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Preoperative Prolonged Steroid Use Is Not Associated with Intraoperative Blood Transfusion in Noncardiac Surgical Patients

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ABSTRACT

Background: Prolonged steroid therapy is reportedly associated with changes in coagulation, suggesting increased intraoperative bleeding or hypercoagulability. The aim of this retrospective study was to assess whether long-term steroid use was associated with increased transfusion requirements, infection, or hypercoagulability in adults undergoing noncardiac surgery.

Methods: In this study the authors evaluated 363,897 patients from the American College of Surgeons National Surgical Quality Improvement Program database. Patients with current pneumonia, ventilator dependence, coma, tumor involving the central nervous system, disseminated cancer, preoperative open wound/wound infection, and/or bleeding disorders were excluded. Each steroid user was matched to a nonsteroid user based on propensity score and type of surgery.

Results: 296,059 patients met the inclusion criteria, of whom 7,760 (2.6%) were taking steroids preoperatively. The incidence of intraoperative erythrocyte transfusion was 3.6% in the steroid user and 7.3% in non–steroid-user groups. After matching, the mean [95% confidence interval] number of units transfused was 0.22 [0.19, 0.25] units in the nonsteroid group and 0.19 [0.17, 0.22] units in the steroid group which was not statistically significant ($P = 0.24$, Wald test). Steroid users were 24% [2, 49] more likely to experience 30-day postoperative systemic infection and 21% [3, 41] more likely to experience postoperative wound infection than nonusers. The risks of postoperative thromboembolic complications did not differ significantly.

Conclusions: The effect of prolonged steroid use on bleeding, if any, thus seems likely to be small and is probably of limited clinical consequence. In contrast, corticosteroid use augments the risk of both systemic and wound infections.

What We Already Know about This Topic

- Long-term use of steroids interferes with a variety of physiological regulatory systems.
- There is controversy on the effects of prolonged steroid therapy on the coagulation system and a potential relationship to increased perioperative bleeding.

What This Article Tells Us That Is New

- This study evaluated 363,897 patients from the American College of Surgeons National Surgical Quality Improvement Program database, 7,760 of whom were taking steroids preoperatively. The results indicate that long-term steroid use is not associated with increased perioperative transfusion requirements or an increased risk of thrombolic events in surgical patients.

THE antiinflammatory and immune-modulating effects of steroids have been established for decades, and the drugs are used extensively for a wide range of inflammatory and autoimmune diseases, including asthma, rheumatoid arthritis, multiple sclerosis, thyroiditis, Crohn disease, ulcerative colitis, systemic lupus erythematosus, and psoriasis. As a consequence of their underlying illness, many long-term users of steroids undergo surgery for one reason or another.

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For example approximately 70% of patients with Crohn disease and 32% of patients with ulcerative colitis will eventually require at least one surgical procedure.[1]

Prolonged steroid use is associated with numerous side effects and presents substantial challenges for anesthesiologists. It is reasonably well established, for example, that steroid use promotes fluid and electrolyte shifts and immune and adrenal-pituitary axis suppression.[2] However, the relationship between steroid use and perioperative coagulation complications remains controversial. Dexamethasone was found to inhibit platelet aggregation in animals.[3] This was supported by human studies, in which glucocorticosteroids were found to significantly decrease the activated partial thromboplastin time, fibrinogen, and plasminogen concentrations.[4] It is noteworthy that this effect was even obvious after 2 days of treatment. In another study, patients with asthma taking glucocorticosteroids were found to have decreased values for prothrombin time, prothrombin index, and international normalized ratio.[5] In patients undergoing bowel resection for Crohn disease, intraoperative blood transfusion requirement was found to be correlated with the dose of steroid.[6]

In contrast, there is substantial controversy regarding the effect of steroids on the coagulation cascade. For example, dexamethasone increases the concentration of von Willebrand factor (vWF) and soluble P-selectin promoting coagulation in human volunteers[7] but also decreases factor XIII concentration and impairs coagulation in humans.[8] Although the putative mechanisms by which glucocorticoids may effect clotting factors are not clear, substantial risk of thromboembolic events in patients with Cushing syndrome has been previously demonstrated.[9]

Available studies thus suggest that prolonged steroid use may be associated with increased bleeding or may cause serious thrombotic complications with hypercoagulability. Whether steroid administration contributes to increased perioperative bleeding, thereby causing increased transfusion requirements, remains unclear. We therefore tested the hypothesis that preoperative steroid use increases intraoperative erythrocyte (RBC) transfusion in adults undergoing noncardiac surgery. Secondary goals of the study were to evaluate associations between prolonged steroid and thrombotic complications, wound infection, and systemic infection.

