

clinical investigations in critical care

A Descriptive Evaluation of Transfusion Practices in Patients Receiving Mechanical Ventilation*

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Study objectives: To characterize and compare transfusion practices in a broad sample of patients receiving mechanical ventilation (MV) and not receiving MV in the ICU.

Design: Retrospective subgroup analysis from the prospective, multicenter, observational CRIT study.

Setting: Two hundred eighty-four medical, surgical, or medical/surgical ICUs.

Patients: Critically ill adults.

Main results: Of the 4,892 patients enrolled in the CRIT study, 60% were receiving MV on ICU admission or within 48 h after admission for a median of 4 days. Patients receiving MV had higher baseline APACHE (acute physiology and chronic health evaluation) II scores than patients not receiving MV (22.8 ± 7.8 and 14.9 ± 6.4 , respectively [mean \pm SD]; $p < 0.0001$). Despite similar baseline hemoglobin levels (11.0 ± 2.3 g/dL and 10.9 ± 2.5 g/dL, $p = 0.17$), more patients receiving MV underwent transfusions (49% vs 33%, $p < 0.0001$), and they received significantly more RBCs than patients not receiving MV ($p < 0.0001$). The principal reason for transfusion in both groups was low hemoglobin level (78.4% and 84.6%, respectively); however, patients receiving MV had higher pretransfusion hemoglobin levels (8.7 ± 1.7 g/dL) than patients not receiving MV (8.2 ± 1.7 g/dL, $p < 0.0001$). Notably, 40.1% of all transfusions in patients receiving MV were administered after day 3 of the ICU stay, compared to 21.2% in patients not receiving MV ($p < 0.0001$), and a higher percentage of patients receiving MV remaining in the ICU after day 3 underwent transfusions (33.4% vs 18.3%, $p < 0.0001$). Mortality was higher (17.2% vs 4.5%, $p < 0.0001$) and mean hospital (15 days vs 10 days, $p < 0.0001$) and ICU stays (9 days vs 4 days, $p < 0.0001$) were longer in the subgroup receiving MV.

Conclusions: Mechanical ventilation appears to be an easily identifiable early marker for allogeneic blood exposure risk in ICU patients. While the longer ICU stays account for much of this risk, patients receiving MV also appear to undergo transfusions at higher hemoglobin thresholds than patients not receiving MV, at least early in the ICU stay. Justification of this relatively liberal transfusion practice in patients receiving MV will require further study.

(CHEST 2005; 127:928–935)

Key words: anemia; blood transfusions; critical care; hemoglobin; length of stay; mechanical ventilation; severity of illness; transfusion triggers

Abbreviations: LOS = length of stay; MV = mechanical ventilation

Transfusions are frequently administered in the ICU despite the well-recognized risks^{1,2} and the growing scarcity of the blood supply.³ Surveys^{4,5} of transfusion practices in both US and Western European ICUs indicate that nearly one half of all critically ill patients receive allogeneic blood transfusions. As reported by Corwin and colleagues,⁶ when the ICU stay is >1 week, the transfusion incidence reaches 85%, virtually

ensuring that severely ill patients will be exposed to allogeneic blood during their ICU stay.

Hébert and colleagues⁷ demonstrated that allogeneic transfusions did not improve outcomes in selected critically ill patients when administered at a liberal hemoglobin threshold (10 g/dL), compared to a more conservative hemoglobin threshold (7 g/dL). Liberal transfusion practices in the critically ill are

also of concern because of mounting evidence that administration of blood in the ICU setting is associated with an increased incidence of nosocomial infections,⁸⁻¹² multiple organ failure,¹³ and higher

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mortality rates.^{5,14} Of note, nearly one third of the critically ill patients in the retrospective study by Corwin and colleagues⁶ received transfusions for no clinically apparent reason.

