Blood transfusion can be lifesaving, but it can also be life-threatening because of adverse transfusion reactions.1

Hemovigilance is defined as a set of surveillance procedures that cover the whole transfusion chain—from the collection of blood and its components to follow-up of transfusion recipients.2,3 Hospital hemovigilance systems aim to increase patient safety and blood transfusion efficacy by collecting and assessing information on unexpected or undesirable effects of the therapeutic use of labile blood products; such systems also aim to prevent the occurrence and recurrence of these effects.3

Reporting the adverse events of transfusion is an essential component of a hemovigilance system.2 A standard operating procedure for documenting, reporting, evaluating, and following up all adverse reactions was established and integrated into our hospital’s information system.4 Routine monitoring of patients’ clinical status during transfusion may permit patients to receive early appropriate treatment. However, the formerly used paper-based reporting procedure is time-consuming and labor-intensive.5 By contrast, online reporting procedures are more effective and can reduce human error in the evaluation of blood transfusion reactions.5,6

Patients’ clinical status should be closely monitored during transfusion and recorded in a health care database. Vital signs are measurements of the body’s most basic functions that help medical professionals evaluate patient health status.9,10 The guidelines of the British Committee for Standards in Haematology recommend that when any of the associated signs and symptoms of transfusion reactions occur, the initial treatment should be based on such signs and symptoms rather than on classification.4 Awareness of the clinical features of acute transfusion reactions (ATRs) and their timely assessment can considerably improve their management. Our hospital’s information system comprises both institutional policies and a hemovigilance system for blood transfusion. Specifically, a Wi-Fi–based vital signs monitoring system automatically records and transmits blood pressure, pulse rate, and body temperature to hospital information system (HIS) database. In this study, we retrospectively compared patients’ vital signs and other laboratory data before and after blood transfusion and analyzed the data to identify potential clinical characteristics associated with the developing of ATRs.

**METHODS**

**Study Population**

This retrospective study collected data on transfusions conducted during 2011–2015 using the computerized HIS of Taichung Tzu-Chi Hospital (499 beds). A flowchart of the enrollment process of this study cohort is shown in Figure 1. This study was approved by the Research Ethics Committee of Taichung Tzu-Chi Hospital (REC 103-42).

**Hospital Hemovigilance Online Reporting System**

To improve the quality of clinical transfusion care, a patient-focused online reporting system was created and implemented in our HIS in 1997 for monitoring transfusion practices (Fig. 2A).
Since 2010, a wireless vital signs monitoring system (Dinamap ProCare 300 Vital Signs Monitor; GE Inc, Milwaukee, Wis) has been integrated into the transfusion management system. The English version of the transfusion reaction reporting web page is shown in Fig. 2B. The web page comprises the following four main components: (1) patient information, including medical record number, sex, age, blood type, doctor’s name, diagnosis, and laboratory data; (2) cloud-based electronic vital signs data, including body temperature, pulse rate, respiratory rate (using the temperature-pulse-respiration reporting system), and blood pressure; (3) use of blood components: indication for transfusion, volume transfused, and start and end times of transfusion; and (4) adverse transfusion reactions: symptoms or signs that occurred during transfusion or within the subsequent 24 hours. All blood components for transfusion were prescribed by a medical practitioner. To use our reporting system, nurses simply click on the appropriate icon and enter the reporting procedure information throughout the transfusion process. Patients’ vital signs are automatically recorded at three time points: before transfusion, 15 minutes after transfusion initiation, and after transfusion of each blood component unit. In addition, patients are asked whether they experience any symptoms during the blood transfusion. The vital signs and symptoms are monitored every 8 hours up to 24 hours after transfusion, and the reporting system automatically connects the nursing record system to the blood bank physician system. In our online reporting system, patients receiving transfusions without any signs and symptoms are identified as “no transfusion reaction.” If one or more signs or symptoms occur, they are documented in the electronic medical records. If any ATRs occur, a notification is automatically sent to a doctor for confirmation. Hospital hemovigilance online reports are recorded for each blood unit transfused, and each unit is considered a single transfusion event.

Vital Signs Checking and Laboratory testing

There are four primary vital signs: body temperature, blood pressure, pulse rate, and breathing rate. The forehead thermometer is a fast and easy way to measure body temperature. Blood pressure and pulse rate were evaluated using an electronic device (Dinamap ProCare 300 Vital Signs Monitor; GE Inc, Milwaukee, Wis). Clinical blood samples from patient were evaluated for complete blood cell counts and white blood cell with differential analysis using the Sysmex XE-5000 hematology analyzer (Sysmex Co, Kobe, Japan).

