

Ability of a Risk Prediction Tool to Stratify Quality and Cost for Older Patients With Operative Distal Radius Fractures

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Abstract

Introduction: Distal radius fractures are the second most common fracture in the elderly population. The incidence of these fractures has increased over time, and is projected to continue to do so. The aim of this study is to utilize a validated trauma risk prediction tool to stratify middle-aged and geriatric patients with operative distal radius fractures as well as compare hospital quality metrics and inpatient hospitalization costs among the risk groups. **Materials and Methods:** Patients were prospectively enrolled in an orthopedic trauma registry. The Score for Trauma Triage in Geriatric and Middle Aged (STTGMA) was calculated using patient demographics, injury severity, and functional status. Patients were then stratified into minimal-risk, moderate-risk, and high-risk cohorts based on their scores. Length of stay, need for escalation of care, complications, mortality, discharge location, 1-year patient reported outcomes, and index admission costs were evaluated. **Results:** Ninety-two patients met inclusion criteria. Sixty-three (68.5%) patients were managed with outpatient surgery. The mean inpatient length of stay for the high-risk cohort was 2.9x and 2.2x higher than the minimal and moderate-risk cohorts, respectively (2.0 + 2.9 days vs. 0.7 + 0.9 and 0.9 + 1.1 days, $P = .019$). There were no complications or mortality in any of the risk groups. No patients required intensive care and all patients were discharged home. There was no difference in readmission rates, inpatient cost, or 1-year patient reported outcomes among the risk cohorts. **Discussion/Conclusions:** The Score for Trauma Triage in Geriatric and Middle-Aged is able to risk-stratify patients that undergo operative intervention of distal radius fractures. Middle aged and elderly patients with isolated closed distal radius fractures can be safely managed on an outpatient basis regardless of risk. Standardized pathways can be created in the management of these injuries, thereby optimizing value-based care. **Level of evidence:** Prognostic Level III

Keywords

distal radius fractures, risk stratification, triage, geriatric, hospital quality measures

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Introduction

Distal radius fractures are the second most common fracture in the elderly population, accounting for 18% of all fractures in patients over 65 years old.¹⁻⁵ They are more common in women likely due to the increased incidence of osteoporosis, and most commonly occur after a low energy fall from standing height.^{1,3,4,6-8}

The incidence of distal radius fractures has increased over time,^{3,9,10} and it is predicted that it will continue to do so as people live longer, healthier, and more active lives.^{3,8,11} In elderly patients, distal radius fractures are commonly managed with closed reduction and casting; however, there has been an increasing trend of operative intervention with internal fixation over the

years.^{3,4,12} Management of this injury in the aging population leaves a substantial financial footprint on the healthcare system.^{3,11-16} In 2007 for example, Medicare made \$170 million worth of payments in distal radius fracture-related cases.^{12,14}

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Given the predicted exponential growth of the elderly population in the coming decades, the high incidence of distal radius fractures as well as the increasing trend of operative intervention in this population, the economic impact of these injuries is expected to grow substantially.

The transition to bundled payment models in lieu of fee-for-service models in the field of orthopedic trauma surgery has led to the necessity of cost optimization strategies in order to provide value-based care. Outcome-driven stratification of patients can assist providers in achieving this goal. Studies have assessed the outcomes and costs of distal radius fracture management relative to the type of operative intervention, implants, facility, and post-injury management.¹⁷⁻²³ However, there is a paucity of literature that risk stratifies patients and evaluates outcomes and costs relative to risk group. Given that middle-aged and geriatric patients are more likely to have expensive hospitalizations owing to increased admissions, longer length of stays, and more complications,^{24,25} risk stratification on admission can aid physicians in counseling patients regarding outcomes and improve resource allocation.

The primary objectives of this study are to stratify middle-aged and geriatric patients with distal radius fractures that require operative intervention using a validated trauma risk prediction tool and compare hospital quality metrics and inpatient hospitalization costs among the risk groups.

