of patients had similar preoperative and intraoperative characteristics except for the preoperative hematocrit, which was lower in the autologous donor group (Table 1). There were significantly more major perioperative complications in the nondonor group (Table 2). The mean perioperative blood loss was 1149 (standard deviation [SD] 494) mL in the autologous donor group and 1237 (SD 569) mL in the nondonor group (*p* = 0.12). The mean hematocrit value at dis-



charge was 0.32 (SD 0.04) and 0.31 (SD 0.05) respectively ($p = 0.28$). Of the 489 predonated units of autologous blood, 246 (50.3%) were transfused perioperatively; the rest were discarded.

A total of 15 (9%) of the autologous donors received any allogeneic blood product, as compared with 63 (36%) of the nondonors (Table 3). This 4-fold difference in allogeneic transfusion rates was statistically significant ($p < 0.001$). However, the rate of exposure to any transfusion (allogeneic or autologous) was twice as high in the autologous donor group (73% v. 36%, $p < 0.001$) (Table 3).

For the 2 groups, the median hematocrit level triggering allogeneic transfusions of red blood cells was 0.19 during cardiopulmonary bypass and 0.23 at other times. There were 35 allogeneic transfusion decisions in the autologous donor group and 163 in the nondonor group ($p < 0.001$). The transfusion criteria were not met for 7 and 29 of the allogeneic transfusion decisions in the autologous donor group and the nondonor group respectively ($p < 0.001$). The transfusions not conforming with the criteria occurred in 7 (4%) of the autologous donors and 21 (12%) of the

nondonors ($p = 0.006$). Many of these patients also received allogeneic transfusions that conformed with the transfusion criteria at other times. Thus, only 4 (2%) of the autologous donors and 10 (6%) of the nondonors would not have received allogeneic blood had transfusion criteria been met for all transfusion decisions ($p = 0.17$).

There were 189 decisions to transfuse autologous blood, of which 91 (48%) did not meet the transfusion criteria. Of the 128 patients in the autologous donor group who were given autologous blood, 79 (62%) received at least one autologous transfusion that did not meet the transfusion criteria and 54 (42%) would not have required autologous blood had transfusion criteria been met at all times.

The nontransfusion of allogeneic blood in the presence of transfusion criteria occurred in 9 (16%) of 58 patients who had used all their autologous blood and in 11 (6%) of the 176 patients who did not predonate blood ($p = 0.03$).

The univariate analysis identified 13 variables associated with transfusions of allogeneic or autologous blood: being a nondonor (for allogeneic transfusions only), being

Table 1: Characteristics of patients who did and did not predonate autologous blood before elective cardiac surgery

Characteristic	Predonated blood <i>n</i> = 176	Did not predonate blood <i>n</i> = 176
Mean age (and SD), yr	56 (11)	57 (11)
Mean weight (and SD), kg	83 (15)	83 (15)
Reoperation, no. (and %) of patients	7 (4)	7 (4)
Preoperative risk score (and SD)	1.2 (1.3)	1.5 (1.5)
Female:male ratio	27:149	28:148
Left ventricular function, no. (and %) of patients		
Normal (EF > 50%)	139 (79)	143 (81)
Mildly depressed (EF 35%–50%)	31 (18)	23 (13)
Severely depressed (EF < 35%)	6 (3)	10 (6)
ASA treatment, no. (and %) of patients	93 (53)	102 (58)
Mean preoperative hematocrit (and SD)	0.37 (0.04)	0.42 (0.04)*
Type of surgery, no. (and %) of patients		
CABG	139 (79)	143 (81)
Single-valve replacement	19 (11)	18 (10)
Atrial septal defect repair	8 (5)	8 (5)
Other	10 (6)	7 (4)
Mean duration of cardiopulmonary bypass (and SD), min	89 (33)	90 (31)
Mean duration of aortic cross-clamping (and SD), min	50 (21)	51 (21)
Tranexamic acid administration, no. (and %) of patients	121 (69)	124 (70)
Transfusion of shed mediastinal blood, no. (and %) of patients	133 (76)	122 (69)

Note: SD = standard deviation, EF = ejection fraction, CABG = coronary artery bypass grafting, CPB = cardiopulmonary bypass.
* $p < 0.001$, for comparison between groups.

