Management of Blood Transfusion in Aortic Valve Surgery: Impact of a Blood Conservation Strategy

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Background. There are limited data in the literature concerning the effect of a blood conservation strategy (BCS) on aortic valve replacement (AVR) patients.

Methods. From 2007 to 2011, 778 patients underwent AVR at a single institution. During this period, a multidisciplinary BCS was initiated with emphasis on limiting intraoperative hemodilution, tolerance of perioperative anemia, and blood management education for the cardiac surgery care providers.

Results. Mortality was 3.0% (23 of 778) overall and 1.7% (9 of 522) for isolated first-time AVR. There was no difference in rates of mortality ($p = 0.5$) or major complications ($p = 0.4$) between the pre-BCS and post-BCS groups; however, the BCS was associated with a lower risk of major complications (odds ratio, 1.7; $p = 0.046$) by multivariable analysis. The incidence of red blood cell (RBC) transfusion decreased from 82.9% (324 of 391) to 68.0% (263 of 387; $p < 0.01$). Of those patients who did not receive any day-of-operation RBC transfusions, 64.5% (191 of 296) did not receive any postoperative RBC transfusions. Lower risk of RBC transfusion was associated with isolated AVR ($p < 0.01$), a minimally invasive approach ($p < 0.01$), and BCS ($p < 0.01$), whereas a greater risk of RBC transfusion was associated with older age ($p < 0.01$), prior cardiac operation ($p = 0.01$), female sex ($p < 0.01$), and smaller body surface area ($p < 0.01$). Day-of-operation RBC transfusion of 2 units or more was associated with increased deaths ($p = 0.01$), prolonged intubation ($p < 0.01$), postoperative renal failure ($p = 0.01$), and increased incidence of any complication ($p < 0.01$).

Conclusions. Perioperative BCS reduced RBC transfusion in AVR patients without an increase in mortality or morbidity. Guidelines for BCS in routine cardiac operations should be extended to AVR patients.

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Blood transfusion is associated with worsened short-term and long-term outcomes [1–3] and increased medical costs [4, 5]. Cardiac operations use up to 20% of the blood supply in the United States [4, 6] and worldwide [2, 3, 7] with approximately 50% of cardiac surgical patients receiving blood products [8] and transfusion rates in some series as high as 95% [3]. Although the number of blood transfusions continues to rise [9], the blood donor pool has stabilized and, in some regions, is decreasing [9, 10], leading to blood product shortages and increasing costs of transfusion [11].

The Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists (STS/SCA) blood conservation clinical practice guidelines propose a multidisciplinary, multimodality approach to blood conservation in cardiac surgery, with recommendations ranging from preoperative pharmacologic approaches, to intraoperative surgical, perfusion, and transfusion strategies, to postoperative management suggestions [7]. However, these guidelines are based almost entirely on data from coronary artery bypass graft (CABG) patients [7, 11–14], raising the question of whether they can be extended to other areas of cardiac surgery.

Aortic valve replacement (AVR) operations have a higher risk for allogeneic blood transfusion than CABG [15–17]. With 80% of the blood transfusions in cardiac surgery going to only 10% to 20% of cardiac surgical patients [7, 18], it may be possible to significantly reduce the amount of blood transfused [19] by focusing on these high-risk patients. However, there is a paucity of data on the safety and efficacy of using a blood conservation strategy (BCS) in AVR patients, with most data arising from case reports [20–22] or in studies where multiple types of procedures were performed [12, 16, 23].

We retrospectively reviewed clinical and transfusion records of patients undergoing AVR before and after BCS implementation to determine the effect of BCS on rates of morbidity, mortality, and blood product use.

Patients and Methods

Institutional Review Board exemption for deidentified patient data with waiver of informed consent was obtained for this study.

