



Blood component utilization in COVID-19 patients in New York City: Transfusions do not follow the curve

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Abstract

Background: Blood suppliers and transfusion services have worked diligently to maintain an adequate blood supply during the COVID-19 pandemic. Our experience has shown that some COVID-19 inpatients require transfusion support; understanding this need is critical to blood product inventory management.

Study Design and Methods: Hospital-wide and COVID-19 specific inpatient blood product utilization data were collected retrospectively for our network's two tertiary academic medical centers over a 9-week period (March 1, 2020-May 2, 2020), when most inpatients had COVID-19. Utilization data were merged with a COVID-19 patient database to investigate clinical demographic characteristics of transfused COVID-19 inpatients relative to non-transfused ones.

Results: Overall, 11 041 COVID-19 patients were admitted and 364 received blood product transfusions for an overall transfusion rate of 3.3%. COVID-19 patients received 1746 blood components in total, the majority of which were red blood cells. COVID-19 patients' weekly transfusion rate increased as the pandemic progressed, possibly reflecting their increased severity of illness. Transfusion was significantly associated with several indicators of severe disease, including mortality, intubation, thrombosis, longer hospital admission, lower hemoglobin and platelet nadirs, and longer prothrombin and activated partial thromboplastin times. As the pandemic progressed, institutional adherence to transfusion guidelines improved for RBC transfusions compared to prior year trends but did not improve for platelets or plasma.

Conclusion: There is a need to closely monitor the blood product inventory and demand throughout the COVID-19 pandemic as patients' transfusion needs may increase over time. Daily or weekly trending of patients' clinical status and laboratory values may assist blood banks in inventory management.

1 | INTRODUCTION

SARS-CoV-2, the causative agent of Coronavirus Disease 2019 (COVID-19), has led to a catastrophic pandemic with 44 614 050 confirmed global cases and 1 175 895 deaths as of October 29, 2020.¹ In the United States (US) alone, there have been 8 861 207 confirmed cases and 227 706 deaths. In late March 2020, New York State quickly became the epicenter of COVID-19 in the United States, now with over 500 677 confirmed cases and 33 435 deaths, the majority of which have occurred in New York City (NYC).²

Transfusion services always run a delicate inventory balance between supply and demand. From the beginning of the pandemic, it was clear that COVID-19 would ultimately decrease blood product donations and subsequently the blood supply due to social distancing requirements and stay-at-home orders.³⁻⁵ Cancellation of elective surgical and non-urgent medical procedures can help preserve necessary inventory levels,⁶ but some critically ill COVID-19 patients may require transfusion support.^{7,8} Published evidence indicates that blood product utilization may be overall low in COVID-19 patients,^{9,10}

but clinical and demographic factors associated with transfusion in these patients are not well described.

With cancellation of elective surgery and conversion of our hospital network in NYC to almost exclusively COVID-19 care units, understanding the utilization of blood products in COVID-19 patients became critical to adjusting our blood orders, auditing transfusion requests, and maintaining an adequate inventory. Herein, we present data on blood product utilization during the beginning, peak, and decline of COVID-19 related hospitalizations from our two academic medical centers (combined 1600 beds) within our hospital enterprise. We also present demographic factors of transfused COVID-19 patients. This analysis will aid transfusion services in understanding the expected trajectory and needs of these patients and improve communication with blood suppliers during surges in the pandemic.

