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Evaluation of Hemoglobin Trigger and Appropriateness of Perioperative Red Cell Transfusion in Surgical Departments

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Background: Red blood cell (RBC) transfusion is an essential practice during surgery to accommodate for bleeding. As such, there are efforts being made to allow for a safe and appropriate transfusion due to shortages of blood components and to minimize transfusion-related adverse reactions. However, a conventional transfusion decision with relatively high hemoglobin (Hb) threshold is still performed in clinical setting. In this study, we investigated the threshold of Hb level and appropriateness of RBC transfusion in patients receiving perioperative RBC transfusion in surgical departments.

Methods: We investigated the pre-transfusion Hb level of 1,379 patients (2,170 episodes) receiving perioperative RBC transfusion in five surgical departments, including cardiothoracic surgery (CS), general surgery (GS), neurosurgery (NS), obstetrics and gynecology (OBGY), and orthopedics (OS), between June 2017 and March 2018. The appropriateness of transfusion was evaluated with two criteria: 1) pretransfusion Hb level ≤ 10 g/dL and 2) posttransfusion Hb level ≤ 10 g/dL.

Results: The median pretransfusion Hb level was 8.5 g/dL (interquartile range 7.7~9.4); that of each department was as follows: 8.6 g/dL (7.9~9.2) in CS, 7.9 g/dL (7.3~8.6) in GS, 9.1 g/dL (8.5~9.8) in NS, 8.5 g/dL (7.7~9.8) in OBGY, and 8.7 g/dL (7.9~9.7) in OS. With a criteria of pretransfusion of Hb level ≤ 10 g/dL, 85.4% of total episodes were appropriate. With criteria of post-transfusion of Hb level ≤ 10 g/dL, 44.7% were appropriate.

Conclusion: This study presents a fundamental data observing the trend of RBC transfusion in a single institution. A significant proportion of inappropriate RBC transfusion are still being conducted in surgical setting. Continuous and effective education of clinicians and implementation of monitoring systems to assess the appropriateness of RBC transfusion may be necessary. (Korean J Blood Transfus 2018;29:151-158)

Key words: Hemoglobin, Trigger, Appropriateness, Red blood cell transfusion, Surgery

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Introduction

Over the past decades, patients were transfused when their hemoglobin (Hb) level fell below 10 g/dL or hematocrit level fell below 30% [1]. This '10/30' transfusion trigger rule, proposed back in 1942, has been widely adopted. A recently proposed restrictive transfusion strategy (Hb 7~8 g/dL) appears to show even better outcome compared with the conventional transfusion strategy [2,3]. Patient blood management, an evidence-based approach to improve patient's outcome and utilize limited resources of blood components effectively, is being implemented worldwide. Although many guidelines now suggest a lower Hb level threshold for red blood cell (RBC) transfusion [4], the '10/30' rule still appears to be practiced habitually. As such, it has recently been of great interest to many clinicians to determine the appropriateness of RBC transfusion.

There are several ways to evaluate the appropriateness of RBC transfusion. Metrics, such as pre-transfusion hemoglobin trigger, proportion of post-transfusion Hb levels, proportion of RBCs administered as single-transfusions, and RBCs/100 acute inpatient days, are simple to obtain; however, Spadbrow et al. [5] suggested that those are not as accurate as assessing the appropriateness of RBC transfusion through medical chart review. However, assessing the appropriateness of RBC transfusion through medical chart review is too labor-intensive. Besides, with regard to perioperative patients, retrospective medical chart review does not seem to be sufficient due to inadequate documentation [6]. In this respect, indirect evaluation using simple metrics was applied to determine the appropriateness of

RBC transfusion in the present study. We aimed to observe the Hb threshold in perioperative transfusion and assess the appropriateness of perioperative RBC transfusion among five surgical departments.

Materials and Methods

1. Data collection

A total of 1,379 patients who received perioperative RBC transfusion in five surgical departments between June 2017 and March 2018 in Seoul St. Mary's Hospital, the Catholic University, were included. The five departments included were cardiothoracic surgery (CS), general surgery (GS), neurosurgery (NS), obstetrics and gynecology (OBGY), and orthopedics (OS). This study was approved by the institutional review board of Catholic Medical Center. The data of pre- and post-transfusion Hb levels, units of RBC products transfused, and time of transfusion were obtained. The pretransfusion Hb level was defined as the lowest Hb level within 24 hours before transfusion. The post-transfusion Hb level was the first Hb level measured after transfusion. Serial transfusion of multiple units given to the same patient in a day without measurement of Hb level was considered as one episode of transfusion.

2. Assessing appropriateness

The Korean society of Blood Transfusion recommends a Hb level of 10 g/dL for intraoperative RBC transfusion in patients with cardiac disease or cerebrovascular disease. Accordingly, the appropriateness of transfusion was evaluated with two different criteria based on the guideline: 1) pretransfusion Hb level $\leq$

10 g/dL and 2) posttransfusion Hb level ≤ 10 g/dL.

