Red Blood Cell Transfusion Practices

Paul C. Hébert, MD, FRCP(C), MHSc, and Sharyn Szick, MHA

Red blood cell (RBC) transfusion therapy is used in the clinical setting for a variety of indications, including patient resuscitation, augmentation of oxygen delivery, and to reverse or alleviate the symptoms of anemia [1–5]. Despite calls for a more conservative approach to blood transfusion as early as the late 1950s [6,7], the trend toward more cautious transfusion practices did not begin until the 1980s. Several factors were responsible: concern over transmission of viruses; new means of processing blood; blood shortages; and the use of alternatives to blood [1–3,8–17]. While the risk of contracting a transfusion-related viral infection (eg, HIV, hepatitis) is lower than ever [17], blood systems worldwide continue to advocate a conservative approach to transfusions. This article reviews recent RBC transfusion practice in North America, including use of guidelines, variations in practice, and the benefits and risks associated with RBC transfusion.

Guidelines

Guideline Recommendations

Guidelines [18] for the administration of RBCs have been developed by the American College of Physicians (ACP) [1], National Institutes of Health [3], and many other organizations [4,10,12–14,19–42]. A review [43] of 13 published guidelines by Calder and colleagues addressing RBC transfusions (Table 1) evaluated the methods by which these guidelines were derived. The recommendations relied heavily on expert opinion. Only 2 described a literature search and the selection and appraisal strategy in any detail [1,2]. Three did not reference any published research [36–38].

The populations targeted by the guidelines varied. Only 1 guideline recommended a transfusion trigger (a hemoglobin concentration or hematocrit below which most patients should receive at least 1 unit of RBCs) [35]. Six recommended a range of thresholds based on clinical judgment or specific risk factors [1–3,8,19,41], while 1 guideline advocated the use of clinical judgment without a specific threshold [14]. The 5 remaining guidelines made no recommendations about use of a trigger or clinical judgment in transfusion decisions [34,36–39]. The authors reported that of 13 guidelines addressing RBC transfusion, only 8 fulfilled their definition of a clinical practice guideline (cite primary studies, include recommendations on the clinical indications for use of RBCs, and be sponsored or endorsed by a medical society or organization).

Two additional transfusion guidelines [4,42] were published after the Calder et al review (Table 1). A special task group for the College of American Pathologists prepared guidelines [42] that outline the indications for RBC transfusion and provide revised recommendations for specific patient populations, including neonates, pregnant and postpartum patients, and patients with sickle cell diseases. The second set of guidelines [4] was a collaborative effort of the Canadian Blood Agency, the Canadian Red Cross Society, and Health Canada and was endorsed by 23 national associations. It offers comprehensive recommendations for use of RBC and plasma transfusions in adults and children and is intended to help both practitioners and patients make transfusion decisions. The topics addressed in these guidelines include informed consent and information disclosure, transfusion thresholds, information about infectious transfusion risks, the use of allogeneic or autologous RBCs, patient populations requiring specific attention in transfusion practice (eg, neonates and patients with cardiac disease and anemia), and alternatives to transfusion.

Guideline Adherence

A literature review [44] of transfusion practice reported that the rates of unnecessary or inappropriate RBC transfusion ranged from 4% to 66% [45–57] (Table 2). In another Canadian study, the majority of inappropriately transfused patients were identified as being normovolemic and hemodynamically stable [58]. A U.S. study found that 21.3% of all transfusions performed in 5 hospitals involved more than 1 unit, despite guidelines recommending that 1 RBC unit be transfused per transfusion episode [59]. In 1 of the study
## Table 1. Guidelines for Red Blood Cell Transfusion