Classification of ATRs by Severity

In this study, ATRs were categorized by severity (i.e., mild, moderate, and severe/life-threatening or grades 1–3, respectively), which were adapted from the blood transfusion safety handbook of the World Health Organization.\(^4\)\(^5\) Mild ATRs were defined as those with one of the following signs: itching, urticaria, or nausea/vomiting. Moderate ATRs were defined as those with any two mild ATR signs lasting longer than 30 minutes or one of the following signs: chills, fever (forehead temperature > 37.5° C),\(^12\) headache, blush, or body temperature increase of 1°C to 2°C during transfusion. Severe ATRs were defined as those with purpura, shock, bleeding, delirium, chest/abdominal pain, back pain, dyspnea, consciousness disturbance, fainting, hemoglobinuria, hemoglobin drop, or body temperature increase of greater than 2°C. In our online reporting system (Fig. 2B), patients receiving...
transfusions without any signs and symptoms are identified as "No transfusion reaction." If any ATRs occur, a notification is automatically sent to a doctor for confirmation.

**Statistical Analysis**

Continuous variables were expressed as means ± standard deviation, and categorical data were expressed as frequencies and percentages. One-way analysis of variance test was used for continuous variables. Pearson’s χ² test was used for categorical variables. Independent predictors eligible for inclusion are as follows: sex, forehead temperature (34°C–37.5°C, >37.5°C), pulse rate, respiratory rate, systolic pressure (<90 mm Hg, 90–110 mm Hg, >110 mm Hg), diastolic pressure (<70 mm Hg, 70–90 mm Hg, >90 mm Hg), hemoglobin, platelet counts, leukocyte counts (<5 × 10⁹/μL, 5–15 × 10⁹/μL, >15 × 10⁹/μL). Multivariate logistic
regression models were used to identify associated factors of developing ATRs (mild, moderate, and severe/life-threatening). The strengths of the relationships were expressed as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). All analyses were conducted using SAS Version 14.0 (SAS Institute Inc, Cary, NC). Statistical significance was set at \( P < 0.05 \).

**RESULTS**

**Data Collection**

The data sources from HIS, including patient information, laboratory data, ATRs, and a detailed bedside database were used. The data were cleaned (purged of inconsistent and/or nonsense values), organized, and merged to create files for the analysis. A transfusion episode was defined as one or more blood component units issued at the same time. As shown in Fig. 1, between 2011 and 2015, there were 59,725 transfusion episodes included in this retrospective study. However, online reports missing data on blood pressure (\( n = 18 \)), pulse rate (\( n = 17 \)), temperature/respiratory rate (\( n = 1927 \)), leukocyte counts (\( n = 12,871 \)), hemoglobin (\( n = 12 \)), and platelet count (\( n = 58 \)) were excluded. The inclusion criteria were 18 years or older. The frequencies of ATRs were calculated by dividing the number of cases of such signs and symptoms by the total number of study events. A total of 44,691 study events were included, of which 1586 (3.5%) were reportable ATR events.

**Pattern of Transfusion-Related Signs and Symptoms**

There are 1586 ATR reporting events were automatically transmitted to the HIS database system, and 1707 transfusion-related signs and symptoms were observed (Table 1). Elevated body temperature was the most common. Of 1267 reports (74.23% of reportable ATRs), body temperature increase of 1°C to 2°C, body temperature increase of greater than 2°C, and overall body temperature of greater than 38°C occurred in 946 (55.42%), 228 (13.36%), and 93 (5.45%) cases, respectively. The most common clinical signs and symptoms in these cases related to allergic reactions were itching (4.98%, \( n = 85 \)), urticaria (4.80%, \( n = 82 \)), and blush (1.23%, \( n = 21 \)), followed by chills (10.78%, \( n = 184 \)), dyspnea (2.05%, \( n = 35 \)), nausea/vomiting (0.41%, \( n = 7 \)), shock (0.29%, \( n = 5 \)), headache (0.29%, \( n = 5 \)), chest pain/abdominal pain/backache (0.23%, \( n = 4 \)), hemoglobinuria (0.06%, \( n = 1 \)), and none of the previously mentioned uncomfortable symptom (0.64%, \( n = 11 \)).