Materials and Methods

This study evaluated 363,897 patient records in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database between 2005 and 2007. Design of the ACS-NSQIP database, sampling strategy, variable definitions, and available outcomes have been published previously.[10,11] Data were prospectively collected in a standardized fashion according to strict definitions of preoperative characteristics, intraoperative information, and postoperative outcomes. A dedicated surgical clinical nurse reviewer collected data from computerized and paper patient medical records, doctor's office records, and telephone interviews with patients. Accuracy and reproducibility of the data have been demonstrated.[11]

Prolonged steroid users were defined in the ACS-NSQIP database as "patients who required regular administration of oral or parenteral corticosteroid medications in the 30 days before surgery for a chronic medical condition." Topical corticosteroids applied to the skin or corticosteroids administered by inhalation or rectally were not included. Patients who received only short-course steroids (duration of 10 days or less) in the 30 days before surgery were not included. We also excluded patients with current pneumonia, ventilator dependence, coma, tumor involving the central nervous system, disseminated cancer, preoperative open wound/wound infection, and/or bleeding disorders (*e.g.*, vitamin K deficiency, hemophilias, thrombocytopenia, or long-term anticoagulation therapy that had not been discontinued before surgery).

Each steroid user was matched to a nonsteroid user based on two variables: propensity score and type of surgery. The propensity score, defined for the present study as the estimated probability of preoperative steroid use, was modeled as a function of all clinically relevant and available potential confounding variables using multivariable logistic regression with backward stepwise selection of predictors (significance-to-enter and significance-to-stay criteria each set at 0.01). The list of covariables considered for inclusion in the propensity model is given in table 1.

Type of surgery was categorized using Current Procedural Terminology (CPT) codes. Specifically, we used the CPT Developer's Tool Kit[12] to exploit the hierarchical (tree-based) structure of CPT code categorizations: The CPT categorization tree was "pruned" back until each category consisted of a minimum of 500 patients. Aggregation of the CPT code hierarchy was necessary because the individual CPT codes themselves were too granular for matching purposes. The most common procedure types are given in table 2.

Successful steroid user/nonsteroid user matches were then restricted to patients with common (aggregated) CPT categorizations (as well as patients with estimated propensity scores within 0.001 units of one another). Euclidean (greedy) distance matching[13] was used for the matching.

Baseline covariable balance was measured using absolute standardized differences (ASDs), defined for symmetric continuous covariables, asymmetric continuous covariables, and categorical covariables as the absolute value of the difference in means, mean rankings, or proportions, respectively, between steroid users and nonusers, standardized by a measure of pooled SD. ASDs are preferred for assessing covariable balance in matching studies, especially when sample sizes are large, because *P* values resulting from standard univariable tests are dependent on sample size; that is, in large studies, the potential exists for clinically irrelevant baseline differences to be statistically significant. Cohen[14] proposed ASD values of 0.2, 0.5, and 0.8 as indicative of small, medium, and large group differences in central tendency. We consid-

Table 1. Comparison between Steroid Users and Nonusers on Baseline Demographic and Morphometric Variables among All Patients Meeting Inclusion/Exclusion Criteria and among Propensity-matched Patients