Materials and Methods

Patients age 55 and older who presented to the emergency department of an urban, academic level I trauma center, a tertiary care academic medical center, and an orthopedic specialty hospital after sustaining a distal radius fracture (OTA 2R3-A/B/C) between October 2014 and August 2018 were queried from an IRB-approved retrospective geriatric database. Patients who subsequently underwent operative fixation during index hospitalization or up to 20 days post-injury, met inclusion criteria for this study. Information regarding emergency department (ED) presentation and subsequent hospitalization was captured in electronic medical records. Patients with concomitant peripheral or axial skeletal fractures were excluded. Upon arrival to the ED, index data such as patient age, race, and comorbidities were gathered. Patients were further assessed with the Glasgow Coma Scale (GCS) and Abbreviated Injury Severity (AIS) scores for the head and neck (AIS-HN), chest (AIS-C), and pelvis and extremity (AIS-EXT). The American Society of Anesthesiologist physical status classification system (ASA), Charlson Comorbidity Index (CCI), and ambulatory status were used to assess health and functional status prior to injury. Injury mechanism was also documented. Low-energy mechanisms of injury were defined as a fall from standing or a fall down less than 2 stairs. High-energy mechanisms of injury included falls from a height greater than 2 stairs, motor vehicle and motorcycle accidents, assault, and pedestrians struck by motor vehicles or motorcycles. These variables were then used to calculate the Score for Trauma Triage in the Geriatric and Middle Aged (STTGMA) for each patient, representing their

risk of inpatient mortality on a scale of 0-100%.²⁶ We then stratified patients into tertiles based on their risk profiles: minimal risk ($\leq 0.08\%$), moderate risk (0.081-0.12%), and high risk ($>0.13\%$).

During index hospitalization, information regarding mortality, complication rates, length of stay (LOS), need for intensive care unit (ICU) and step-down unit (SDU)-level care, and discharge location was gathered. Complications assessed were divided into major and minor categories. Minor complications included acute renal failure, surgical site infections, decubitus ulcers, urinary tract infections, and acute anemia. Major complications included sepsis, pneumonia, acute respiratory failure, acute myocardial infarction, deep vein thrombosis, pulmonary embolism, cardiac arrest, stroke, and inpatient mortality. Thirty and 90-day readmission and mortality within 30 days of discharge were evaluated. Direct variable cost data was obtained from the hospital finance department and subdivided into room/board, ED, pharmacy, laboratory/pathology, radiology, dialysis, cardiology, procedure, allied health costs, and others (e.g. blood products). Patients were prospectively followed up to 1 year or greater, at which time their functional outcomes were collected using the EQ-5D-3 L questionnaire. All data was collected via phone interviews using phone numbers collected on index presentation. The EQ-5D-3 L index score consists of 5 dimensions, rated from 1 to 3, for mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Higher EQ 5-D index scores denote better function. EQ-5D indices were calculated using the Crosswalk Index Value Calculator provided by the EQ-5D website. (Euroqol.org; Rotterdam, Netherlands).

Analysis of variance (ANOVA) and chi-squared tests were utilized to determine differences between the risk groups with $P < .05$ considered significant. Statistical analyses were conducted with SPSS software. (Version 24; Chicago, IL).

Results

Of the 544 consecutive patients who sustained an isolated, unilateral distal radius fracture, 92 (16.9%) patients underwent operative fixation and were included in the analysis. Thirty-one (33.7%) patients were determined to be minimal risk, 31 (33.7%) were moderate risk, and 30 (32.6%) were high risk. The mean patient age was 67.1 years old \pm 7.9 years (Table 1). Eighty-two (89.1%) patients experienced low-energy injuries and 10 (10.9%) experienced high-energy injuries. Sixty-three (68.5%) patients were managed with outpatient surgery and 29 (31.5%) were managed with surgery during the index admission. Of the 29 patients that had inpatient surgeries, 16 (55.2%) of the admissions were due to patient preference for early management, 12 (41.4%) were due to open fractures, and 1 (3.4%) was due to the patient being admitted to a non-orthopedic service for management (Table 2). The mean GCS of the entire cohort was 14.99 \pm 0.1. The mean AIS scores were: 0.09 \pm 0.35 for AIS-HN, 0.01 \pm 0.1 for AIS-C, and 3.1 \pm 0.3 for AIS-EXT. The mean CCI was 0.35 \pm 0.72 with 76% of patients, including all of the minimal-risk cohort, having a CCI of 0. The mean ASA

Table 1. Baseline Characteristics of Patients.