<table>
<thead>
<tr>
<th><strong>Guideline</strong></th>
<th><strong>Sponsor</strong></th>
<th><strong>Setting</strong></th>
<th><strong>Methods</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical red blood cell transfusion practice policies [14] (1995)</td>
<td>None</td>
<td>Perioperative</td>
<td>No</td>
</tr>
<tr>
<td>Consensus statement on red cell transfusion [34] (1994)</td>
<td>Royal College of Physicians of Edinburgh</td>
<td>All patients</td>
<td>No</td>
</tr>
<tr>
<td>Pratiques transfusionnelles en hématologie clinique [35] (1993)</td>
<td>Collège français des hématologistes</td>
<td>Acute leukemia</td>
<td>No</td>
</tr>
<tr>
<td>Practice strategies for elective red blood cell transfusion [1] (1992)</td>
<td>American College of Physicians</td>
<td>All patients</td>
<td>Yes</td>
</tr>
<tr>
<td>Criteria for transfusion of blood components [36,37] (1992, 1993)*</td>
<td>Toronto, Vancouver regional Red Cross Society</td>
<td>All patients</td>
<td>No</td>
</tr>
<tr>
<td>Clinical guide to transfusion [38] (1993)</td>
<td>Canadian Red Cross Society</td>
<td>All patients</td>
<td>No</td>
</tr>
<tr>
<td>Strategies for the review of transfusion practices [8] (1989)</td>
<td>American Association of Blood Banks</td>
<td>All patients</td>
<td>No</td>
</tr>
<tr>
<td>Contemporary transfusion practice [41] (1987)</td>
<td>American Association of Blood Banks</td>
<td>All patients</td>
<td>No</td>
</tr>
<tr>
<td>Practice parameter for the use of red blood cell transfusions [42] (1998)</td>
<td>College of American Pathologists</td>
<td>Acute anemic hemolytic anemia, hypoproliferative anemia, and chronic blood loss</td>
<td>No</td>
</tr>
</tbody>
</table>


*These 2 guidelines are virtually identical and were treated as one guideline.
†Refers only to red cell or plasma recommendations.
hospitals, 48% of all transfusions were multiple-unit transfusions and nearly half of all transfusions were potentially avoidable. A study of 82 consecutive adult patients admitted for elective surgery reported that more than half of total transfusions (53%) were inappropriate per ACP guidelines [1,58].

A retrospective audit of total hip joint replacement surgery patients in New Zealand sought to quantify the inappropriate use of RBC transfusion in this population [60]. Although unable to quantify the magnitude of the problem, they indicated that a source of inappropriate usage was the transfusion of 2 units in a given transfusion episode when a single unit would have sufficed.

Methods to Improve Adherence
Educational sessions have been advocated as means of improving transfusion practice and thereby decreasing unnecessary transfusions [60–65]. Such sessions include one-on-one meetings with physicians, teaching sessions at scheduled conferences, daily clinical rounds [65], and scheduled teaching rounds. Other reported strategies for reducing unnecessary transfusions include the use of an intraoperative transfusion algorithm [65,66] and implementation of a quality-assurance program or an auditing system [58,62–71].

A teaching hospital in the United Kingdom revised its crossmatching guidelines based on the findings from a retrospective audit implemented as a pilot study [57]. A subsequent prospective audit showed that crossmatch requests, crossmatch/transfusion ratios, and associated costs had decreased without a negative impact on patient outcome. Investigators in Australia also found that a monitoring system proved useful in reducing unnecessary transfusions, with rates decreasing from 16% to 3% (P = 0.004) [71]. Conversely, a study designed to evaluate the effectiveness of a retrospective audit of RBC utilization at 4 California hospitals found no effect on altering RBC utilization [67].

Practice Variation
A number of studies have examined variation in transfusion practice [55,59,69,72–85]. Several studies have indicated that practice variation is interinstitutional, while others have noted variation within specific disease categories [76,86], clinical settings [82–84], and surgical procedures [55,59,73,79–81].

Historically, hemoglobin concentration has been the most commonly used trigger for RBC transfusion. Although transfusion guidelines advise against using this laboratory measurement in isolation, surveys have repeatedly shown that physicians attribute great importance to hemoglobin concentration in making transfusion decisions [84,85]. A recent survey of blood transfusion practices involving critically ill patients documented significant variation in transfusion...