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Abbreviations and Acronyms

AVR	= aortic valve replacement
BCS	= blood conservation strategy
BSA	= body surface area
CABG	= coronary artery bypass graft
COPD	= chronic obstructive pulmonary disease
CPB	= cardiopulmonary bypass
FFP	= fresh frozen plasma
OR	= odds ratio
RBC	= red blood cell
SCA	= Society of Cardiovascular Anesthesiologists
SD	= standard deviation
STS	= The Society of Thoracic Surgeons

From November 2007 through November 2011, 778 patients underwent AVR at our institution. Mean age was 71.7 ± 13.3 years (range, 18 to 96) with 33.0% (257 of 778) aged 80 years or older. All patients who underwent AVR during this interval were included in the analysis. During this period, a multidisciplinary BCS was initiated with emphasis on minimization of intraoperative hemodilution, tolerance of perioperative anemia, and education of all cardiac surgical team members. Intraoperative hemodilution was minimized by using shortened cardiopulmonary bypass (CPB) circuits with in-line arterial filters and smaller diameter tubing (~800 mL total volume), retrograde and antegrade autologous priming, and preferential use of vasopressors rather than intravenous fluids to manage anesthetic-induced hypotension.

Cardiac surgical multidisciplinary team members, including surgeons, surgical residents, perfusionists, anesthesiologists, and recovery room and intensive care unit nurses, were educated to tolerate a perioperative hemoglobin of 8 g/dL or higher rather than the previously often used transfusion trigger of less than 10 mg/dL. In addition, transfusions were performed according to physiologic need and not reflexively in response to laboratory values or for empiric or prophylactic reasons. There was no use of preoperative pharmacologic methods to increase red blood cell (RBC) volume, use of autologous blood donation, or use of intraoperative normovolemic hemodilution.

All patients, regardless of study cohort, underwent reversal of heparinization with protamine sulfate. Mechanical and flowable prothrombotic materials were used where indicated in all patients; however, no additional agents were used in the BCS group for hemostasis or promotion of coagulation.

The introduction of BCS occurred gradually during the middle of the study period. To simplify analysis, the study period was divided into two equal time periods (November 1, 2007, to December 3, 2009, and December 4, 2009, to November 31, 2011) resulting in pre-BCS (n = 391) and post-BCS (n = 387) groups. Preoperative patient characteristics are listed in Table 1.

Outcomes for hospital death, postoperative complications, and major complications, a composite of death, postoperative respiratory failure (mechanical ventilation >72 hours), renal failure requiring dialysis, and sepsis were tabulated. Total transfusion, including packed RBCs, platelets, and fresh frozen plasma (FFP), was calculated for each patient and additionally subdivided into perioperative (day of operation) and postoperative (postoperative day 1 through discharge) transfusion. Transfusion requirements were monitored until hospital discharge.

To minimize the effect of baseline differences on outcomes, independent risk factors for death, major complications, and RBC transfusion were determined by multivariable analysis using general linear models. Comparative cost savings analysis was performed for differences in RBC utilization. The monetary savings secondary to RBC conservation was estimated using Formula 1:

$$\text{Cost savings} = (N_{BCS}) \times (\text{mean } RBC_{non\_BCS} - \text{mean } RBC_{BCS}) \times (\text{mean cost per unit of RBC})$$

Where N_{BCS} was the number of BCS patients, RBC_{non_BCS} and RBC_{BCS} were the number of units of RBCs transfused for each non-BCS and BCS patient, respectively, and mean cost per unit of RBC was $1,032.14, which was adjusted for inflation [24] from the mean cost of transfusion of a single unit of RBC in the United States estimated to be $954.68 by Shander and colleagues [4] in 2008.

Statistical analyses were performed using SPSS 20 software (IBM Corp, Armonk, NY). Results are presented as mean ± standard deviation for continuous variables and incidence (%) for categoric variables. Comparisons were performed using nonpaired *t* tests for continuous variables, Pearson χ^2 analyses for categoric variables, and the Mann-Whitney *U* test for median values. Odds ratios (OR) are presented for categoric variables. Statistical significance was set at a *p* value of less than 0.05.

Results

Baseline patient characteristics were similar between the pre-BCS (n = 391) and post-BCS (n = 387) patients except for lower incidences of congestive heart failure, chronic obstructive pulmonary disease, peripheral vascular disease, aortic calcification, and previous cardiac operations in the post-BCS group, likely reflecting a change in referral practices. There was also an increase in the number of procedures performed though minimally invasive incisions as well as a shift in minimally invasive technique from anterior thoracotomy to partial sternotomy (Table 1).

Overall mortality was 3.0% (23 of 778), including 1.7% (9 of 522) for isolated, first-time AVR patients. Deaths were only observed in patients who received 2 units or more