	All Patients			Matched Patients		
	Nonusers (n = 288,299)	Steroid Users (n = 7,760)	ASD	Nonusers (n = 6,350)	Steroid Users (n = 6,350)	ASD
Male, %	40.2	43.9	0.07	45.0	43.5	0.03
Race, %						
Asian	1.9	1.2	0.20	1.3	1.3	0.04
African American	9.2	10.3	—	10.3	10.6	—
Hispanic	7.6	4.4	—	4.4	4.9	—
Caucasian	70.8	77.0	—	76.6	76.5	—
Unknown/other	10.5	7.1	—	7.4	6.6	—
Age, yr	54 ± 17	56 ± 17	0.13	57 ± 18	56 ± 17	0.05
Height, in	66 ± 4	66 ± 4	0.02	66 ± 4	66 ± 4	0.02
BMI, kg/m^2	28 [24, 34]	27 [23, 32]	0.22	27 [23, 31]	27 [23, 32]	0.08
Smoker, %	20.1	18.1	0.05	18.9	18.6	0.01
Alcohol, %	2.4	1.9	0.04	2.1	2.0	0.01
ASA Classification	2 [2, 3]	3 [2, 3]	0.69	3 [2, 3]	3 [2, 3]	0.01
Admission from Home, %	98.4	95.9	0.15	96.8	96.5	0.01
Inpatient, %	58.3	76.6	0.40	79.9	77.7	0.05
Emergency, %	8.0	7.8	0.01	7.7	6.6	0.04
Diabetes, %						
None	88.2	82.5	0.25	84.9	83.5	0.04
Insulin	3.8	10.1	—	7.8	8.7	—
Oral	8.0	7.4	—	7.3	7.8	—
History of COPD, %	3.3	12.4	0.34	8.5	10.0	0.05
History of CHF, %	0.4	1.4	0.11	1.1	1.2	0.01
History of MI, %	0.3	0.8	0.06	0.7	0.6	0.02
Previous PCI, %	4.0	5.8	0.08	5.9	5.9	0.00
Previous Cardiac Surgery, %	4.6	8.3	0.15	9.2	8.0	0.04
History of Angina, %	0.6	1.2	0.06	1.2	1.1	0.01
Hypertension (with Medication), %	41.3	53.3	0.24	52.9	52.9	0.00
History of PVD, %	2.2	3.6	0.08	3.9	3.5	0.02
History of TIA, %	2.3	3.2	0.06	3.3	3.3	0.00
Previous CVA/Stroke, %	3.1	4.9	0.10	5.0	4.7	0.01
Dyspnea, %	10.0	18.9	0.26	16.2	17.2	0.03
Functional Dependence, %	2.6	6.7	0.19	5.9	5.7	0.01
Ascites, %	0.7	1.5	0.08	1.6	1.3	0.03
Esophageal Varices, %	0.1	0.2	0.03	0.2	0.2	0.01
Rest Pain/Gangrene, %	0.9	1.6	0.05	1.6	1.4	0.01
Acute Renal Failure, %	0.2	0.9	0.10	0.6	0.5	0.00
On Dialysis, %	1.3	4.2	0.18	3.5	3.5	0.00
Impaired Sensorium, %	0.2	0.4	0.05	0.3	0.3	0.00
Recent Chemo/radiotherapy, %	1.3	2.0	0.06	2.1	2.0	0.00
>10% Weight Loss (Past 6 mo), %	2.0	5.3	0.18	4.5	4.7	0.01
Prior Operation (Past 1 mo), %	1.8	2.8	0.06	2.7	2.5	0.02
Preoperative Hematocrit, %	40 ± 5	38 ± 6	0.43	38 ± 6	38 ± 5	0.03
General Anesthesia, %	90.6	92.8	0.08	93.5	93.8	0.01
Operation Time, min	83 [49, 138]	108 [64, 174]	0.32	111 [65, 176]	112 [67, 178]	0.01

Data are presented as mean ± SD for symmetrically distributed continuous variables, median [1st and 3rd quartiles] for asymmetrically distributed continuous variables, and percentage of patients for factors.

ASA = American Society of Anesthesiologists; ASD = absolute standardized difference, a measure of treatment group balance defined as the difference in means, mean rankings, or proportions divided by an estimate of the pooled SD, was used to evaluate performance of the propensity matching process on covariable balance; BMI = Body Mass Index; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular attack; ETOH = alcohol drinking; MI = myocardial infarction; PCI = percutaneous coronary intervention; PVD = peripheral vascular disease; TIA = transient ischemic attack.

ered covariables to be sufficiently balanced if the estimated ASD was less than 0.1.

We evaluated the primary hypothesis of our study—that the distribution of number of RBC units transfused intraoperatively is independently associated with preoperative steroid use—using a Wald-type *z* test within a negative binomial model, including as covariables any baseline variables showing evidence of residual imbalance after matching (*i.e.*, ASD more than 0.1). Based on this negative binomial model, we also estimated the (geometric) mean number of units transfused for the steroid users and the nonsteroid users, as well as the ratio of these means.

