ANNALS OF LABORATORY MEDICINE

Predictors of Red Blood Cell Transfusion in Elderly COVID-19 Patients in Korea

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Background: Patients who experience clinical deterioration from coronavirus disease (COVID-19) require blood transfusion support. We analyzed blood component usage in COVID-19 patients and identified the predictors of red blood cell (RBC) transfusion in elderly (≥65 years) patients.

Methods: Blood component usage in 882 COVID-19 patients hospitalized between January 24, 2020 and April 30, 2021 was analyzed. Elderly patients were categorized into transfused and non-transfused groups according to their RBC transfusion history; their demographic and clinical characteristics, disease severity, and outcomes were compared. Associations were determined using multiple logistic regression.

Results: The overall transfusion rate was 8.3% (73/882), and the transfusion rate was 2.7% (14/524) in patients aged <65 years and 16.5% (59/358) in those aged ≥65 years. Among the 358 elderly patients, 344 patients, including 50 who received transfusion and 294 who did not, were enrolled for the analysis. The prevalence of diabetes mellitus (DM), white blood cell count, absolute neutrophil count, and neutrophil-to-lymphocyte ratio (NLR) on admission were significantly higher in the transfused group, whereas Hb and platelet counts were significantly lower. Disease severity in the transfused group was relatively high on admission and increased thereafter. DM, intensive care unit entrance on admission, Hb, platelet count, and NLR on admission were independently associated with RBC transfusion.

Conclusions: This study presents transfusion rates in COVID-19 patients according to age groups and predictors of RBC transfusion in elderly patients. The results provide a basis for developing a strategy for the medical treatment of infectious diseases emerging during pandemics.

Key Words: COVID-19, Elderly, Blood transfusion, Red blood cell, Predictors

INTRODUCTION

The coronavirus disease (COVID-19) pandemic has been going on for over two years now. From the viewpoint of transfusion medicine, blood donation and supply concerns were the most prominent during the early stage. During the pandemic, the use of blood components reportedly has decreased [1-3].

As the numbers of severely ill COVID-19 patients are increasing, concerns have shifted toward their transfusion needs. The clinical deterioration of COVID-19 patients can present as cytopenia or spontaneous bleeding due to coagulopathy. Furthermore, invasive procedures, such as extracorporeal membrane oxygenation (ECMO) therapy, have been performed in severely ill COVID-19 patients. For these patients, blood transfusions are needed [4-6]. The overall transfusion rates in COVID-19 patients widely range from 1.2% to 18.9% [7-14]. Studies have compared the demographic and clinical characteristics of COVID-19 patients according to whether or not they received transfusion

[8, 11]. Age is a well-known risk factor for severe and critical COVID-19 [15-18]. However, these previous comparative studies included COVID-19 patients of all ages.

We studied blood component usage in COVID-19 patients hospitalized at a dedicated infection disease hospital in Korea during the COVID-19 pandemic. For elderly (≥65 years) COVID-19 patients, demographic and clinical characteristics, disease severity, and outcomes were compared between those who received red blood cell (RBC) transfusion during hospitalization and those who did not, to identify predictors of RBC transfusion in elderly COVID-19 patients.

MATERIALS AND METHODS

Analysis of blood component usage in all COVID-19 patients
Blood component usage data were retrieved from the laboratory information system from January 24, 2020 (when the confirmed COVID-19 patient was admitted to our hospital for the first time) to April 30, 2021. In total, 882 COVID-19 patients were hospitalized during this period. Blood components used in all COVID-19 patients were categorized into RBCs, platelets, and plasma.

Patients and data collection
Among the elderly (≥65 years) COVID-19 patients hospitalized between January 24, 2020 and April 30, 2021, those who underwent emergency operations in the negative-pressure operating room were excluded. Additionally, patients who were transfused with platelets or plasma alone were excluded. The following demographic and clinical characteristics of the included patients were retrieved from their electronic medical records: age, sex, body mass index (BMI), comorbidity, initial symptoms, transfer history, intensive care unit (ICU) admission, peripheral hematological markers, including the complete blood cell count and neutrophil-to-lymphocyte ratio (NLR) on admission, ABO/RhD blood type, and chest radiologic characteristics on admission. For the patients who received transfusion, peripheral hematological markers on the first day of RBC transfusion were also retrieved. Transfer history was categorized as direct admission or transfer from other hospitals. The presence of lung infiltration on admission was evaluated using radiography and computed tomography (CT).