2 | MATERIALS AND METHODS

Hospital-wide and COVID-19 specific inpatient blood product utilization data were collected retrospectively for our network's two tertiary academic medical centers over a

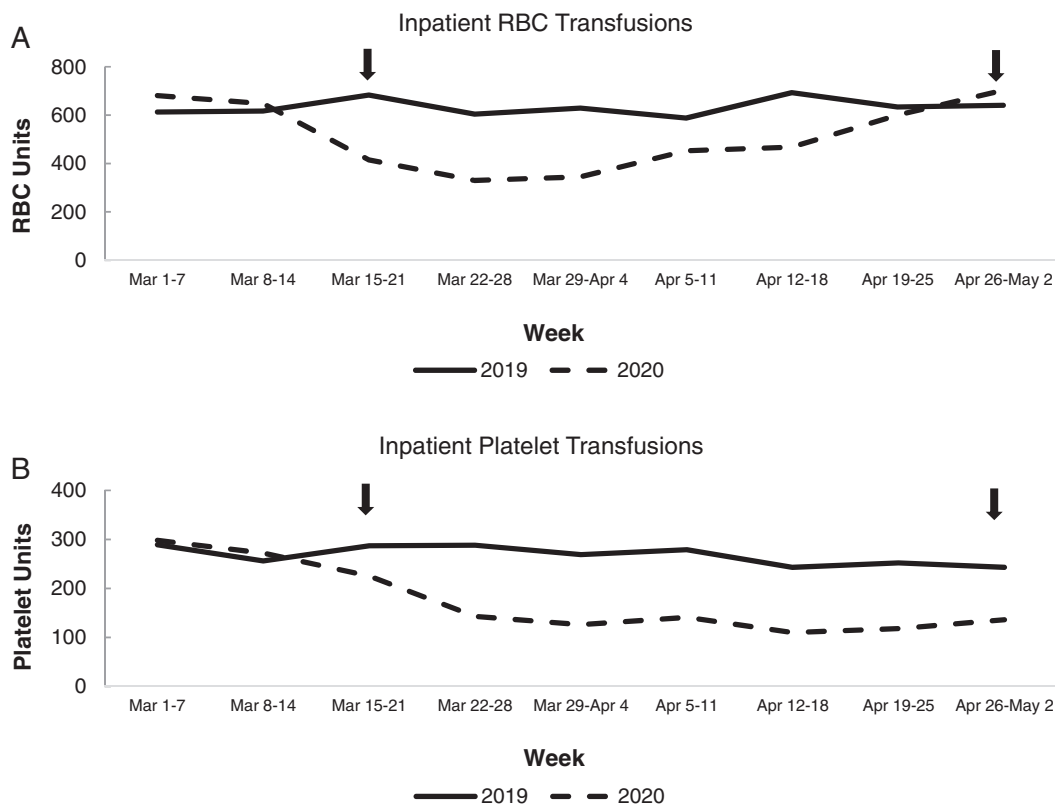


FIGURE 1 Inpatient, non-operating room red blood cell (RBC) (A) and platelet (B) transfusions in 2020 compared to 2019. Arrows designate when hospital-wide announcements were made regarding critical blood product shortages. Both RBC and platelet transfusions began decreasing during the third week of the pandemic. Overall, there was an 18.6% reduction in RBC transfusions and a 34.8% reduction in platelet transfusions in 2020 compared to 2019. As the pandemic hospitalizations decreased, red blood cell transfusions in 2020 approached those seen the year prior, whereas platelet transfusions remained less throughout the period

