Blood Use in Cerebrovascular Neurosurgery

Daniel E. Couture, MD; Dilantha B. Ellegala, MD; Aaron S. Dumont, MD; Paul D. Mintz, MD; Neal F. Kassell, MD

Background and Purpose—This study reviews the perioperative use of red blood cell transfusion in cerebrovascular neurosurgery. The current algorithm for preoperative ordering of red cells is historical and dated. More blood is ordered than is actually transfused, and considerable variability exists between different institutions. We determine the use of blood transfusion in cerebrovascular surgery to develop a rational blood ordering practice.

Methods—Records of 301 patients undergoing cerebrovascular neurosurgery at the University of Virginia were reviewed to quantitatively evaluate red blood cell transfusion practices. The amount and reason for transfusion were noted in each case.

Results—In 126 patients undergoing carotid endarterectomy, there were no preoperative or intraoperative transfusions and 5 postoperative transfusions (4.0%). In 71 ruptured aneurysm patients, there were 2 preoperative blood transfusions (2.8%), 4 intraoperative transfusions (5.6%), and 15 postoperative transfusions (21.1%). Forty-seven patients underwent surgery for unruptured aneurysms, with no preoperative transfusions, 2 intraoperative transfusions (4.3%), and 22 were transfused postoperatively (40.7%). None of the 3 patients undergoing surgery for concomitant arteriovenous malformations and aneurysms received intraoperative blood transfusions, but 1 received blood both preoperatively and postoperatively, and another received a transfusion postoperatively only. The overall ratio of perioperative cross-match to transfusion in this series is 41.4.

Conclusions—In vascular neurosurgery at our institution, blood has routinely been ordered excessively. We recommend an ABO-Rh type and antibody screen for aneurysm and arteriovenous malformation surgery and no screen for carotid endarterectomy to efficiently utilize transfusion therapy in cerebrovascular surgery. (Stroke. 2002;33:994-997.)

Key Words: aneurysm ■ blood transfusion ■ carotid endarterectomy ■ cerebral arteriovenous malformations ■ neurosurgery

The amount of blood transfused in the perioperative period has changed significantly over the last decade, largely because of increased awareness of transfusion-associated risks and increasing costs of transfusions.1 The number of units of red blood cells (RBCs) ordered before surgery has been based on the physician’s transfusion experiences with previous patients. At the University of Virginia, 4 U has been ordered before aneurysm and arteriovenous malformation (AVM) surgeries and 2 U before carotid endarterectomy (CEA). Studies examining the physiology and effects of anemia during and after surgery have led to new strategies to reduce the perioperative use of blood products. The number of RBC units ordered in the past may not be an appropriate standard of practice. This study analyzes the existing blood ordering policy for CEA, AVM, and ruptured and unruptured aneurysm surgeries at a single institution. New guidelines are proposed to direct future blood ordering in cerebrovascular surgery.

Methods

Records of 301 patients who underwent neurological surgery for cerebrovascular disease at the University of Virginia were retrospectively reviewed. One hundred twenty-six patients undergoing CEA, 118 patients with cerebral aneurysms (71 ruptured, 47 unruptured), 54 patients with AVMs, and 3 patients with both AVMs and aneurysms were reviewed. Determination of RBC use was undertaken in the preoperative, intraoperative, and postoperative periods (within 3 days of surgery), and the reason for use was noted in each case. This information was compared with the policies at other institutions.

Results

Results of this review are depicted in Table 1. In 126 patients undergoing CEA, there were no preoperative or intraoperative transfusions and 5 postoperative transfusions for postoperative complications. One patient was transfused on postoperative day (POD) 1 after blood was noted in the oropharynx, most likely because of a traumatic nasal intubation, and the
hematocrit (Hct) was slowly trending downward. One patient developed a non–Q-wave myocardial infarction postoperatively and received an RBC transfusion on POD 0 for an Hct of 30.3. One patient received RBCs on POD 1 for a coagulopathy, and another patient developed a postoperative wound hematoma requiring an emergency clot evacuation and received a transfusion of RBCs on POD 0 before his emergency surgery (Hct not checked). The last patient underwent a CEA without complication and with an estimated blood loss of 50 cm$^3$, but on arrival at the postanesthesia care unit after embolization. She subsequently developed an intraparenchymal hemorrhage with estimated blood loss of 500 cm$^3$, and 4 U of RBCs was transfused intraoperatively. Another patient was embolized for dilutional decrease in Hct secondary to hypertension, hypervolemia, and hemodilution therapy to treat vasospasm except for the following exceptions. One patient experienced torrential hemorrhage as the frontal lobe was retracted because of rupture of the left carotid artery and experienced torrential hemorrhage as the frontal lobe was retracted because of rupture of the left carotid artery and received 2 U of blood intraoperatively. Another lost an estimated 1000 cm$^3$ of blood and was transfused intraoperatively with 2 U. Eight patients were transfused postoperatively. Six of these patients received 2 U of RBCs for dilutional decrease in Hct. The other 2 patients experienced intraoperative bleeding with estimated blood loss of 500 cm$^3$ each and were transfused on POD 0 with 1 U of RBCs each and then another 1 and 2 U, respectively, on POD 1.