### Recommendations

<table>
<thead>
<tr>
<th>Number</th>
<th>Grading</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Yes</td>
<td>Evidence inconsistently applied, many recommendations, very detailed</td>
</tr>
<tr>
<td>4</td>
<td>No</td>
<td>Report from consensus conference, not evidence-based</td>
</tr>
<tr>
<td>1</td>
<td>No</td>
<td>Only guideline recommending a trigger (80 g/L), use of platelets addressed</td>
</tr>
<tr>
<td>26</td>
<td>No</td>
<td>Focus on blood avoidance, literature search not reproducible</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>Broad recommendations, focus on blood avoidance</td>
</tr>
<tr>
<td>11</td>
<td>Yes</td>
<td>Most rigorously developed guidelines, evidence limited to clinical studies</td>
</tr>
<tr>
<td>10</td>
<td>No</td>
<td>All blood components mentioned, indications used, contraindications stated, no primary evidence cited</td>
</tr>
<tr>
<td>9</td>
<td>No</td>
<td>Locally developed, recommendations limited and not graded, no literature review</td>
</tr>
<tr>
<td>13</td>
<td>No</td>
<td>All blood components mentioned, no literature review, detailed product information</td>
</tr>
<tr>
<td>8</td>
<td>No</td>
<td>Vague recommendations</td>
</tr>
<tr>
<td>13</td>
<td>No</td>
<td>Audit criteria only, not a clinical practice guideline, not evidence-based</td>
</tr>
<tr>
<td>12†</td>
<td>No</td>
<td>More a position paper than a clinical practice guideline, consensus process not mentioned</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>Transfusion strategies given for each of 3 patient groups plus modifications for neonates of obstetric patients, no literature review</td>
</tr>
<tr>
<td>17</td>
<td>Yes</td>
<td>Focus on red cell and plasma transfusion, extensive guideline development process, very detailed</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>No. of Subjects</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>----------------</td>
</tr>
<tr>
<td>Dietrich [45] (1965)</td>
<td>Retrospective review</td>
<td>217</td>
</tr>
<tr>
<td>Reece and Beckett</td>
<td>Retrospective review</td>
<td>2921</td>
</tr>
<tr>
<td>Friedman [47] (1978)</td>
<td>Database analysis</td>
<td>3616</td>
</tr>
<tr>
<td>Stehling and Esposito</td>
<td>Retrospective review</td>
<td>627</td>
</tr>
<tr>
<td>Coffin et al [49] (1989)</td>
<td>Retrospective review</td>
<td>156</td>
</tr>
<tr>
<td>Brien et al [50] (1989)</td>
<td>Retrospective review</td>
<td>297</td>
</tr>
<tr>
<td>Goodnough et al [51] (1992)</td>
<td>Retrospective review</td>
<td>525</td>
</tr>
<tr>
<td>Saxena et al [52] (1993)</td>
<td>Retrospective review</td>
<td>438</td>
</tr>
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</table>

(continued on page 33)
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>No. of Subjects</th>
<th>Study Population</th>
<th>Evaluation Criteria</th>
<th>Unnecessary Transfusions, %</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodnough et al [53] (1993)</td>
<td>Retrospective review</td>
<td>498</td>
<td>CABG patients</td>
<td>Estimated blood loss &gt; 10% of blood volume</td>
<td>18% of units transfused</td>
<td>Study done to assess impact of conservation strategies; Criteria limited to blood loss; difficult to apply prospectively</td>
</tr>
<tr>
<td>Ghali et al [54] (1994)</td>
<td>Retrospective review</td>
<td>55</td>
<td>Medical and surgical patients</td>
<td>Need for transfusion according to ACP guidelines</td>
<td>55.3% of units transfused</td>
<td>Small study; Limited to 1 institution; ACP guidelines not designed for audits</td>
</tr>
<tr>
<td>Sanguis study group [55] (1994)</td>
<td>Retrospective review</td>
<td>200</td>
<td>Consecutive patients in tertiary care hospital</td>
<td>Hb &lt; 70 g/L; Hb 70 to 100 g/L and various clinical indications; Preoperative 80 g/L; Excessive (abnormal) bleeding at operation</td>
<td>16% of transfusion episodes; 10% of units transfused</td>
<td>Also reviewed platelet and plasma transfusion; Criteria based on ACP guidelines</td>
</tr>
<tr>
<td>Corwin et al [56] (1995)</td>
<td>Retrospective review</td>
<td>142</td>
<td>ICU patients with length of stay &gt; 1 week</td>
<td>Active bleeding or surgery; Hct &lt; 25%; Low cardiac output; Myocardial infarction/ ischemia; Oxygen transportation; Renal ischemia; Preoperative; Adapted from NIH consensus conference</td>
<td>29% of transfusion episodes</td>
<td>Criteria vague and not reproducible; Many transfusions administered based on arbitrary trigger; Diagnostic blood tests result in significant blood loss in ICU</td>
</tr>
<tr>
<td>Mozes et al [57] (1989)</td>
<td>Retrospective review</td>
<td>383</td>
<td>All patients in tertiary care hospital</td>
<td>Symptomatic refractory anemia; Symptomatic cardiovascular disorders with anemia; Hct &lt; 26% with history of cardiovascular disorders; Preoperative Hct &lt; 26%</td>
<td>57.7% of transfusion episodes</td>
<td>Unnecessary use greatest in end-stage renal failure and terminal cancer; Also reviewed platelet and plasma transfusion</td>
</tr>
</tbody>
</table>