Disease severity was assessed on admission, hospital day 7 and day 14. To evaluate disease severity, eight-category severity scores were adopted from the WHO clinical progression scale, with modifications [17, 19]. The eight-category severity scores were as follows: 1) no limitation of daily activities; 2) limitation of

daily activities, but no need for supplemental oxygen therapy; 3) need for supplemental oxygen therapy via nasal cannula; 4) need for supplemental oxygen therapy via facial mask; 5) need for high-flow supplemental oxygen therapy or noninvasive mechanical ventilation; 6) need for invasive mechanical ventilation; 7) need for ECMO therapy; and 8) death [17].

Outcomes were classified into discharged, hospitalized, and death. Patients who could not be discharged because of complications despite a negative conversion of COVID-19 real-time reverse-transcription PCR were categorized as hospitalized.

This study was approved by the Institutional Review Board (IRB) of the National Medical Center, Seoul, Korea (IRB No. NMC-2012-100). This study was a retrospective study, and routine laboratory tests and transfusion had already been performed. Therefore, informed consent was waived by the IRB.

Statistical analysis
Student's *t*-test was used to compare continuous parameters between the transfused and non-transfused groups. Pearson's chi-square test and linear model ANOVA were performed to compare categorical parameters between two groups. Multiple logistic regression models were used to determine independent predictors of RBC transfusion. Variables showing a significant association with RBC transfusion in univariate analysis were entered into a multivariate backward selection procedure. Continuous variables were categorized using the cut-off points for multiple logistic regression analysis. The cut-off points for the continuous variables were as follows: BMI, 30 kg/m^2 [20]; Hb concentration, 100 g/L; white blood cell (WBC) count, absolute neutrophil count, and platelet count, upper and/or lower values of the reference range; and NLR, median for the enrolled patients. Adjusted odds ratios (ORs) are presented with 95% confidence intervals (CIs). $P < 0.05$ was considered statistically significant. All statistical analyses were conducted using Statistical Package for Social Sciences version 27 (IBM Corp., Armonk, NY, USA).

RESULTS

Blood component usage in COVID-19 patients
Table 1 shows the numbers of COVID-19 patients who received transfusion and blood components received. Among the 882 patients, 73 (8.3%) received transfusion of any blood component. When classified according to age, 524 patients were <65 years, and 14 (2.7%) of these patients received transfusion. The minimum age of patients who received transfusion was 45 years. The remaining 358 patients were ≥65 years, and 59 (16.5%)

Table 1. Numbers of COVID-19 patients who received transfusion and blood components transfused.

Age (yr)	Number of patients (%)		Number of blood components transfused (%)			
	Total	Patients who received transfusion	Total	RBCs	Platelets*	Plasma
<65	524	14 (2.7)	306	113 (36.9)	182 (59.5)	11 (3.6)
≥65	358	59 (16.5)	700	267 (38.1)	348 (49.7)	85 (12.1)
Total	882	73 (8.3)	1,006	380 (37.8)	530 (52.7)	96 (9.5)

