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Preoperative platelet transfusions and perioperative red blood cell requirements in patients with thrombocytopenia undergoing noncardiac surgery

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Abstract

BACKGROUND—Perioperative hemorrhage impacts patient outcomes and health care resource utilization, yet the risks of transfusion therapies are significant. In patients with preoperative thrombocytopenia, the effects of prophylactic preoperative platelet (PLT) transfusion on perioperative bleeding complications remain uncertain.

STUDY DESIGN AND METHODS—This is a retrospective cohort study of noncardiac surgical patients between January 1, 2008, and December 31, 2011. Propensity-adjusted analyses were used to evaluate associations between preoperative thrombocytopenia, preoperative PLT transfusion, and the outcomes of interest, with a primary outcome of perioperative red blood cell (RBC) transfusion.

RESULTS—A total of 13,978 study participants were included; 860 (6.2%) had a PLT count of not more than $100 \times 10^9/L$ with 71 (8.3%) receiving PLTs preoperatively. Administration of PLTs was associated with higher rates of perioperative RBC transfusion (66.2% vs. 49.1%, $p = 0.0065$); however, in propensity-adjusted analysis there was no significant difference between groups (odds ratio [OR] [95% confidence interval {95% CI}], 1.68 [0.95–2.99]; $p = 0.0764$). Patients receiving PLTs had higher rates of intensive care unit (ICU) admission (OR [95% CI], 1.95 [1.10–3.46]; $p = 0.0224$) and longer hospital lengths of stay (estimate [95% bootstrap CI], 7.2 [0.8–13.9] days; $p = 0.0006$) in propensity-adjusted analyses.

CONCLUSION—Preoperative PLT transfusion did not attenuate RBC requirements in patients with thrombocytopenia undergoing noncardiac surgery. Moreover, preoperative PLT transfusion

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CONFLICT OF INTEREST

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was associated with increased ICU admission rates and hospital duration. These findings suggest that more conservative management of preoperative thrombocytopenia may be warranted.

Perioperative hemorrhage necessitating red blood cell (RBC) transfusion is an undesirable surgical complication, as RBC transfusion has consistently been associated with adverse patient outcomes.¹⁻⁷ In addition, the economic toll of transfusion is increasingly well recognized, with nearly 3 million units of RBCs transfused perioperatively each year in the United States, representing more than \$2.25 billion.^{8,9} Furthermore, hospital blood supplies are limited with more than one-quarter of US hospitals reporting surgical delays due to insufficient blood supplies and 10% of hospitals reporting at least 1 day per year where surgical blood needs cannot be met.⁸ It is therefore imperative in this era of increased scrutiny on health care quality that transfusion practices be uniquely tailored to clinical scenarios in which transfusion may provide evidence-based improvement in patient outcome.

Preoperative platelet (PLT) counts and coagulation tests have long been used as a marker of perioperative bleeding risk; however, the value of this practice remains unclear.¹⁰ Prior studies have shown that routine preoperative coagulation tests, including PLT counts, do not reliably predict surgical bleeding complications,¹¹⁻¹⁵ prompting the 2012 American Society of Anesthesiologists Task Force on Preanesthesia Evaluation to recommend against this practice unless clearly indicated by patient history and physical examination.¹⁶ However, recent evidence suggests that pre-operative thrombocytopenia is associated with significantly higher risk of blood transfusion and death in noncardiac surgery, prompting the authors to question recommendations against routine preoperative screening.¹⁷

In clinical practice, administration of PLTs in those with thrombocytopenia is frequently performed in the preoperative period in an attempt to mitigate perioperative bleeding complications including RBC requirements, surgical blood loss, and reoperation for bleeding. However, evidence to support or guide such perioperative transfusion practices is lacking.¹⁸ As such, the decision to transfuse in the perioperative period is often based on the gestalt or clinical experience of the surgeon or anesthesiologist rather than by quality evidence suggesting benefit. Moreover, PLT transfusions are associated with substantial patient risk, including a myriad of allergic, infectious, and inflammatory transfusion reactions.^{19,20}

This investigation was designed to determine the relationship between preoperative PLT transfusion and perioperative bleeding complications in patients with thrombocytopenia undergoing noncardiac surgery in a large, tertiary care center. We hypothesized that while preoperative thrombocytopenia (i.e., PLT count $< 100 \times 10^9/L$) would be predictive of perioperative RBC requirements, prophylactic PLT administration would not attenuate this risk. In addition, we aimed to assess the impact of preoperative PLT transfusion on other patient-important outcomes.

