Octogenarian and Nonagenarians Are at a Higher Risk for Experiencing Adverse 30-Day Outcomes Following ORIF of Ankle Fractures

Mitchell T. Gray, BS1, Krystin A. Hidden, MD2, Azeem T. Malik, MBBS2, Safdar N. Khan, MD2, Laura Phieffer, MD2, Thuan V. Ly, MD2, and Carmen E. Quatman, MD, PhD2

Abstract
Introduction: Despite an increasing number of elderly individuals undergoing surgical fixation for ankle fractures, few studies have investigated peri-operative outcomes and safety of surgery in an octogenarian and nonagenarian population (age >80 years).

Materials and Methods: The 2012-2017 American College of Surgeons database was queried for patients undergoing open reduction internal fixation for isolated uni-malleolar, bi-malleolar and tri-malleolar ankle fractures. The study cohort was divided into 3 comparison groups (age <65 years, 65-75 and >80). Multi-variate regression analyzes were used to compare the independent effect of varying age groups on 30-day post-operative outcomes while controlling for baseline clinical characteristics and co-morbidity burdens.

Results: A total of 19,585 patients were included: 5.3% were >80 years, 18.1% were 65-79 years, and 76.6% were <65 years. When compared to the non-geriatric population, individuals >80 years were at a significantly higher risk of 30-day wound complications (OR 1.84; p = 0.019), pulmonary complications (OR 3.88; p < 0.001), renal complications (OR 1.96; p = 0.015), septic complications (OR 3.72; p = 0.002), urinary tract infections (OR 2.24; p < 0.001), bleeding requiring transfusion (OR 1.90; p = 0.025), mortality (OR 7.44; p < 0.001), readmissions (OR 1.65; p = 0.004) and non-home discharge (OR 13.91; p < 0.001).

Discussion: Octogenarians undergoing ankle fracture fixation are a high-risk population in need of significant pre-operative surgical and medical optimization. With the majority of patients undergoing non-elective ORIF procedures, it is critical to anticipate potential complications and incorporate experienced geriatric providers early in the surgical management of these patients.

Conclusions: Octogenarians and nonagenarians are fundamentally distinct and vulnerable age groups with a high risk of complications, readmissions, mortality and non-home discharges compared to other geriatric (65-79 years) and non-geriatric (<65 years) patients. Pre-operative counseling and risk-stratification are essential in this vulnerable patient population.

Keywords
geriatric trauma, octogenarian, ankle fracture, surgical outcomes, nonagenarian

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Introduction
Ankle fractures are the third most common orthopedic injury sustained in the elderly, behind hip and distal radius fractures, thus contributing to a significant economic burden in the geriatric population.1,2 A large percentage of these fractures are the sequelae of falls, which lead to many non-elective surgical procedures.3 Despite an increasing number of elderly individuals undergoing open reduction and internal fixation (ORIF) of ankle fractures, few studies have investigated peri-operative

1 Indiana University School of Medicine, Indianapolis, IN, USA
2 Department of Orthopedics, The Ohio State University Wexner Medical Center, Columbus, OH, USA

Corresponding Author:
Carmen E. Quatman, Division of Orthopaedic Trauma, Department of Orthopaedics, The Ohio State University Wexner Medical Center, Columbus, OH 43210, USA.
Email: carmen.quatman@osumc.edu

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outcomes and safety of surgery in an octogenarian and nonagenarian population (age ≥ 80 years). Past literature has shown octogenarians to be a more vulnerable population, with greater rates of adverse outcomes and higher resource utilization across a variety of orthopedic procedures as compared to individuals < 80 years.4,5

Octogenarian and nonagenarian patients require careful surgical consideration due to increased mortality risk and short-term surgical complications.5-7 Age ≥ 80 has been documented as a risk factor for poor surgical outcomes following primary knee arthroplasty and total hip arthroplasty.8,9 In ankle-specific studies, risk factors for poor outcomes in geriatric populations include pre-existing diabetes, obesity,10 nursing home discharge,11 operative time12 and weight bearing restrictions.13 Limited studies summarize the risks and outcomes for ankle fractures in the octogenarian and nonagenarian populations. Thus, this study aims to define these risks associated with co-morbidity burden, dependency status, discharge disposition, as well as to identify adverse outcomes following ORIF of ankle fractures in the octogenarians compared to a non-geriatric patient population.