A recent, large, international, prospective cohort study¹⁵ reported that approximately one third of all patients admitted to an ICU require mechanical ventilation (MV) at some point during their stay. This number approaches 70 to 85% in some published randomized, controlled trials^{7,16,17} of ICU patients. It is well accepted that patients receiving MV are generally sicker and, as a result, tend to exhibit poorer outcomes, including prolonged ICU stays.¹⁸⁻²⁰ These patients, therefore, are likely to consume relatively large volumes of blood and represent a population whose transfusion characteristics are of considerable interest.

The US-based CRIT study⁴ was a prospective, multicenter, observational evaluation of anemia and transfusion practices in 4,892 patients from 284 ICUs. Within this broad data set, 60% of patients required MV within 48 h after ICU admission. This retrospective analysis of data collected during the CRIT study⁴ was performed to quantify and compare patterns of transfusions and blood usage in patients receiving MV and in patients not receiving MV. To understand better whether the propensity to remain in the ICU for a prolonged time period exposes patients to more blood transfusions, both the volume and timing of blood transfusions in the MV and non-MV cohorts of the CRIT population were examined. Differences in outcomes, namely, the ICU and hospital length of stay (LOS) and mortality, were also evaluated in these patient subsets.

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This work was presented, in part, at the Annual Meeting of the American Thoracic Society in Seattle, WA 2003.

This study was sponsored by Ortho Biotech Clinical Affairs, LLC, Bridgewater, NJ.

Manuscript received February 9, 2004; revision accepted August 24, 2004.

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MATERIALS AND METHODS

Study Overview

The CRIT study,⁴ which enrolled 4,892 patients in 284 US ICUs between August 2000 and April 2001, was a prospective, multicenter, observational study aimed at quantifying anemia and transfusion practices in the critically ill. All patients were enrolled within 48 h of ICU admission. The study inclusion criteria were as follows: age \geq 18 years, anticipated ICU stay $>$ 48 h, and informed consent. Exclusion criteria were as follows: admission to a pediatric, cardiothoracic, cardiac, neurologic, or burn ICU; renal failure on dialysis; patients prohibited from receiving RBC transfusions; and patients involved in other transfusion research protocols. Patients were followed up for 30 days, or until hospital discharge or death, whichever occurred sooner. The study protocol was approved by the institutional review board of each participating institution. Subsets of this population have since been used to describe transfusion practices in trauma patients²¹ and to explore the relationship of ventilator-associated pneumonia to RBC transfusions.²²

Subjects and End Points

For the current analysis, MV patients were defined as those who were intubated on admission to the ICU or within 48 h of ICU admission. Because patients requiring new-onset MV late in their ICU course may represent a unique cohort, with ICU-related complications that likely influenced the process of care and outcomes, patients who were intubated later ($>$ 48 h after ICU admission) were not included. Patients whose MV status was unknown were also excluded.

The primary purpose of the present analysis was to examine and quantify transfusion practices in the MV population of the CRIT study⁴ and compare them to practices in the population of non-MV patients. The hypothesis—that increased illness severity and propensity to remain in the ICU for a prolonged period of time put MV patients at an increased risk of receiving allogeneic blood—was assessed by examining the percentage of patients receiving transfusions with packed RBCs during their ICU stay, the total volume of RBCs transfused to each subgroup, and per-patient numbers of RBC units transfused. Additionally, pretransfusion hemoglobin levels, reasons for transfusion, as well as the timing of RBC transfusions were analyzed, the latter to quantify the incidence of late (*eg*, later than ICU day 3) transfusions.

Statistical Analysis

Descriptive analyses of MV and non-MV populations and comparisons of transfusion requirements and outcomes between these groups were performed. SAS PROC MEANS procedure (SAS Institute; Cary, NC) was used to analyze means, SDs, and medians of continuous variables. Means are represented as \pm SD, and medians are reported with their interquartile ranges (25th and 75th). A Student *t* test was used to detect significant differences between the mean values of two continuous variables. The nonparametric Brown-Mood test was used to compare differences between median values. SAS PROC FREQ procedure (SAS Institute) was used to tabulate frequencies of categorical variables, and χ^2 tests were used to detect significant differences between them; $p < 0.05$ was considered statistically significant.