*All platelets transfused to COVID-19 patients in this study were platelet concentrates.
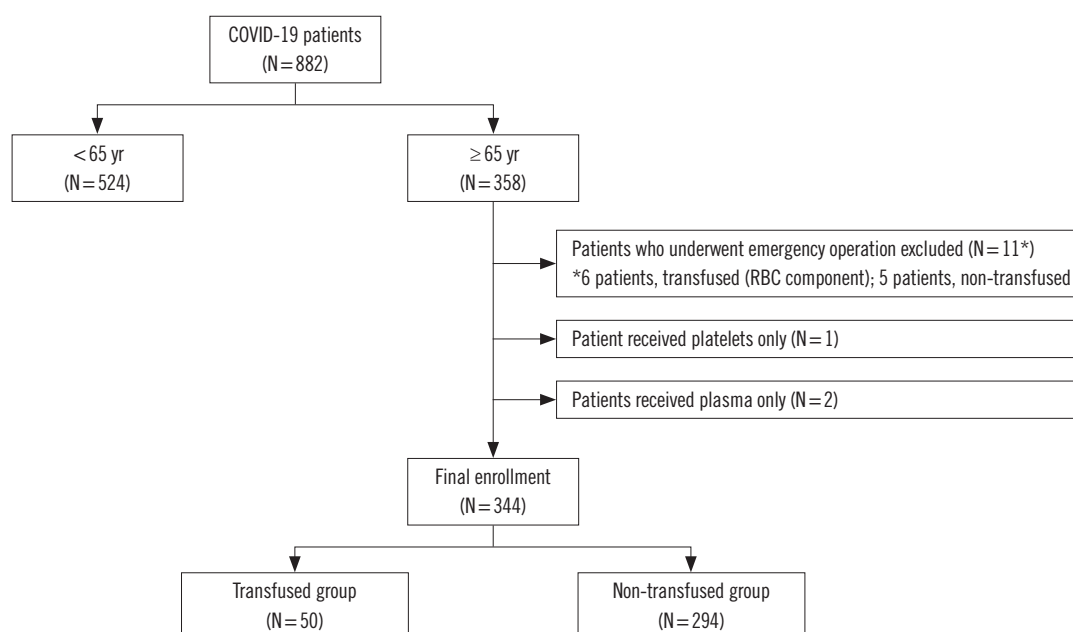Abbreviations: RBCs, red blood cells; COVID-19, coronavirus disease 2019.

Fig. 1. Flow chart of patient inclusion and exclusion.

received transfusion. In total, 1,006 units of blood components were transfused. Among these, 700 units (69.5%) were transfused to patients aged ≥65 years and 306 units (30.4%) to patients aged <65 years.

Patient selection

Among the 358 elderly patients, 11 were excluded because they had received emergency operations. These procedures were conducted for COVID-19 patients with acute diseases, such as fracture, traumatic epidural hemorrhage, and traumatic subdural hemorrhage. Additionally, three patients were excluded because one patient received platelets only (six units) and two patients received plasma only (four and eight units, respectively). Finally, 344 elderly patients were included in the subsequent analysis. The demographic and clinical characteristics, disease severity, and outcomes of these patients are presented in Supplemental Data Table S1. According to their RBC transfusion

history, 50 patients were classified into the transfused group and the remaining 294 patients were classified into the non-transfused group (Fig. 1).

Detailed description of the patients and blood component usage in the transfused group

A detailed description of the patients in the transfused group and their transfusion history are presented in Supplemental Data Table S2. Among the 50 patients in the transfused group, 30 received RBCs only. Six patients received platelets and RBCs, seven patients received plasma and RBCs, and seven patients received all three blood components. Thirty-nine patients received RBCs because of anemia. In total, these patients received 491 units: 156 units of RBCs, 287 units of platelets, and 48 units of plasma. In six patients, RBC transfusion was related to the ECMO procedure. These patients received 139 units in total: 73 units of RBCs, 55 units of platelets, and 11 units of plasma. In the remaining

Table 2. Demographic and clinical characteristics, disease severity, and outcomes of elderly COVID-19 patients according to their RBC transfusion history