Table 2. Most Common Surgical Procedures Observed in Steroid Users and Nonusers

Surgical Category	Steroid Users (%)	Nonusers (%)
Colorectal Resection	22.5	21.1
Other Hernia Repair	8.9	8.9
Cholecystectomy and Common Duct Exploration	8.8	8.8
Other or Lower GI Therapeutic Procedures	5.9	6.8
Inguinal and Femoral Hernia Repair	3.8	3.9
Other or Procedures on Vessels Other Than Head and Neck	3.7	3.5
Lumpectomy, Quadrantectomy of Breast	3.2	3.1
Small Bowel Resection	3.1	3.7
Gastric Bypass and Volume Reduction	2.8	2.8
Total	62.7	62.6

GI = gastrointestinal.

The secondary outcomes were 30-day systemic infection (including sepsis and septic shock), wound infection (including superficial and deep surgical site), and thrombotic complications (identification of a new blood clot or thrombus within the venous system) within 30 days of the operation. To qualify in the NSQIP database, thrombotic complications were confirmed by a duplex, venogram, or computed tomography scan; furthermore, patients must have been treated with anticoagulation therapy, placement of a vena cava filter, and/or clipping of the vena cava). They were modeled jointly using a marginal generalized linear mixed model, which adjusts odds ratio estimates comparing steroid users to nonusers for any correlation present among the outcomes. Because these are postoperative outcomes, we adjusted for number of intraoperative RBC units transfused in this model. In addition, the estimated propensity score and those covariables included in the primary model (*i.e.*, with ASD more than 0.1) were adjusted for in the generalized linear mixed model. The Bonferroni adjustment for three simultaneous comparisons was used in the analysis of the secondary outcomes.

SAS statistical software version 9.2 (SAS Institute, Cary, NC) and R statistical software version 2.8.1 (The R Foundation for Statistical Computing, Vienna, Austria) were used for all analysis. We considered *P* values less than 0.05 to be statistically significant.

Results

Among the 363,897 surgical cases in the ACS-NSQIP database, 296,059 patients (81.4%) met our inclusion criteria, 7,760 (2.6%) of whom were taking steroids preoperatively. The incidence of intraoperative RBC transfusion among the entire sample (*i.e.*, before propensity matching) was 3.6%; within the steroid-user and non–steroid-user groups, the incidence was 7.3 and 3.5%, respectively.

Table 3. Number of Systemic Infection, Wound Infection, and Thrombotic Complications Observed in Steroid Users and Nonusers

Complication	No. (%) with Complication: Nonsteroid (n = 6,350)	No. (%) with Complication: Steroid (n = 6,350)	Adjusted Odds Ratios (95% CI)
Systemic Infection	298 (4.7)	361 (5.7)	1.24 (1.02–1.49)
Wound Infection	474 (7.5)	559 (8.8)	1.21 (1.03–1.41)
Thrombotic Complication	77 (1.2)	105 (1.7)	1.38 (0.96–1.98)

Adjusted odds ratios are based on a generalized linear mixed model that adjusts confidence interval estimates for any intrasubject correlation among outcomes.

CI = confidence interval.

Before matching, steroid users had higher American Society of Anesthesiologists physical status classifications, were more likely to be in-patients, more likely to have a history of chronic obstructive pulmonary disease, more likely to be diabetic, and had lower preoperative hematocrit levels (table 1). Among the 7,760 patients taking steroids, 6,350 (81.8%) were successfully matched to a control patient not taking steroids. Excellent covariable balance between matched steroid users and matched nonusers was achieved, as evidenced by the fact that the maximum ASD between groups on any covariable was 0.08. Thus, no covariables were included in the final models.

Adjusting for the correlation among outcomes within a patient as well as the number of intraoperative RBC units transfused within a generalized linear mixed model, the odds ratios [Bonferroni-adjusted 95% confidence interval (CI)] for 30-day postoperative systemic infection, wound infection, and thrombotic complication—comparing steroid users and nonusers—were 1.24 [1.02, 1.49], 1.21 [1.03, 1.41], and 1.38 [0.96, 1.98], respectively (table 3). The Bonferroni-adjusted *P* values for these comparisons, respectively, were 0.02, 0.01, and 0.13 (Wald test). Systemic and wound infection risks were thus significantly increased in patients who took preoperative steroids, but thrombotic complications were not.

The fitted distribution of number of RBC units transfused intraoperatively corresponded reasonably well with the observed distributions within both groups (table 4). The proportion of patients transfused [95% CI] was 7.4% [6.8%, 8.1%] in both groups.