RESULTS

Patient Characteristics

A total of 4,892 patients were enrolled in the CRIT study⁴ during a 9-month period. Of these, 2,915 patients (59.6%) were receiving MV on ICU admission or within 48 h of ICU admission, and 1,801 patients (36.8%) were not receiving MV. There were 176 patients (3.6%) excluded from this analysis who either had MV initiated past 48 h (n = 153) or had unknown MV status (n = 23). At baseline (Table 1), the two groups were similar with respect to gender distributions. The MV population was slightly younger than the non-MV population (59.5 ± 18.5 years and 60.7 ± 18.0 years, respectively; p = 0.03). While both APACHE (acute physiology and chronic health evaluation) II (22.8 ± 7.8 and 14.9 ± 6.4, p < 0.0001) and sequential organ failure assessment scores (7.7 ± 3.5 and 3.9 ± 2.8, p < 0.0001) were significantly higher in the MV cohort compared to the non-MV cohort, their baseline hemoglobin levels were similar (11.0 ± 2.3 g/dL and 10.9 ± 2.5 g/dL, p = 0.17).

Table 2 lists the major ICU admitting diagnoses. The most common reason for ICU admission in the MV group was respiratory failure (44% of patients), as defined by Zimmerman et al,²³ followed by postoperative recovery (22%), pneumonia (17%), and trauma (14%). In the non-MV group, postoperative recovery (16%), GI bleeding (15%), and cardiovascular (14%) were the most prevalent diagnoses recorded. Of the MV and non-MV populations, respectively, 51% and 21% exhibited at least one respiratory diagnosis (either respiratory failure, pneumonia, or ARDS).

RBC Transfusions and Pretransfusion Hemoglobin Levels

A total of 9,250 U of blood were administered to the 4,716 patients included in this analysis. The

Table 1—Patient Baseline Characteristics*

Characteristics	MV (n = 2,915)	Non-MV (n = 1,801)
Male gender	1,624 (55.7)	960 (53.3)
Age, yrs†	59.5 ± 18.5	60.7 ± 18.0‡
APACHE II score	22.8 ± 7.8§	14.9 ± 6.4
SOFA score	7.7 ± 3.5§	3.9 ± 2.8
Hemoglobin, g/dL	11.0 ± 2.3	10.9 ± 2.5

*Data are presented as No. (%) or mean ± SD. APACHE = acute physiology and chronic health evaluation; SOFA = sequential organ failure assessment.

†Age reported for 2,903 patients in the MV group and 1,797 patients in the non-MV group.

‡p = 0.03.

§Significantly higher than the non-MV group (p < 0.0001, Student t test comparison of mean values).

Table 2—Major Admitting Diagnoses by MV Status*

Category	MV (n = 2,915)	Non-MV (n = 1,801)
Respiratory failure†	1,292 (44.3)	215 (11.9)
Postoperative	648 (22.2)	295 (16.4)
Pneumonia	496 (17.0)	221 (12.3)
Cardiovascular	332 (11.4)	247 (13.7)
Trauma	420 (14.4)	141 (7.8)
Sepsis/SIRS	328 (11.3)	185 (10.3)
Hemodynamic instability	289 (9.9)	187 (10.4)
Neurologic	231 (7.9)	139 (7.7)
GI bleeding	117 (4.0)	263 (14.6)
ARDS	113 (3.9)	22 (1.2)
Primary hematologic disease	21 (0.7)	14 (0.8)
Major burns	0 (0.0)	1 (0.1)
Other	547 (18.8)	558 (31.0)

*Data are presented as No. (%). SIRS = systemic inflammatory response syndrome. Percentages total > 100% because 1,966 (40% of patients) had more than one admitting diagnosis.

