


Trauma Risk Score Also Predicts Blood Transfusion Requirements in Hip Fracture Patients

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Abstract

Introduction: The purpose of this study is to determine if the risk of receiving a blood transfusion during hip fracture hospitalization can be predicted by a validated risk profiling score (Score for Trauma Triage in Geriatric and Middle Aged (STTGMA)). **Materials and Methods:** A consecutive series of 1449 patients 55 years and older admitted for a hip fracture at one academic medical center were identified from a trauma database. The STTGMA risk score was calculated for each patient. Patients were stratified into risk groups based on their STTGMA score quantile: minimal risk (0–50%), low risk (50–80%), moderate risk (80–95%), and high risk (95–100%). Incidence and volume of blood transfusions were compared between risk groups. **Results:** There were 562 (38.8%) patients who received a transfusion during their admission. 58.3% of patients in the high risk group received a transfusion during admission compared to 31.2% of minimal risk group patients, 42.6% of low risk group patients, and 50.0% of moderate risk group patients ($p < 0.001$). STTGMA was predictive of first transfusion incidence in both the preoperative and postoperative periods. There was no difference in mean total transfusion volume between the four risk groups. **Conclusion:** The STTGMA model is capable of risk stratifying hip fracture patients more likely to receive blood transfusions during hospitalization. Surgeons can use this tool to anticipate transfusion requirements.

Keywords

geriatric trauma, hip fracture, transfusion, risk stratification, STTGMA

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Introduction

Hip fractures are a common injury in the elderly population due to their predisposition to falls and bone frailty.¹ The incidence of these injuries is expected to rise in the future due to the aging of the population.² The rising incidence is concerning from a public health standpoint, given the morbidity associated with hip fractures. While hospitalized, patients with hip fractures are prone to an array of medical complications, which can even lead to in-hospital mortality in anywhere from 2 to 5% of patients.^{3,4} Acute blood loss anemia is one of the most common complications seen in these patients and often leads to blood

transfusions. Hip fracture patients who receive blood transfusions are more likely to experience several poor outcomes including longer lengths of stay, readmissions,

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medical complications, as well as higher short- and long-term mortality rates.⁵⁻⁸

The Score for Trauma Triage in the Geriatric and Middle Aged (STTGMA) is a risk predictive tool developed to predict inpatient mortality in orthopedic trauma patients over 55 years of age.⁹ The tool uses variables obtained from the history and physical when the patient first presents to the hospital to calculate a percentage score indicative of the patient's mortality risk during hospitalization. Since its development, studies have also shown STTGMA to successfully risk stratify additional outcomes such as need for ICU, length of stay, readmissions, and hospital costs in hip, ankle, tibia, and humerus fracture patients.¹⁰⁻¹⁷ Clinicians can use these scores to identify high risk patients who may benefit from a higher level of care.

Given the reported poor outcomes associated with blood transfusions in hip fracture patients, it is important for clinicians to be able to identify patients more likely to receive a transfusion who may benefit most from blood conservation strategies. The objective of this study is to determine if the STTGMA tool is able to risk stratify hip fracture patients more likely to receive a blood transfusion during admission. Second, the study will assess whether the model is capable of predicting the total volume of blood product transfused in these patients.

Materials and Methods

An institutional review board–approved trauma database was queried for any patient 55 years or older admitted for a hip fracture between October 2014 and February 2020. All patients were treated by faculty and residents at one of four hospitals within one academic medical center.

The electronic medical records for all identified patients were reviewed for demographic and baseline health data including age at time of admission, sex, body mass index (BMI), Charlson Comorbidity Index (CCI) without age adjustment, albumin level at admission, and pre-injury ambulatory status defined as either community ambulator (patients who ambulate outside of their home >50% of the time), household ambulator (patients who ambulate within their household >50% of the time), or non-ambulatory (patients who require use of a wheelchair or are only able to perform transfers). Injury and treatment information collected from the medical record included Glasgow Coma Scale (GCS), injury mechanism categorized as low energy (falls from heights less than or equal to two stairs) or high energy (falls from heights greater than two stairs, motor vehicle accidents, and pedestrian struck by motor vehicles), fracture classification according to the system of the Orthopedic Trauma Association,¹⁸ ASA class, type of procedure performed, and abbreviated injury scores for head/neck (AIS-HN), chest (AIS-C), and extremity/pelvis (AIS-EXT).

Additional review of the electronic medical record was performed to identify patients who received a blood transfusion of packed red blood cells (pRBCs) during their hospitalization. Timing of transfusions relative to surgery (preoperative, intraoperative, or postoperative) and total volume of blood product transfused were recorded. The hospitals in this study transfuse hip fracture patients at hemoglobin levels below 8 g/dl or when symptoms of anemia are present.