Based on the negative binomial regression model, the geometric mean [95% CI] number of units transfused intraoperatively was 0.22 [0.19, 0.25] units in the nonsteroid group and 0.19 [0.17, 0.22] units in the steroid group, correspond-

Table 4. Observed and Fitted Distribution of Number of Units Transfused Intraoperatively by Steroid Use Group

Number of Units Transfused	Observed No. (%)		Fitted No. (%)	
	Nonusers	Steroid Users	Nonusers	Steroid Users
0	5,875 (92.6)	5,925 (93.4)	5,886 (92.8)	5,910 (93.1)
1	130 (2.0)	116 (1.8)	202 (3.2)	199 (3.1)
2	177 (2.8)	163 (2.6)	88 (1.4)	85 (1.3)
3	55 (0.9)	56 (0.9)	51 (0.8)	48 (0.8)
4	46 (0.7)	33 (0.5)	32 (0.5)	30 (0.5)
5	19 (0.3)	14 (0.2)	22 (0.3)	20 (0.3)
6+	43 (0.7)	40 (0.6)	62 (1.0)	52 (0.9)

The negative binomial regression model produced distribution estimates reasonably close to the observed distributions within each group. No significant difference in the distribution was observed between steroid users and nonusers ($P = 0.24$, Wald test).

ing to a ratio of means [95% CI] of 0.89 [0.74, 1.08] (comparing steroid users and nonusers). This difference was not statistically significant ($P = 0.24$, Wald test). Twenty-six of 6350 nonsteroid users (0.41%) and 30 of 6,350 steroid users (0.47%) had transfusions (defined as 5+ units) within 72 h of surgery (postoperatively). These incidence rates did not differ significantly ($P = 0.59$, Wald test); the odds ratio [95% CI] of bleeding transfusions, comparing steroid users to nonusers, was 1.15]0.68, 1.95].

Discussion

Inflammatory disorders such as allergies, asthma, and autoimmune diseases are major causes of illness and death. Asthma affects approximately 22 million adults[15] and 9 million children[16]; autoimmune diseases affect an additional 8.5 million Americans.[17] Steroids are the primary treatment for each of these conditions. The benefit of steroid use in these patients is clear, but a consequence of prolonged use is that many long-term users of steroids will eventually undergo surgery for one reason or another.

Perioperative steroid use is associated with major complications, including impaired wound healing,[18] decreased glucose tolerance, and increased risk of infectious complications.[19–21] For example, postoperative infections were more common in steroid-treated patients than in untreated patients (38 *versus* 25% after elective colorectal resection).[22] Furthermore, a meta-analysis evaluating the risk of postoperative complications after abdominal surgery found a 68% increase in risk of postoperative infectious complications in steroid-treated patients.[23] Preoperative prolonged steroid use was also associated with a 4-fold increase in wound infections in another retrospective study evaluating factors associated with wound infection in ventral hernia repair.[24] And finally, it is widely recognized that glucocorticoids suppress immune responses by decreasing leukocyte migration[25] and by inhibiting synthesis of proinflammatory cytokines.[26] Consistent with previous reports, we observed a significant increase in both systemic and wound infection: steroid users were 24% more likely to experience 30-day postoperative systemic infection and 21% more likely to experience postoperative wound infection than nonusers. Preoperative steroid use is probably not a modifiable risk factor for postoperative infection, but because their risk is high, prophylactic measures to prevent infections may be especially helpful in patients taking steroids.

Although it is reasonably established that steroid use promotes perioperative infection, the relationship between steroid use and increase in perioperative bleeding remains unclear. Bleeding related to corticosteroid use has been recently reported as an important complication in tonsillectomy patients.[27] Furthermore, Bruewer *et al.*[6] retrospectively evaluated complications related to long-term steroid treatment in patients undergoing bowel resection for Crohn disease. They reported that intraoperative blood transfusion requirement was higher in patients on high-dose steroids compared with low-dose steroids. In a recent retrospective study Trésallet *et al.*[22] assessed the effect of systemic corticosteroids on elective colorectal surgery and found, controversially, that 19% of steroid users and 25% of nonusers had perioperative blood transfusion, a similar result. Our results from a relatively large patient population demonstrated no difference with regard to intraoperative transfusion requirements. The effect of long-term steroid use on increased intraoperative bleeding, if any, thus seems likely to be small, because it does not increase transfusion requirements and is thus probably of limited clinical consequence.