†Defined as the presence of one or more of the following²³: respiratory rate ≤ 5 breaths/min or ≥ 49 breaths/min; PaCO₂ ≥ 50 torr; P(A-a)O₂ ≥ 350 torr; and dependent on ventilator on day 4 of organ-system failure.

incidence of transfusions was significantly greater in the MV group than in the non-MV group (49.2% vs 33.3%, p < 0.0001). While the MV cohort represented 62% of the analyzed population, those patients received more than three fourths (7,083 U) of all of the blood administered during the study period. The per-patient transfusion rates were 4.9 ± 4.9 U and 3.6 ± 4.0 U (p < 0.0001) for MV and non-MV patients, respectively (Table 3). The overall mean pretransfusion hemoglobin level was 8.7 ± 1.7 g/dL in MV patients, compared to 8.2 ± 1.7 g/dL in non-MV patients; this between-group difference was statistically significant (p < 0.0001).

The reasons for administering transfusions to MV and non-MV patients included low hemoglobin, active bleeding, clinical condition (not otherwise specified), hemodynamic status, surgery, ischemia, and low cardiac output (Fig 1). Although multiple reasons might have been given for any one transfusion, low hemoglobin was, by far, the most common, having been cited as at least one of the reasons for 78.4% and 84.6% (p < 0.0001) of transfusions administered to MV and non-MV patients, respectively. Figure 2 displays the mean pretransfusion hemoglobin levels by their corresponding reasons for transfusion. Corresponding to the reason of “low hemoglobin,” pretransfusion hemoglobin levels were 8.4 ± 1.4 g/dL in MV patients (n = 1,271) and 8.0 ± 1.6 g/dL in non-MV patients (n = 553). These values differ slightly from the overall mean pretransfusion hemoglobin because they represent only the subset of patients for whom low hemoglobin was designated as one reason for transfusion. This

Table 3—Transfusion Profile by ICU Time Period and Patient Ventilation Status*

Variables	MV (n = 2,915)	Non-MV (n = 1,801)
Entire ICU stay Patients transfused	1,434 (49.2)†	599 (33.3)
Total RBC units transfused	7,083	2,167
RBC units per patient transfused	4.9 ± 4.9‡	3.6 ± 4.0
Pretransfusion hemoglobin, g/dL	8.7 ± 1.7‡	8.2 ± 1.7
Early (ICU days 1–3) Patients transfused	1,122 (38.5)†	550 (30.5)
RBC units transfused, No. (% of total within cohort)	4,246 (59.9)	1,707 (78.8)
RBC units per patient transfused	3.8 ± 4.1‡	3.1 ± 2.3
Late (ICU days 4 through study end)		
Patients remaining in the ICU	2,151 (73.8)†	645 (35.8)
Patients receiving transfusion, No. (% of remaining)	718 (33.4)†	118 (18.3)
RBC units transfused, No. (% of total within cohort)	2,837 (40.1)†	460 (21.2)
RBC units per patient transfused	4.0 ± 3.6	3.9 ± 6.5

*Data are presented as No. (%) or mean ± SD unless otherwise indicated.

†MV higher than non-MV ($p < 0.0001$, χ^2 comparison of percentages).

‡MV higher than non-MV ($p < 0.0001$, t test comparison of mean values).

threshold was, again, significantly higher in the MV group ($p < 0.0001$). Patients receiving MV, whose reason for transfusion was active bleeding or hemodynamic instability, were also transfused at significantly higher hemoglobin levels (8.5 ± 2.3 g/dL and 8.6 ± 2.1 g/dL, respectively) than non-MV patients with active bleeding (8.0 ± 1.9 g/dL, $p < 0.0001$) or hemodynamic instability (8.1 ± 2.2 g/dL, $p = 0.0019$).