Variable	Transfused (N=50)	Non-transfused (N=294)	P
Age (yr)	76.7±7.2	74.4±6.7	0.023
Sex			
Male	31 (62.0%)	159 (54.1%)	0.298
Female	19 (38.0%)	135 (45.9%)	
BMI (kg/m^2)	24.3±3.9	24.0±3.1	0.643
Comorbidity			
(+)	38 (76.0%)	213 (72.4%)	0.601
(−)	12 (24.0%)	81 (27.6%)	
Hypertension			
(+)	28 (56.0%)	167 (56.8%)	0.916
(−)	22 (44.0%)	127 (43.2%)	
Diabetes mellitus			
(+)	25 (50.0%)	93 (31.6%)	0.011
(−)	25 (50.0%)	201 (68.4%)	
Initial symptom			
(+)	39 (88.6%)	200 (76.6%)	0.074
(−)	5 (11.4%)	61 (23.4%)	
Transfer history			
Transfer	18 (36.0%)	71 (24.1%)	0.077
Direct admission	32 (64.0%)	223 (75.9%)	
ICU entrance on admission			
Yes	15 (30.0%)	27 (9.2%)	<0.001
No	35 (70.0%)	267 (90.8%)	
Peripheral hematological markers on admission			
Hb (g/L)	119±23	129±17	0.006
WBCs (×10^9/L)	8.630±5.395	6.600±3.106	0.012
ANC (×10^9/L)	7.338±5.317	5.150±3.106	0.007
ALC (×10^9/L)	0.808±0.415	0.933±0.547	0.124
NLR	12.6±10.9	8.8±11.0	0.027
Platelets (×10^9/L)	170±70	215±88	0.001
ABO/RhD blood type			
A+	18 (36.0%)	103 (40.1%)	0.867
B+	16 (32.0%)	72 (28.0%)	
O+	10 (20.0%)	45 (17.5%)	
AB+	6 (12.0%)	37 (14.4%)	
Lung infiltration on admission			
None	3 (6.0%)	55 (19.2%)	0.075
Unilateral	6 (12.0%)	31 (10.8%)	
Bilateral	41 (82.0%)	201 (70.0%)	

(*Continued to the next*)

Table 2. Continued

Variable	Transfused (N=50)	Non-transfused (N=294)	P
Disease severity score			
On admission			<0.001
1–2	15 (30.0%)	173 (58.8%)	
3–4	22 (44.0%)	91 (31.0%)	
5–7	13 (26.0%)	30 (10.2%)	
8	0 (0.0%)	0 (0.0%)	
On hospital day 7			<0.001
Discharge	0 (0.0%)	8 (2.7%)	
1–2	11 (22.0%)	164 (55.8%)	
3–4	9 (18.0%)	83 (28.2%)	
5–7	29 (58.0%)	36 (12.2%)	
8	1 (2.0%)	3 (1.0%)	
On hospital day 14			<0.001
Discharge	1 (2.0%)	95 (32.3%)	
1–2	10 (20.0%)	136 (46.3%)	
3–4	7 (14.0%)	36 (12.2%)	
5–7	28 (56.0%)	17 (5.8%)	
8	4 (8.0%)	10 (3.4%)	
Outcome			
Discharged	20 (40.0%)	271 (92.2%)	<0.001
Hospitalized	3 (6.0%)	2 (0.7%)	
Death	27 (54.0%)	21 (7.1%)	

Plus-minus values (±) are the standard deviation of the mean.
Abbreviations: RBC, red blood cell; BMI, body mass index; ICU, intensive care unit; WBCs, white blood cells; ANC, absolute neutrophil count; ALC, absolute lymphocyte count; NLR, neutrophil-to-lymphocyte ratio.

five patients, RBC transfusion was because of bleeding complications, such as hematochezia. These patients received 32 units in total: 18 units of RBCs and 14 units of plasma.

Comparison of demographic and clinical characteristics, disease severity, and outcomes according to RBC component transfusion history

Table 2 shows the demographic and clinical characteristics, disease severity, and outcomes in the transfused and non-transfused groups. The mean patient age in the transfused group was 76.7±7.2 years, and the patients in the transfused group were older than those in the non-transfused group (74.4±6.7 years, P= 0.023). The DM prevalence rate was significantly higher in the transfused group than in the non-transfused group (P=0.011).