Table 2: Occurrence of major perioperative complications

Complication	No. of patients	
	Predonated blood	Did not predonate blood
Death	1	3
Stroke	1	2
Bleeding necessitating reoperation	2	8
Reoperation for reason other than bleeding	1	4
Low cardiac output or hypotension necessitating treatment with IABP or ≥ 2 inotropes	4	9
Pulmonary edema after discharge from ICU	2	1
Complete heart block necessitating insertion of permanent pacemaker	1	1
Postoperative mechanical ventilation > 48 h	1	3
Gastrointestinal bleeding or ischemia	2	2
Sepsis or deep wound infection	2	2
All	17	35*

Note: IABP = intra-aortic balloon pump, ICU = intensive care unit.
* $p = 0.03$, for comparison between groups.

Table 3: Rate of exposure to blood products

Exposure	No. (and %) of patients			<i>p</i> value
	Predonated blood	Did not predonate blood		
Any allogeneic product	15 (9)	63 (36)		< 0.001
Allogeneic red blood cells	14 (8)	63 (36)		< 0.001
Allogeneic components*	6 (3)	14 (8)		0.066
Autologous red blood cells	128 (73)	–		–
Any blood product (autologous or allogeneic)	129 (73)	63 (36)		< 0.001

*Include platelets, fresh frozen plasma and cryoprecipitates.



an autologous donor (for all types of blood), age more than 65 years, weight less than 70 kg, female sex, preoperative hematocrit value less than 0.34, reoperation, valvular procedure, cardiopulmonary bypass lasting more than 120 minutes, no administration of tranexamic acid, postoperative blood loss of more than 1500 mL, major perioperative complications and having a surgeon who was 1 of 5 with a significantly higher transfusion rate in both patient groups than 3 other surgeons participating in the study. The allogeneic and overall transfusion rates among the autologous donors were unrelated to the number of predonated units.

After multivariate analysis, only 7 variables, including being a nondonor (OR 14.0, 95% CI 5.8–33.8), remained significant predictors of exposure to allogeneic transfusions (Table 4). The multivariate analysis was repeated with patients being considered “untransfused” if they received allogeneic transfusions that did not meet the transfusion criteria. In this analysis, the same 7 variables remained significant predictors of exposure to allogeneic blood, with comparable ORs (for the nondonor group OR 19.3, 95% CI 6.7–55.7). For exposure to any transfusion (allogeneic or autologous) another group of 7 variables, including being an autologous donor (OR 10.8, 95% CI 5.7–20.3), were identified as significant predictors through multivariate analysis (Table 5). After exclusion of transfusions not meeting the transfusion criteria, being an autologous donor remained a significant risk factor, but with a much lower influence on exposure to any transfusion (OR 1.9, 95% CI 1.1–3.2). In the latter analysis, valvular procedures and major perioperative complications replaced prolonged cardiopulmonary bypass and surgeon as risk factors for any transfusion.

Interpretation

The patients who predonated autologous blood before cardiac surgery had a 4-fold reduction in exposure to allogeneic blood transfusions compared with the matched nondonors. Concurrently, they had a 2-fold increase in exposure to any transfusion (allogeneic or autologous). As observed in noncardiac surgery, significant changes in

transfusion practices were associated with the availability of autologous blood.

Two findings uncovered a tendency to withhold allogeneic transfusions from the autologous donors in our study. First, decisions to transfuse allogeneic blood in the absence of the selected transfusion criteria occurred in only 4% of the autologous donors, as compared with 12% of the patients who did not predonate blood. Second, decisions not to transfuse allogeneic blood in the presence of transfusion criteria occurred in a significantly larger proportion of autologous donors who had used all their autologous blood than of nondonors (16% v. 6%). However, the effect of these differences on the rate of exposure to allogeneic blood was minimal, because many transfusions not conforming with the transfusion criteria were given to patients who required allogeneic blood at other times for reasons that did not conform with the criteria. Consequently, as shown through multivariate analyses performed before and after exclusion of transfusions not meeting the criteria, the risk of being exposed to allogeneic blood among the nondonors was not significantly modified by transfusion decision-making.