Timing of Transfusion Administration in the ICU

An evaluation of the time course of RBC transfusions administered to MV and non-MV patients was conducted as part of the present analysis. For this purpose, the early time period was defined as ICU days 1 to 3, and the late period was defined as ICU day 4 through the end of the study (day 30, discharge, or death). The percentage of patients who received transfusions both early and late in the ICU stay was significantly higher in the MV group than in the non-MV group (Table 3). Among the patients remaining in the ICU at day 4 and beyond (73.8% MV and 35.8% non-MV), there was a nearly twofold higher incidence of transfusion in the MV cohort compared to the non-MV cohort (33.4% vs 18.3%, respectively; $p < 0.0001$). Of all the blood administered in the ICU to the MV patients, 40.1% (2,837 of 7,083 total units administered to the MV group) was administered on ICU day 4 and after, compared to 21.2% (460 of 2,167 U) in the non-MV group ($p < 0.0001$).

On a RBC unit per-patient basis, the difference in RBC units transfused in MV and non-MV patients was apparent in the early period (3.8 ± 4.1 U vs 3.1 ± 2.3 U, respectively; $p < 0.0001$), but this difference disappeared in the late ICU period (4.0 ± 3.6 U vs 3.9 ± 6.5 U, $p = 0.9$). The pretransfusion hemoglobin levels recorded as a function of the number of days spent in the ICU are shown in Figure 3. The mean pretransfusion hemoglobin levels were significantly higher in MV patients in the first 3 days of the ICU stay ($p < 0.0001$), but thereafter showed no difference. This difference appears to fade because pretransfusion hemoglobin levels increase in non-MV patients as they spend more time in the ICU.

Patient Outcomes

The median duration of MV was 4 days (interquartile range, 2 to 9 days). Outcomes data for MV and non-MV patients are summarized in Table 4. The median length of ICU stay was twofold longer for MV patients than for non-MV patients ($p < 0.0001$). Similarly, the median hospital LOS was 1.6-fold longer for MV patients than for non-MV patients ($p < 0.0001$). Mortality rates for patients while in the study were 17.2% in the MV group and 4.5% in the non-MV group ($p < 0.0001$).

DISCUSSION

It has been well documented that blood transfusions are administered frequently in the ICU,^{4–6,24,25} yet few studies have specifically addressed the incidence of blood transfusions in critically ill patients receiving MV. One retrospective, single-center study²⁶ reported that 47.5% of the 61 patients undergoing MV for > 48 h received, on average, 4.1 ± 1.0 U of RBCs per patient, at a mean pretransfusion hematocrit of $24.9 \pm 0.9\%$. The present retrospective subgroup analysis of data from the CRIT study,⁴ one of the largest prospective samplings of ICU patient data to date, contributes to the body of knowledge about transfusion practices in the MV population and affirms that MV patients have high transfusion rates (49.2%), with substantial per-patient transfusion amounts (4.9 U of RBCs per patient). Furthermore, this analysis documents that these amounts are significantly higher than in patients who are not receiving MV (33.3% transfused; 3.6 U of RBCs per patient, $p < 0.0001$). The difference in the per-patient transfusion rate between MV and non-MV patients is most evident in the first 3 days of the ICU stay (3.8 U vs 3.1 U of RBCs per patient, respectively; $p < 0.0001$); yet, 40% of the blood administered to the MV population is admin-