	Minimal risk (n = 31)	Moderate risk (n = 31)	High risk (n = 30)	P
Age (y) (mean ± SD)	60.9 ± 3.6	70.5 ± 6.1	70.1 ± 9.0	<.001
Female Sex (N, %)	26 (83.9%)	29 (93.5%)	22 (77.3%)	.102
GCS (mean ± SD)	15.0 ± 0.0	15.0 ± 0.0	14.97 ± 0.2	.360
AIS-HN (mean ± SD)	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.6	.002
AIS-C (mean ± SD)	0.0 ± 0.0	0.03 ± 0.2	0.0 ± 0.0	.378
AIS-EXT (mean ± SD)	3.1 ± 0.3	3.0 ± 0.2	3.2 ± 0.4	.066
CCI (mean ± SD)	0.0 ± 0.0	0.1 ± 0.3	0.9 ± 1.0	<.001
STTGMA (%) (mean ± SD)	0.07 ± 0.0	0.1 ± 0.0	0.3 ± 0.1	<.001
ASA Score	1.8 ± 0.5	2.1 ± 0.6	2.3 ± 0.6	.005

GCS = Glasgow Coma Scale (GCS); AIS-HN = Abbreviated Injury Severity scores for the head and neck; AIS-C = Abbreviated Injury Severity scores for the chest; AIS-EXT = Abbreviated Injury Severity scores for the pelvis and extremity; ASA = The American Society of Anesthesiologist physical status classification system; CCI = Charlson Comorbidity Index.

Bolded *p* values are statistically significant.

Table 2. Injury Characteristics.

Characteristic	Number	Percent
Total	92	100
OTA Classification		
2R3 A	1	1.1
2R3 B	12	13
2R3 C	79	85.9
Fracture Type		
Open	12	13
Closed	80	87
Energy Mechanism		
High	10	10.9
Low	82	89.1
Treatment Location		
Inpatient	29	31.5
Outpatient	63	68.5

score was 2.1 ± 0.61 . All patients were community ambulators. Patients in the high-risk cohort had higher AIS-HN, ASA, and CCI scores (Table 1).

The mean LOS for the entire cohort was 1.2 ± 1.9 days, with the high-risk group having a 2-fold increase in duration of stay compared to the moderate and minimal risk groups. Patients in the minimal risk cohort had a mean LOS of $0.9 + 1.1$ days compared with $0.7 + 0.9$ in the moderate risk group, and $2.0 + 2.9$ in the high-risk cohort ($P = .019$). No patients in any risk group required ICU/SDU level care. Additionally, no patients experienced any minor or major inpatient complications, nor was there any inpatient mortality. All patients were discharged home, without requiring admission to a skilled nursing facility or subacute rehabilitation center. There was no difference between the groups in regard to 30 or 90-day readmissions. One-year patient reported outcomes could only be obtained for one third of the patients (9 in the minimal risk, 13 in moderate risk, and 9 in high risk cohorts). No difference between the EQ-5D indices across the groups was noted ($P = .809$) (Table 3).

Cost data was available for 34 patients (36.9%) and extrapolated to fit the total patient population. Of the 34 patients, 23 patients were admitted from the ED and underwent surgery during inpatient admission, whereas 11 patients were managed with outpatient surgery. The mean total inpatient admission costs for the high-risk cohort was \$3000 higher than the minimal and moderate risk cohorts; however, this difference did not reach statistical significance (minimal-risk $\$14,225 \pm \$2,637$, moderate-risk $\$15,183 \pm 3,245$, and high-risk $\$17,483 \pm 9,981$, $P = .501$). Cost subdivision analysis including room and board, pharmacy, laboratory and pathology, and radiology and cardiology costs did not reveal any differences among groups (Table 4).

Discussion

This study demonstrates the capacity of a trauma triage score to risk stratify elderly and middle-aged patients, as well as evaluate the relationship between risk cohorts and patient demographics, hospital quality measures and costs. Patients in the high-risk cohort were found to have longer length of stays. Although the hospitalization costs for the high-risk cohort were higher, the differences were not statistically significant.

STTGMA

At its inception, the STTGMA was intended to predict inpatient mortality risk.^{26,27} This risk assessment tool considers various patient factors, such as age, medical comorbidities, and injury severity, that have been shown to affect outcomes in the middle-aged and geriatric populations.²⁶⁻³⁰ Its use as a tool for prompt triage analysis of patients evaluated in the emergency room has been validated by the National Trauma Databank as well as prospectively at our Level I Trauma center.^{26,27,31,32} The risk stratification provided by this score can aid provider decision making in order to personalize care for patients prior to admission.

The STTGMA has also been used in the evaluation of hospital quality metrics, inpatient costs, and patient outcomes.^{31,33}

Table 3. Hospital Quality Metrics Across Tertiles.