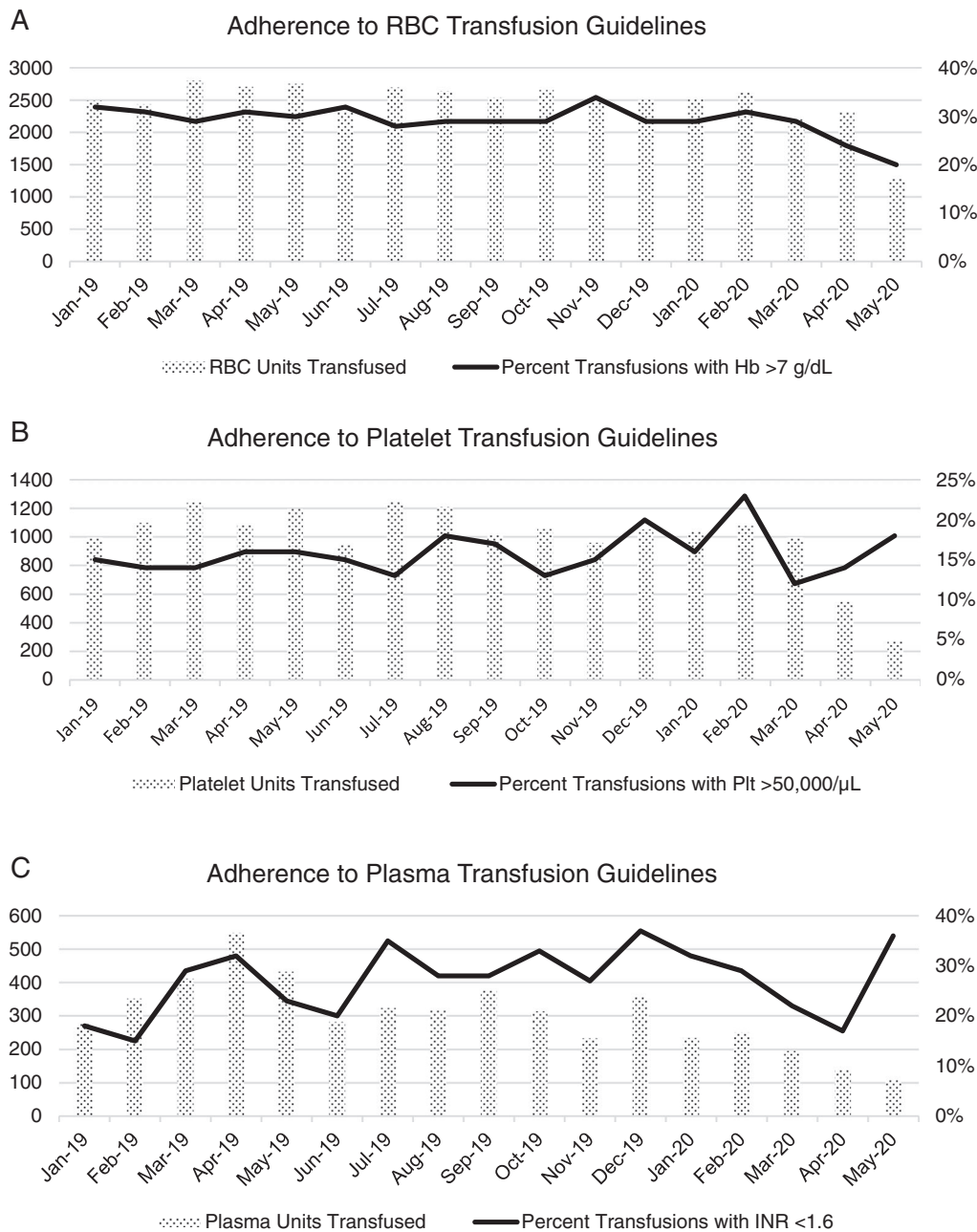


FIGURE 2 Adherence to transfusion guidelines. For inpatient, non-operating room transfusions, adherence to transfusion guidelines improved during the pandemic for red blood cells (RBCs) (A) but did not particularly improve for platelet (B) or plasma (C) transfusions compared to prior year trends. (Hb, hemoglobin; Plt, platelet count; INR, international normalized ratio). For plasma transfusions (C), COVID-19 convalescent plasma transfusions were excluded

9-week period (March 1, 2020-May 2, 2020), during which the majority (>95%) of inpatients had COVID-19. Data were collected via existing institutional patient blood management program dashboards which are interfaced with our electronic medical records (Allscripts SCM, Chicago, Illinois and Epic, Verona, Wisconsin) and laboratory information system (SafeTrace Tx, Haemonetics, Braintree, Massachusetts). Blood product utilization data were merged with a COVID-19 patient database to investigate

clinical demographic characteristics of transfused COVID-19 inpatients relative to non-transfused COVID-19 inpatients. All COVID-19 diagnoses were confirmed via SARS-CoV-2 PCR testing during admission. Operating room transfusions were excluded because of the very low number of procedures during this time. Pearson's Chi-squared tests and a linear model analysis of variance (Stata 15.1, College Station, Texas), with $P < .05$ designating statistical significance, were used with adjustments for multiple