ACP = American College of Physicians; CABG = coronary artery bypass grafting; ICU = intensive care unit; Hb = hemoglobin concentration; Hct = hematocrit; NIH = National Institutes of Health. (Adapted with permission from Hébert PC, Schwitzer I, Calder L, Blajchman M, Giulivi A. Review of the clinical practice literature on allogeneic red blood cell transfusion. CMAJ 1997;156:S9–S26.)
thresholds (ranging from 5 to 12 g/dL) and reported that many intensivists (40%) still adhere to the 10 g/dL threshold [85]. A cohort study of patients who received transfusions found that 35% of pretransfusion hemoglobin measurements were between 9.5 and 10.5 g/dL [84]. Another study of hip fracture patients in the United States found that 56% of transfused patients had a preoperative hemoglobin concentration between 8.0 and 9.9 g/dL [87]. Other studies in the United States, Spain, and Australia have also demonstrated the importance physicians place on pretransfusion hemoglobin and hematocrit values [59,69,88].

Hébert and colleagues conducted a cohort study involving 6 tertiary-level intensive care units (ICUs) [84]. They documented that RBC transfusions were received by 25% (range, 12% to 35%; P < 0.001) of 5298 consecutive patients. Variation in transfusion practice was more pronounced in sicker patients, indicating that critical care physicians may individualize decisions based on disease severity. Conflicting evidence and partial implementation of published guidelines may also have impacted on the observed variation. Interinstitutional practice variation such as total number of transfusions per patient-day in an ICU and average pretransfusion hemoglobin concentrations (range, 8.7 to 9.5 g/dL, P = 0.0001) was identified as a significant independent predictor of transfusion threshold.

Transfusion practice variation has been observed in other diseases and clinical settings. In a population of patients who underwent surgery at 19 U.S. hospitals to repair a hip fracture, postoperative rates of transfusion ranged from 31.2% to 54.0% (P = 0.001) [89]. The authors noted that the pattern of variation of transfusion among hospitals varies according to how one adjusts for relevant patient characteristics. Another group in Finland surveyed 1161 primary total joint replacement patients in 11 hospitals. Of all patients undergoing total hip replacement surgery or total knee replacement surgery, 92% and 84%, respectively, received 1 or more allogeneic RBC transfusions [80]. Using regression analysis and controlling for patient- and procedure-related variables, the authors found evidence of interhospital variation in the number of units transfused (ranging from 2.4 to 4.1 units in hip surgery patients and from 1.8 to 2.8 units in knee surgery patients). The author noted that the use of allogeneic RBC transfusions in this patient population in Finland was liberal compared to that in other parts of Europe and in the United States. She concluded that hospital-specific policies were primarily responsible for the variances seen between hospitals.

Audet and colleagues examined transfusion practice in the elective orthopedic surgical population (n = 384) in 5 Massachusetts hospitals [59] and identified substantial interhospital variation in transfusion practice. Variation in the use of autologous RBCs was particularly pronounced, with rates of transfusion ranging from 21.1% to 54.1% (P < 0.05) of all transfusions derived from autologous donation. Of these autologous units, 12.5% were not used. The results showed a decrease in the need for allogeneic blood when autologous blood was available, suggesting that the observed variation in autologous versus allogeneic blood use may be explained by the availability of autologous blood. Patient differences were also identified as a potential explanation for the observed variation in transfusion practice; these include clinical ability to predonate and economic and access status (at the time of this study, Medicare in the United States did not reimburse for presurgical autologous donations). Significant interhospital variations in the use of methods to minimize exposure of patients to allogeneic RBC units, such as cell salvage and hemodilution, were also noted. The authors concluded that improvement in transfusion practices is still needed; they identified the use of hematocrit thresholds as indicators for transfusion regardless of patients’ clinical status and significant use of multiple unit transfusions as areas to target for improvement.

