Injury, Int. J. Care Injured 50 (2019) 2116–2122

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Comparison of risk factors for postoperative complications across age groups in patients undergoing ORIF of the ankle

Haley M. McKissack, Gean C. Viner, Aaradhana J. Jha, John T. Wilson, Matthew C. Anderson, Gerald McGwin Jr., Ashish B. Shah*

Division of Orthopaedic Surgery, Department of Surgery, University of Alabama, Birmingham, School of Medicine, 1313 13th Street South, Suite 226, Birmingham, Alabama, 35205, USA

ARTICLE INFO

Keywords:
Ankle fractures
Adverse outcomes
Risk factors
Age

ABSTRACT

Introduction: Risk factors associated with various adverse outcomes for patients undergoing open reduction and internal fixation (ORIF) of the ankle, and how these risks differ between younger and older patient populations, has not been clearly established. Objective quantitative data may aid physicians in surgical decision making, individualizing postoperative management, and targeting interventions for reducing postoperative comorbidity. The purpose of this study is to compare the incidence of and risk factors for adverse postoperative outcomes following ORIF of ankle fractures across patient age groups.
Materials and methods: Charts of patients age 18 years and older who underwent open reduction and internal fixation (ORIF) for any closed, non-polytraumatic, non-pilon ankle fracture at a single institution between the years 2008 and 2018 were reviewed. Demographic information, comorbidities, and postoperative outcomes were collected. Relative risks for adverse outcomes were calculated and compared between patients younger than 50 and patients 50 years and older.
Results: A total of 886 patients were included, 375 (42.3%) of which were over age 50. In both age groups, risk of infection was significantly increased among patients with hypertension, although risk among older patients (RR = 3.52, p = 0.004) was greater than that among younger patients (RR = 2.46, p = 0.017). In patients younger than 50, significant risk of wound dehiscence was associated with tobacco use (RR = 3.39, p = 0.022), substance use (RR = 3.07, p = 0.020), and CHF (RR = 12.77, p < 0.001). Risk of implant failure was significantly increased among younger patients with HIV (RR = 4.33, p = 0.026), CHF (RR = 10.54, p < 0.001), and CKD (RR = 10.54, p < 0.001), and among older patients with HTN (RR = 4.51, p = 0.006), CHF (RR = 5.83, p < 0.001), and tobacco use (RR = 3.82, P = 0.001).
Conclusion: Patients undergoing ORIF of the ankle should be well-informed of the potential risks of surgery as they pertain to specific comorbidities. Multidisciplinary approaches are warranted for appropriate management of patients with multiple comorbidities.

Introduction

Ankle fractures are among the most common osseous orthopaedic injuries with studies showing an incidence of 122–184 per 100,000 patients [1–3]. Open reduction and internal fixation (ORIF) is the mainstay of treatment for the nonelderly population and is still employed commonly in the elderly population on a case by case basis [4]. Some studies have shown that age itself is a significant risk factor for major complication after ORIF of fractures [3]. Others have primarily assessed risk factors for postoperative complications among elderly patients, with minimum patient ages ranging from 60 to 80 years old [5,6].

It is important to take into account that the incidence of specific comorbidities varies across age ranges, and may impact patient health and recovery differently as physiology changes with increasing age. For example, among the geriatric population in particular, dementia, smoking, peripheral vascular disease, and diabetes have been cited as sources of wound complications [7]. For the general population, the literature has cited various factors as risks for postoperative complications after ankle fractures; impaired wound healing, infection, and malunion have been cited as common complications [8], while diabetes, obesity, and smoking have all been cited as general predictors of complications, regardless of patient age [9].