Fifty-four patients underwent surgery for resection of AVMs. Five patients were transfused preoperatively (all had ruptured AVMs) for decreased Hct. Four patients were transfused intraoperatively. One of these patients developed an intraparenchymal hemorrhage during embolization and was taken emergently to the operating room. The blood loss was estimated to be 1800 cm$^3$, and 4 U of RBCs was transfused intraoperatively. Another patient was embolized for apparent complication and was taken to the intensive care unit after embolization. She subsequently developed intracerebral hemorrhage with intraventricular extension and clinical deterioration and was taken to the operating room for decompression of the hematoma. Multiple bleeding vessels from the AVM were discovered, and a partial resection was performed. She received 3 U of RBCs for preoperative and intraoperative blood loss. One patient developed an occipital hematoma after surgical resection of an occipital AVM. Although a coagulopathy was diagnosed, the emergent circumstances necessitated surgery. She received 8 U of RBCs intraoperatively for intraoperative blood loss. One patient received 2 U of RBCs intraoperatively after an estimated blood loss of 800 cm$^3$ caused by intraoperative bleeding from a large central parasagittal AVM that was extraordinarily difficult to resect because of unusual and unexpected ana-
TABLE 2. Blood Ordering Schedules at Different Institutions

<table>
<thead>
<tr>
<th>Institution</th>
<th>Aneurysm,</th>
<th>AVM,</th>
<th>CEA,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RBCs</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>University of Virginia Health Science</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Center</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stanford University Medical Center</td>
<td>2</td>
<td>2</td>
<td>T&amp;S T&amp;S</td>
</tr>
<tr>
<td>University of Southern California–University Hospital</td>
<td>T&amp;S</td>
<td>T&amp;S T&amp;S</td>
<td></td>
</tr>
<tr>
<td>University of Washington Medical Center</td>
<td>2–4</td>
<td>2–4</td>
<td>2</td>
</tr>
<tr>
<td>Handbook of Neurosurgery(^1)</td>
<td>2</td>
<td>2</td>
<td>T&amp;S T&amp;S</td>
</tr>
</tbody>
</table>

T&S indicates type and screen.
*Personal communications.

TABLE 3. C/T Ratio by Type of Surgery

<table>
<thead>
<tr>
<th>Type of Surgery</th>
<th>n</th>
<th>RBCs Ordered, U</th>
<th>Total RBCs Ordered, U</th>
<th>RBCs Transfused Preoperatively, U</th>
<th>RBCs Transfused Intraoperatively, U</th>
<th>RBCs Transfused Postoperatively, U</th>
<th>Total RBCs Transfused, U</th>
<th>Intraoperative C/T Ratio</th>
<th>Perioperative C/T Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEA</td>
<td>126</td>
<td>2</td>
<td>252</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>17</td>
<td>Und</td>
<td>14.82</td>
</tr>
<tr>
<td>Ruptured aneurysm</td>
<td>70</td>
<td>4</td>
<td>280</td>
<td>4</td>
<td>5</td>
<td>38</td>
<td>47</td>
<td>56.0</td>
<td>5.96</td>
</tr>
<tr>
<td>Unruptured aneurysm</td>
<td>48</td>
<td>4</td>
<td>192</td>
<td>0</td>
<td>6</td>
<td>20</td>
<td>26</td>
<td>Und</td>
<td>7.38</td>
</tr>
<tr>
<td>AVM</td>
<td>54</td>
<td>4</td>
<td>216</td>
<td>8</td>
<td>12</td>
<td>72</td>
<td>50</td>
<td>18.0</td>
<td>4.32</td>
</tr>
<tr>
<td>Aneurysm + AVM</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>Und</td>
<td>0.00</td>
</tr>
<tr>
<td>Total neurovascular</td>
<td>301</td>
<td>952</td>
<td>14</td>
<td>23</td>
<td>151</td>
<td>146</td>
<td>41.4</td>
<td>6.52</td>
<td></td>
</tr>
</tbody>
</table>

Und indicates undetermined.
of outdated the RBCs is increased. RBCs can be stored for 35 days when stored in citrate phosphate dextrose adenine, which can be extended to 42 days when AS-1 (Adsol) or AS-3 (Nutricel) is used. This duration has been set by federal regulation and is determined by the requirement that ≥75% of the transfused cells remain in circulation after infusion. However, evidence suggests that the oxygen delivery capacity of the RBCs decreases with time in storage and that patients fare worse after receiving blood stored for increasing lengths of time.

Several new strategies shown to effectively reduce the perioperative transfusion of blood products are being implemented to reduce the perioperative use of blood components. Many physicians use a hemoglobin concentration of 70 rather than 100 g/L as the level that prompts transfusion. There is no evidence that mild to moderate anemia contributes to perioperative morbidity. The timing of transfusion has also changed, so many patients who were previously transfused intraoperatively are now given blood in the postoperative period. Thus, cross-matches performed preoperatively may result in an increasing number of reserved units not being transfused, thereby unnecessarily elevating the preoperative C/T ratio.

Another method to increase efficiency of preoperative blood ordering is to develop a preoperative blood ordering schedule based on local experiences and implement a type and screen more regularly to avoid routine cross-matching for surgical procedures in which blood is rarely transfused. The efficacy of this practice has been demonstrated. A type and screen invokes a one-time charge of $30.50. A blood transfusion performed after a type and screen is still very safe; the chance of missing a potentially dangerous antibody is estimated to be no more than 1 in 10,000. In neurovascular procedures, there is a possibility that the blood supply is not emergent. Therefore, we believe even a type and screen is unnecessary for CEA. Implementing these changes not only would reduce costs but also would allow more efficient use of the nation’s blood supply.

From the results of our study, we feel an ABO-Rh type and antibody screen is sufficient preparation preoperatively for aneurysm and AVM surgery. In this study, if a transfusion was needed for CEA, the need was always postoperative and never emergent. Therefore, we believe even a type and screen is unnecessary for CEA.

**References**

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