MATERIALS AND METHODS

This is a retrospective cohort study conducted under the approval of the Mayo Clinic (Rochester, MN) Institutional Review Board. The Strengthening the Reporting of

Observational Studies in Epidemiology (STROBE) guidelines were used in the design and conduct of this study, as well as in the reporting of results.²¹

Study population

Inclusion criteria for this investigation included adult patients at least 18 years of age, undergoing noncardiac surgery between January 1, 2008, and December 31, 2011, at a single tertiary care center, and the presence of an international normalized ratio (INR) and PLT count available in the medical record in the 30-day interval preceding surgery. Exclusion criteria included lack of valid research authorization, American Society of Anesthesiologists Physical Status (ASA PS) VI classification, and prior inclusion in the study.

Outcome variables

The primary outcome of interest was the need for RBC transfusion in the early perioperative period. To qualify, the RBC transfusion initiation time was required to occur during the operative encounter or within 24 hours after discharge from the operating room environment. RBC transfusions initiated before entering the operating room were not included in the outcome evaluation. Secondary outcome measures included intraoperative RBC transfusion, defined as RBC transfusion initiated in the operating room environment, estimated blood loss as recorded in the anesthetic record, and return to the operating room within 24 hours for a primary indication of bleeding. Additional patient-important outcomes such as intensive care unit (ICU) length of stay, need for ventilatory support, duration of hospital stay, and hospital mortality were also evaluated.

Predictor variables

The primary predictor variables for this investigation were preoperative thrombocytopenia (defined as a PLT count $< 100 \times 10^9/L$) and the presence of a preoperative PLT transfusion in those with thrombocytopenia. For patients with multiple preoperative PLT count values, the value closest to the time of surgery was utilized. The presence and timing of all perioperative transfusion episodes were extracted from the electronic health record. Qualifying preoperative PLT transfusions were defined as those administered after the qualifying PLT count and within 24 hours of the surgical procedure. As our aim was to specifically investigate the impact of preoperative PLT administration, intraoperative and postoperative PLT transfusions were not considered in the analyses. This design (exclusion of intraoperative and postoperative PLT transfusion episodes) was also endorsed to avoid the potential for cause-effect inversion with the outcomes of interest. To further ensure against cause-effect inversion, the timing of PLT transfusion was defined as the actual transfusion initiation time as documented in the electronic health record rather than the time of PLT issue from the blood bank. Patient demographics, baseline clinical characteristics, and procedural and anesthesia-related details were also extracted from the electronic medical record.

Data sources

Screening for potential study participants was performed using the Perioperative Datamart. This is an institutional resource that captures and records pertinent data for all patients who are admitted to an acute care environment (operating room, ICU, progressive care unit) at the study's participating institution.²² In addition to containing detailed information regarding the surgical encounter, this robust data warehouse also contains information on baseline demographics and clinical characteristics, fluid and transfusion therapies, as well as a vast amount of related information that is pertinent to the perioperative course (e.g., perioperative medications and laboratory values, postoperative outcomes, and lengths of stay). Additional baseline characteristics pertinent to this investigation but not available in the Perioperative Datamart were obtained from a second validated database, the Mayo Clinic Life Sciences System (MCLSS).²³ These databases have previously undergone extensive validation and accuracy has been shown to be superior to manual data collection alone.²⁴