FIGURE 3 COVID-19 inpatient transfusion rate from March 16, 2020 until May 3, 2020. Weekly transfusion rate calculated as (unique patients receiving blood product transfusion)/(unique COVID-19 inpatients) × 100%. Arrows designate when hospital-wide announcements were made regarding critical blood product shortages. Despite a decreasing overall number of COVID-19 inpatients during the last 2 weeks, the transfusion rate increased compared to earlier in the pandemic. The transfusion rate in COVID-19 inpatients was also high during the first week of admissions

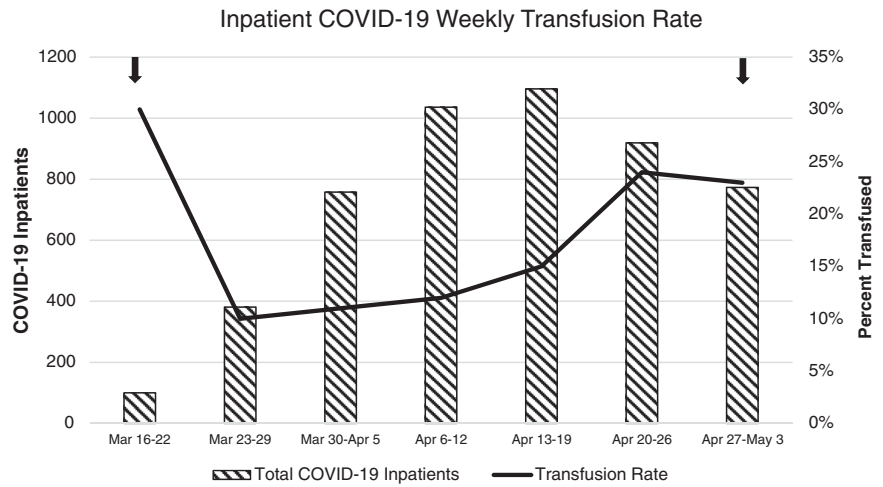


TABLE 1 Clinical/demographic characteristics of transfused COVID-19 inpatients relative to those not requiring transfusion support

	Transfused (n = 364)	Not transfused (n = 10 677)	P-value
Sex			0.12
Female	148 (40.7%)	4952 (46.4%)	
Male	216 (59.3%)	5692 (53.3%)	
Unknown	0 (0%)	32 (.3%)	
Age in years (mean, [SD])	60.1 (17.9)	59.9 (19.4)	0.91
Hospital admission duration in days (mean, [SD])	20.2 (9.8)	3.4 (6.7)	<.001
Deceased			<.001
No	147 (69.3%)	3537 (84.1%)	
Yes	65 (30.7%)	671 (15.9%)	
Intubated			<.001
No	54 (24.5%)	3594 (84.9%)	
Yes	166 (75.5%)	639 (15.1%)	
Thrombosis			<.001
No	62 (82.7%)	917 (97.9%)	
Yes	13 (17.3%)	20 (2.1%)	
Hemoglobin (g/dL) nadir (mean, [SD])	6.6 (.7)	11.4 (2.6)	<.001
Platelet (×10 ⁹ /L) nadir (mean, [SD])	111 (94.4)	172 (69.3)	<.001
Prothrombin time (seconds) maximum (mean, [SD])	23.3 (12)	16.1 (6)	<.001
Activated partial thromboplastin time (seconds) maximum (mean, [SD])	99.8 (52.7)	46.0 (31.1)	<.001
Fibrinogen (mg/dL) nadir (mean, [SD])	434.1 (281.8)	526.6 (180.2)	.16

comparisons. Institutional review board approval was obtained at both centers.