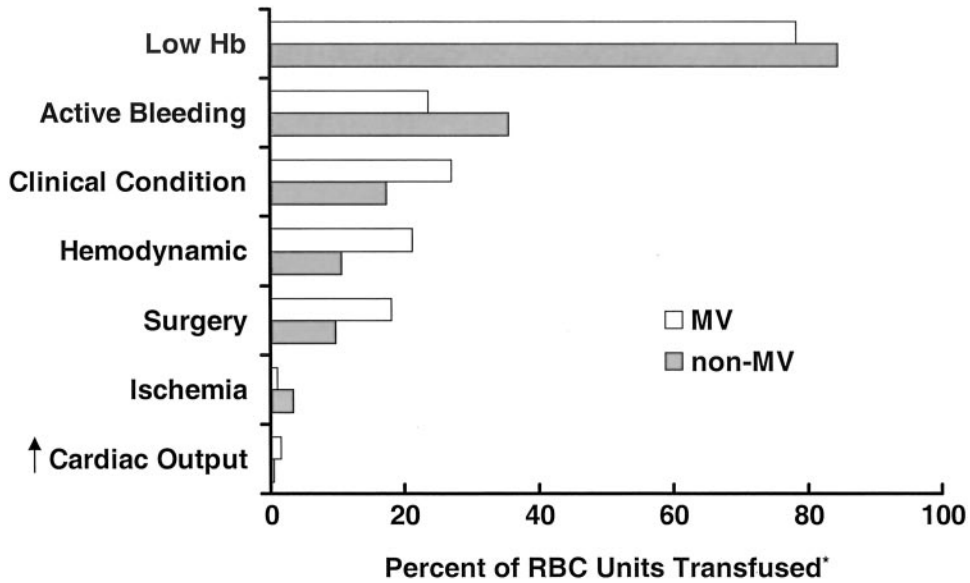


FIGURE 1. Reasons for transfusion in MV and non-MV patients. Percentages are based on data from 7,055 RBC units transfused in MV patients and 2,161 RBC units transfused in non-MV patients. Thirty-four units transfused could not be classified and were excluded from the analysis. *Sum > 100% because more than one reason may have been recorded for each unit transfused. Hb = hemoglobin.

istered after ICU day 3. Perhaps an even more important and clinically relevant observation in this study is that MV patients receive transfusions at a higher mean pretransfusion Hb (8.7 g/dL) than

non-MV patients (8.2 g/dL). This observation is significant, however, only in the first few days of the ICU stay (Fig 3).

Two prospective observational studies,^{4,5} one of

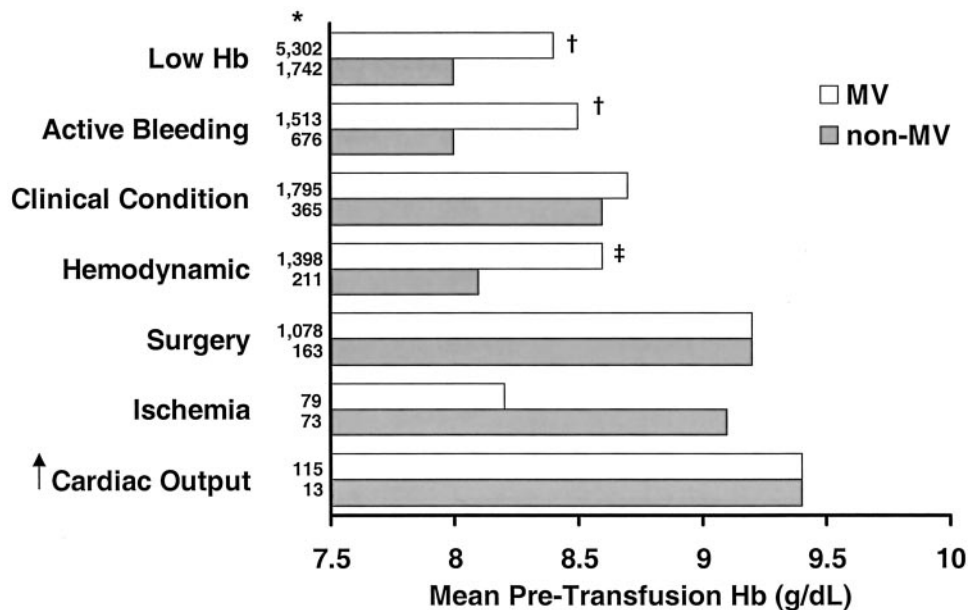


FIGURE 2. Pretransfusion hemoglobin by reason for transfusion in MV and non-MV patients. *Represents the total number of transfused RBC units that had a nonmissing hemoglobin value. Since a patient could have more than one reason for transfusion, the sum of the transfused units over different reasons is greater than the total number of unique units transfused; †MV greater than non-MV, $p < 0.0001$; ‡MV greater than non-MV, $p < 0.002$. p values were based on Student t test comparing the means between MV and non-MV patients. See Figure 1 legend for expansion of abbreviation.