A low-energy STTGMA score was calculated using age, GCS, AIS-HN, AIS-C, CCI, and baseline ambulatory status as input variables for all patients with a low-energy injury mechanism. A high-energy STTGMA score was calculated using age, GCS, AIS-HN, AIS-C, AIS-EXT, and albumin level at admission as input variables for all patients with a high-energy injury mechanism. STTGMA scores were used to stratify patients into four quantiles based on their risk score for inpatient mortality.⁹ Patients were considered minimal risk in the 0–50% quantile, low risk in the 50–80% quantile, moderate risk in the 80–95% quantile, and high risk in the 95–100% quantile. The incidence of receiving a transfusion during hospitalization was compared between risk groups using chi-squared tests. Cumulative volume of blood product transfused during admission was compared between risk groups using Kruskal Wallis test. Patients were further stratified into preoperative, intraoperative, and postoperative groups based on when they received their first transfusion relative to surgery. Transfusion incidence and cumulative blood product volume were compared between risk groups following stratification into the preoperative, intraoperative, and postoperative groups. Categorical and numeric demographic variables were compared using chi-squared and Kruskal Wallis tests, respectively. All analyses were performed using R software version 4.02.¹⁹

Results

A total of 1449 hip fracture patients were identified with a mean age of 80.49 ± 10.32 years (Table 1). The overall cohort had 438 (30.2%) males and 1011 (69.8%) females. The mean CCI and STTGMA score for the group were 1.45 ± 1.72 and $1.72 \pm 6.08\%$. The majority of patients had an ASA class of 3 (54.3%). Prior to their injury, 1061 (73.2%) patients were community ambulators, while 342 (23.6%) were household ambulators and 46 (3.2%) were nonambulatory. The most common fracture classification was 31A (50.0%). Repair with short cephalomedullary nail (41.3%) was the most frequent procedure performed.

STTGMA inpatient mortality risk group stratification resulted in a high risk cohort with a higher mean CCI score (5.06 ± 2.62 , $p < 0.001$) and more nonambulatory individuals (27.8%, $p < 0.001$) than the other three risk cohorts. The moderate and high risk groups had more patients with

Table 1. Demographic and Baseline Patient Characteristics.

	Minimal risk cohort STTGMA: 0–0.3% (n = 725)	Low risk cohort STTGMA: 0.3–1.5% (n = 434)	Moderate risk cohort STTGMA: 1.5–6.1% (n = 218)	High risk cohort STTGMA: 6.1–100% (n = 72)	Total (n = 1449)	p value
Age, mean ± SD, years	77.26 ± 10.44	83.52 ± 8.95	84.40 ± 9.54	82.92 ± 8.88	80.49 ± 10.32	<0.001
Sex	—	—	—	—	—	0.166
Male	202 (27.9%)	136 (31.3%)	73 (33.5%)	27 (37.5%)	438 (30.2%)	—
Female	523 (72.1%)	298 (68.7%)	145 (66.5%)	45 (62.5%)	1011 (69.8%)	—
Body Mass index, mean ± SD	24.60 ± 4.95	24.23 ± 4.84	23.93 ± 4.53	24.43 ± 5.21	24.38 ± 4.87	0.462
Charlson Comorbidity Index, mean ± SD	0.46 ± 0.62	1.65 ± 1.15	3.19 ± 1.70	5.06 ± 2.62	1.45 ± 1.72	<0.001
ASA class, n %	—	—	—	—	—	<0.001
1	18 (2.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	18 (1.2%)	—
2	277 (38.3%)	58 (13.4%)	11 (5.0%)	7 (9.7%)	353 (24.4%)	—
3	376 (51.9%)	280 (64.5%)	95 (43.6%)	35 (48.6%)	786 (54.3%)	—
4	53 (7.3%)	96 (22.1%)	112 (51.4%)	30 (41.7%)	291 (20.1%)	—
Ambulatory status, n (%)	—	—	—	—	—	<0.001
Community ambulator	718 (99.0%)	245 (56.5%)	71 (32.6%)	27 (37.5%)	1061 (73.2%)	—
Household ambulator	7 (1.0%)	185 (42.6%)	125 (57.3%)	25 (34.7%)	342 (23.6%)	—
Nonambulatory	0 (0.0%)	4 (0.9%)	22 (10.1%)	20 (27.8%)	46 (3.2%)	—
STTGMA score, mean ± SD	0.16% ± 0.07%	0.72% ± 0.30%	2.95% ± 1.14%	19.74% ± 19.60%	1.72% ± 6.08%	<0.001
AO/OTA fracture classification, n (%)	—	—	—	—	—	<0.001
31A	330 (45.5%)	236 (54.4%)	124 (56.9%)	34 (47.2%)	724 (50.0%)	—
31B	307 (42.3%)	173 (39.9%)	80 (36.7%)	34 (47.2%)	594 (41.0%)	—
32A	34 (4.7%)	2 (0.5%)	3 (1.4%)	2 (2.8%)	41 (2.8%)	—
32B	0 (0.0%)	2 (0.5%)	0 (0.0%)	0 (0.0%)	2 (0.1%)	—
32C	14 (1.9%)	9 (2.1%)	6 (2.8%)	1 (1.4%)	30 (2.1%)	—
Periprosthetic	40 (5.5%)	12 (2.8%)	5 (2.3%)	1 (1.4%)	58 (4.0%)	—
Procedure	—	—	—	—	—	<0.001
Closed reduction percutaneous pinning	60 (8.3%)	28 (6.5%)	16 (7.3%)	11 (15.3%)	115 (7.9%)	—
Hemiarthroplasty	129 (17.8%)	115 (26.5%)	54 (24.8%)	18 (25.0%)	316 (21.8%)	—
Long cephalomedullary nail repair	98 (13.5%)	53 (12.2%)	37 (17.0%)	8 (11.1%)	196 (13.5%)	—
Periprosthetic fracture plating	8 (1.1%)	7 (1.6%)	3 (1.4%)	0 (0.0%)	18 (1.2%)	—
Revision total hip arthroplasty	32 (4.4%)	4 (0.9%)	2 (0.9%)	1 (1.4%)	39 (2.7%)	—
Short cephalomedullary nail repair	275 (37.9%)	202 (46.5%)	94 (43.1%)	28 (38.9%)	599 (41.3%)	—
Sliding hip screw repair	43 (5.9%)	19 (4.4%)	7 (3.2%)	5 (6.9%)	74 (5.1%)	—
Total hip arthroplasty	80 (11.0%)	6 (1.4%)	5 (2.3%)	1 (1.4%)	92 (6.3%)	—