**Characteristics of the 44,691 Study Events With and Without ATRs**

Table 2 summarizes the pretransfusion characteristics of the 44,691 transfusion episodes. The mean ± SD age was 65.6 ± 15.5 years, and the median (interquartile range) age was 68 (18–105) years. Of the 1586 ATR events, 790 (49.8%) occurred in women and 796 (50.2%) in men. Compared with patients without ATRs, those with ATRs exhibited elevated body temperature (forehead temperature >37.5°C, 5.5% versus 3.8%, \( P = 0.001 \)), abnormal systolic pressure (\( < 90 \text{ mm Hg} \) or \( > 110 \text{ mm Hg} \), 78.9% versus 75.1%, \( P = 0.001 \)), abnormal diastolic pressure (\( < 70 \text{ mm Hg} \) or \( > 90 \text{ mm Hg} \), 55.9% versus 59.9%, \( P = 0.001 \)), and abnormal leukocyte count (\( < 5 \times 10^9/\mu L \) or \( > 15 \times 10^9/\mu L \), 40.2% versus 36.5%, \( P = 0.003 \)).

**Potential Associated Factors for ATRs**

Multivariate logistic regression models were employed to estimate the associations (ORs and 95% CI) between pretransfusion predictors and in developing ATRs. In this study, ATRs were categorized as mild, moderate, and life-threatening. We used multivariable logistic regression models to calculate absolute risk differences while adjusting for possible independent variables, including sex, body temperature, pulse rate, respiratory rate, systolic blood pressure, diastolic pressure, hemoglobin count, platelet count, and leukocyte count. Transfusion patients with leukocyte counts below the normal range (5–15 × 10^9/μL) were associated with mild ATRs (OR = 2.38, 95% CI = 1.68–3.35, \( P < 0.001 \)) (Fig. 3A). Multivariate analysis indicated that patients with elevated body temperature (forehead temperature >37.5°C) were associated with moderate ATRs (OR = 1.55, 95% CI = 1.22–1.98, \( P < 0.001 \)) (Fig. 3B). Patients with diastolic pressure above the normal range (>90 mm Hg) were associated with life-threatening ATRs (OR = 1.78, 95% CI = 1.06–2.99, \( P = 0.030 \)) (Fig. 3C).

**DISCUSSION**

Blood transfusions are lifesaving, and clinicians and laboratorians endeavor to ensure that blood transfusions are as safe as possible for patients. Each blood product transfusion is associated with some degree of potential risk of an acute or late adverse reaction. Thus, blood transfusion reactions remain unpredictable, and hospitals should establish a hemovigilance system for effectively reporting and real-time awareness of ATRs to improve patient safety during transfusion. To further ensure patient safety during transfusion, clinicians and nurses should be aware of any signs and symptoms exhibited by transfusion recipients before, during, and after blood transfusion. Vital signs monitoring has been a standard blood transfusion assessment for decades. In our hospital’s online hemovigilance reporting system, patients’ vital signs are monitored at the following three time points: before transfusion, 15 minutes after transfusion initiation, and after transfusion completion. To date, the clinical practice in monitoring patients’ body temperature after blood transfusion and documenting vital signs data correctly has been neglected. Thus, our hospital developed and implemented a Wi-Fi-based vital signs monitoring hemovigilance system to enhance user-friendliness and monitor ATRs in real time; this system was integrated into the electronic online reporting system and launched at our hospital in 2010 (Fig. 2).

We identified 1267 reports (74.23% of reportable ATRs) of febrile nonhemolytic transfusion reactions (FNHTRs), including...
Leukocyte counts—Age, y 65.6 ± 15.5, 68 (18 complications during transfusion.23,25 leukoreduced blood components can prevent leukocyte-associated Studies have also shown that the transfusion of prestorage VER (13.36%, n = 228) (Table 1). The incidence of FNHTR has been reported to vary from 17% to more than 54%.14,18 body temperature increase of greater than 2°C (5.45%, n = 93), and fe-