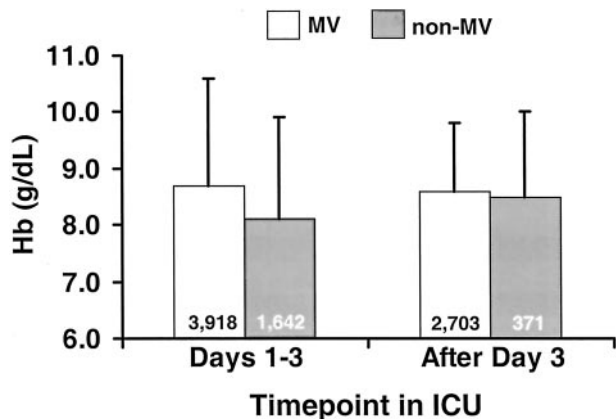


FIGURE 3. Pretransfusion hemoglobin by time in ICU in MV and non-MV patients. The pretransfusion hemoglobin level is based on transfusions occurring in the ICU. A patient could have multiple transfusions during the ICU stay. The numbers at the bottom of each bar indicate the number of transfusions. Error bars represent SD. The pretransfusion hemoglobin levels were significantly different in MV vs non-MV patients early in the ICU stay (days 1 to 3, * $p < 0.0001$) but not after day 3 ($p = 0.9$). See Figure 1 legend for expansion of abbreviation.

which provides the study population for this subset analysis,⁴ documented that transfusions continue to be administered quite liberally in the ICU setting. This occurs despite mounting evidence about transfusion risks,^{8,9,13} and despite data from Hébert et al⁷ that a restrictive transfusion policy (hemoglobin, 7 g/dL) produces outcomes similar to that of a liberal policy (hemoglobin, 10 g/dL) in selected critically ill patients.

The MV patients in this study had poorer outcomes than the non-MV patients. As may have been predicted from the severity of illness scores in the MV cohort, mortality, ICU LOS, and hospital LOS were higher than in the non-MV cohort. Because it is not valid to draw any causal inferences from an observational study, these data have not been analyzed with respect to allogeneic blood exposure and outcomes, and no implication of cause and effect is

Table 4—Patient Outcomes by MV Status*

Outcome Variables	MV (n = 2,915)	Non-MV (n = 1,801)	p Value
Mean ICU LOS, d	9.4 ± 8.0	3.7 ± 3.5	< 0.0001†
Median ICU LOS, d	6 (3 to 12)	3 (2 to 4)	< 0.0001‡
Mean Hospital LOS, d	15.0 ± 9.3	10.0 ± 7.2	< 0.0001†
Median Hospital LOS, d	13 (7 to 23)	8 (5 to 13)	< 0.0001‡
Mortality	501 (17.2)	81 (4.5)	< 0.0001§

*Data are presented as mean ± SD, median (25th to 75th percentiles, or No. (%)).

†One-way analysis of variance with contrast.

‡Nonparametric Brown-Mood test.

§ χ^2 test for group comparisons.

intended. Conversely, because of the close relationship observed between LOS and MV in the present data set, it is difficult to assess whether the higher amounts of RBC units transfused are due to prolonged LOS or MV alone. Future studies are warranted to further examine the relationships between transfusions and outcomes in MV patients.

Transfusion practices in critically ill MV patients are of interest for several reasons, not the least of which relates to the large amount of blood that this population consumes. A large proportion of ICU patients are intubated and placed on MV during their ICU stay; 60% in the present analysis were intubated within 48 h after ICU admission. While it may seem obvious, MV patients are generally sicker, their ICU stays are longer and, as a result, are a population likely to be transfused. Because these patients receive a significant number of RBC transfusions after ICU day 3, the MV population represents one in which a carefully constructed transfusion management strategy would benefit blood conservation efforts.

