Brief Reports

Etiology of preoperative anemia in patients undergoing scheduled cardiac surgery

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Purpose: Ten percent of our cardiac surgical patients have preoperative anemia. Anemia diagnosed before scheduled cardiac surgery is a strong predictor of the need for homologous blood transfusion (RBC) perioperatively but the cause of this preoperative anemia is not known. The purpose of this study was to evaluate the etiology of preoperative anemia.

Methods: Seventy-five consecutive anemic cardiosurgical patients ($Hb = < 120 \text{ g}\cdot\text{L}^{-1}$ the day before surgery) were studied prospectively. All had multiple diagnostic blood tests done in the preoperative period to diagnose the cause of the anemia and subsequently underwent non-emergency cardiac surgery. Anesthesia and RBC transfusion were standardized according to the protocol. Data in respect to operation, RBC and other blood product transfusion during operation and hospital stay were recorded.

Results: Hospital-acquired anemia was present in 37.3% of anemic patients (hemoglobin decrease during hospitalization before surgery $\geq 9 \text{ g}\cdot\text{L}^{-1}$). The second most common diagnosis was iron deficiency anemia (29.3% patients) followed by anemia of chronic renal disease (10.7% patients). When coronary angiography was performed close to operation time, patients had a higher decrease in hemoglobin concentration during hospitalization - suggesting that blood loss during angiography was, in part, responsible for anemia. Seventy-five percent of anemic patients were transfused with RBC perioperatively compared with our overall transfusion rate of 30% of cardiac surgery patients.

Conclusions: In the majority of patients, preoperative anemia is potentially preventable. Investigation and treatment of anemia before cardiac surgery should be a priority in preparing the patient for surgery.

Objectif : Dix pour cent des patients de cardiochirurgie présentent de l'anémie préopératoire. Le diagnostic d'anémie avant une intervention cardiaque élective laisse fortement envisager la nécessité d'une transfusion de sang homologue périopératoire. La cause de cette anémie n'est cependant pas connue. L'objectif de la présente étude était d'évaluer l'étiologie de l'anémie.

Méthode : Soixante-dix patients anémiques qui se sont successivement présentés en cardiochirurgie ($Hb = < 120 \text{ g}\cdot\text{L}^{-1}$ le jour précédant l'opération) ont participé à l'étude prospective. Tous ont subi de multiples tests sanguins diagnostiques avant l'opération pour déterminer la cause de l'anémie et ils ont été admis ensuite en cardiochirurgie non urgente. L'anesthésie et la transfusion ont été normalisées selon le protocole. Les données concernant l'opération, la transfusion de globules rouges, et d'autre produit pendant l'intervention et le séjour hospitalier, ont été enregistrées.

Résultats : L'anémie s'étant développée à l'hôpital était présente chez 37,3 % des patients anémiques (l'hémoglobine a baissé pendant l'hospitalisation, avant l'opération $9 \text{ g}\cdot\text{L}^{-1}$). Le deuxième diagnostic en importance a été l'anémie ferriprive (29,3 % des patients) suivie de l'anémie de la néphrite chronique (10,7 %). Lorsque la coronarographie a été réalisée peu avant l'opération, les patients présentaient une plus forte baisse de la concentration d'hémoglobine pendant l'hospitalisation, ce qui laisse supposer que la perte sanguine produite pendant l'angiographie était en partie responsable de l'anémie. Soixante-quinze pour cent des patients anémiques ont été transfusés comparativement à une proportion globale de 30 % de transfusion chez les patients de cardiochirurgie.

Conclusion : Dans la majorité des cas, on peut prévenir l'anémie préopératoire. La recherche et le traitement de l'anémie préopératoire doivent être une priorité dans la préparation du patient en cardiochirurgie.

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THE presence of anemia (hemoglobin ≤ 120 g·L⁻¹) in patients immediately before cardiac surgery is one of the strongest predictors of the need for red blood cell (RBC) transfusion in the perioperative period.¹⁻³ Without RBC transfusion, anemic patients have insufficient hemoglobin to withstand hemodilution during CPB and perioperative blood loss.

Ten percent of patients (250 per annum) scheduled for cardiac surgery in our institution are anemic, but the etiology of this anemia has not been studied.^{2,3}

Methods

After institutional approval and informed consent, 75 consecutive anemic patients undergoing first time elective heart surgery were studied prospectively. A hemoglobin value of 120 g·L⁻¹ was based on review of our previously published studies.

All patients received low dose fentanyl anesthesia. Tranexamic acid was given (50 mg·kg⁻¹) before sternotomy. Heparin (300 u·kg⁻¹) was given to achieve an ACT of >400 sec before CPB. Membrane oxygenator (MAXIMA by Medtronic) was used. Patients were cooled to $33.4 \pm 2.0^\circ\text{C}$. Heparin was neutralized with protamine sulfate, up to 1 mg for every 100 u heparin.

Blood from the CPB circuit was transfused into the patient at the end of surgery. After surgery, blood loss from mediastinal drains was autotransfused once the drainage exceeded 150 ml during the initial six hours postoperatively. Blood loss after the operation was measured at 6 and 24 hr. Strict protocol for blood products transfusion was followed.^{2,3}

Hematology

Complete blood counts, including platelet counts, were performed before surgery with a TOA Electronic Blood Cell Counter (Baxter Industries, Toronto, Ontario) and checked for accuracy with a microscopic examination of a fixed, stained film. Morphology of red blood cells was checked on stained blood film.

The prothrombin time (PT), and activated partial thromboplastin time (PTT) were performed with standard commercial reagents (Thromborel-S, Hoechst-Roussel, Montreal, PQ; Platelet LS) Organon-Teknika, Akzo, Pharma Group, Scarborough, Ontario, in an automatic coagulation device (Automated Coagulation Laboratory, ACL, Coulter Electronics of Canada, Burlington, Ontario).