TABLE 2. Baseline Characteristics of All Included Study Events With and Without ATRs

| Characteristic                  | All Study Events (n = 44,691) | With ATRs (n = 1586) | Without ATRs (n = 43,105) | P     |
|--------------------------------|-------------------------------|----------------------|--------------------------|-------|
| Age, y                         | 65.6 ± 15.5, 68 (18–105)      | 63.1 ± 16.1, 64 (18–102) | 65.7 ± 15.5, 68 (18–105) | <0.001|
| Sex                            |                               |                       |                          |       |
| Female                         | 19,903 (44.5%)                | 790 (49.8%)           | 19,113 (44.3%)           | <0.001|
| Male                           | 24,788 (55.5%)                | 796 (50.2%)           | 23,992 (55.7%)           |       |
| Vital sign                     |                               |                       |                          |       |
| Pulse rate, beat per minute    | 89.5 ± 19.6                   | 91.0 ± 19.9           | 89.4 ± 19.5              | 0.002 |
| Respiratory                    | 19.7 ± 3.9                    | 19.8 ± 4.1            | 19.7 ± 3.9               | 0.398 |
| Body temperature               |                               |                       |                          |       |
| Normal (34–37.5°C)             | 42,967 (96.1%)                | 1499 (94.5%)          | 41,468 (96.2%)           | 0.001 |
| Abnormal (>37.5°C)             | 1724 (3.9%)                   | 87 (5.5%)             | 1637 (3.8%)              |       |
| Systolic pressure              |                               |                       |                          |       |
| Normal (90–110 mm Hg)          | 11,064 (24.8%)                | 335 (21.1%)           | 10,729 (24.9%)           | 0.001 |
| Abnormal                       | 33,627 (75.2%)                | 1251 (78.9%)          | 32,376 (75.1%)           |       |
| Diastolic pressure             |                               |                       |                          |       |
| Normal (70–90 mm Hg)           | 17,964 (40.2%)                | 700 (44.1%)           | 17,264 (40.1%)           | 0.001 |
| Abnormal                       | 26,727 (59.8%)                | 886 (55.9%)           | 25,841 (59.9%)           |       |
| Hb, g/dL                       | 9.0 ± 2.5                     | 8.9 ± 2.6             | 9.0 ± 2.5                | 0.161 |
| Platelet counts, × 10^12/μL    | 165.8 ± 125.1                 | 175.5 ± 132.6         | 165.4 ± 124.9            | 0.002 |
| Leukocyte counts               |                               |                       |                          |       |
| Normal (5–15 × 10^12/μL)       | 28,339 (63.4%)                | 949 (59.8%)           | 27,390 (63.5%)           | 0.003 |
| Abnormal                       | 16,352 (36.6%)                | 637 (40.2%)           | 15,715 (36.5%)           |       |

Continuous variables were reported as mean ± SD. Categorical variables were reported as counts (%); one-way analysis of variance test was used for continuous variables; Pearson's χ² test was used for categorical variables.

Body temperature increase of 1°C to 2°C (55.42%, n = 946), body temperature increase of greater than 2°C (5.45%, n = 93), and fever (13.36%, n = 228) (Table 1). The incidence of FNHTR has been reported to vary from 17% to more than 54%.14,18,19,20 Fever is a crucial and the most common sign of ATRs; it is an early sign that can be used to monitor patients’ vital signs during transfusions, and transfusions should be stopped immediately if any change in vital signs or unexpected symptoms occur.21–24 According to our blood transfusion reaction definition, a body temperature increase of 1°C to 2°C was a moderate ATR (grade 2); this type of ATR was also considered an FNHTR. We found that a body temperature increase of greater than 2°C was reported as a systemic symptom (grade 3 ATR) and occurred in 5.45% (93/1707) of cases. The development of a febrile reaction must be conducted promptly because fever may also be the first sign of other more severe reactions, including acute hemolysis and sepsis. Studies have reported that the transfusion of leukoreduced blood components effectively decreases febrile reaction.23,24 Leukoreduction may be performed at the prestorage or poststorage filtration stage.24 Studies have also shown that the transfusion of prestorage leukoreduced blood components can prevent leukocyte-associated complications during transfusion.23,25–27 The national insurance policy of Taiwan has meant that these types of blood components have been in use in our hospital since 2016. At our hospital, the incidence of adverse transfusion reactions was 3.5% (1586/44,691) blood units transfused (Table 2). Furthermore, we reported that vital signs monitoring and leukocyte count before transfusion were significantly associated with the subsequent occurrence of ATRs (Fig. 3). Currently, leukocyte count is not comprehensively performed in pretransfusion assessments.28 We believe that pretransfusion leukocyte count is crucial in assessing patients’ clinical status such as infection and sepsis. Clinicians should be more aware of the occurrence of ATRs when patients are leukopenia.