The present observations clearly indicate that clinicians transfuse MV patients, *a priori*, at higher hemoglobin levels (8.7 g/dL) than the non-MV patients (8.2 g/dL), at least early in the ICU course (Fig 3). Although the stated reason for most (80.2%) of the transfusions administered overall was low hemoglobin, these data also show that low hemoglobin has a statistically and clinically different meaning in MV and non-MV patients (8.4 ± 1.4 g/dL vs 8.0 ± 1.6 g/dL, respectively; $p < 0.0001$).

The clinical reasoning behind this difference in transfusion trigger between MV and non-MV patients is not obvious, since there is little existing evidence that hemoglobin should be corrected more aggressively in MV patients. It is noteworthy that multiple clinical trials^{27–29} of liberation from MV have utilized hemoglobin levels of 8 g/dL or 10 g/dL as an enrollment criterion, perhaps representing a tacit assumption that there is a hemoglobin threshold necessary for successful extubation. Several studies^{30,31} lend some support to this practice, including one by Khamiees et al,³² in which medical and cardiac ICU patients with hemoglobin levels ≤ 10 g/dL were more than five times as likely to have extubation failure as patients with hemoglobin levels > 10 g/dL. In contrast to the limited data suggesting that higher hemoglobin provides an advantage when weaning patients from MV, analysis of the MV subset from the Transfusion Practices in Critical Care study¹⁷ found no difference between the liberal and restrictive transfusion groups with respect to the duration of MV or the number of ventilator-free days. However, the Transfusion Practices in Critical Care study¹⁷ was neither designed nor powered to

demonstrate MV outcome differences. Given the paucity of published data on the topic, the question of whether a higher hemoglobin is beneficial in MV patients remains unanswered and needs to be rigorously investigated in a prospective study.

The significant transfusion requirement in the MV population after ICU day 3 (40% of all blood administered to this group) is another pertinent observation arising from the present analysis. Although the number of RBC units transfused per patient in this late period was similar in both the MV and non-MV groups, the proportion of total blood administered to MV patients after ICU day 3 was higher (40% vs 21%). The MV patients were more than twice as likely to remain in the ICU past day 3 (73.8% MV vs 35.8% non-MV, $p < 0.0001$), and this longer ICU stay explains why such a large volume of blood is administered late to the MV population. Patients receiving ventilation received more than six times more blood than non-MV patients in this period (2,837 U vs 460 U, $p < 0.0001$), despite the fact that MV patients had shorter survival durations. MV is apparently an easily identifiable, early marker for predicting longer lengths of ICU stay and, hence, transfusion risk in the ICU. The observation that non-MV patients who continue to stay long in the ICU are transfused at higher hemoglobin levels lends support to the notion that LOS is an important factor in the decision to transfuse. Furthermore, the observation that the transfusion "trigger" increases over time in the ICU may reflect an attitude among clinicians that higher hemoglobin levels are beneficial with increasing severity of illness, despite a lack of data to support this clinical practice.

In summary, MV patients consume a significant amount of allogeneic blood while in the ICU, and blood is administered to these patients at a relatively high pretransfusion hemoglobin level. A large proportion of blood is administered late in the ICU course. Given the potential for untoward consequences of blood administration and the scarcity of the resource, it is appropriate to regularly evaluate blood utilization patterns in the MV critically ill population. Additional studies are also needed to address the potential beneficial effects of higher hemoglobin on outcomes in MV patients, whether achieved through transfusion or through strategies that minimize allogeneic blood exposure.

ACKNOWLEDGMENT: We wish to thank Analysis Group, Inc., Boston, MA, for their expert assistance with data analysis for this article, and Kathryn Lucchesi, PhD, RPh, for editorial assistance.

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