The percentages of the presence of initial symptoms and transfer from other hospitals were higher, albeit not significantly, in the

Table 3. Multiple logistic regression analysis of predictors of RBC transfusion in elderly COVID-19 patients

Variable	Univariable analysis		Multivariable model	
	OR (95% CI)	P	OR (95% CI)	P
Sex				
Male	1.38 (0.74–2.55)	0.309		
Female	1			
BMI (kg/m^2)				
>30	2.29 (0.45–11.57)	0.277		
≤30	1			
Hypertension				
(+)	0.96 (0.53–1.76)	0.895		
(−)	1			
Diabetes mellitus				
(+)	2.15 (1.17–3.94)	0.012	2.31 (1.17–4.56)	0.016
(−)	1			
Initial symptom				
(+)	2.39 (0.90–6.33)	0.072		
(−)	1			
Transfer history				
Transfer	1.76 (0.93–3.32)	0.079		
Direct admission	1			
ICU entrance on admission				
Yes	4.22 (2.05–8.70)	<0.001	3.67 (1.58–8.52)	0.002
No	1			
Peripheral hematological markers on admission				
Hb (g/L)				
<100	4.38 (1.78–10.75)	0.002	6.69 (2.37–18.87)	<0.001
≥100	1			
WBCs (×10^9/L)				
<4.0, >10.0	2.20 (1.19–4.08)	0.011		
4.0–10.0	1			
ANC (×10^9/L)				
<1.8, >7.0	2.38 (1.29–4.40)	0.005		
1.8–7.0	1			
NLR				
≥5.5	2.44 (1.29–4.61)	0.005	2.37 (1.09–5.14)	0.029
<5.5	1			
Platelets (×10^9/L)				
<130	4.15 (2.11–8.16)	<0.001	5.86 (2.67–12.85)	<0.001
≥130	1			
Lung infiltration on admission				
Bilateral	3.76 (1.12–12.60)	0.022		
Unilateral	3.55 (0.83–15.19)	0.147		
None	1			
Disease severity score on admission				
5–7	5.00 (2.16–11.55)	<0.001		
3–4	2.82 (1.39–5.70)	0.003		
1–2	1			

The predictive performance of the multivariable logistic regression model was 84.2%.
Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; ICU, intensive care unit; WBCs, white blood cells; ANC, absolute neutrophil count; NLR, neutrophil-to-lymphocyte ratio.

transfused group than in the non-transfused group. The percentage of patients hospitalized in the ICU on admission was significantly higher in the transfused group ($P<0.001$). Among the peripheral hematological markers on admission, Hb concentration and platelet count were significantly lower in the transfused group than in the non-transfused group ($P=0.006$ and $P=0.001$, respectively). WBC count, absolute neutrophil count, and NLR were significantly higher in the transfused group ($P=0.012$, $P=0.007$, and $P=0.027$, respectively).

The distributions of the disease severity scores on admission, hospital day 7, and day 14 were significantly different between the two groups (all $P<0.001$). In the transfused group, the most common disease severity score on admission was 3–4, and the second most common was 1–2. However, the score progressed to 5–7 on hospital day 7. Of the 29 patients with a score of 5–7 on hospital day 7, three patients had progressed to a score of 8 (death) on hospital day 14. Only one patient improved to a score of 3–4 on hospital day 14. By hospital day 7, none of the patients in the transfused group was discharged, and only one patient in this group was discharged by hospital day 14. In the non-transfused group, the most common disease severity score on admission, hospital day 7, and hospital day 14 was 1–2. By hospital day 14, 95 (32.3%) of the 294 patients were discharged.

The transfused and non-transfused groups showed a remarkable difference in outcomes ($P<0.001$). Most patients (92.2%, 271/294) in the non-transfused group were discharged with complete recovery. In contrast, only 40.0% (20/50) of the patients in the transfused group were discharged. Moreover, the mortality rate was very high (54.0%, 27/50) compared with that (7.1%, 21/294) in the non-transfused group.

Predictors of RBC component transfusion in elderly COVID–19 patients

Table 3 shows the results of univariate and multiple logistic regression analyses to identify predictors of RBC transfusion. Among the variables showing significant association with RBC transfusion in the univariate analysis, DM, ICU entrance on admission, Hb concentration, platelet count, and NLR on admission were independently associated with RBC transfusion in the multiple logistic regression analysis.

