Effectiveness of Computerized Physician Order Entry with Decision Support to Reduce Inappropriate Blood Transfusions

Danielle Bowen Scheurer, MD, MSc, Christopher L. Roy, MD, Siobhan McGurk, BS, and Allen Kachalia, MD, JD

Abstract

- **Objective:** To reduce unnecessary transfusions, our hospital instituted transfusion guidelines and computerized physician order entry (CPOE) with decision support. Two years after implementation, we sought to determine the number of inappropriate transfusions, determine reasons for decision support bypasses and overrides, and determine patient specific predictors of inappropriate transfusions.

- **Methods:** We conducted a retrospective 1-year cohort study of general medical inpatients with a hemoglobin $\geq 9$ g/dL who received at least 1 transfusion of red blood cells. Inpatient charts and CPOE decision support were compared to determine transfusion appropriateness. Decision support was further evaluated to determine bypasses and overrides. Patient specific predictors of inappropriate transfusions were determined by logistic regression.

- **Results:** Of 214 transfusions, 54% and 62% were inappropriate by chart review and CPOE decision support, respectively. Of the 141 transfusion orders that bypassed decision support by indicating active bleeding, active bleeding could not be found in 54% of chart reviews. Of the 45 deemed inappropriate by decision support, 73% of overrides indicated their superior instructed them to transfuse the patient. No patient-specific predictors associated with inappropriate transfusions were found.

- **Conclusion:** After institution of transfusion guidelines and CPOE decision support, over half of our transfusion prescribing is still inappropriate. Decision support was bypassed altogether in two-thirds of transfusion orders, and over two-thirds of the overrides indicated a superior instructed the transfusion. This suggests that decision support alone will not completely remove inappropriate transfusions and other front-ended interventions targeted at the deciding provider may be needed.

In the United States, there are approximately 14 million packed red blood cell (RBC) transfusions administered per year [1–3]. The risks associated with transfused blood are substantial and include both noninfectious and infectious etiologies. The noninfectious risks are many and include febrile reactions, hemolytic reactions, transfusion-related acute lung injury (TRALI), and anaphylaxis. The infectious risks are numerous as well, including HIV, the hepatitis viruses, West Nile virus, and human T cell lymphotropic viruses. According to the U.S. Department of Health and Human Services, there were over 32,000 transfusion-related adverse reactions reported in the United States in 2004 [3]. These risks readily highlight the need to restrict transfusions to only when necessary.

In fact, restricted use of RBC transfusions may not only be safe but may also improve outcomes in general medical patients [4–7]. In line with the evidence, there are several consensus guidelines that stress the importance of abandoning automatic transfusion triggers, particularly in patients with hemoglobin $\geq 7$ g/dL [8–10]. Despite this, inappropriate and inconsistent use of RBC transfusions still abound. In a study of postoperative blood transfusions, only 35% to 68% of cases documented either blood loss or a change in vital signs in the medical record, and documentation supported the rationale for transfusion in only 16% to 27% of cases [11]. In another study of critically ill patients with nonacute blood loss, almost half of all RBC transfusions were given without an identifiable indication or for low hematocrit alone [12]. In another study of non–intensive care unit general medical patients, over one-third of RBC transfusions were deemed unjustified or equivocal by 5-physician consensus [13].

To combat the problem of inappropriate transfusions, our institution developed and disseminated a pocket guideline for RBC transfusions and implemented a sophisticated decision support tool within a computerized physician order...
Table 1. Brigham and Women’s Hospital 2003 Guidelines for Red Blood Cell Transfusions

<table>
<thead>
<tr>
<th>Clinical Setting</th>
<th>Target Hematocrit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No sign/symptom* or comorbidity†</td>
<td>21</td>
</tr>
<tr>
<td>Either a sign/symptom or comorbidity</td>
<td>26</td>
</tr>
<tr>
<td>Both a sign/symptom and comorbidity</td>
<td>29</td>
</tr>
<tr>
<td>Acute coronary syndrome‡</td>
<td>30–33</td>
</tr>
</tbody>
</table>

*Orthostasis, tachycardia, shortness of breath/dyspnea on exertion, lightheadedness, confusion, lethargy, or chest pain.
†Coronary artery disease, cerebrovascular disease, left ventricular dysfunction, shock/impaired O₂ transport, or chronic lung disease/acute respiratory failure.
‡Unstable angina or acute myocardial infarction.