Statistical analysis

The sample size was estimated by assuming a perioperative RBC transfusion rate of 30% (historical data from the participating institution) and an estimated prophylactic PLT transfusion rate of 25% in those with a PLT count of less than $100 \times 10^9/L$, which would require a sample size of approximately 600 study subjects with preoperative thrombocytopenia to identify an odds ratio (OR) of 0.5 in those who receive prophylactic PLT transfusion compared to those who do not (two-sided alpha of 0.05, $\beta=0.20$). In an effort to adequately power the investigation for a priori subgroup and sensitivity analyses (e.g., PLT thresholds of 75×10^9 and $50 \times 10^9/L$), a 4-year time period was chosen that would obtain an estimated sample size of 1200 patients.

Baseline demographics, clinical characteristics, and procedure-related information were summarized and presented as median (25%–75% interquartile range [IQR]) for continuous data elements and frequencies (%) for categorical data, respectively. Univariate hypothesis testing for continuous variables was performed using the Wilcoxon rank-sum test. Univariate hypothesis testing for categorical variables was performed with Pearson's chi-squared tests or Fisher exact tests as appropriate.

To explore the relationship between preoperative PLT count and the outcomes of interest, a PLT count of not more than $100 \times 10^9/L$ was used as a threshold for the diagnosis of thrombocytopenia. This threshold was employed for two reasons: 1) ASA practice guidelines indicate that a PLT count of more than $100 \times 10^9/L$ rarely requires transfusion, while significant clinical equipoise exists for management of the surgical patient with a PLT count of not more than $100 \times 10^9/L$,²⁵ and 2) our experience suggests that the decision to transfuse PLTs is frequently based on threshold values, with $100 \times 10^9/L$ being commonly used in local practice. Recognizing that transfusion strategies may vary significantly by local practice,²⁶ sensitivity analyses using PLT counts of 75×10^9 and $50 \times 10^9/L$ were planned a priori. Univariate and multivariable logistic regression analyses were performed to assess the relationship between preoperative thrombocytopenia and perioperative RBC transfusion and reoperation for bleeding.

With regard to the primary aim of this investigation, relationships between preoperative PLT transfusion and perioperative bleeding complications were explored with univariate and multivariable analyses. Recognizing that observational studies risk unequal distributions of key confounding variables due to lack of subject randomization, propensity-adjusted analyses were planned a priori. Briefly, logistic regression was used to calculate propensity scores for preoperative PLT transfusion utilizing all hypothesized confounding variables. Visual inspection of the distribution of propensity scores according to preoperative PLT transfusion revealed adequate overlap between groups throughout the range of observed values. Patients were stratified into quintiles of the propensity distribution.²⁷ Cochran-Mantel-Haenszel statistics and linear models were used to verify that potential confounding variables did not differ between those receiving preoperative PLT transfusions versus those that did not after adjusting for propensity strata. Conditional logistic regression was then used to assess the relationship of early perioperative RBC transfusion with preoperative PLT transfusion. Similar analyses were performed for secondary outcomes using conditional logistic regression for binary outcomes and mixed linear models for hospital length of stay. ICU length of stay and duration of mechanical ventilation were analyzed for patients who required these interventions with the rank-sum test used to compare those who did and did not receive preoperative PLT transfusion.

To further assess the robustness of the study findings, multiple additional sensitivity analyses were planned a priori. These prespecified analyses included: 1) restriction to study participants undergoing elective surgery; 2) restriction to study participants undergoing general surgery; and 3) restriction to patients with a PLT count of 75×10^9 and $50 \times 10^9/L$, respectively. All statistical analyses were performed with computer software (SAS, Version 9.3, SAS Institute, Cary, NC).