Patients and Methods
This was a retrospective cohort study carried out using prospectively collected data from the American College of Surgeons—National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP is a comprehensive surgical outcomes database, that contains surgical data from over 600 hospitals across the United States. The data are recorded and stored in the database using a strict and regular audit process conducted by trained clinical reviewers. The specifics of data collection, risk adjustment, and accuracy measures have been outlined.14 The 2012-2017 ACS-NSQIP database was queried using Current Procedural Terminology codes for patients undergoing open reduction internal fixation (ORIF) for isolated uni-malleolar (CPT-27766, CPT-27769, CPT-27792), bi-malleolar (CPT-27814) and tri-malleolar (CPT-27822,CPT-27823) ankle fractures. Polytrauma patients with concomitant lower extremity injuries were excluded.

The study cohort was divided into 3 distinct groups for comparisons (age < 65 years, age 65-79 years and age ≥ 80 years/octogenarians + nonagenarians). Screening for thirty-day complications included superficial and deep wound infections, pulmonary compromise, cardiac complications, thromboembolic events, sepsis, renal insufficiency, urinary tract infections, blood transfusions, mortality rate, re-operations, re-admissions and non-home discharges. Pearson-Chi square tests were used to assess for significant differences in baseline demographics and procedural characteristics between the 3 age groups. Multi-variate logistic regression analyzes were used to assess for the impact of increasing age group on 30-day outcomes while controlling for baseline demographics and procedural characteristics (age, gender, sex, race, fracture type/severity, open vs. closed fracture, admission status, BMI, co-morbidities, functional health status, ASA group and operative time). For analytical purposes, age < 65 years was utilized as the reference group. Results from regression models have been reported as adjusted odds ratio (OR) with their 95% confidence intervals and p-values. A p-value < 0.05 was considered significant. All statistical analyzes were performed using SPSSv24 (IBM, Armonk, NY).

### Table 1. Baseline Demographics and Comorbidity Comparison of the Study Population Divided into 3 Age Ranges.

| Demographics | (% <65 years) | (% 65-79 years) | (% ≥80 years) | P-value |
|--------------|---------------|-----------------|---------------|---------|
| Gender       |               |                 |               |         |
| Female       | 55.3          | 71.8            | 78.4          | <0.001  |
| Male         | 44.7          | 28.2            | 21.6          |         |
| Race         |               |                 |               |         |
| White        | 63.5          | 75.3            | 77.5          | <0.001  |
| Black or African-American | 11.8  | 5.9            | 4.5           |         |
| Other        | 3.7           | 1.9             | 2.1           |         |
| Unknown      | 21            | 16.9            | 15.9          |         |
| BMI          |               |                 |               |         |
| <25.0        | 20.1          | 16.7            | 26.5          | <0.001  |
| 25.0-29.9    | 33.1          | 34.7            | 36.7          |         |
| 30.0-34.9    | 23.9          | 27.3            | 22.1          |         |
| ≥35.0        | 22.8          | 21.3            | 14.7          |         |
| Functional health status |             |                 |               |         |
| Independent  | 97.1          | 94.1            | 85.4          | <0.001  |
| Dependent    | 1.6           | 4.9             | 13.3          |         |
| Unknown      | 1.3           | 1               | 14.4          |         |
| Diabetes Mellitus |         |                 |               |         |
| Insulin-Dependent | 3.3  | 11.6           | 9.4           | <0.001  |
| Non-insulin-dependent | 96.7 | 88.4           | 90.6          |         |
| Pre-operative systemic sepsis |           |                 |               |         |
| Sepsis       | 0.1           | 0.1             | 0.3           | <0.001  |
| Septic shock | 2.2           | 3.1             | 4.7           |         |
| Smoking      | 29.8          | 10.4            | 3.2           | <0.001  |
| Dyspnea      | 1.9           | 6               | 7.7           | <0.001  |
| Pre-operative ventilator dependence |     |                 |               |         |
| <0.1         | 0.1           | 0.1             | 0.082         |         |
| Pre-operative infection |         |                 |               |         |
| COPD         | 1.9           | 7.8             | 8.8           | <0.001  |
| Acute renal failure | 0.1  | 0.5             | 0.7           | <0.001  |
| Dialysis     | 0.5           | 1.2             | 1.5           | <0.001  |
| Disseminated Cancer | 0.2  | 0.6             | 0.9           | <0.001  |
| Open wound/ fracture | 2    | 3.5             | 7.7           | <0.001  |
| Chronic steroid use | 1.3  | 3.5             | 3.7           | <0.001  |
| Weight loss <10% body weight in last 6 months | <0.1 | 0.2             | 0.2           | <0.001  |
| Bleeding disorders | 1.6  | 7.1             | 12.4          | <0.001  |
| Pre-op transfusion | 0.2  | 0.9             | 1.5           | <0.001  |
Table 2. Operative and Procedural Factor Comparison of the Population Divided Into 3 Age Ranges.