In the nonbleeding cases, the decision support tool processes the inputted information and then indicates whether transfusion according to BWH guidelines is warranted, and if so, how many units are necessary to get to the desired hematocrit. If the clinician inputs all 6 screens but does not agree with the final decision support suggestion, they must enter a reason for the override (Appendix 1) [14]. If the clinician agrees with the decision support suggestion, the initial transfusion order is finalized.

Participants
The cases for this analysis were identified from the BWH blood bank as inpatients who had received at least 1 RBC transfusion on the general medical service with a hemoglobin ≥ 9 g/dL between June 2005 and May 2006. We reviewed the first transfusion event if the patient was repeatedly transfused during the hospital stay. This hemoglobin cutoff value was chosen in order to review those patients on the general medical service at highest risk for receipt of an inappropriate RBC transfusion. It was also assumed that decision support should have the greatest effect in this population. A total of 232 cases were identified for analysis.

Measurements
Each chart was initially reviewed by 1 physician out of a group of 3 (DBS, CLR, AK) to determine patient comorbidities, signs, and symptoms at the time of the transfusion. Using the BWH guidelines (Table 1) and an abstraction form, the initial physician reviewer determined if the blood transfusion was appropriate or inappropriate. For those patients deemed acutely bleeding, the transfusion was automatically categorized as appropriate regardless of hemoglobin level. If the initial reviewer deemed the transfusion appropriate, that was the end of the review.

For cases deemed to be inappropriate by the first reviewer, a 2-reviewer consensus was achieved through discussion. Only the inappropriate transfusions were subject to consensus review since we sought to obtain the most conservative estimate of inappropriate transfusions. For each transfusion occurrence, the corresponding CPOE screens (that were inputted by the ordering provider) and the decision support logic (that was viewed by the ordering provider) were reviewed.

Statistical Analysis
Rates of inappropriate transfusions, both by chart review and decision support, were calculated as simple percentages. For transfusion orders that bypassed decision support (by indicating the patient was actively bleeding), the percentage of those with corroboration by chart review was calculated. For transfusion orders deemed inappropriate by decision support, the percentage of each override indication was...
calculated. The decision support logic (deeming the transfusion order as appropriate or inappropriate) was compared with the chart review consensus (also deeming the transfusion order as appropriate or inappropriate) by calculating a kappa statistic.

Differences in patient characteristics between the chart review appropriate and inappropriate blood transfusion groups were compared by chi-square or Fisher’s exact (for dichotomous variables) and simple $t$ test or ANOVA (for continuous variables), where appropriate. $P$ values $\leq 0.01$ were considered significant to account for multiple testing. A logistic regression model was created with the outcome variable being appropriate or inappropriate blood transfusion, and with dependent variables being patient demographics (age, sex), hemoglobin prior to transfusion, patient comorbidities (coronary artery disease, acute coronary syndrome, left ventricular dysfunction, impaired oxygen delivery, respiratory failure, chronic lung disease, shock, or cerebrovascular disease), and patient symptoms (hypotension, dyspnea, confusion, tachycardia, lightheadedness, or lethargy).

**Results**

There was a total of 232 blood transfusion events administered to patients with a hemoglobin $\geq 9$ g/dL over the study period (170 with hemoglobin 9–10 g/dL and 62 with hemoglobin $\geq 10$ g/dL). Of those, 18 were excluded due to the transfusion not being prescribed while the patient was on the general medical service (eg, the patient had been transferred to the surgical service). Of the 214 transfusions, 115 (54%) were inappropriate by chart review. Of the 73 with available decision support, 45 (62%) were inappropriate by decision support (Figure).