In 1 European study, physicians rather than the patient population accounted for the variation observed in transfusion practice [74]; in 3 other studies the specific hospital played a role in the variation [79-81]. Sorgenor et al [79] examined the degree of variability between transfusion practices among 5 American university teaching hospitals. They concluded that the variation in transfusion practice results from ingrained institutional differences due to training or hierarchy, irrespective of practice among surgeons within the same hospital. It should be noted that the patient population examined in this study had favorable clinical characteristics with only moderate transfusion requirements.

Transfusion Strategies and Effect on Outcomes

Historically, physicians have predicated their decision to transfuse on a patient’s hemoglobin concentration. The hemoglobin value used most commonly as a trigger is 10 g/dL because it is easy to remember [84]. Evidence supporting this arbitrary value has not been conclusive. In a recent randomized controlled trial, Hébert and colleagues compared a liberal transfusion strategy (maintenance of hemoglobin at 10 to 12 g/dL) with a restrictive transfusion strategy (hemoglobin maintained at 7 to 9 g/dL) in 838 critically ill patients [90]. The transfusion triggers in this study were the lower limits of the hemoglobin ranges for each study group. The authors found that a more restrictive transfusion strategy was at least equivalent, if not superior, to the liberal strategy for critically ill patients, with the possible exclusion of patients with unstable angina and myocardial infarction. In a subgroup analysis, a restrictive transfusion
strategy was also found to be at least as effective as a liberal strategy in volume-resuscitated critically ill patients with cardiovascular disease, with the possible exception of patients with active ischemic heart disease. The effect was most prominent in patients with an Acute Physiology and Chronic Health Evaluation II score below 20 and who were under the age of 55 years.

Four smaller randomized controlled trials also sought to identify the optimal transfusion indication by comparing liberal and restrictive transfusion strategies in different patient populations [91-94]. All 4 failed to identify a statistically significant difference in clinical outcomes between the restrictive and liberal transfusion strategies. This may be due to the limited power of these studies to detect changes in the outcome. Three of the 4 studies did, however, note a significant difference in blood utilization, which was lower in the restrictive groups.

A review in 1998 by Carson and Chen reported that observational data suggest that transfusion of RBCs has no positive effect on the rates of mortality in patients whose preoperative and postoperative hemoglobin concentration is 8 g/dL or greater [95]. No conclusions were available for patients whose hemoglobin was less than 8 g/dL. An earlier study by Spence and colleagues [96] analyzed the results of 113 major elective surgeries in 107 consecutive Jehovah’s Witness patients. Of the 93 patients whose preoperative hemoglobin was greater than 10 g/dL, mortality was 3.2%, while the mortality rate was 5% for the 20 patients whose hemoglobin was between 6 and 10 g/dL. The authors established that elective surgery can be safely performed in patients whose hemoglobin is low provided total blood loss is maintained below 500 mL.

Although moderate levels of anemia may be safely tolerated in critically ill patients with other diagnoses, increasing degrees of anemia have been associated with a disproportionate increase in mortality in patients with cardiac disease. Other studies [97,98] independently reported that a significantly increased risk of death was associated with low preoperative hemoglobin in patients with cardiovascular disease compared with patients without. Another observational study of the effects of liberal versus restrictive transfusion strategies [99] in the subgroup of critically ill patients with cardiovascular disease failed to identify adverse effects from the restrictive strategy. In their review of transfusion triggers, Carson and Chen recommended that a higher threshold be used in this patient population [95].

In summary, although 10 g/dL has commonly been used as a transfusion threshold in the past, current evidence indicates that a restrictive strategy is at least as effective and possibly superior to a liberal transfusion strategy.

Risks Associated with Transfusion

Viral and Bacterial Infection

Measures have been implemented over the past 15 to 20 years to lower the risk of bacterial and viral infections via transfusion [100,101]. Policies and procedures regarding the collection and processing of blood that have been implemented dictate stricter donor screening protocols and collection procedures, removal of high-risk donors from the donor pool, and stringent testing for a variety of viral markers [102]. Despite the large amount of blood being transfused, the rate of disease transmission is too low to measure [17]. Health statistic agencies currently depend on mathematical models to estimate the risks of blood transfusion. The American Blood Bank estimates the risk of viral infection, including HIV, hepatitis B and C virus, and human T-lymphocyte virus as 189 to 296 infections per 10,000,000 screened donations [100]. While the estimated risks associated with blood transfusion are lower than ever, they are expected to decrease further with the advent of more sensitive and specific tests [17,101].