| Operative factors | (%) <65 years (n = 15,008) | (%) 65-79 years (n = 3,544) | (%) ≥80 years (n = 1,033) | P-value |
|-------------------|-----------------------------|-----------------------------|--------------------------|---------|
| Location of surgery |                            |                             |                          |         |
| Inpatient         | 31.5                        | 56.9                        | 79                       |         |
| Outpatient        | 68.5                        | 43.1                        | 21                       |         |
| Type of fracture  |                             |                             |                          | <0.001* |
| Uni-malleolar     | 41.3                        | 24.8                        | 21.2                     |         |
| Bi-malleolar      | 34.4                        | 42.4                        | 52.1                     |         |
| Tri-malleolar     | 24.3                        | 32.8                        | 26.7                     |         |
| ASA Class >II     | 20                          | 52.7                        | 75.8                     | <0.001* |
| Total operative time >90 mins | 29.9 | 25.7 | 24.5 | <0.001* |

* Asterix indicates significance.

Table 3. Thirty-Day Outcomes Comparing the 3 Age Ranges Before Adjusting for Baseline Characteristics.

| 30-day outcomes | <65 years (%) | 65-79 years (%) | ≥80 years (%) | P-value |
|-----------------|---------------|-----------------|--------------|---------|
| Wound complications | 166 (1.1%)    | 53 (1.5%)       | 24 (2.3%)    | <0.001* |
| Pulmonary complications | 28 (0.2%)    | 41 (1.2%)       | 29 (2.8%)    | <0.001* |
| Thromboembolic complications | 69 (0.5%)    | 26 (0.7%)       | 4 (0.4%)     | 0.101   |
| Cardiac complications | 14 (0.1%)    | 9 (0.3%)        | 6 (0.6%)     | <0.001* |
| Renal complications | 6 (<0.1%)     | 9 (0.3%)        | 7 (0.7%)     | <0.001* |
| Septic complications | 27 (0.2%)    | 16 (0.5%)       | 14 (1.4%)    | <0.001* |
| Urinary tract infections | 49 (0.3%)  | 65 (1.8%)       | 40 (3.9%)    | <0.001* |
| Bleeding requiring transfusions | 46 (0.3%) | 46 (1.3%) | 32 (3.1%) | <0.001* |
| Mortality | 11 (0.1%) | 10 (0.3%) | 18 (1.7%) | <0.001* |
| Reoperations | 173 (1.2%) | 63 (1.8%) | 29 (2.8%) | <0.001* |
| Readmissions | 258 (1.7%) | 154 (4.3%) | 63 (6.1%) | <0.001* |
| Non-Home discharge | 816 (5.4%) | 1,087 (30.7%) | 710 (69.1%) | <0.001* |

* Asterix indicates significance.

Results

A total of 19,585 patients met inclusion criteria: 1,033 (5.3%) were octogenarians (≥80 years), 3,544 (18.1%) were ages 65-79 years, and 15,008 (76.6%) were non-geriatric (age <65 years). Significant differences among these groups were identified in all demographic categories (Table 1) as well as baseline operative/procedural factors (Table 2). Patients with an age ≥80 years were more likely white females with an overall greater comorbidity burden and ASA class when compared to younger patients. Additionally, octogenarian and nonagenarian patients underwent fixation more often in an inpatient setting.