3. Statistical analysis

Continuous data are summarized using the mean and standard deviation, or median and interquartile range (IQR), as appropriate. Comparison was evaluated using ANOVA for continuous data and Pearson's chi-square test for categorical variables. All analyses were conducted using SPSS software (Version 24.0, Armonk, NY, USA). A *P* value of

less than 0.05 was considered statistically significant.

Results

A total of 2,170 episodes with 5,250 units of RBC components were included. The median number of units transfused per person was 2 units (IQR, 1~2). The proportion of single unit transfused was 710 episodes (32.7%) of total episodes. Demographic features are listed in Table 1. The median age of pa-

Table 1. Characteristics of patients in each department

Department	Number of patient	Transfusion episode	Age, median (year)	Male (%)	Female (%)
CS	182	294 (13.5%)	60.8	60.9	39.1
GS	335	705 (32.5%)	60.8	56.5	43.5
NS	255	419 (19.3%)	63.3	41.3	58.7
OBGY	163	216 (10.0%)	49.2	0.0	100
OS	448	536 (24.7%)	68.3	25.4	74.6
Total	1,383	2,170 (100%)	62.0	40.8	59.2

Abbreviations: CS, cardiothoracic surgery; GS, general surgery; NS, neurosurgery; OBGY, obstetrics and gynecology; OS, orthopedics.

Fig. 1. Distribution of pretransfusion Hb level (A) and posttransfusion Hb level (B) in total patients.

tients was 62.0 years, and 40.8% was male. The highest frequency of transfusion episode was observed in GS (705 episodes, 32.5%) and lowest in OBGY (216 episodes, 10.0%). The distribution of pretransfusion Hb level in total patients is shown in Fig. 1A. The Hb level range of 8.1~9.0 g/dL was the most frequent level for transfusion decision. About 14.6% of patients had a Hb level of >10 g/dL, which appears to be an inappropriate transfusion decision. The Hb level after transfusion was distributed, as seen in Fig. 1B. Among the total study population, 55.3% had a post-transfusion Hb level of >10 g/dL. The median (IQR) pretransfusion Hb level was 8.5 g/dL (7.7~9.4) among all patients. The median (IQR) pretransfusion Hb level of each department was as follows (Fig. 2): 8.6 g/dL (7.9~9.2) in CS, 7.9 g/dL (7.3~8.6) in GS, 9.1 g/dL (8.5~9.8) in NS, 8.5 g/dL (7.7~9.8) in OBGY, and 8.7 g/dL (7.9~9.7) in OS. GS and NS showed the lowest and the highest pretransfusion Hb level, respectively (P value <0.001). The Proportion

of appropriate transfusion is seen in Fig. 3. The criteria of pretransfusion Hb level ≤ 10 g/dL showed a higher proportion of appropriateness compared with the criteria of post-transfusion Hb level ≤ 10 g/dL. GS showed highest proportion of appropriateness, while OS showed the lowest with statistical significance ($P < 0.001$). In regard to the time of transfusion, pre-operation day (pre-OP), operation day (OP), and post-operation day (post-OP) comprised 13.8% (301 episodes), 28.0% (606 episodes) and 58.2% (1,263 episodes) of total episodes of transfusion, respectively. The proportion of inappropriate transfusion to appropriate transfusion was highest in the OP group (Fig. 4). In the OP group, there were twice as many inappropriate transfusions (418 episodes) than appropriate transfusions (188 episodes) with a criteria of posttransfusion Hb ≤ 10 g/dL (Fig. 4B). When comparing the pre-transfusion Hb level between the different clinical departments according to the perioperative period, the Hb level was highest in the OP group in every clinical

Fig. 2. Distribution of pretransfusion Hb level in five surgical departments.

Fig. 3. Proportion of appropriate transfusion with two criteria in five surgical departments.

Fig. 4. Proportion of appropriate and inappropriate transfusion with criteria of pretransfusion Hb (A) and posttransfusion Hb (B) according to perioperative period.

Table 2. Pretransfusion Hb level according to the perioperative period in each department

Department	Pretransfusion Hb (g/dL, median)			<i>P</i> value*
	pre-OP	OP	post-OP	
CS	8.5	8.9	8.4	0.005
GS	8.3	8.8	7.7	<0.001
NS	9.0	10.0	8.9	<0.001
OBGY	7.8	10.1	8.3	<0.001
OS	8.5	10.1	8.5	<0.001
Total	8.4	9.6	8.3	<0.001

*Comparison among three groups using ANOVA.

Abbreviations: Hb, hemoglobin; pre-OP, pre-operation day; OP, operation day; post-OP, post-operation day; CS, cardiothoracic surgery; GS, general surgery; NS, neurosurgery; OBGY, obstetrics and gynecology; OS, orthopedics.

department (Table 2). In terms of appropriateness by clinical departments according to the time of transfusion, OS and NS showed inappropriate transfusion episodes by more than double that of appropriate transfusion during OP (OS: 125 episodes, 82.8%, NS: 102 episodes, 76.7%) and post-OP (OS: 227 episodes, 69.4%, NS: 170 episodes, 69.1%) with the criteria of post-transfusion Hb level ($P < 0.001$).