Immunosuppression

There is a growing concern among transfusion medicine practitioners regarding the effect of red blood cells on the immune responses of recipients [103]. Both clinical and laboratory studies [103–112] have compiled evidence identifying the important role of allogeneic RBC transfusions on the immunosuppressive effects observed in transfused patients. The majority of these studies have been observational, but a small number of randomized controlled trials have been conducted. A trial by Opelz et al [113] demonstrated that renal allograft recipients had a longer graft survival if transfused up to 5 RBC units prior to transplant. A meta-analysis involving 10 randomized controlled trials sought to determine whether an association exists between perioperative allogeneic RBC transfusion and an increased risk of clinically important adverse sequelae (cancer recurrence, postoperative infection, and death) in patients with cancer undergoing surgery [114]. The authors found no evidence of this association, although there was insufficient power to detect a relative difference of less than 20% in these effects. The authors repeated their original analysis with the addition of a study by van der Watering et al [105], but the results of this analysis did not differ from the original meta-analysis (McAlister FA, personal communication). Although laboratory evidence is convincing, this meta-analysis suggests that immune suppression is not significant enough to cause a large increase in rates of postoperative infection.

Definitive evidence of an association between allogeneic transfusion and an increased risk of bacterial infection remains elusive, despite reports by numerous researchers.
of this effect. In a recent editorial, Blajchman [115] acknowledged that contradictory results of studies published to date renders this issue unresolved, even though a clinical association between transfusion-associated immune suppression and increased susceptibility to infection appear to have been established.

Many countries, including Canada and France, have implemented universal prestorage leukoreduction programs despite the lack of confirmatory evidence regarding the immunosuppressive effects of RBC and platelet transfusion. Studies of immunosuppressive effects of leukocytes in the transfused patient suggest that filtration of leukocytes decreases adverse effects, including infection and mortality. Evidence suggests that leukoreduction should be done shortly after collection and processing but previous to storage, before leukocytes are able to fragment or synthesize biologic response modifiers, such as cytokines [116]. While clinical trials in humans remain inconclusive, laboratory evidence that leukocytes cause immunosuppression in the host is convincing. Laboratory studies have accumulated substantial data that provide evidence of the immunosuppressive effect of leukocytes, but neither the precise mechanisms nor the clinical implications of this effect have been fully defined. Thus, further studies are needed, particularly regarding the effects in humans.

As described by Heddle and associates [117], a platelet refractoriness response may also result from exposure to donor leukocytes. This randomized controlled trial compared the effectiveness of poststorage leukocyte versus plasma depletion to prevent transfusion-related reactions. Its results indicated significantly lower (£P = 0.008) reaction frequencies in patients receiving plasma-reduced platelets. Furthermore, severe reactions occurred more frequently in patients transfused with platelets (£P = 0.048), with interleukin-6 identified as the most significant of the evaluated factors in its correlation with the risk of reaction. The investigators concluded that plasma removal is more effective than poststorage leukoreduction in the prevention of reactions to platelets, specifically severe reactions.

Implications for Clinical Practice

Although transfusion therapy has seen much progress in the past few years, there is still a great deal to learn about transfusion therapy. For example, studies have indicated that a threshold for initiating transfusion therapy more restrictive than a 10 g/dL hemoglobin concentration does not adversely affect patient outcomes. Indeed, the majority of published transfusion guidelines recommend a more conservative and cautious approach to transfusion practice, primarily to reduce the risk of transfusion-related infection and adverse effects. However, transfusion trigger studies do not have sufficient data to conclusively claim that the outcomes observed are the sole result of the transfusion strategy. Perhaps the conclusions reported are the results of other effects yet to be more clearly defined, including immunosuppressive effects attributed to leukocytes and clinical effects of stored red cells. More studies are necessary to determine the effects of storage time and leukocytes in transfusion practice. This information, combined with detailed information about alternatives to transfusion, will enable physicians to optimize the morbidity and mortality outcomes in transfused patients.

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