an ASA class of 4 compared to the minimal and low risk groups ($p < 0.001$). Distribution of age, fracture classification, and procedure differed between risk cohorts ($p < 0.001$ for all).

Of the 1449 patients in our cohort, 562 (38.8%) received at least one pRBC transfusion during their hospitalization (Table 2). STTGMA risk group stratification yielded 58.3% of high risk patients receiving any pRBC

transfusion compared to 31.2% of minimal risk patients, 42.6% low risk patients, and 50.0% of moderate risk patients ($p < 0.001$) (Figure 1). One hundred twenty-seven (8.8%) patients were first transfused during the preoperative period compared to 78 (5.4%) intraoperatively and 357 (24.6%) postoperatively ($p < 0.001$). Preoperative first transfusions were received by 22.2% of high risk patients compared to 4.6% of minimal risk patients, 10.8% of low

Table 2. Transfusions as a Function of STTGMA Risk cohort.

	Minimal risk cohort STTGMA: 0–0.3% (n = 725)	Low risk cohort STTGMA: 0.3–1.5% (n = 434)	Moderate risk cohort STTGMA: 1.5–6.1% (n = 218)	High risk cohort STTGMA: 6.1–100% (n = 72)	Total (n = 1449)	p value
Any transfusion, n (%)	226 (31.2%)	185 (42.6%)	109 (50.0%)	42 (58.3%)	562 (38.8%)	<0.001
Preoperative transfusion, n (%)	33 (4.6%)	47 (10.8%)	31 (14.2%)	16 (22.2%)	127 (8.8%)	<0.001
Intraoperative transfusion, n (%)	36 (5.0%)	26 (6.0%)	10 (4.6%)	6 (8.3%)	78 (5.4%)	0.559
Postoperative transfusion, n (%)	157 (21.7%)	112 (25.8%)	68 (31.2%)	20 (27.8%)	357 (24.6%)	0.027

risk patients, and 14.2% of moderate risk patients ($p < 0.001$). There was no difference in intraoperative first transfusion incidence between STTGMA risk groups. Postoperative first transfusions were received by 27.8% of high risk patients compared to 21.7% of minimal risk patients, 25.8% of low risk patients, and 31.2% of moderate risk patients ($p = 0.025$). There were no differences in the mean total volume of blood product transfused during admission between the four risk groups (Table 3). Patients receiving their first transfusion preoperatively received more total blood product over the course of their admission than patients receiving their first transfusion intraoperatively or postoperatively (828 ± 616 ml vs. 620 ± 431 ml vs. 675 ± 501 ml respectively, $p = 0.003$).