Controversy surrounding bleeding in patients on long-term steroids seems to exist in acute use also. For example, steroid administration before functional endoscopic sinus surgery does not increase bleeding,[28] and three additional studies in patients having rhinoplasties found no effect in amount of intraoperative bleeding.[29–31] Another recent study in colorectal patients evaluated short-term corticosteroid administration before surgery and found no difference in amount of transfusion.[32] Of course, this conclusion supports our results: because long-term steroid use does not seem to augment intraoperative bleeding, as demonstrated in our study, it is certainly unlikely that single perioperative dose would increase bleeding. Small doses of steroids given before surgery to prevent postoperative nausea and vomiting are thus extremely unlikely to aggravate perioperative bleeding.

The current literature is conflicting with regard to glucocorticoids and associated hypercoagulability. *In vivo* stud-

ies suggest that dexamethasone impairs coagulation and promotes bleeding by decreasing platelet aggregation[3] and decreasing factor XIII.[8] *In vivo* studies indicate that glucocorticoids are associated with elevations in plasminogen activator inhibitor-1, platelet marker (soluble P-selectin), vWF, and factor VIII concentrations—a combination that suggest a combined hypofibrinolytic and hypercoagulable state.[33–35] Soluble P-selectin, for example, contributes importantly to hemostasis and thrombosis. It induces a procoagulant state by triggering the generation of procoagulant microparticles from leukocytes, up-regulating the expression of tissue factor on monocytes, and inducing phosphatidylserine exposure. It also increases surface-dependent thrombin generation on monocytes. Increased soluble P-selectin has been implicated as a risk factor for venous thromboembolism.[36] The probable underlying mechanism for elevation in soluble P-selectin and vWF is a steroid-induced up-regulation of vWF-Messenger ribonucleic acid transcription.[7] The presence of a steroid-induced hypercoagulable and hypofibrinolytic state has been defined in patients with Cushing disease with high levels of factor VIII, factor IX, and vWF with subsequent shortening of activated partial thromboplastin time and evidence of enhanced thrombin generation.[9,33] A similar phenomenon has been described in patients with long-term steroid treatment after renal transplantation.[37] In our study, the incidence of thrombotic complications was likely to be between 4% lower and 98% higher among steroid users compared with nonusers. Despite basing our analysis on a large registry, our results remain inconclusive. Additional data will be necessary to evaluate the potential association between preoperative steroid use and postoperative thromboembolic complications.

It seems unlikely that a randomized trial of long-term steroid use and perioperative bleeding will be possible, especially considering the large number of patients that would be required. We therefore analyzed a large data set using sophisticated statistical techniques, especially propensity matching, to control for confounding variables and comorbidities. An advantage of the ACS-NSQIP database is that it pools data from more than 200 participating institutions, thus allowing the analysis of a very large sample size. Uniform inclusion criteria, data collection, and auditing ensures the reliability of the data. Another important aspect is that ACS-NSQIP data are generalizable to the U.S. surgical population to a much greater extent than results from controlled clinical trials.

There are nonetheless distinct limitations to retrospective analysis of quality improvement registries. First, the dose, type, and duration of the steroid use were not recorded in the ACS-NSQIP data base, although by definition, patients must take steroids for at least a month preoperatively to be considered prolonged steroid users. There is lack of a clear definition of prolonged or long-term steroid use in the literature; however, studies have demonstrated that even a 5-day treatment course with steroids was found to effect hemostatic and antifibrinolytic factors,[38] so 1 month of usage seems to be adequate to see those changes. Second, there are potentially important baseline data that were unavailable to us at the time of the study (*e.g.*, number of units transfused preoperatively). And third, analysis of actual intraoperative blood loss might have been a more precise comparison. Unfortunately, data on intraoperative blood loss is not recorded and thus was unavailable to us. Furthermore, there is little consensus on how best to determine intraoperative blood loss, and blood loss is difficult to objectively quantify. From a clinical perspective, however, the number of transfused units is probably more important than blood loss *per se*.

In summary, our analysis of a large well-validated registry indicates that long-term corticosteroid use was not independently associated with increased intraoperative transfusion requirement. Considering all available data, we also conclude that there remains insufficient evidence to support an association between long-term steroid use and an increased risk of thromboembolic events in surgical patients. In contrast, our results confirm previous reports that long-term corticosteroid use augments the risk of both systemic and wound infections. Clinicians might thus take precautions against infections in patients who are long-term steroid users, but the effect of long-term steroid use on coagulation-related complication—if any—seems to be of limited clinical consequence.

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