The increased transfusion rate associated with preoperative autologous donation has recently raised some concern about its safety as an alternative transfusion approach.^{7,11,21} This is because the most common transfusion-related complications are not viral infections, but ABO incompatibility due to erroneous identification of the patient or unit at the time of phlebotomy or transfusion.^{10,11} In our study 42% of the 129 autologous donors given a transfusion would not have received any blood had the transfusion criteria been met at all times. Therefore, exposure to a transfusion was more likely among the autologous donors than among the nondonors (OR 10.8). After correction for nonconforming transfusion decisions, being an autologous donor was a much weaker risk factor for transfusion exposure (OR 1.9). Thus, transfusion decision-making contributes significantly to the increased transfusion rate and, consequently, to the potential increase in risk associated with preoperative autologous donation. The reason why the factor of being an autologous donor remained a weak predictor for transfusion is likely because we did not fully control for preoperative hematocrit (dichotomized in the logistic regression analysis).

Table 4: Risk factors for exposure to allogeneic blood products before exclusion of transfusions not meeting selected transfusion criteria

Risk factor	Odds ratio (and 95% CI)	p value
Postoperative blood loss > 1500 mL	23.0 (6.6–80.3)	< 0.001
No predonation of autologous blood	14.0 (5.8–33.8)	< 0.001
Major perioperative complication	6.7 (2.6–17.7)	< 0.001
Female sex	6.3 (2.8–14.1)	< 0.001
Preoperative hematocrit < 0.34	5.3 (1.9–14.8)	0.002
Duration of cardiopulmonary bypass > 120 min	4.1 (1.8–9.7)	0.001
Surgeon with high transfusion rate*	2.9 (1.4–5.8)	0.003

Note: CI = confidence interval.

*Of the 8 surgeons participating in the study, 5 had significantly higher transfusion rates in both patient groups than the 3 other surgeons.

Table 5: Risk factors for exposure to any blood product (allogeneic or autologous) before exclusion of transfusions not meeting selected transfusion criteria

Risk factor	Odds ratio (and 95% CI)	p value
Postoperative blood loss > 1500 mL	36.1 (7.2–181.3)	< 0.001
Preoperative hematocrit < 0.34	17.1 (3.8–76.5)	< 0.001
Predonation of autologous blood	10.8 (5.7–20.3)	< 0.001
Female sex	9.5 (3.8–24.1)	< 0.001
Age > 65 yr	4.8 (2.3–10.0)	< 0.001
Duration of cardiopulmonary bypass > 120 min	4.7 (2.0–11.0)	< 0.004
Surgeon with high transfusion rate	3.0 (1.7–5.2)	< 0.002



Considering the unproven efficacy of preoperative autologous blood donation as well as recent improvements in the safety of allogeneic blood and the risk of cardiac complications with preoperative blood donation,^{22,23} recent cost-effectiveness analyses have questioned the use of preoperative autologous donation in cardiac surgical centres where allogeneic transfusion rates are less than 50%.^{24,25} However, economic studies ignore the risk of immunomodulation, alloimmunization and transmission of new and emerging diseases through blood. The true value of preoperative autologous donation may be unproven in cardiac surgery, but its effectiveness in reducing allogeneic transfusion has been demonstrated repeatedly.¹⁻⁵ Our study suggests that preoperative autologous donation remains highly effective, even in centres with low transfusion rates (Fig. 1). Discouraging its use in cardiac surgery on the basis of economic analyses may represent a risk that the recent Commission of Inquiry on the Blood System in Canada has recommended not taking.²⁶

One limitation of our study was the lack of randomization. Patients who predonated blood were possibly healthier than others with apparently similar characteristics. This unavoidable bias may explain why the autologous donors had fewer major perioperative complications than the nondonors despite a fairly thorough matching process. Through multivariate analyses we partially addressed this problem by evaluating the risk of exposure to allogeneic transfusion after controlling for factors ignored by the matching process. However, this approach does not have the power of a blinded randomized study. The hematocrit threshold we selected for the analysis of transfusion deci-

sions may also limit the application of these results to other centres that may be more liberal or conservative with blood transfusions. However, in the absence of recognized hematocrit thresholds for transfusion,¹⁹ the median hematocrit values triggering the transfusion of allogeneic red blood cells reflected local practice objectively.