RESULTS

A total of 13,978 patients met inclusion criteria and were included in this investigation (Fig. 1). Of these, 860 (6.2%) had a PLT count of not more than $100 \times 10^9/L$ before their surgical procedure. Among these, 71 (8.3%) received a qualifying preoperative PLT transfusion administered before entry into the operating suite. Of note, no patient with preoperative thrombocytopenia received a PLT transfusion after entry into the operating suite and before surgical incision. The median (IQR) time between PLT count measurement and surgical onset was 24.4 (7.7–141.9) hours. In those who received a preoperative PLT transfusion as defined by the study protocol, the median (IQR) time from initiation of the last qualifying PLT component to the onset of the surgical procedure was 1.0 (0.5–2.7) hours. The longest recorded interval between initiation of the last qualifying PLT component and the onset of the surgical procedure was 9.1 hours.

Comparison of baseline clinical, demographic, and procedural characteristics for those who received preoperative PLTs and those who did not are shown in Table 1. Several important between-group differences were identified. Briefly, patients receiving preoperative PLT transfusion had higher ASA PS and lower preoperative hemoglobin (Hb) and PLT values. They were also more likely to undergo emergency surgery and had shorter surgical durations. Those receiving preoperative PLTs had a higher incidence of hematologic

malignancies and chronic pulmonary disease but a lower incidence of liver disease and nonhematologic malignancies. After propensity adjustment, there were no significant differences between groups.

A total of 2847 of the study subjects (20.4%) received a perioperative RBC transfusion as defined by the study protocol. Those with PLT counts of not more than $100 \times 10^9/L$ had significantly higher rates of perioperative RBC transfusion (50.2% vs. 18.4%; $p < 0.0001$) and reoperation for bleeding (8.1% vs. 2.1%; $p < 0.0001$) than those with PLT counts of more than $100 \times 10^9/L$. These relationships remained significant in multivariable analyses (Table 2). Preoperative thrombocytopenia was also associated with increased all-cause mortality after adjustment for between-group differences (OR [95% CI], 1.87 [1.29–2.70]; $p = 0.0009$).

Results of unadjusted analyses evaluating the associations between preoperative PLT transfusion and perioperative bleeding complications and other patient-important outcomes in patients with thrombocytopenia are shown in Table 3. The frequency of RBC transfusion among those who received a preoperative PLT transfusion versus those who did not was 66.2% versus 48.8% (OR [95% CI], 2.03 [1.22–3.39]; $p = 0.0065$). In addition, preoperative PLT transfusion was associated with increased ICU admission rates, hospital length of stay, and hospital mortality. Estimates of intraoperative blood loss were available for only 52.2% of patients and were therefore excluded from related analyses given the unanticipated magnitude of missing data.

In total, 853 of 860 study subjects were assigned a propensity score for preoperative PLT transfusion and were subsequently stratified into quintiles based upon their propensity score. Subsequent analyses were restricted to subjects whose propensity score resided within the range of propensity scores that overlapped between those that were transfused preoperatively and those that were not. In total, 71 patients receiving a preoperative PLT transfusion were propensity stratified as were 482 study subjects who did not receive a qualifying preoperative PLT transfusion. Propensity adjustment was effective in addressing baseline covariate imbalances (Table 1, Fig. 2).

Among this propensity-stratified cohort, 47 (66.2%) of the PLT transfusion study subjects received a perioperative RBC transfusion compared with 231 (47.9%) of those who did not receive a PLT transfusion preoperatively. Conditional logistic regression on the propensity-adjusted cohort did not identify a statistically significant difference in perioperative RBC transfusions (OR [95% CI], 1.68 [0.95–2.99]; $p = 0.0764$). Those who received a preoperative PLT transfusion had a higher rate of ICU admission and longer hospital lengths of stay (Table 4). As a sensitivity analysis, the relationship between prophylactic PLT transfusion and the volume of RBC transfusion was also evaluated finding no significant difference between propensity-adjusted groups (Table S1, available as supporting information in the online version of this paper). Preoperative PLT transfusions in patients undergoing non-emergency surgery and utilizing lower PLT transfusion thresholds (i.e., $75 \times 10^9/L$ and $50 \times 10^9/L$) were associated with increased rates of perioperative RBC transfusion (Table S2, available as supporting information in the online version of this paper).