* Corresponding author.
E-mail addresses: hmckissack@uabmc.edu (H.M. McKissack), gviner@uabmc.edu (G.C. Viner), ajha@uabmc.edu (A.J. Jha), jwilson4@uab.edu (J.T. Wilson), mca18@uab.edu (M.C. Anderson), gmcgwin@uabmc.edu (G. McGwin), ashishshah@uabmc.edu (A.B. Shah).

https://doi.org/10.1016/j.injury.2019.09.014
0020-1383/

Quantified associated risks of specific variables and outcomes, and how these risks differ between younger and older patient populations has not been clearly established. While it is important to understand possible risk factors associated with adverse outcomes in the geriatric population, clinical care must be optimized for all patients. Identification of at-risk patients may aid physicians in surgical decision making, individualizing postoperative management, and targeting interventions for reducing postoperative comorbidity. As such, a fundamental understanding of the risk factors associated with adverse outcomes as they pertain to patient age is necessary. The purpose of this study is to compare the incidence of and risk factors for adverse postoperative outcomes across different patient age groups.

Methods

Data collection

A retrospective chart review of patients age 18 years and older who underwent open reduction and internal fixation (ORIF) for a medial malleolar, lateral malleolar, posterior malleolar, bimalleolar, or trimalleolar ankle fracture at a single institution between 2008 and 2018 was conducted. Patients were selected using Current Procedural Terminology (CPT) codes 27766, 27769, 27784, 27792, 27814, 27822, and 27829. Patients with polytraumatic injuries, open fractures, and pilon fractures were excluded.

Patient demographics, comorbidities, and postoperative complications were collected. Incidence of complications was compared between patients younger than 50 years old and patients age 50 and older. Secondary analysis compared incidence of complications across four age groups: 18–25, 26–49, 50–74, and greater than or equal to 75 years of age.

Risk factors for adverse postoperative outcomes were then compared between patients age 18–49 years and patients age 50 years and older. Comorbid conditions assessed as risk factors included HIV status, diabetes mellitus (DM), peripheral neuropathy, hypertension (HTN), chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), chronic kidney disease (CKD), and “other pulmonary disorders” (hyperactive airway disease, asthma, history of pulmonary embolism, obstructive sleep apnea, bronchitis, or pulmonary hypertension, as documented in the patient note). Immunosuppressive drug use, tobacco use, alcohol use, and substance abuse were also assessed.

Clinical outcomes were evaluated during follow-up visits at 2 weeks, 6 weeks, 3 months, 6 months, and 12 months. Absence of tenderness to palpation at the fracture site and ability to fully bear weight through the affected extremity defined union clinically. Radiographic union was defined as continuity of at least three cortices in two radiographic views and the presence of trabeculae traversing through the fracture line. Radiographs were independently evaluated by a fellowship-trained foot and ankle surgeon who was not otherwise involved in clinical care, surgical management, or data collection.

Operative and postoperative care

All operations were performed by foot and ankle fellowship-trained orthopaedic surgeons. Postoperatively, patients were splinted and instructed to be non-weight bearing for six to eight weeks. At the 6–8 week timeframe, patients were allowed to weight bear with the use of a walking boot as tolerated. Non-weight bearing status was extended for an additional 2–6 weeks if clinical or radiographic union was determined to be delayed by the surgeon. A standardized 12-week non-weight bearing protocol was established for all diabetic patients.

Statistical analysis

Relative risks for adverse outcomes were calculated and compared between the two patient age groups. SAS software (SAS Institute, Cary, NC) was used to perform all statistical analyses. When appropriate, analysis of variances (ANOVA), chi-square, and Fischer's exact test were used. Cochran-Mantel-Haenszel tests were used for risk assessment to adjust for confounding variables. Statistical significance was set at $p < 0.05$.

Results

A total of 1654 patients were identified. Of these, 257 were excluded as repeats, and 511 were excluded due to diagnosis of polytrauma, pilon fracture, open fracture, or injury which was not specifically an ankle fracture. The remaining 886 patients were included, 375 of which (42.3%) were 50 years or older. Older patients had significantly higher rates of wound dehiscence ($p = 0.033$) and nonunion ($p = 0.004$). Differences in rate of infection, sepsis, deep vein thrombosis, implant failure and other complications between the two age groups were not significant (Table 1). Further stratification of patients into four age groups showed significant differences in rate of nonunion, with greatest incidence in patients 50–74 years (6.3%), followed by 75 and older (5.0%), 18–25 (3.7%), and 26–49 years (1.7%), respectively (Table 2).