All anemic patients were evaluated prior to surgery. Reticulocyte counts were done manually on routine blood film stained by methylene blue. Serum iron concentration was measured by spectrophotometry on a Cobas Fara II analyzer (Roche Diagnostic Systems,

TABLE I Sensitivity and precision of laboratory tests

Test	Sensitivity	Precision (CV%)
PT		2.2
PTT		2.7
Serum iron	3 mmol·l ⁻¹	4.2
Transferrin	0.01 g·l ⁻¹	4.0
Ferritin	0.5 ng·ml ⁻¹	2.76
Serum folate	0.2 nmol·l ⁻¹	4.9

TABLE II Demographic data of anemic patients

	Anemic patients (n=75)
Age (yr)	67 $\pm$ 8.9
Weight (kg)	72.8 $\pm$ 15.3
Temperature CPB ($^\circ\text{C}$)	33.5 $\pm$ 2
CPB time (min)	85 $\pm$ 32
Lowest hematocrit CPB	0.19 $\pm$ 0.016
24 hr blood loss (mL)	514 $\pm$ 431
Hb on admission (g·l ⁻¹)	118 $\pm$ 13.2
Hb day of operation	110.8 $\pm$ 7.1
Hb after surgery	76.8 $\pm$ 9.8

mean $\pm$ SD

Hb - hemoglobin concentration

CPB - cardio-pulmonary bypass

Mississauga, ON) using the Synermed Iron Reagent Kit Cat. IR220X (Synermed Inc, Lachine QC). Transferrin was measured on a Cobas FARA II analyzer using the AMES Sera-Pak Immuno reagent kit (Bayer, Etobicoke, ON) for quantitative determination of transferrin (TRN)(cat. no 6805).

Ferritin concentration was measured by immunoassay using the Ciba Corning ACS ferritin assay. Serum folate level and red blood cell folate concentrations were measured by radioimmune assay using Bio-Rad Folate Radioassay.

Patients with valvular heart disease also underwent tests to exclude hemolysis as the cause of anemia.

Haptoglobin concentration was measured using an automated Nephelometer Analyzer II, Behring and lactate dehydrogenase (LDH) concentration was measured using kit # 149993 (Boehringer Mannheim Canada Laval QC) and an Olympus AU 800 Analyzer (Olympus America Inc. Melville, NY.) (Table I).

Postoperatively, anemic patients were referred to a hematology clinic for follow-up and treatment.

Data analysis

Data with respect to diagnosis of anemia were analyzed in a descriptive manner. Comparison of mean values was by one way ANOVA and predictors were analyzed by logistic regression.

FIGURE Hospital induced anemia was diagnosed when hemoglobin drop was 9 g/L or more between admission to hospital and surgery and hemoglobin on the day of surgery was ≤ 120 g/L

Results

Hospital acquired anemia was present in 37.3% of anemic patients (hemoglobin decrease during hospitalization; prior to surgery ≥ 9 g·L⁻¹). The second most common diagnosis was iron deficiency anemia (29.3%) followed by anemia of chronic renal disease (10.7%) (Figure). Demographics from anemic patients and controls are presented in Table II.

Seventy-five percent of anemic patients were transfused with RBC perioperatively compared with our overall transfusion rate of 30% of patients in cardiac surgery.

Discussion

We were surprised to see that 37.3% of the anemic patients had a mean hemoglobin decrease of 18.5 ± 10.2 g·L⁻¹ during hospitalization and became anemic while awaiting surgery. Possible explanations are blood sampling while in the hospital and blood losses during coronary angiography.⁵ When we compared hemoglobin difference (from admission to OR time) and angiography time we found that group one $n=32$ (angiography < 30 days from OR time, mean 8.3 ± 5.6 days) had a higher hemoglobin decrease (mean 9.6 ± 13.2 g·L⁻¹) than group two $n=22$ (angiography > 30 days from OR time, mean 94 ± 64 days) mean Hb decrease 2.7 ± 5.8 ($P=0.036$). This suggests that blood loss during angiography is, in part, responsible for the overall decrease in hemoglobin concentration during hospitalization.

The second largest group consisted of patients with iron deficiency anemia (22%) followed by anemia of chronic renal failure (8%). A large proportion of our

patients (74.7%) were taking aspirin preoperatively and this could be the precipitating factor for iron deficiency anemia related to occult blood loss via the gastrointestinal tract.^{6,7}

The female group (50.7%) of our anemic patient population is larger than that of the general population of heart surgery patients (females-30% of all cardiac surgery patients) indicating that women are at increased risk of anemia in the preoperative period. No hemolytic anemia was detected.

We compared transfused anemic patients (75%) with anemic patients who were not transfused (25%) in an attempt to find a predictor for the need to transfuse among anemic patients. Only immediate preoperative hemoglobin concentration was a predictor ($P=0.03$ logistic regression) of the need to transfuse perioperatively in anemic patients. Age, sex, type of anemia, and Hb decrease while in hospital did not have predictive value.

Conclusion

Preoperative anemia in cardiac patients undergoing first time non-emergency cardiac surgery is potentially preventable 80% of the time. We assume that preoperative investigation and diagnosis of anemia combined with cause-specific treatment may reduce the number of anemic patients undergoing heart surgery. Meticulous attention to the control of blood loss during and after angiography coupled with the reduction of the number of blood tests ordered in the preoperative period may reduce blood loss before surgery, thus preventing hospital-acquired anemia.^{5,8-10} Investigation and treatment of anemia in the preoperative period should be in the hands of the referring cardiologist, cardiac surgeons and anesthesiologists seeing the patient in the pre-admission clinic.

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