Discussion

In this study, we assessed whether a validated trauma triage score is able to successfully identify hip fracture patients who will receive in-hospital pRBC blood transfusions. After stratifying patients into four risk cohorts based on their STTGMA scores, patients in the high risk group were more likely than the minimal, low, and moderate risk groups to receive a transfusion during their hospitalization. Following additional stratification by transfusion timing relative to surgery, patients with higher STTGMA risk scores were more likely to receive preoperative and postoperative transfusions. There were no differences between risk cohorts for receiving intraoperative transfusions, but it should be noted this subgroup only contained 78 patients. Although STTGMA was able to stratify the increasing need for transfusion with increasing risk groups, there was no difference in mean total blood volume transfused between the four risk groups.

Several previous studies have utilized STTGMA risk groups in order to assess the model's ability to predict various clinical outcomes, quality measures, and costs. In a study of 64 tibia fracture patients, Konda et al.¹⁷ stratified the overall cohort into minimal, moderate, and high risk

groups based on STTGMA score. The study showed that patients in the high risk group had the greatest likelihood of experiencing medical complications and were least likely to be discharged home. Additionally, they showed that high risk patients had longer and more expensive hospital stays. In a separate study stratifying 50 ankle fracture patients into four risk groups, the authors showed that STTGMA was able to successfully predict length of stay, discharge location, and hospital costs in this patient population.¹⁵ Another study of ankle fracture patients concluded STTGMA is also able to identify patients at risk of being readmitted following discharge from their index hospitalization.¹⁶ Furthermore, the model's predictive ability has also been validated in several other patient populations such as hip, femur, and humerus fracture patients.¹⁰⁻¹⁴

In the clinical setting, the STTGMA tool has the potential to aid clinicians in providing more value-based care.^{10,14,15,17} Healthcare providers can use the score early in a patient's admission to gain insight into what the trajectory of the patient's hospital course may look like. Using risk groups similar to the ones used in this study, clinicians can triage patients into more cost-effective standardized care pathways based on their risk group. Moreover, identifying patients with poor prognoses can help clinicians determine who may benefit from a palliative care consultation. Utilizing palliative care specialists earlier in the admission can aid with providing more cost-effective care that also aligns with the patient's wishes. Additionally, a patient's score can be used to predict into his/her most likely discharge location,¹⁰ which can help facilitate discharge planning earlier in the admission to minimize unnecessary days in the hospital due to issues with disposition.

While we are not aware of any studies using risk stratification to predict the need for blood transfusion, several studies have tried to identify risk factors associated with receiving a transfusion in hip fracture patients. In a study of 8416 hip fracture patients, Arshi, and colleagues⁶ performed a multivariate logistic regression to identify risk

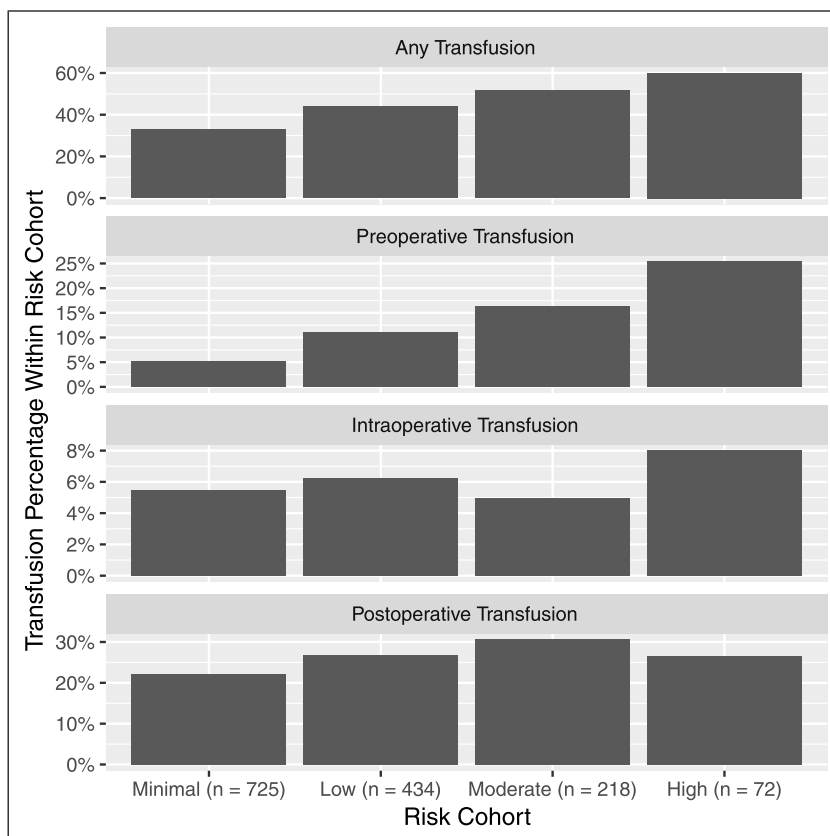


Figure 1. Risk of receiving packed red blood cell transfusions for minimal, low, moderate, and high risk groups.