Decision support was bypassed (the provider indicated “active bleeding/associated hypovolemia” on the initial input screen) and therefore unavailable to analyze for 141 (66%) of the transfusions (Figure). Of these 141 decision support bypasses, active bleeding was substantiated by chart review in only 65 (46%).

Of those with available decision support, the transfusion was deemed inappropriate in 62%. The indication for override in 73% of these cases was “instruction from my resident/fellow/attending/staff physician.” Only 1 override indicated the provider did not agree with the guidelines (Figure).

There was moderate agreement in determining appropriateness between chart review and decision support (Kappa, 0.55 [95% confidence interval (CI), 0.35–0.75]). There was a small number of orders with discordance by chart review and decision support (Kappa, 0.55 [95% confidence interval (CI), 0.35–0.75]).
The differences in patients between those deemed appropriately and inappropriately transfused (by chart review) are outlined in Table 2. There were no significant differences between the groups with respect to patient age, sex, hemoglobin prior to the transfusion, or comorbid conditions (other than those with acute coronary syndrome, who were more likely to be appropriately transfused). There were differences between the groups in patient symptoms; those in the appropriate transfusion group were much more likely to be symptomatic with hypotension (odds ratio [OR], 29.1 [CI, 3.4–249.3]), tachycardia (OR, 9.6 [CI, 2.13–42.95]), or lightheadedness (OR, 3.7 [CI, 1.03–13.2]) but not with lethargy, confusion, or dyspnea.

### Discussion

Two years after institutional RBC transfusion guidelines and CPOE decision support were developed and implemented at our hospital, we sought to determine the rate of inappropriate transfusion of general medical patients with hemoglobin ≥ 9 g/dL. We found that institutional transfusion guidelines were well accepted (as evidenced by only 1 provider indicating that they did not agree with the guidelines) and found that our decision support logic was valid (as evidenced by moderate agreement between chart review and decision support). Despite that, we found that over half of the transfusions administered to patients in this group were still inappropriate.

We also found that almost two-thirds of the CPOE orders had bypassed decision support by indicating the patient was actively bleeding, although clinical corroboration of active bleeding could not be substantiated in almost half of the patient’s chart review. This could be due to the insensitivity of chart review to determine “active bleeding” or could reflect the desire of the ordering clinician to rapidly bypass the remaining CPOE input screens. Force functioning the ordering physician to input more substantial or objective evidence of active bleeding may reduce this bypass. However, as this and previous studies have shown, decision support may be ignored regardless of the recommendation.

Our study also showed that the indication for decision support override in over two-thirds of cases was instruction from a senior physician. This indicates that at the time of CPOE decision support, decisions to transfuse have already likely been made (from the attending, housestaff, and/or patient perspective), which may make any decision support intervention too “back-ended” to have a substantial effect on ordering practices. It also indicates that targeting the ordering provider (ie, the intern in academic medical centers) on ordering practices. It also indicates that targeting the ordering provider (ie, the intern in academic medical centers) for transfusion reduction interventions may be the wrong audience, and that targeting the more senior, or supervising, physicians (residents, fellows, and attendings), or “deciding" provider may prove higher yield in reducing inappropriate transfusions.

Previous studies of CPOE decision support in transfusion prescribing have shown limited effectiveness in reducing inappropriate transfusion. A previous study from our institution of a mixed patient population found that implementation of CPOE decision support resulted in a change in provider transfusion orders in 11% of patients, but 73% of those orders were for an increase in RBC units, not a
increase [14]. A recent before–after study reported decision support reduced mean transfusions per patient from 1.5 to 1.3 (P = 0.045) [15], and another reported decision support reduced mean transfusions per patient from 1.08 to 0.86 (P < 0.001) [16]. However, neither study had a control group or otherwise accounted for the impact of temporal changes (eg, educational initiatives or changes in local standard transfusion practices), and neither study directly evaluated whether the decision support suggestion actually changed the physician’s original transfusion order. A systematic review of behavioral interventions to reduce transfusions found that guidelines, audit/feedback, audit/approval, reminders forms, and education (alone or in combinations) can reduce transfusion utilization anywhere from 12% to 65% [17], validating the difficulty in discerning the solitary effect that any one intervention can have.