DISCUSSION

This study presented blood component usage in COVID-19 patients in Korea and identified predictive factors of RBC transfusion in elderly COVID-19 patients. Transfusion in COVID-19 patients is generally related to anemia of critical illness, procedure-related bleeding, and spontaneous bleeding due to coagulopathy [21-23]. Reports during the early stage of the COVID-19 pandemic demonstrated that the transfusion demand was generally low in COVID-19 patients, except in those needing ECMO therapy [5, 9]. Patients requiring ECMO therapy are especially in need of transfusion support to maintain an adequate Hb concentration [23]. However, in this study, the number of patients transfused because of anemia was higher than that of patients transfused because of ECMO therapy among elderly COVID-19 patients. The mean number of RBC units transfused into one patient on ECMO support (12.2 units/patient) was three times higher than that in patients with anemia (4.0 units/patient) and bleeding (3.6 units/patient). RBCs have been reported as the main blood component transfused to COVID-19 patients [5, 7, 8, 13]. Platelets accounted for the highest number of units among all blood components transfused in this study. This finding is different from those of previous studies [7, 8, 13], which is attributable to all COVID-19 patients enrolled in this study receiving a transfusion of platelet concentrates (mean, 7.6 units at once).

Studies have described risk factors for severe and critical deterioration of COVID-19, and advanced age is a major risk factor [15-18]. According to the Korea Disease Control and Prevention Agency, the mortality rate in Korea is <0.5% in patients aged <60 years. However, the mortality rate increases to approximately 1.0% in patients aged 60–70 years and rises abruptly to approximately 14.5% in patients aged ≥80 years [24]. Regarding transfusion needs according to age, the transfusion rate was higher in elderly COVID-19 patients than in patients <65 years.

Besides advanced age, the following risk factors have been reported for severe and critical progression of COVID-19: male sex, obesity, and underlying comorbidities, such as HTN, DM, chronic pulmonary disease, cardiovascular disease, malignancy, chronic kidney disease, and immunodeficiency [16]. Clinical courses and outcomes of COVID-19 patients during the first wave of the epidemic in Korea have been reported [17, 20]. The following risk factors for clinical deterioration of COVID-19 were reported in these studies: obesity (BMI >30), quick sepsis-related organ failure assessment score ≥1, underlying DM, chronic kidney disease, dementia, and age >65 years.

According to the results of this study, which focused on elderly COVID-19 patients, there were no differences in the transfusion rate according to sex or BMI. Among the underlying comorbidities, DM was the second most common comorbidity in elderly COVID-19 patients. Additionally, the DM prevalence rate

was significantly higher in the transfused group. Furthermore, the adjusted OR for DM as a predictor of RBC transfusion was 2.307. DM has been previously associated with a severe clinical course and poor prognosis of COVID-19 patients [25, 26]. We found no difference in the mean Hb concentration on admission between patients with DM and those without (126±20 g/L in patients with DM; 129±17 g/L in patients without DM; $P=$ 0.198; data not shown). Therefore, it is presumed that DM is associated with complications in COVID-19 patients and the need for transfusion may increase in these patients. The Hb concentration and platelet count on admission were lower in the transfused group. These results correspond to those of a previous study that identified low baseline Hb concentration and platelet count as predictors of transfusion need [27].

The NLR is a good predictor of disease severity and mortality in COVID-19 patients. There is no authorized NLR cut-off value to predict severity and mortality. The NLR cut-off values presented in previous studies ranged from 3.0 to 13.4 [28, 29]. Patients with a high NLR on admission have shown higher mortality than those with a low NLR, independent of age [29]. This study showed a relatively high NLR on admission in elderly COVID-19 patients. The NLR on admission was higher in the transfused group than in the non-transfused group, reflecting the possibility of progression to higher disease severity. The NLR was also higher when patients received their first RBC transfusion than on admission, reflecting disease progression. When the median NLR value (5.5) on admission was adopted as the cut-off value for predicting RBC transfusion, the adjusted OR of the NLR on admission was 2.368. A high NLR (≥5.5) was determined to be a predictor of RBC transfusion.