DISCUSSION

In this investigation, we aimed to evaluate the relationship between prophylactic PLT transfusion and perioperative RBC requirements in those with a preoperative PLT count of not more than $100 \times 10^9/L$. While preoperative thrombocytopenia was associated with increased perioperative bleeding complications, preoperative PLT transfusion did not mitigate these risks. In propensity adjusted analyses, there was no evidence for improved patient outcomes with preoperative PLT transfusion.

Thrombocytopenia is relatively common in the pre-operative period, occurring in 6% of patients in the present investigation. Similar to recently published data from Glance and colleagues,¹⁷ preoperative thrombocytopenia was associated with adverse patient outcomes including increased perioperative RBC requirements, higher rates of reoperation for bleeding, and greater hospital mortality. While the precise mechanism associating thrombocytopenia with poor patient outcomes remains unclear and causality cannot be established based on these data alone, there are several plausible explanations for poor outcomes in the setting of preoperative thrombocytopenia including a potential increase in perioperative blood loss in those with low starting PLT counts, a higher rate of transfusion-associated complications, and more severe systemic disease (diagnosed or occult) in patients with thrombocytopenia with PLT count serving as a surrogate marker for disease or as an inherent disease manifestation.

It would then seem logical that correction of thrombocytopenia preoperatively would prevent perioperative bleeding complications. However, results from the present investigation suggest that preoperative PLT transfusions do not have their intended effect, as perioperative RBC requirements were not significantly different between those who received preoperative PLTs and those who did not. When utilizing lower PLT transfusion thresholds of 75×10^9 and $50 \times 10^9/L$, preoperative administration of PLTs was associated with increased rates of perioperative RBC transfusion.

There are several theoretical mechanisms to explain the lack of observed benefit after treatment of preoperative thrombocytopenia. The first explanation assumes that the relationship between preoperative PLT transfusion and perioperative bleeding complications is a reflection of inherent heterogeneity of provider-specific transfusion practices. In other words, it may be that providers inclined to transfuse PLTs preoperatively will also be more likely to transfuse RBCs in the perioperative period. It is also possible that the aforementioned results are confounded by residual indication bias regarding the decision to administer preoperative PLTs or perioperative RBCs. It should be noted that the precise etiology of thrombocytopenia was not delineated in this investigation, and patient responses to PLT transfusion may depend on the underlying reason for thrombocytopenia.²⁸ PLT administration is also associated with a variety of transfusion-related reactions, including febrile nonhemolytic, hemolytic, allergic, anaphylactic, transient immune-mediated thrombocytopenia (also referred to as passive alloantibody thrombocytopenia), transfusion-related acute lung injury (TRALI), and septic complications.²⁹ It is possible that management of these transfusion-associated reactions could contribute to increased perioperative RBC requirements, although this is unlikely given the low incidence of these

reactions. Finally, given the lack of association between preoperative PLT transfusions and the outcomes of interest with propensity adjustment, it may simply be that PLT transfusions are not effective in preventing bleeding complications in the studied surgical population.

Notable strengths of this investigation include a large sample size, a heterogeneous surgical population, innovative data extraction strategies with precise determinations of event timings, and a robust statistical approach with propensity adjustments and multiple sensitivity analyses planned a priori. However, this study also has important limitations. The first major limitation is the observational study design with the associated inherent risks for residual bias and confounding. As an example, precise determinations of the circumstances influencing the decision to transfuse when confronted with preoperative thrombocytopenia remains an important limitation. By the same token, transfusion practices were likely impacted by unique considerations relating to the anesthesiologist or surgeon providing care. In addition, the relationship between prophylactic PLT transfusion and perioperative bleeding complications represents an association, and direct causality cannot be inferred. As this study relies on retrospective observational data, it is possible that unmeasured bias and confounding remain despite the robustness of the data extraction strategies and methodical statistical approach. Moreover, this investigation represents only a single institution's experience. Confirmation of these results in differing care locations will be needed to confirm the generalizability of the study findings. Additionally, the exclusion of intraoperative PLT transfusions could have impacted the study results. However, this exclusion was intentional and prespecified in the study protocol to prevent cause-effect inversion with the outcomes of interest. As mentioned previously, it must also be noted that estimates of intraoperative blood loss were missing for approximately 50% of cases, including simple procedures with low bleeding risk and longer procedures with high bleeding risk. Hence, estimated blood loss could not be reliably used as an outcome measure. Finally, data were not available to adequately assess PLT recovery responses after prophylactic transfusion, and hence it is unclear if outcomes in patients who remained thrombocytopenic despite preoperative transfusion differed from those who achieved higher PLT counts after transfusion. Certainly, the results of this study would greatly benefit from validation in a large multicenter cohort or a randomized clinical trial.

