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Original contribution

Factors associated with blood transfusion during intracranial aneurysm surgery☆,☆☆

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ABSTRACT

Study objective: The purpose of this study was to identify risk factors associated with intraoperative blood transfusions in patients presenting for intracranial aneurysm surgery in the current era of more restrictive transfusion guidelines.
Design: Retrospective observational cohort study with stepwise, multivariate binary logistic regression analysis.
Setting: Tertiary care university teaching hospital.
Patients: Four hundred seventy-one consecutive patients undergoing intracranial aneurysm surgery at Northwestern Memorial Hospital (Chicago, IL) from 2006 to 2012.
Intervention: Red blood cell transfusion (retrospective observational).
Measurements: Demographic data, medical comorbidities, hemoglobin levels, Hunt-Hess grades, intracranial aneurysm characteristics, presenting intracranial bleeding states, estimated blood losses, transfused red blood cells, and blood products.
Main results: Forty-six patients (9.5%) received intraoperative red blood cell transfusions. Preoperative risk factors associated with transfusions were highly related to aneurysm rupture, including such parameters as older age ($P < .001$), lower presenting hemoglobin level ($P < .001$), preoperative rupture ($P < .001$), and higher Hunt-Hess grade ($P < .001$). Intraoperative risk factors included larger aneurysm size (>10 mm; $P = .03$), intraventricular hemorrhage ($P < .001$), and intracerebral hematoma evacuation ($P = .02$). Binary logistic regression modeling identified age ($P < .001$), presenting hemoglobin level ($P < .001$), larger aneurysm size (>10 mm; $P = .003$), elevated Hunt-Hess grade ($P = .021$), and intraoperative rupture ($P = .013$) as independent predictors of intraoperative red blood cell transfusion.
Conclusion: The incidence of intraoperative red blood cell transfusion in intracranial aneurysm surgery in our patient cohort was 9.5%, and the most significant factors associated with transfusion were presenting hemoglobin level less than 11.7 g/dL and age greater than 52 years. It would seem advisable that these patients undergo routine type and cross-matching of red blood cells before intracranial aneurysm surgery.

1. Introduction

Approximately 14 million units of red blood cells (RBCs) are transfused each year in the United States [1]. Many of these transfusions are administered to surgical and obstetric patients to prevent anemia and hypovolemia. However, transfusions have also been associated with many adverse effects such as fever, infection, incompatibility reactions, and negative immunomodulatory effects [2], not to mention the costs associated with cross-matching. Although most transfusions are necessary, approximately 16% of RBC transfusions are administered inappropriately [3]. Several organizations have established guidelines to prevent unnecessary usage of blood supplies and to reduce the incidence of adverse transfusion reactions, including the American Association of Blood Banks [4], the American College of Physicians [5], and the American Society of Anesthesiologists [6].

The criteria for transfusion in intracranial aneurysm surgeries are not well defined. One single-centered retrospective study from 2001

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Table 1
Clinical characteristics associated with intraoperative RBC transfusions

	Transfused (n = 46)	Not transfused (n = 425)	Difference (95% CI)	*P*
Age (y)	61.5 (52.5 to 69.5)	52 (44-60)	9.5 (3.0 to 13.5)	<.001
Male, n (%)	10 (22)	105 (25)	−3% (−17% to 11%)	.65
History of smoking, n (%)	28 (61)	239 (57)	4% (−12% to 20%)	.63
Current smoker, n (%)	12 (26)	149 (35)	−9% (−24% to 6%)	.22
Hypertension, n (%)	30 (65)	226 (53)	12% (−3% to 28%)	.12
Admission Hgb (g/dL)	11.5 (9.7 to 12.8)	12.9 (12.3 to 13.9)	1.6 (0.5 to 2.3)	<.001
Postoperative Hgb (g/dL)	10.0 (9.2 to 10.8)	11.1 (10.0 to 12.3)	1.2 (0.6 to 1.7)	<.001
Preoperative aneurysm rupture, n (%)	25 (54)	116 (27)	27% (11% to 43%)	<.001
Hunt-Hess grade				
0	22 (48.9)	309 (73)	−24% (−41% to −8%)	<.001
1	6 (13.3)	26 (6.1)	7% (−4% to 19%)	.07
2	4 (8.9)	53 (12.5)	−4% (−14% to 6%)	.48
3	7 (15.6)	24 (5.7)	10% (−2% to 22%)	.01
4+	6 (13.3)	11 (2.6)	11% (−0.4% to 22%)	.04

Data presented as median (interquartile range) or n (%) of group. RBC = red blood cell; CI = confidence interval; Hgb = hemoglobin.