Table 3. Transfusion Volume as a Function of STTGMA Risk Cohort.

	Minimal risk cohort STTGMA: 0–0.3% (n = 226)	Low risk cohort STTGMA: 0.3–1.5% (n = 185)	Moderate risk cohort STTGMA: 1.5–6.1% (n = 109)	High risk cohort STTGMA: 6.1– 100% (n = 42)	Total (n = 562)	p value
Total transfusion volume, mean ± SD, mL	655 ± 475	725 ± 500	743 ± 596	747 ± 667	702 ± 525	0.365
Preoperative transfusion volume, mean ± SD, mL	762 ± 500	781 ± 448	874 ± 777	1017 ± 876	828 ± 616	0.854
Intraoperative transfusion volume, mean ± SD, mL	580 ± 355	583 ± 371	817 ± 629	693 ± 683	620 ± 431)	0.859
Postoperative transfusion volume, mean ± SD, mL	649 ± 493	735 ± 542	672 ± 486	547 ± 356	675 ± 501	0.184

Note: Transfusion volume is cumulative of entire admission with preoperative, intraoperative, or postoperative designating timing of first transfusion.

factors for receiving a postoperative transfusion. In the 28.3% of patients that received transfusions in the study, the authors identified increased age, preoperative anemia, female sex, increased ASA class, chronic obstructive

pulmonary disease, hypertension, increased operation time, and extracapsular fractures as independent risk factors for receiving a postoperative transfusion. Many of these findings have also been replicated in other studies

investigating transfusion risk factors in hip fracture patients. In 986 hip fracture patients over 60 years of age, Madsen et al.²⁰ showed that age, ASA class, preoperative anemia, and extracapsular fractures were all risk factors for receiving a transfusion, similar to the Arshi et al. study. Madsen et al. also concluded that taking aspirin or other platelet inhibitor medications prior to admission was associated with receiving pRBC transfusions greater than four units. Other risk factors that have been proposed in the literature also include long intramedullary nail procedures, delays to surgery, and lower BMIs.²¹⁻²³

Given the poor outcomes associated with blood transfusions in hip fracture patients, it is crucial for surgeons to identify patients early who are at increased risk of needing a transfusion during their hospitalization. While the above risk factors are helpful, they lack specificity as many elderly hip fracture patients often exhibit several of these risk factors. A patient's STTGMA score is another datapoint that clinicians can use, in addition to any of the above risk factors, to identify patients at high risk of receiving a transfusion. When a high risk patient is identified, surgeons can consider various blood conservation strategies such as performing a less invasive procedure or administering an antifibrinolytic agent such as tranexamic acid perioperatively, which has been shown to decrease the risk of receiving transfusions in hip fracture patients.²⁴ Furthermore, when a high risk patient is identified, surgeons may want to consider raising their preoperative Hgb transfusion threshold in an effort to avoid severe post-operative anemia. Since STTGMA scores are available when a patient is first evaluated in the ED, treating physicians can start planning these strategies at the very beginning of the patient's admission.

This study has several limitations. First, it is limited by its retrospective design. While STTGMA's ability to predict the need for transfusion on a retrospective basis is encouraging, a study evaluating its ability to prospectively predict the need for transfusion would provide stronger evidence for the model's clinical utility. Second, the study was conducted within one academic medical center in a major urban city, so its results may not be generalizable to more rural or community-based clinical settings. Lastly, it is possible that treating clinicians may have deviated from hospital transfusion protocol in certain cases and thus introduced heterogeneity into when patients were transfused.

In conclusion, we showed the STTGMA tool is able to accurately triage which hip fracture patients are more likely to receive a pRBC blood transfusion during their admission. After calculating a patient's STTGMA score at the start of the admission, clinicians can utilize risk groups similar to the ones used in our study to assess a patient's risk of receiving a transfusion during the hospitalization. When a patient is identified as high risk, the clinician can

consider utilizing blood conservation strategies in an effort to minimize the need for transfusion.

Declaration of conflicting interests

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