In conclusion, preoperative thrombocytopenia is associated with increased perioperative RBC requirements. However, attempts to mitigate bleeding complications with preoperative PLT transfusions do not result in improved outcomes. In light of these findings, more conservative management of preoperative thrombocytopenia may be warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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ABBREVIATIONS

ASA PS	American Society of Anesthesiologists Physical Classification Score
ICU	intensive care unit
INR	international normalized ratio
IQR	interquartile range

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Fig. 1.
Study population flow diagram.

Fig. 2. Propensity-adjusted analysis of the thrombocytopenic cohort showing quintiles of propensity for preoperative PLT transfusion among patients receiving (□) or not receiving (■) a preoperative PLT transfusion.

TABLE 1

Baseline demographic and clinical characteristics of patients with preoperative thrombocytopenia

Variable*	No therapy (n =789)	Preoperative PLTs (n =71)	p value†	
			Unadjusted	Stratified
Demographics				
Age (years)	61.0 (52.0, 71.0)	63.0 (53.0, 72.0)	0.5006	0.7843
Body mass index‡	27.5 (24.3, 32.3)	27.9 (23.7, 32.2)	0.9502	0.8970
Male sex	487 (62)	43 (61)	0.8473	0.7998
ASA PS			<0.0001	0.4011
1	4 (1)	0 (0)		
2	113 (14)	5 (7)		
3	412 (52)	27 (38)		
4	247 (31)	32 (45)		
5	13 (2)	7 (10)		
Comorbidities				
Myocardial infarction	72 (9)	5 (7)	0.5559	0.9701
Congestive heart failure	109 (14)	12 (17)	0.4737	0.8931
Peripheral vascular disease	14 (2)	2 (3)	0.5335	0.9766
Cerebrovascular disease	76 (10)	10 (14)	0.2310	0.8544
Dementia	9 (1)	1 (1)	0.8402	0.9064
Chronic pulmonary disease	66 (8)	11 (15)	0.0439	0.7578
Connective tissue disease	28 (4)	5 (7)	0.1422	0.9288
Ulcer disease	22 (3)	2 (3)	0.9888	0.7676
Mild liver disease	342 (43)	13 (18)	< .0001	0.9419
Diabetes mellitus	243 (31)	18 (25)	0.3390	0.9155
Hemiplegia	1 (0)	0 (0)	0.7641	
Moderate to severe renal disease	139 (18)	14 (20)	0.6575	0.8919
Diabetes with end organ damage	61 (8)	5 (7)	0.8345	0.8806
Tumor	238 (30)	10 (14)	0.0042	0.9786
Leukemia	42 (5)	10 (14)	0.0030	0.6770
Lymphoma	51 (6)	9 (13)	0.0491	0.9782
Moderate to severe liver disease	182 (23)	6 (8)	0.0043	0.9399
Metastatic solid tumor	220 (28)	9 (13)	0.0055	0.9937
AIDS	0 (0)	0 (0)		
Perioperative medications				
Aspirin	403 (51)	34 (48)	0.6066	0.9608
Clopidogrel	18 (2)	2 (3)	0.7743	0.9702
Coumadin	137 (17)	12 (17)	0.9215	0.9832
Heparin	154 (20)	16 (23)	0.5409	0.7624
NSAIDs	0 (0)	0 (0)		
Baseline laboratory values				
INR	1.2 (1.1, 1.5)	1.3 (1.2, 1.5)	0.1759	0.9501