Analysis of risk factors for complications are shown in Tables 3–7. Risk of infection (Table 3) was significantly increased among patients with HTN in both age groups, although relative risk among patients 50 years and older (RR = 3.52, $p = 0.004$) was greater than that among patients younger than 50 (RR = 2.46, $p = 0.017$). Risk of infection was also significantly increased among those with CHF in both groups, though again greater in the younger group (RR = 15.81, $p < 0.001$) than the older group (RR = 4.04, $p = 0.001$). Risk of infection among patients with CKD younger than 50 (RR = 6.92, $p = 0.002$) was greater than that of patients older than 50 (RR = 1.81, $p = 0.201$).

Table 4 displays risk factors for wound dehiscence. Patients younger than 50 were at significantly increased risk of wound dehiscence if concurrent tobacco use (RR = 3.39, $p = 0.022$), substance use (RR = 3.07, $p = 0.020$), or CHF (RR = 12.77, $p < 0.001$) were present. These factors were not significant risks for dehiscence among patients 50 years and older.

Risk factors for implant failure are shown in Table 5. Younger patients with HIV (RR = 4.33, $p = 0.026$), CHF (RR = 10.54, $p < 0.001$), and CKD (RR = 10.54, $p < 0.001$) were at greater risk of implant failure than older patients. Older patients with HTN (RR = 4.51, $p = 0.006$) were at greater risk of implant failure than younger patients (RR = 2.75, $p = 0.008$) although relative risks were significant for both age groups. Similarly, older patients who used tobacco were at significantly increased risk of implant failure (RR = 3.82, $p = 0.001$) as well as revision surgery (RR = 1.74, $p = 0.017$); younger patients were not (Table 6). No significant

Table 1
Incidence of complications between younger and older age group.

Outcome (%)*	Age 18 – 49	Age ≥50	p-value
Total patients	511	375	
Infection	27 (5.32)	31 (8.29)	0.080
Wound dehiscence	16 (3.16)	23 (6.15)	0.033
Sepsis	1 (0.20)	3 (0.80)	0.187
DVT	1 (0.20)	4 (1.07)	0.088
Implant failure	25 (4.92)	23 (6.15)	0.427
Revision surgery	102 (20.07)	66 (17.60)	0.363
Other complications	21 (4.13)	21 (5.61)	0.307
Nonunion	11 (2.34)	23 (6.34)	0.004

* Percentages are expressed as percent of respective age group.

Table 2
Incidence of complications across four age groups.

Outcome	18 – 25	26 – 49	50–74	≥75	p-value
Total Patients	108	403	335	40	
Infection	6 (5.6%)	21 (5.2%)	27 (8.1%)	4 (10%)	0.347
Wound dehiscence	3 (2.8%)	13 (3.2%)	22 (6.6%)	1 (2.5%)	0.111
Sepsis	0 (0%)	1 (0.2%)	2 (0.6%)	1 (2.5%)	0.194
DVT	0 (0%)	1 (0.2%)	4 (1.2%)	0 (0%)	0.272
Implant failure	5 (4.6%)	20 (5.0%)	23 (6.9%)	0 (0%)	0.268
Revision surgery	18 (16.7%)	84 (20.6%)	62 (18.5%)	4 (10%)	0.326
Other complications	1 (0.9%)	20 (5.0%)	20 (5.0%)	1 (2.5%)	0.167
Nonunion	4 (3.7%)	7 (1.7%)	21 (6.3%)	2 (5.0%)	0.001

*Percentages are expressed as percent of respective age group.

Table 3
Risk Factors for Infection.