Table 4. Thirty-Day Outcomes After Controlling for Baseline Demographics, Comparing the Adjusted OR for (Age ≥80 Years) and (Age 65-79 Years) With the (Age <65 years) Group.

| 30-day outcomes | Adjusted OR [95% CI] | P-value |
|-----------------|----------------------|---------|
| Wound complications | 1.84 [1.10-3.06] | 0.019* |
| Pulmonary complications | 1.15 [0.80-1.65] | 0.451 |
| Thromboembolic complications | 3.88 [1.99-7.56] | <0.001* |
| Cardiac complications | 2.30 [1.31-4.05] | 0.004 |
| Cardiac complications | 0.64 [0.22-1.92] | 0.431 |
| Cardiac complications | 1.34 [0.79-2.26] | 0.274 |
| Renal complications | 1.64 [0.52-5.21] | 0.398 |
| Renal complications | 0.92 [0.36-2.37] | 0.868 |
| Septic complications | 1.96 [0.59-6.44] | 0.015* |
| Septic complications | 5.28 [1.38-20.26] | 0.271 |
| Urinary tract infections | 3.72 [1.60-8.63] | 0.002* |
| Urinary tract infections | 1.36 [0.66-2.83] | 0.404 |
| Mortality | 2.24 [1.45-3.44] | <0.001* |
| Mortality | 3.55 [3.12-4.04] | <0.001* |
| Mortality | 2.30 [1.31-4.05] | 0.274 |
| Mortality | 1.34 [0.66-2.83] | 0.274 |
| Mortality | 2.30 [1.31-4.05] | 0.274 |
| Mortality | 1.34 [0.66-2.83] | 0.274 |
| Mortality | 2.30 [1.31-4.05] | 0.274 |
| Mortality | 1.34 [0.66-2.83] | 0.274 |

* Asterix indicates significance.

Unadjusted outcomes (Table 3) included significant associations between age ≥80 and wound, pulmonary, cardiac, renal and septic complications, as well as urinary tract infections and bleeding requiring transfusion. Additionally, unadjusted 30-day mortality, reoperations, readmissions and non-home discharges were all significantly associated with age ≥80.

Ensuring the effect of age on 30-day operative outcomes was independent of baseline characteristics and operative/procedural factors (Table 4), multivariate regression was used to compare patients ≥80 with those 65-79 years and <65 years.

Final adjusted analysis demonstrated that patients ≥80 years old were at a greater odds of 30-day mortality (OR: 7.44 [95% CI 2.66-20.83]; p ≤ 0.001), readmissions (OR: 1.65 [95% CI 1.18-2.31]; p = 0.004), non-home discharge (OR: 13.91 [95% CI 11.46-16.89]; p ≤ 0.001), pulmonary complications (OR: 3.88 [95% CI 1.99-7.56]; p ≤ 0.001), renal complications (OR:
1.96 [95% CI 0.59-6.44]; \( p = 0.015 \), septic complications (OR: 3.72 [95% CI 1.60-8.63]; \( p = 0.002 \)), urinary tract infections (OR: 3.06 [95% CI 1.81-5.16]; \( p \leq 0.001 \)) and bleeding requiring transfusion (OR: 1.90 [95% CI 1.08-3.34]; \( p = 0.025 \)). Figure 1 shows a representation of the odds ratios comparing patients \( \geq 80 \) years to patients <65 years.

Additionally, multivariate analysis was performed comparing patients age 65-79 to patients <65. This revealed a greater odds of readmission (OR: 1.41 [95% CI 1.11-1.79]; \( p = 0.005 \)), non-home discharge (OR: 3.55 [95% CI 3.12-4.04]; \( p \leq 0.001 \)) and urinary tract infections (OR: 2.24 [95% CI 1.45-3.44]; \( p \leq 0.001 \)).

**Discussion**

Operative fixation of unstable ankle fractures has become the accepted standard of care with predictably good surgical outcomes in both the geriatric and non-geriatric populations. However, octogenarian and nonagenarian patients are a special trauma cohort that requires appropriate attention to perioperative medical optimization. A multidisciplinary approach for post-operative recovery in order to minimize the higher rate of complications expected within this population is critical.15 This study uniquely identifies perioperative outcomes specific to ankle fractures in the octogenarian and nonagenarian populations.