Variable [*]	No therapy (n =789)	Preoperative PLTs (n =71)	p value [†]	
			Unadjusted	Stratified
Hb (g/dL)	10.4 (9.1, 12.3)	9.1 (8.2, 11.4)	<0.0001	0.5977
PLT count	73.0 (55.0, 88.0)	49.0 (34.0, 71.0)	<0.0001	0.7033
APTT [‡] (sec)	33.0 (29.0, 41.0)	34.0 (29.5, 39.0)	0.6001	0.5304
Creatinine [‡] (mg/dL)	1.0 (0.8, 1.4)	1.0 (0.7, 1.6)	0.9230	0.6003
Albumin [‡] (g/dL)	3.4 (2.9, 3.8)	3.1 (2.7, 3.8)	0.1653	0.7351
Procedural characteristics				
Procedure type			<0.0001	0.5931
ENT/oral	65 (8)	14 (20)		
General	257 (33)	23 (32)		
Neurology	12 (2)	4 (6)		
O/G	19 (2)	4 (6)		
Orthopedic	92 (12)	2 (3)		
Spine	15 (2)	3 (4)		
Thoracic	46 (6)	9 (13)		
Transplant	167 (21)	2 (3)		
Urology	41 (5)	3 (4)		
Vascular	30 (4)	6 (8)		
Other [§]	45 (6)	1 (1)		
Emergency	198 (25)	29 (41)	0.0039	0.7936
Primary anesthesia [‡]			0.4603	0.7661
General	781 (99)	71 (100)		
Regional block	6 (1)	0 (0)		
Surgical duration (min)	192.1 (115.9, 295.2)	147.0 (99.4, 203.3)	0.0016	0.4749

^{*} Continuous variables are summarized as median (Q1, Q3). Categorical variables are summarized as number (%).

[†] p values for continuous variables are from rank sum tests. p values for categorical variables are from chi-square tests. Stratified p values correspond to the comparison of the given characteristic for the propensity-matched strata.

[‡] Body mass index was available for 751 (87%) patients. APTT was available for 618 (72%) patients. Creatinine was available for 853 (99%) patients. Albumin was available for 526 (61%) patients. Anesthesia type was available for 858 (99%) patients.

[§] Procedure categories with less than 50 subjects were grouped into the “other” category for comparison.

AIDS =acquired immunodeficiency syndrome; APTT =activated partial thromboplastin time; ENT =ears, nose, throat; NSAIDs =nonsteroidal anti-inflammatory drugs; O/G =obstetrics/gynecology.

Univariate and multivariable analyses of primary and secondary outcomes in those with preoperative thrombocytopenia compared to those with PLT counts of more than $100 \times 10^9/L$

TABLE 2

Outcome	Univariate analysis			Multivariable analysis [†]		
	OR [*]	95% CI	p value	OR [*]	95% CI	p value
Preoperative RBCs	4.48	3.89–5.15	<0.0001	2.15	1.72–2.68	<0.0001
Intraoperative RBCs	3.96	3.42–4.58	<0.0001	1.67	1.31–2.12	<0.0001
Reoperation	4.12	3.14–5.40	<0.0001	1.75	1.18–2.59	0.0053
Mortality	6.39	5.04–8.10	<0.0001	1.87	1.29–2.70	0.0009

^{*} ORs are for preoperative thrombocytopenia. ORs higher than 1.00 indicate increased likelihood of the listed outcome in patients with thrombocytopenia.

[†] Adjusted including all baseline characteristics having significant differences between patient groups with PLT counts of more than $100 \times 10^9/L$ and those with PLT counts of not more than $100 \times 10^9/L$, utilizing a threshold p value of less than 0.1. Variables included in conditional logistic regression modeling—age; sex; Charlson score; perioperative warfarin, heparin; preoperative Hb, PLT count, INR, creatinine; ASA type (“ASA I,” as reference); emergency surgery; procedure type (“general surgery,” as reference); anesthetic type (general vs. regional); surgical duration.