Most elderly COVID-19 patients enrolled in this study showed bilateral lung infiltration, and there was no association with RBC transfusion. A previous study of Korean COVID-19 patients of all ages reported that 68.4% of the patients showed no abnormalities and 17.7% showed bilateral lung infiltration on chest radiographs [17]. The National Medical Center was equipped with mobile X-ray and CT systems that were installed outside the hospital building. Therefore, lung infiltration in COVID-19 patients could be evaluated using both radiological systems and separate from non-COVID-19 patients. CT studies have revealed bilateral involvement in 88.0%–98.0% of cases [30, 31]. Therefore, the high percentage of patients showing bilateral lung infiltration may have been mainly due to the adoption of the CT system, not patient age.

There were evident differences in disease severity distribution between the transfused and non-transfused groups. However, we did not find an association between the disease severity score on admission and RBC transfusion. The modified WHO clinical progression scale is based on the need for and degree of oxygen therapy; therefore, it is presumed that the severity score does not reflect the clinical and laboratory characteristics associated with transfusion.

This study had some limitations. First, this was a single-center retrospective study; therefore, the results may not be fully representative. However, numerous COVID-19 patients from all over the country are hospitalized at or transferred to the National Medical Center as the Ministry of Health and Welfare has designated the center as a dedicated infection disease hospital for severe COVID-19 patients. Second, the results of peripheral hematological markers and disease severity on admission of some enrolled patients do not represent those in their initial stage of COVID-19. Approximately 26% of the enrolled patients were transferred from other hospitals, while disease severity on hospital days 7 and 14 of these patients was evaluated on the day of admission to our hospital. However, there was no difference in the percentage of transferred patients between the transfused and non-transfused groups. Additionally, there was no difference in the mean hospitalization period at other hospitals before transfer (6.7 days in the transferred patients of the transfused group; 7.2 days in the transferred patients of the non-transfused group; $P=0.704$; data not shown). Further study is needed to ascertain the roles of the peripheral hematological markers in the initial stage of COVID-19 and disease severity on admission as predictors of RBC transfusion, with a focus on patients who were admitted to our hospital directly after the diagnosis of COVID-19.

Additionally, we demonstrated the response of the laboratory regarding transfusion support for COVID-19 patients through this report. The Blood Bank and Transfusion Medicine Unit has released blood components to patients suspected of having or confirmed to have emerging infectious diseases under emergency release criteria, using universal donor blood components, without performing pre-transfusion tests for the safety of the laboratory staff. However, numerous blood components units need to be transfused to COVID-19 patients on ECMO support, indicating that the transfusion of universal donor blood components is unsuitable. Therefore, a distinct transfusion policy has been established for COVID-19 patients. For most COVID-19 patients, there was no information regarding their ABO/RhD type in their electronic medical records. In these cases, two determinations of the patient's ABO/RhD type were needed. However, there was insufficient time to perform ABO/RhD typing twice in cases of emergency transfusion because of ECMO and bleeding compli-

cations. Therefore, the ABO/RhD typing and unexpected antibody screening tests were included in the admission laboratory tests for all COVID-19 patients. When patients need transfusion, the Blood Bank and Transfusion Medicine Unit can determine the ABO/RhD type through ABO/RhD typing using the specimen for cross-matching.

In conclusion, this is the first study to present blood component usage and transfusion rates according to age groups of COVID-19 patients in Korea. Further, this study demonstrated low Hb concentration, low platelet count, and high NLR on admission to be predictors of RBC transfusion in elderly COVID-19 patients, and DM a comorbidity. These results can provide a basis for developing a strategy for the medical treatment of emerging infectious diseases during pandemics.

AUTHOR CONTRIBUTION

Lee HR designed the study, analyzed the data, and wrote the manuscript.

CONFLICT OF INTEREST

The author declares no potential conflicts of interest.

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SUPPLEMENTARY MATERIAL

Supplemental Data Table S1. Demographic and clinical characteristics, disease severity, and outcomes of the 344 elderly COVID-19 patients.
Supplemental Data Table S2. Detailed description of the patients who received transfusion and their transfusion history.
Supplementary materials are available from: https://doi.org/10.3343/alm.2022.42.6.666.

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