Other studies investigating the outcomes following ORIF for ankle fracture in the geriatric population cautioned similar risk of morbidity and mortality. Gil et al. completed an ACS-NSQIP study comparing outcomes within the geriatric population but with a smaller cohort of patients.16 They identified that patients age \( \geq 80 \) when compared to patients 65-79 had higher rates of mortality, revision surgery, length of stay, and blood transfusions within a 30-day follow up period. However, when stratifying patients by ASA class, they found no significant differences between the same groups across all outcomes. Our study also demonstrated differences in ASA class between each age cohort, but after adjusting for baseline characteristics (including ASA class) our results showed greater odds of mortality for patients \( \geq 80 \) years compared to those <65 years. However, there was no difference in mortality comparing age <65 years to patients 65-79 years after adjusting for baseline characteristics. While our study didn’t compare the same age cohorts as Gil et al, we share similar cautionary evidence for ankle fracture ORIF in patients \( \geq 80 \) years with significant pre-operative comorbidity burden.

Octogenarians who undergo total hip arthroplasty (THA) are known to experience greater medical complications such as urinary tract infections, delirium, myocardial infarction, pneumonia and anemia.8,17 Kennedy et al. described a “snowballing” of complications in some patients \( \geq 80 \) years following THA, where multiple sequential adverse events can lead to rapid deterioration. Other studies of nonagenarian patients after hip fracture repair reported increased medical complications, greater risk of mortality (in-hospital through
2-year follow-up) and increased non-home discharges\(^{18}\). Eastern et al. demonstrated similar findings in total knee arthroplasty (TKA) for patients recorded in the NSQIP database. Their results indicated that age was an independent risk factor for adverse outcomes following TKA after controlling for comorbid conditions. When compared to non-geriatric patients, they found a significant increase in mortality in patients \(>85\) years as well as an increase in total complications starting at \(\geq 70\) years.\(^9\) Mortality, non-home discharge, bleeding, urinary tract infections and pneumonia are all increased following ankle fracture repair, which is comparable to other common orthopedic procedures.

Outpatient fixation of ankle fractures has been widely applied in the general population due to reduced cost and lower post-operative complication rate.\(^{19}\) Cost savings in outpatient isolated ankle fracture repair is substantial, with a 90-day cost reduction of $5788-$8943 compared to inpatient treatment.\(^{18,20}\) Patients also benefit from fewer readmissions and ED visits, as well as lower rates of pneumonia and acute renal failure. However, the application of outpatient fixation in the octogenarian population remains limited due to factors such as higher pre-operative comorbidity and greater fracture complexity. During our investigation, non-geriatric patients sustained 41.3% unimalleolar fractures compared to 21.2% in octogenarians, underscoring the greater complexity of fracture types in older populations. Octogenarians also experienced higher preoperative comorbidity burdens with 75.8% having an ASA \(\geq 2\) compared to 20% of non-geriatric patients. In our study, 21% of octogenarian patients underwent outpatient fixation while prior studies report figures as high as 29.5%. It is clear that many octogenarian patients are at high risk for complications, and outpatient surgery should be carefully considered given patients pre-operative risk factors.

Beyond the weaknesses common to retrospective studies, limitations of this study include those inherent to the NSQIP database. These include the inability to capture complications outside of the 30-day post-operative window, which could change the estimate of long-term operative success in this population. Additionally, due to the limiting eligibility criteria for NSQIP sites and differences in variable collection between hospitals, the data may not represent the same complication rates for smaller or more rural hospital systems. With more extensive pre-operative optimization necessary for older adults, delays in surgery could be a potential source of confounding. Future studies exploring outcomes beyond the 30-day timeframe as well as the economic burden of readmission in octogenarian patients are needed.

Our data show that octogenarians and nonagenarians (age \(\geq 80\)) are a fundamentally distinct and vulnerable age group that is at higher risk of complications, readmissions, mortality and non-home discharges compared to other geriatric (65-79 years) and non-geriatric (<65 years) patients. It is critical for providers to recognize and understand the importance of pre-operative counseling as well as risk-stratification in this vulnerable patient population.

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**ORCID iD**

Mitchell T. Gray, BS, https://orcid.org/0000-0003-4010-0500

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