	Minimal risk (n = 31)	Moderate risk (n = 31)	High risk (n = 30)	P-Value
Admitted to the hospital (N, %)	10 (32.3%)	7 (22.6%)	15 (50%)	.075
Length of Stay (days)	0.9 + 1.1	0.7 + 0.9	2.0 + 2.9	.019
Discharge destination other than home	0	0	0	–
Inpatient Complications	0	0	0	–
Inpatient Mortality	0	0	0	–
30-day Mortality	0	0	0	–
30-Day Readmission (N, %)	12 (38.7%)	15 (48.4%)	12 (40%)	.705
90-Day Readmission (N, %)	11 (35.5%)	13 (41.9%)	7 (23.3%)	.297
EQ-5D Score	0.86 + 0.20	0.90 + 0.10	0.88 + 0.09	.809

Bolded *p* values are statistically significant.

Table 4. Index Admission Costs of Care of the Minimal, Moderate, and High-Risk Cohorts.

	Minimal risk (n = 10)	Moderate risk (n = 9)	High risk (n = 15)	P
Total (\$) (mean ± SD)	14,225 ± 2,637	15,183 ± 3,245	17,483 ± 9,981	.501
Room/Board (\$) (mean ± SD)	2,022 ± 1,469	1,718 ± 1,267	2,896 ± 2,977	.415
ED (\$) (mean ± SD)	584 ± 443	646 ± 399	732 ± 515	.735
Pharm (\$) (mean ± SD)	165 ± 97	294 ± 250	343 ± 322	.244
Lab/Path (\$) (mean ± SD)	106 ± 55	100 ± 73	158 ± 119	.238
Radiology (\$) (mean ± SD)	1,076 ± 280	1,464 ± 188	1,530 ± 797	.142
Dialysis (\$) (mean ± SD)	0 ± 0	0 ± 0	0 ± 0	–
Cardio (\$) (mean ± SD)	61 ± 91	37 ± 35	90 ± 134	.481
Procedures (\$) (mean ± SD)	9,313 ± 2,359	10,202 ± 3,363	11,057 ± 6,356	.671
Allied Health (\$) (mean ± SD)	72 ± 88	58 ± 75	160 ± 445	.669
Other (\$) (mean ± SD)	826 ± 465	666 ± 285	518 ± 219	.081

For example, among middle-aged and elderly patients with ankle fractures, those identified as high risk were more likely to need an escalated level of inpatient care, had more complications, readmissions, and longer more expensive hospitalizations. They were also more likely to be discharged to rehab facilities or nursing homes.^{34,35} Similar findings have been noted in patients with tibial plateau and tibial shaft fractures.³⁶

Distal Radius Fractures

Distal radius fractures are common in the middle-aged and elderly population. The incidence of this injury has increased over time and is predicted to continue to rise with the exponential growth of the elderly population.^{3,9-11}

Patient outcomes. Patient healthcare resource utilization and outcomes after injuries like distal radius fractures can be predicted by patient factors such as frailty.^{27,29,37-40} Frailty can be inferred from the STTGMA due to its inclusion of pre-hospitalization ambulatory status and the Charlson Comorbidity Index; which has been shown to be comparable to the modified frailty index (mFI), a 5-item score based on patient comorbidities, in predicting mortality in surgical patients.³⁸ Wilson et al use the mFI, to evaluate the impact of frailty on outcomes in patients over age 50 that underwent operative management of distal radius fractures.³⁷ Patients with mFI

scores 2 were more likely to have postoperative complications, increased length of stay and readmission rates, and less likely to be discharged home. Notably, age alone was not predictive of these outcomes.³⁷ These results are consistent with our finding of the high-risk cohort having a longer length of stay compared to the minimal and moderate risk cohorts. Though the mean length of stay was less than 2 days in both our study and the Wilson et al study, other studies have demonstrated inpatient hospitalizations of up to 9 days after operative management of distal radius fractures in this population.^{41,42} Prolonged hospitalization is often attributable to a lack of appropriate home care.⁴¹

Additionally, although patients are more likely able to be discharged home both after initial injury and definitive management, these injuries still significantly alter patient quality of life.^{12,14,20,42} In this study, patient reported outcome scores were high, with no significant differences noted between the risk cohorts. It is probable that most patients had returned to near-baseline function given that distal radius fractures are typically healed by 1 year. However, in the initial injury and postoperative period, patients often experience a loss of independence as they struggle to perform activities of daily living, with more pronounced limitations in the elderly population.^{12,14,20} Though not observed in our sample size, these patients at times require admission to rehabilitation facilities.⁴³ Risks include age greater than or equal to 80, multiple

fractures, living in a private home prior to admission, and operative intervention.⁴³ Risk stratification assists in identifying patients that would benefit from preemptive planning of discharge disposition, including the provision of home health services, at the time of admission, therefore shortening length of stay and optimizing costs.