In conclusion, our findings suggest that preoperative autologous blood donation, independent of transfusion decisions, is most likely an effective way to decrease exposure to allogeneic transfusions in cardiac surgery. More liberal decisions to transfuse autologous blood represent the main reason for the overall increase in transfusion rates among cardiac surgery patients who predonated autologous blood. The risk of transfusion reactions associated with preoperative autologous donation could be almost eliminated if decisions to transfuse autologous blood were made using the same criteria as those for transfusing allogeneic blood.

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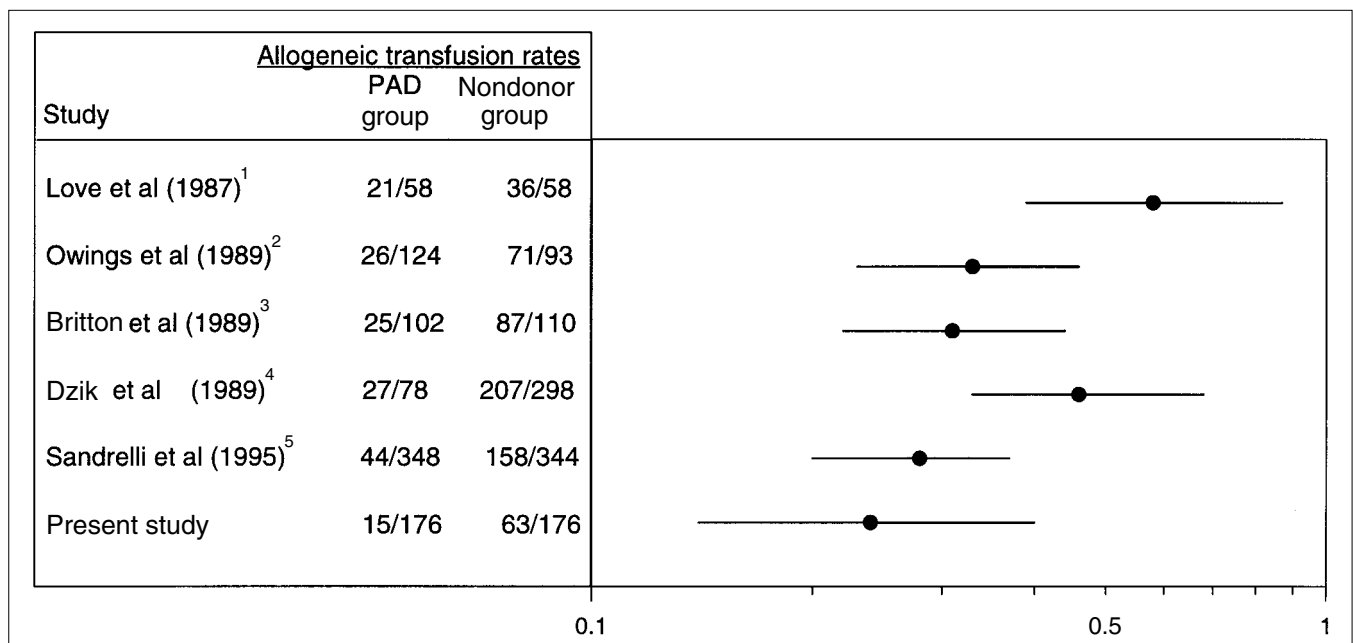


Fig. 1: Analysis of effectiveness of preoperative autologous donation (PAD) before cardiac surgery in reducing exposure to allogeneic transfusion, presented as relative risks and 95% confidence intervals for exposure to allogeneic blood in patients who predonated autologous blood. The effectiveness of predonation was well maintained in the last 2 studies, despite allogeneic transfusion rates of less than 50% among patients who did not predonate blood.



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