Given the limited effect that CPOE decision support has on transfusion prescribing (in the literature and in our institutional experience), we also attempted to identify patient factors associated with inappropriate transfusion receipt with hopes of designing an intervention targeted at specific patient populations (that could be identified at the time of admission). We found no identifiable patient demographic or comorbidities that could predict which would receive an inappropriate transfusion. Therefore, patient-specific interventions based on these factors are unlikely to yield significant reductions in inappropriate transfusions. Other studies have yielded similar results, as there is considerable variability of transfusion thresholds that cannot be explained by patient factors [18–22]. Although asymptomatic patients are more likely to be inappropriately transfused, patient symptoms are not an easily identified characteristic on which an intervention can be based.

This study has several limitations. As a retrospective single institution study at an academic medical center, it may have limited generalizability to medical centers without the same attributes. Since this was a sample of general medical inpatients with hemoglobin ≥ 9 g/dL, the information may not be accurately extrapolated to patients on different medical or surgical services or with lower hemoglobin levels. The relatively small sample size also may have made it underpowered to detect a difference in comorbidities between the groups. Assessing transfusion appropriateness by chart review may have been insensitive, due to underdocumentation of transfusion indications, patient comorbidities, or symptoms, which has been noted in other studies [11]. This would have inflated the number of transfusions deemed inappropriate by chart review.

In summary, the decision to transfuse a patient is a complicated one, and interventions designed to change transfusion practices have been variable in their success rates. We found that in general medical patients with hemoglobin ≥ 9 g/dL, despite having well-accepted transfusion guidelines and well-built CPOE decision support, over half of our transfusions were still inappropriate. We found that physicians either bypassed decision support altogether or overrode the decision support by indicating their superior told them to order the transfusion. We also found no patient factors associated with inappropriate transfusions. These findings suggest that CPOE decision support may be too “back-ended” an approach and may be targeting the wrong audience (ie, the prescribing provider vs. the deciding provider). Future studies will need to address the relative effectiveness of more “front-ended” approaches (eg, admission-determined patient-specific transfusion triggers) in reducing inappropriate transfusions. Additionally, provider-specific characteristics (both the prescribing and the deciding provider) need to be further examined to evaluate the appropriateness of targeting interventions to specific provider subgroups.

Corresponding author: Danielle Scheurer, MD, MSc, Brigham and Women’s Hospital, 45 Francis Street, PB/B/4/112, Boston, MA 02115, dscheurer@partners.org.

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References
Appendix. Input Screens for Blood Transfusion Physician Order Entry
Appendix. Input Screens for Blood Transfusion Physician Order Entry (continued)
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RBC Transfusion Decision Support Screen

Most recent Hct is [extracted from BICS] [39.6]

You have requested [extracted from POE] 1 unit of RBC.

CDSS recommends [from DSS algorithm] 0 units of RBC.

Indicate your decision

1. CDSS transfusion recommendation

2. Continue with original order.

*if select [2] -> provide reason for maintaining original order

You may see the following by selecting

1. Evidence-based transfusion recommendations

References

Type blue letter/number, press “Alt” and red character (or use mouse to select)

Please provide your reason for maintaining the original transfusion order

1. Instruction from my resident/fellow physician

2. Instructions from my attending/staff physician

3. Following the standards of my division/department

4. Following the standards of this patient care unit

5. Do not agree with the guidelines for this blood product

6. Agree with guidelines but in my clinical judgment does not currently apply to this patient

7. Other

References

Type blue letter/number, press “Alt” and red character (or use mouse to select)
Appendix. Input Screens for Blood Transfusion Physician Order Entry (continued)

![Image of RBC Transfusion Decision Support Screen]

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