This study has several limitations. First, this was a longitudinal observational study. The data were limited to those files available in the computerized database of the HIS. Second, some online records were incomplete because of transmission errors. However, during the data transmission process, some data may be lost during the Wi-Fi signal loss or device not online (thermometer) and resulted failure of archive data. In addition, some data may incomplete because of the human error, which nurses forget to measure vital sign before or after transfusion. In particular, respiratory rate was less frequently recorded than other vital signs.29,30 The incomplete vital sign data were only 4% (1962/59,725) in our total collected data, which may not cause significantly interference of our statistical analysis. This study used the data that had been entered into the system by medical personnel. Therefore, the accuracy of reporting relies on the recognition and communication of transfusion reactions by medical personnel, availability of relevant patient data, and reporters’ proficiency in applying the definition, imputability, and severity criteria. Third, pretransfusion testing such as leukocyte counts, hemoglobin, or platelet counts were not detected for all patients, resulting in missing data (n = 14,903) (Fig. 1). Fourth, delayed transfusion reactions could not be evaluated in the study setting. However, any signs and symptoms occurring within 24 hours of a transfusion are required to be reported for
all transfusion patients. Hence, ATRs were the focus of this study. Based on the study results, prompt and effective preventive strategies, such as recognizing increased body temperature as an early sign, can be developed for ATRs.

**CONCLUSIONS**

In summary, we reported on the patient-focused hemovigilance system implemented in our hospital. Establishing a standard procedure that uses Wi-Fi to transmit patients’ vital signs and collect data correctly during the whole blood transfusion procedure is vital. A well-established hospital hemovigilance system not only reduces possible human errors but also improves the safety of blood transfusion. It is an essential step toward nationwide hemovigilance. Our results indicated that patients with leukopenia, elevated body temperature, and high diastolic blood pressure were associated with ATRs occurrence.

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**TABLE 3. Potential risk for ATRs.**

| Predictors before transfusion | Odds ratio (95% CI) | P     |
|------------------------------|--------------------|-------|
| Male                         | 0.89 (0.66-1.21)   | 0.453 |
| Body temperature (34–37.5°C) |                    |       |
| > 37.5°C                     | 0.81 (0.29-2.21)   | 0.681 |
| Pulse rate                   | 0.99 (0.98-1.00)   | 0.997 |
| Respiratory rate             | 0.90 (0.84-0.95)   | <0.001|
| Systolic pressure (90-110 mmHg) |              |       |
| < 90 mmHg                    | 0.22 (0.05-0.89)   | 0.334 |
| > 110 mmHg                   | 0.91 (0.61-1.35)   | 0.645 |
| Diastolic pressure (70-90 mmHg) |               |       |
| < 70 mmHg                    | 0.63 (0.44-0.90)   | 0.011 |
| > 90 mmHg                    | 0.91 (0.51-1.64)   | 0.752 |
| Hb                           | 1.14 (1.08-1.21)   | <0.001|
| Platelet counts              | 1.00 (0.99-1.00)   | 0.777 |
| Leukocyte counts (5-15 × 10⁹/µL) | |       |
| < 5 × 10⁹/µL                 | 2.38 (1.68-3.35)   | <0.001|
| > 15 × 10⁹/µL                | 0.88 (0.51-1.53)   | 0.646 |

**FIGURE 3.** Potential risk for ATRs. A, Odds ratio for grade 1 ATRs. B, Odds ratio for grade 2 ATRs. C, Odds ratio for grade 3 ATRs.
REFERENCES

1. Harvey AR, Basavaraju SV, Chung KW, et al. Transfusion-related adverse reactions reported to the National Healthcare Safety Network Hemovigilance Module, United States, 2010 to 2012. Transfusion. 2015;55:709–718.

2. Robillard P, Chan P, Kleinman S. Hemovigilance for improvement of blood safety. Transfus Apher Sci. 2004;31:95–98.

3. de Vries RR, Faber JC, Stengers PF, et al. Haemovigilance: an effective tool for improving transfusion practice. Vox Sang. 2011;100:60–67.

4. Tinegate H, Birchall J, Gray A, et al. Guideline on the investigation and management of acute transfusion reactions. Prepared by the BCSH Blood Transfusion Task Force. Br J Haematol. 2012;159:143–153.

5. Hussain S, Moiz B, Ausat FA, et al. Monitoring and reporting transfusion reactions as a quality indicator - a clinical audit. Transfus Apher Sci. 2015;52:122–127.

6. Crookston KP, Koenig SC, Reyes MD. Transfusion reaction identification and management at the bedside. J Infus Nurs. 2015;38:104–113.

7. Yeh SP, Chang CW, Chen JC, et al. A well-designed online transfusion reaction reporting system improves the estimation of transfusion reaction incidence and quality of care in transfusion practice. Am J Clin Pathol. 2011;136:842–847.