examined the factors associated with intraoperative and postoperative blood transfusions [7]. This study determined that 1 in 5 aneurysm surgery patients requires a blood transfusion, and that preoperative factors associated with intraoperative blood use included older patient age ($P < .001$), lower hematocrit level on admission ($P = .007$), ruptured rather than unruptured aneurysm ($P = .004$), severe intraventricular hemorrhage ($P = .03$), and larger aneurysm size ($P = .004$). Patients with subarachnoid hemorrhage (SAH) undergoing intracranial aneurysm surgery are at high risk for anemia, with 36% to 47% of patients developing a hemoglobin less than10 g/dL within the first 4 days after surgery [8,9]. Most of these patients do not require any blood transfusion; however, 7.6% of patients with SAH require RBC transfusions intraoperatively, and 3.5% require a transfusion postoperatively [10]. Higher hemoglobin levels have been associated with improved outcomes, including less cerebral infarction and death, in patients with SAH at 14 days and 3 months after discharge [11-13]. Other studies have shown that blood transfusion after SAH was associated with increased risk for vasospasm and poorer outcomes [13,14]. This has led to a wide variation in the use of allogeneic blood for these patients.

The purpose of this study was to identify risk factors associated with intraoperative blood transfusions in patients presenting for intracranial aneurysm surgery in the current era of more restrictive transfusion guidelines. We hypothesized that the risk factors associated with blood transfusions may have changed in association with more current transfusion guidelines compared with those previously identified and used.

2. Methods

This retrospective study was approved by the Northwestern University Institutional Review Board (STU00028295). Four hundred seventy-one consecutive patients who underwent intracranial aneurysm surgery at Northwestern Memorial Hospital (Chicago, IL) from 2006 to 2012 were included in the analysis.

Charts were abstracted by a single investigator (JY) into a de-identified data set for statistical analysis. The following information was extracted: age, sex, smoking history, history of hypertension, state of aneurysm at presentation (ruptured or not), Hunt-Hess grade, presenting and postoperative hemoglobin, intraventricular bleed, intracerebral hemorrhage, intracerebral hematoma evacuation performed, and intraoperative rupture. Data specific to the aneurysm(s), such as size, location, and number, were also recorded.

Transfusion data were obtained from the medical record, anesthesia record, and the blood bank. The number of units and volume of packed RBCs, fresh-frozen plasma, platelets, and cryoprecipitate was recorded. Transfusions were classified according to the timing of administration as preoperative, intraoperative, or postoperative.

2.1. Statistical analysis

The primary outcome of the study was the administration of RBC units intraoperatively. We anticipate that approximately 500 procedures were performed during the study period. Given the prior rate of reported intraoperative RBC transfusions (7.6%), the sample we chose should provide approximately 45 cases of intraoperative transfusion. This sample has a power of 0.81 to detect an independent factor with an odds ratio of 1.6 at an α of .05.

The percentage of patients and the 95% confidence limits of the incidence of intraoperative RBC transfusion were calculated using standard formulae. Risk factors for transfusion between subjects that received an RBC transfusion and those that did not were compared using the Mann-Whitney and Fisher exact test. Differences in percentages and 95% confidence limits were determined using the Coppler Pearson method. Differences in medians and confidence intervals of the median differences were calculated using a 10,000-sample bootstrap method. A stepwise, multivariate binary logistic regression was used to identify independent risk factors associated with an intraoperative blood transfusion. Performance of the model was assessed using the *c* statistic. Before

Table 2
Operative characteristics associated with intraoperative RBC transfusions

	Transfused (n = 46)	Not transfused (n = 425)	Difference (95% CI)	*P*
Intraventricular hemorrhage, n (%)	17 (37)	66 (16)	21% (5% to 37%)	<.001
Intracerebral hemorrhage, n (%)	4 (9)	17 (4)	5% (−5% to 15%)	.14
Intracerebral hematoma evacuation, n (%)	6 (13)	19 (4)	9% (−2% to 20%)	.02
Intraoperative aneurysm rupture, n (%)	12 (26)	40 (9)	17% (3% to 31%)	.002
No. of aneurysms	1 (1 to 1)	1 (1 to 1)		.59
1	40 (87)	358 (84.6)	2% (−9% to 14%)	.68
2	2 (8.7)	54 (12.8)	−4% (−14% to 6%)	.42
3+	7 (4.3)	11 (2.6)	2% (−6% to 9%)	.49
Largest aneurysm size (mm)	7 (4 to 15)	6 (4 to 8)	1 (−1 to 3)	.03

Data presented as median (interquartile range) or n (%) of group. RBC = red blood cell; CI = confidence interval.