Risk Factors	Age Group (years)	Relative Risk	Confidence Interval	p-Value
HIV	18-49	0	–	0.449
	≥50	0	–	0.422
Diabetes	18-49	0.71	0.1-5.04	0.730
	≥50	1.29	0.64-2.60	0.482
Peripheral Neuropathy	18-49	1.26	0.18-8.69	0.815
	≥50	2.05	0.90-4.70	0.091
Immunosupressive Drugs	18-49	0	–	0.528
	≥50	0	–	0.250
HTN	18-49	2.46	1.16-5.19	0.017
	≥50	3.52	1.38-8.96	0.004
Other comorbidities	18-49	1.63	0.78-3.4	0.192
	≥50	0.71	0.36-1.42	0.340
Tobacco Use	18-49	1.22	0.58-2.54	0.598
	≥50	1.75	0.87-3.51	0.116
Alcohol use	18-49	0.66	0.31-1.40	0.274
	≥50	0.67	0.32-1.41	0.283
Substance Use	18-49	2.16	0.98-4.76	0.055
	≥50	1.28	0.33-4.97	0.723
COPD	18-49	2.13	0.32-14.02	0.436
	≥50	0.76	0.19-3.05	0.699
CHF	18-49	15.81	8.48-29.49	<0.001
	≥50	4.04	1.77-9.21	0.001
Other pulmonary disorders	18-49	0	–	0.071
	≥50	0.27	0.067-1.13	0.049
Chronic Kidney Disease	18-49	6.92	2.54-18.86	0.002
	≥50	1.81	0.74-4.41	0.201

No confidence interval; RR of 0.

associations were found between diabetes and risk of any of the aforementioned complications, regardless of age.

Discussion

Physicians should understand the potential risk factors for negative outcomes among specific patient populations in order to optimize care. The results of this study indicate that certain risk-outcome relationships exist for patients undergoing ORIF of ankle fractures which differ in strength of association depending upon patient age. Understanding these associations can assist physicians with better assessing the risk-benefit tradeoff that each patient presents if subjected to surgery.

Prior studies have assessed risk factors for surgical complications in older patient populations, many of which address patients age 60 and older [1,10]. Zaghloul et al. (2014) found a complication rate of 21.5%, with risk factors of smoking, age, diabetes, and local factors (osteopenia, peripheral neuropathy, PVD, lymphedema, venous insufficiency) in patients over 60 [1]. Varenne et al. (2016) proposed that age greater than 80, presence of two or more comorbidities, and open fractures were significantly associated with postoperative complications [5]. Although these studies assess risk factors among older patients, none compare risks between older and younger populations.

The current study demonstrated significantly greater incidence of nonunion among patients age 50 years and older than patients younger than 50. Appropriate management of ankle fractures in older patients has been debated due to risks of poor bone quality and outcomes associated with osteoporosis, diabetes, and peripheral vascular disease [11]. Beauchamp et al. (1983) found that among ankle fracture patients age 50 and older, many did not achieve stable fixation. Several had porotic bone intraoperatively with associated difficulty with screw placement [12]. Increased incidence of nonunion may be attributable to physiologic decline in bone quality with increasing patient age.

Lynde et al. (2012) also assessed risk factors for postoperative complications among patients age 60 and older. Hardware failure occurred among six of 216 patients (2.8%), but was not significantly associated with CHF, DM (diabetes mellitus), obesity, CAD (coronary artery disease), osteoporosis, or tobacco use [10]. In contrast, results of the current study demonstrated significant risk of hardware failure among tobacco users and patients with CHF, and the sample size used was larger at 886 patients. Physicians should be vigilant in identifying older patients with these characteristics, educating them about potential surgical risks, and maintaining close postoperative follow-up.

Older patients using tobacco had significantly increased risk of implant failure and revision surgery, which was greater than that

Table 4
Risk Factors for Wound Dehiscence.