TABLE 3

Univariate analyses of primary and secondary outcomes by the presence or absence of preoperative PLT transfusion in patients with thrombocytopenia

Outcome [*]	No therapy (n =789)	Preoperative PLTs (n =71)	p value [†]	Estimate (95% CI) [‡]
Perioperative RBC transfusion	387 (49)	47 (66)	0.0065	2.03 (1.22–3.39)
Intraoperative RBC transfusion	301 (38)	32 (45)	0.2527	1.33 (0.82–2.17)
Reoperation	63 (8)	7 (10)	0.5806	1.23 (0.55–2.87)
ICU admission	232 (30)	41 (58)	<0.0001	3.26 (1.99–5.36)
ICU length of stay (days), n =273 [§]	1.8 (0.8, 3.8)	2.6 (1.2, 3.9)	0.2659	0.12 (–0.73 to 0.86)
Postoperative MV	56 (8)	8 (14)	0.1006	1.95 (0.88–4.31)
Duration of MV (days), n =64 [§]	1.1 (0.1, 5.1)	6.5 (2.0, 17.2)	0.0618	5.8 (–1.8 to 13.3)
Hospital LOS (days), n =859 [§]	8.7 (3.5, 17.3)	15.1 (6.5, 41.1)	<0.0001	9.3 (3.1–15.9)
Mortality	80 (10)	19 (27)	<0.0001	3.20 (1.80–5.67)

^{*}Data are reported as number (%) for binary outcomes and median (Q1, Q3) for continuous outcomes.

[†]p values are from logistic regression for binary outcomes and the rank-sum test for continuous outcomes.

[‡]For binary outcomes the estimate is for the OR for preoperative PLT transfusion versus no therapy. For continuous outcomes the estimate is the difference in mean (preoperative PLTs minus no therapy) with the 95% CI calculated from 1000 bootstrap samples.

[§]ICU length of stay is summarized only for those patients who were admitted to the ICU and duration of mechanical ventilation is summarized only for those patients who received mechanical ventilation postoperatively.

MV =mechanical ventilation; LOS =length of stay.

TABLE 4

Conditional regression analysis in the propensity-stratified cohort

Outcome*	No therapy (n =482)	Preoperative PLTs (n =71)	p value [†]	Estimate (95% CI) [†]
Perioperative RBC transfusion	231 (48)	47 (66)	0.0764	1.68 (0.95–2.99)
Intraoperative RBC transfusion	178 (37)	32 (45)	0.7100	1.11 (0.64–1.94)
Reoperation	37 (8)	7 (10)	0.6846	0.82 (0.31–2.17)
ICU admission	174 (36)	41 (58)	0.0224	1.95 (1.10–3.46)
ICU length of stay (days), n =215	1.9 (0.9, 4.1)	2.6 (1.2, 3.9)	0.6971	–0.04 (–0.7 to 0.8)
Postoperative MV	33 (7)	8 (14)	0.7936	1.14 (0.43–3.00)
Duration of MV (days), n =41	2.0 (0.1, 8.6)	6.5 (2.0, 17.2)	0.2112	3.8 (–4.0 to 12.3)
Hospital LOS (days)	9.3 (3.8, 21.3)	15.1 (6.5, 41.1)	0.0006	7.2 (0.8–13.9)
Mortality	70 (15)	19 (27)	0.5968	1.20 (0.62–2.32)

* Data are reported as number (%) for categorical outcomes and median (Q1, Q3) for continuous outcomes.

[†] Estimates and p values are from stratified logistic regression for categorical outcomes and mixed-effects model for hospital length of stay. ICU length of stay and duration of mechanical ventilation are summarized for those who required these interventions and compared between groups using the rank-sum test.

LOS =length of stay; MV =mechanical ventilation.