8. Fujihara H, Yamada C, Furumaki H, et al. Evaluation of the in-hospital hemovigilance by introduction of the information technology-based system. Transfusion. 2015;55:2898–2904.

9. Gosmann F, Nørgaard A, Rasmussen MB, et al. Transfusion-associated circulatory overload in adult, medical emergency patients with perspectives on early warning practice: a single-centre, clinical study. Blood Transfus. 2018;16:1–8.

10. Andrzejewski C Jr, Popovsky MA, Stec TC, et al. Hemotherapy bedside biovigilance involving vital sign values and characteristics of patients with suspected transfusion reactions associated with high-risk scenarios: can some cases of transfusion-associated circulatory overload have proinflammatory aspects? Transfusion. 2012;52:2310–2320.

11. Sanders RP, Geiger TL, Heddle N, et al. A revised classification scheme for acute transfusion reactions. Transfusion. 2007;47:621–628.

12. Masters JE. Comparison of axillary, oral, and forehead temperature. Arch Dis Child. 1980;55:896–898.

13. Diaz-Quijano FA. A simple method for estimating relative risk using logistic regression. BMC Med Res Methodol. 2012;12:14.

14. Sahu S, Hemlata, Verma A. Adverse events related to blood transfusion. Indian J Anaesth. 2014;58:543–551.

15. Delaney M, Wendel S, Bercovitz RS, et al. Transfusion reactions: prevention, diagnosis, and treatment. Lancet. 2016;388:2825–2836.

16. Li N, Williams L, Zou H, et al. Incidence of acute transfusion reactions to platelets in hospitalized pediatric patients based on the US hemovigilance reporting system. Transfusion. 2014;54:1666–1672.

17. Pahuja S, Puri V, Mahajan G, et al. Reporting adverse transfusion reactions: a retrospective study from tertiary care hospital from New Delhi, India. Asian J Transfus Sci. 2017;11:6–12.

18. St Bernard R, Yan M, Ning S, et al. Sustained and significant increase in reporting of transfusion reactions with the implementation of an electronic reporting system. Transfusion. 2016;56:1247–1248.

19. Sanders RP, Maddirala SD, Geiger TL, et al. Premedication with acetaminophen or diphenhydramine for transfusion with leukoreduced blood products in children. Br J Haematol. 2005;130:781–787.

20. Savage WJ. Transfusion reactions. Hematol Oncol Clin North Am. 2016;30:619–634.

21. Rajesh K, Harsh S, Amarkk K. Effects of prestorage leukoreduction on the rate of febrile nonhemolytic transfusion reactions to red blood cells in a tertiary care hospital. Ann Med Health Sci Res. 2015;5:185–188.

22. Wang RR, Triulzi DJ, Qu L. Effects of prestorage vs poststorage leukoreduction on the rate of febrile nonhemolytic transfusion reactions to platelets. Am J Clin Pathol. 2012;138:255–259.

23. Cho J, Choi SJ, Kim S, et al. Frequency and pattern of noninfectious adverse transfusion reactions at a tertiary care hospital in Korea. Ann Lab Med. 2016;36:36–41.

24. Heddle NM, Blajchman MA, Meyer RM, et al. A randomized controlled trial comparing the frequency of acute reactions to plasma-removed platelets and prestorage WBC-reduced platelets. Transfusion. 2002;42:556–566.

25. Weisbach V, Wanke C, Zingsem J, et al. Cytokine generation in whole blood, leukocyte-depleted and temporarily warmed red blood cell concentrates. Vox Sang. 1999;76:100–106.

26. Katharina A, Downes M, Ira A, et al. Pre-transfusion testing. ISBT Science Series. 2008;15:437–460.

27. Caso V, Agnelli G, Alberti A, et al. High diastolic blood pressure is a risk factor for in-hospital mortality in complete MCA stroke patients. Neurol Sci. 2012;33:545–549.

28. Qureshi AL. Acute hypertensive response in patients with stroke: pathophysiology and management. Circulation. 2008;118:176–187.

29. Mochizuki K, Shintani R, Mori K, et al. Importance of respiratory rate changes for the prediction of clinical deterioration after emergency department discharge: a single-center, case-control study. Acute Med Surg. 2017;4:172–178.

30. Flenady T, Dwyer T, Applegarth J. Accurate respiratory rates count: so should you! Australas Emerg Nurs J. 2017;20:45–47.

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