3 | RESULTS

Compared to the same period (March 1-May 2) in 2019, there was a 18.6% and 34.8% reduction in red blood cell

(RBC) and platelet inpatient non-operating room transfusions, respectively, with large reductions in blood component use by week 3 of the pandemic (Figure 1). Platelet use remained low throughout the pandemic (Figure 1B), but RBC transfusions started to increase back to 2019 levels as the pandemic decreased starting in week 9 (Figure 1A). As the pandemic progressed, institutional adherence to transfusion guidelines improved for RBC

transfusions compared to prior year trends (Figure 2A) but did not improve for platelet (Figure 2B) or plasma (Figure 2C) transfusions.

Overall, 11 041 COVID-19 patients were admitted to our hospital during this period and 364 received blood product transfusions for an overall transfusion rate of 3.3%. In comparison, our overall hospital patient transfusion rate in 2019 was much greater at 12.5% (9579 unique patients transfused out of 76 395 unique patients admitted). The 364 COVID-19 patients received 1746 blood components in total (mean 4.8 units/patient), the majority of which were RBC units ($n = 1452$, 83% of all components). Other transfused components included platelets ($n = 153$, 9%), plasma ($n = 89$, 5%), and pooled doses of cryoprecipitate (1 pooled dose = 5 units) ($n = 52$, 3%). Of note, 9 of the 89 plasma transfusions were COVID-19 convalescent plasma administered through a randomized controlled trial.

The weekly transfusion rate amongst COVID-19 patients started relatively high at 30%, reflecting that the first wave of patients admitted were quite ill (Figure 3). In subsequent weeks at the height of the pandemic, the weekly transfusion rate ranged from 11% to 15%. Interestingly, as the pandemic began to resolve, the transfusion rate increased to 23% to 24% despite decreasing numbers of COVID-19 inpatients, possibly reflecting that those remaining hospitalized became more ill as their disease progressed (Figure 3). Longer hospital admission duration (mean 20.2 vs 3.4 days, $P < .001$), intubation during admission (75.5% vs 15.1%, $P < .001$), thrombosis during admission (17.3% vs 2.1%, $P < .001$), and death during admission (30.7% vs 15.9%, $P < .001$) were significantly associated with need for transfusion support in COVID-19 patients (Table 1). Patient laboratory values significantly associated with need for transfusions included lower hemoglobin nadir (mean 6.6 vs 11.4 g/dL), lower platelet nadir (111 vs $172 \times 10^9/L$), and higher maximum prothrombin time (PT) (23.3 vs 16.1 seconds) and maximum activated partial thromboplastin time (aPTT) (99.8 vs 46.0 seconds) during admission. Patient sex, age, and fibrinogen nadir during admission were not significantly associated with transfusion.

4 | DISCUSSION

Blood product utilization was low in mild-to-moderately ill hospitalized COVID-19 patients and greater in those with severe illness. Clinical factors including longer hospital admission duration, experiencing a thrombotic event, and intubation were associated with need for blood product transfusions. Laboratory values seen in COVID-19 patients with more severe illness, including

lower hemoglobin and platelet nadirs and coagulopathy in the form of increased PT and aPTT were also associated with transfusion. It is reassuring that institutional transfusion guidelines were generally adhered to in this cohort. Our transfused patients showed significantly lower hemoglobin (6.6 g/dL) and platelet ($111 \times 10^9/L$) nadirs than those described in a cohort of patients with COVID-19 (median 13.3 g/dL and $185 \times 10^9/L$, respectively).⁸ In addition, our transfusion rate amongst COVID-19 inpatients increased over time despite decreasing numbers of admitted patients with COVID-19, supporting that those with longer hospital admissions required ongoing transfusion support. The first week of admitted patients also showed higher transfusion rates, consistent with previous publications from our centers describing that patients presenting earlier in the pandemic had greater morbidity and mortality.^{11,12}