Discussion

According to previously reported studies [7,8], the rates of inappropriate RBC transfusion in surgical patients ranged from 25% and 74%, similar to our findings in this study. This huge difference is likely attributed to the decision of the appropriate transfusion [9]. Indeed, in this study, the inappropriate-

ness rate was 55.3% with the criteria of post-transfusion Hb >10 g/dL, while it was 14.6% with pre-transfusion Hb >10 g/dL. It also depends on whether it is a medical or surgical setting. Assessing the appropriateness of RBC transfusion in surgical patients is especially complex due to the amount of potential blood loss. However, it is almost impossible to measure the exact amount of perioperative blood loss and reflect it in the calculation of blood loss and gain. Subsequently, indirect evaluation should be applied when assessing the appropriateness of RBC transfusion in surgical patients. In other studies, hematocrit <33% in discharge [10], post-transfusion Hb level <8 g/dL, or <10 g/dL [7] were used as criteria dealing with surgical patients. Spradbrow et al. [5] suggested that a chart audit of 50 RBC transfusions with adjudication using robust criteria is the optimal means to evaluate RBC transfusion appropriateness at an institution for benchmarking and quality-improvement initiatives. Further study would be needed to determine whether it is applicable in surgical setting. As Barr et al. [11] suggested, the lack of guidance on the appropriate target range of post-transfusion Hb is likely to compound the variation in transfusion practice observed. The guidelines on the appropriate target range of posttransfusion Hb, as well as the creation of simple metrics that can be applied to surgical patients in assessing the appropriateness of RBC transfusion is required.

Many studies are being published on the benefit of restrictive transfusion rather than liberal transfusion. Carson et al. [12] analyzed 31 randomized clinical trials (RCT) and demonstrated that restrictive RBC transfusion threshold (Hb 7~8 g/dL) was not asso-

ciated with higher rates of adverse clinical outcomes and a restrictive transfusion threshold is safe in most clinical settings [2]. In another RCT, liberal transfusion strategy, as compared with a restrictive strategy, did not reduce the mortality rates or inability to walk independently on 60-day follow-up or in-hospital morbidity in elderly patients at high cardiovascular risk. Villanueva et al. [3] not only showed that restrictive transfusion was harmful, but that it had better outcome with lower mortality compared with liberal transfusion in patients with gastrointestinal bleeding. Even with these growing evidences of superiority of restrictive transfusion, clinicians seem to be still passive or reluctant to accept the new guidelines of transfusion, as evident in this study with a relatively high proportion of inappropriate transfusions. Effort for continuous education as well as implementation of effective auditing program should be necessary to minimize inappropriate transfusion. Tinmouth et al. [13] showed in their systematic research, that behavioral interventions were effective in changing the transfusion practices of physician and reducing blood utilization. Another study also reported that engagement of physicians who prescribed inappropriate RBC resulted in a significant decline in RBC use without evidence of a change in mortality [14]. Moreover, Yerrabothala et al. [15] reported that substantial decrease in RBC utilization had been observed with the implementation of restrictive transfusion policy using prospective computerized order auditing.

In this study, most episodes of transfusion were done during the post-operative period; however, the proportion of inappropriate to appropriate transfusion was higher during the operative period.

Intraoperative transfusion could be reduced with several strategies, such as minimizing blood loss, autologous blood cell salvage, and improving tolerance of anemia [16]. Patient positioning, use of tourniquet, and infusion of local vasoconstrictor can be used to limit the blood flow to the site of surgery. Methods for improving hemostasis at the site of bleeding include the use of electrocautery, argon-beam coagulation, and anti-fibrinolytic agents. OS and NS showed higher frequency of inappropriate transfusion during both operative and post-operative periods. This seems to be originated from the higher Hb level required for cerebrovascular patients and inherent nature of orthopedic surgery that retains post-operational heavy bleeding from bones.

There are some limitations in this study. First, for the criteria of inappropriate transfusion, the pre- and post-transfusion Hb level >10 g/dL might be too generous, resulting in a small proportion of inappropriate transfusions. We set the criteria of inappropriate transfusion relatively wide because the Hb threshold of RBC transfusion for patients with cardiac disease or other comorbidities is 10 g/dL. Since a chart review of each patient to determine the underlying disease was not attained, we set the criteria wide enough to include patients regardless of different comorbidities. Second, the type of operation was not applied in determining the appropriateness of transfusion. Since the amount of bleeding and patient demography differ according to the types of operation, reflection of types of operation on the evaluation of appropriate transfusion should provide results with greater precision.

Conclusion

This study provides fundamental data on the trend of RBC transfusion in a single institution. Significant proportion of inappropriate RBC transfusions was still conducted in surgical setting. Despite the lowered Hb threshold recommended in the current guidelines, practitioners seem to be unwilling or uncomfortable to adopt and accept the new guidelines. Continuous and effective education of clinicians and implementation of monitoring systems to assess the appropriateness of RBC transfusion may be necessary.

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