Prior studies evaluating patient risk stratification with the STTGMA have identified minimal risk groups as having scores <0.6% and <0.45% for ankle and tibia fractures respectively. In this study, the high-risk group included patients with scores >0.13%. Therefore, most of the patients in this study can likely be deemed minimal risk despite increased age, AIS, CCI, and ASA scores. Taken with the high percentage of outpatient surgeries, in addition to patient preference as the reason for the majority of admissions for inpatient surgery noted in this study, the data suggests that isolated closed distal radius fractures in middle aged and elderly patients can be safely managed on an outpatient basis, even in higher risk patients, depending on the presence of concomitant visceral organ or head injuries. It should also be noted that patient preference for inpatient admission is possibly due to social factors (e.g. lack of social and physical support at home) and that the admissions and length of stay recorded in this study likely reflect social factors that are prevalent in similar demographic patient populations in urban centers.

Health care costs. Although a significant difference in costs between risk groups was not demonstrated in this study, distal radius fractures still confer significant costs to the healthcare system.³

The increasing rate of operative intervention alone may result in Medicare spending up to \$240 million annually in the future.^{3,4,12,14,44-46} The lack of standardized care, for example with protocolized outpatient follow-up, likely contributes to costs.¹⁶ Shah et al conducted a study that evaluated physical and occupational therapy utilization after common hand procedures, including operative management of distal radius fractures, over a 7-year period.¹⁷ They observed substantial geographical variation in utilization rates and an increase in the use of these services over time.¹⁷ Standardizing postoperative care would reduce unwarranted clinic visits and other services, ultimately optimizing costs. Giladi et al demonstrate improved outcomes with significantly less total direct costs when appropriate care was provided for distal radius fractures according to the American Academy of Orthopaedic Surgeons Clinical Practice Guidelines.⁴⁷ Implant selection can also be considered, as they are another cost driver that the operating surgeon can control.²³ Additionally, these surgeries should be performed at ambulatory surgical facilities when possible, as they have been shown to have lower mean operative costs per case compared to inpatient facilities.²¹

The field of orthopedic trauma surgery is not immune to the increasing popularity of a fixed payment per episode care model. Healthcare costs for musculoskeletal care in patients 65 years old nearly doubled from 1996 to 2011, while reimbursements for orthopedic procedures have decreased.^{48,49}

Therefore, the importance of value-based care initiatives in this climate cannot be overstated. In addition to efforts to prevent these injuries, as well as standardization of care through pathways created to eliminate waste; the identification of high resource utilization patients, such as with the risk stratification offered by the STTGMA, is pivotal.

Limitations/Future Directions

This study has limitations. Despite the observation of patients over a 4-year period, the sample size was small, likely due to the fact that nonoperative management remains the most common management of these injuries in this population. Also, we did not evaluate the complications managed in the outpatient setting, therefore the lack of complications observed in this study is not reflective of patient outcomes in the general population. Lastly, the 1-year patient reported outcomes and cost data could only be obtained for one third of the sample size. The former is due to patients being lost to follow up. This is likely owing to the fact that patients with these injuries are typically considered healed within 3 to 6 months of surgery, which would give them less incentive to follow up. The latter is due to administrative restrictions preventing the procurement of financial data from the tertiary care academic hospital. Given that more patients had inpatient surgery in the group for which cost data was attained compared to the total cohort it is possible that the cost analysis is not representative of the general population. A multi-center study evaluating these outcomes would likely have an increased sample size and provide further insight on this topic.

Conclusion

The Score for Trauma Triage in Geriatric and Middle-Aged is able to risk-stratify patients that undergo operative intervention of distal radius fractures. Middle aged and elderly patients with isolated closed distal radius fractures can be safely managed on an outpatient basis regardless of risk grouping, but safe outpatient management depends on the presence of concomitant visceral organ or head injuries that may require inpatient hospitalization. Standardized pathways can be created in the management of these injuries to optimize value-based care.

Declaration of Conflicting Interests

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