Similar to recently published work from other centers involving smaller numbers of patients,^{3,9,10} our large retrospective study demonstrates low overall blood product utilization in COVID-19 patients. Only 3.3% of COVID-19 inpatients admitted to our hospitals required blood component support during their admissions, and the transfusion rate of COVID-19 inpatients was much less than our overall hospital transfusion rate in 2019 (12.5%). The overall decrease in blood utilization during the pandemic observed in our hospital network and others is likely multi-factorial, including low utilization amongst COVID-19 patients who comprised the majority of our hospital's census, cancellation of elective surgeries and procedures, and hospital-wide announcements promoting blood conservation strategies. Despite decreased overall blood utilization at our center, our hospital network experienced two critical inventory shortages during the 9-week period reviewed in this study at which times the hospital-wide announcements were sent. Shortages occurred during week 3 when social distancing led to the cancellation of blood drives and week 9 when both our hospital network and other regional hospitals began to resume elective surgeries and procedures. Our announcements concerning the shortages likely influenced provider practice in ordering transfusions, but our blood banks were still able to fill all blood product orders throughout this period.

A study limitation is that our clinical COVID-19 database did not contain information on use of extracorporeal membrane oxygenation (ECMO). Our centers offer both adult and pediatric ECMO services, and ECMO use has been previously associated with blood product transfusions at other centers offering it, in particular RBCs and cryoprecipitate.^{10,13} In one of these studies, 3 out of 128 (2.4%) COVID-19 inpatients required ECMO and all received transfusions.

Communication and flexibility with our blood suppliers was critical to avoiding additional inventory shortages; during the peak of the pandemic, we communicated with our blood suppliers daily to inform them of our inventory needs and for them to update us on their available supply. In addition, a New York City weekly discussion of the blood supply between hospitals and blood suppliers was convened by the New York City Office of Emergency Management. We also encouraged eligible hospital staff to donate at our blood suppliers' fixed collection centers and suspended our orders for pathogen-reduced platelets which allowed for increased availability of apheresis platelets for the entire region.

Although the AABB Interorganizational Task Force on Domestic Disasters and Acts of Terrorism is available to assist and coordinate the response of blood banks during crises, it is important for each facility to develop an internal plan with conservative transfusion guidelines for times when supply is unavailable or critically short. As described previously,¹⁴ to facilitate the identification of a shortage and quickly implement a mitigation strategy we developed a rubric that describes four levels of inventory status and an associated pre-determined response. Our rubric was developed in collaboration with all network hospitals' blood bank leadership, who met on a weekly basis throughout the pandemic to discuss the status of our blood component inventory and staffing levels. Even when our blood banks were at standard supply levels, pathology residents rotating in transfusion medicine increased their prospective audits of any orders exceeding institutional transfusion guidelines as well as second dose of any blood product in a 24-hour period. In addition, we reduced our maximum surgical blood ordering schedule by 40% for liver transplants (from 10 RBC and 10 plasma units to 6 RBC and 6 plasma units), a high blood use surgery which continued during the pandemic. In conjunction with hospital-wide communications promoting blood conservation, these efforts were associated with improved adherence to transfusion guidelines for RBCs compared to prior year data, but not for plasma or platelet transfusions. More of our Patient Blood Management program guidelines focus on RBCs compared to other products and RBCs may be disproportionately affected by surgery volumes compared to other blood products. Future work for pandemic planning in Patient Blood Management can address how to optimize communication and audit strategies to improve conservation of all blood components.^{5,15,16}

In summary, our study identified several factors associated with transfusion in critically ill COVID-19 patients. Our experience highlights the need to remain vigilant of blood product inventory supply and demand throughout the pandemic as patients' transfusion needs may increase or decrease over time. Daily or weekly

trending of patients' clinical status and laboratory values may assist blood banks in inventory management.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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