Risk Factors	Age Group (years)	Relative Risk	Confidence Interval	p-Value
HIV	18-49	0	–	0.565
	≥50	0	–	0.495
Diabetes	18-49	1.23	0.17-8.98	0.836
	≥50	1.5	0.67-3.37	0.322
Peripheral Neuropathy	18-49	2.19	0.31-15.49	0.430
	≥50	1.28	0.40-4.13	0.676
Immunosupressive Drugs	18-49	0	–	0.631
	≥50	0.95	0.14-6.67	0.963
HTN	18-49	2.5	0.93-6.72	0.062
	≥50	2.44	0.93-6.42	0.060
Other comorbidities	18-49	1.22	0.45-3.30	0.694
	≥50	0.49	0.22-1.08	0.074
Tobacco Use	18-49	3.39	1.11-10.38	0.022
	≥50	1.12	0.46-2.76	0.802
Alcohol use	18-49	0.96	0.37-2.52	0.935
	≥50	0.71	0.30-1.69	0.441
Substance Use	18-49	3.07	1.15-8.22	0.020
	≥50	1.77	0.45-7.00	0.420
COPD	18-49	3.69	0.54-25.01	0.169
	≥50	1.66	0.52-5.28	0.394
CHF	18-49	12.77	4.39-37.17	<0.001
	≥50	2	0.51-7.84	0.325
Other pulmonary disorders	18-49	1.25	0.29-5.35	0.764
	≥50	1.41	0.57-3.45	0.456
Chronic Kidney Disease	18-49	0	–	0.585
	≥50	1.41	0.44-4.51	0.567

No confidence interval; RR of 0.

Table 5
Risk Factors for Implant Failure.

Risk Factors	Age Group (years)	Relative Risk	Confidence Interval	p-Value
HIV	18-49	4.33	1.18-15.93	0.026
	≥50	0	–	0.495
Diabetes	18-49	1.61	0.40-6.47	0.503
	≥50	1.02	0.43-2.42	0.958
Peripheral Neuropathy	18-49	2.86	0.74-11.03	0.127
	≥50	1.8	0.65-5.03	0.262
Immunosupressive Drugs	18-49	0	–	0.545
	≥50	0	–	0.280
HTN	18-49	2.75	1.28-5.95	0.008
	≥50	4.51	1.37-14.92	0.006
Other comorbidities	18-49	2.59	1.20-5.58	0.012
	≥50	1.62	0.62-4.27	0.317
Tobacco Use	18-49	0.75	0.34-1.64	0.471
	≥50	3.82	1.71-8.53	0.001
Alcohol use	18-49	0.64	0.29-1.39	0.256
	≥50	1.63	0.73-3.66	0.233
Substance Use	18-49	1.28	0.50-3.32	0.608
	≥50	0.88	0.13-6.23	0.902
COPD	18-49	2.31	0.35-15.24	0.390
	≥50	0.5	0.07-3.61	0.480
CHF	18-49	10.54	4.54-24.46	<0.001
	≥50	5.83	2.46-13.83	<0.001
Other pulmonary disorders	18-49	0.76	0.18-3.14	0.703
	≥50	1.11	0.42-2.89	0.835
Chronic Kidney Disease	18-49	10.54	4.54-4.46	<0.001
	≥50	1.41	0.44-4.51	0.567

No confidence interval; RR of 0.

for younger patients. Tobacco use has been associated with increased rates of postoperative healing complications, including ankle fracture non-union, as shown by Matson et al. [13]. Lampley et al. (2016) found that current and former smokers had an increased risk of revision surgery, although the difference was not statistically significant [14]. Our results indicate that patients who are older and smoke have a higher risk of revision surgery following ORIF of the ankle than patients who are younger and smoke.

Among the younger patient age group, tobacco use and substance use were both associated with more than three times the risk of wound dehiscence compared to patients who used neither. Although slightly increased, risk in the older population was not statistically significant. From a retrospective review of patients with positive drug screens, Saldanha et al. (2015) concluded that patients with illicit drug use are at increased risk of complications, including nonunion and deep infection, following ORIF of ankle fractures [15]. However, wound dehiscence was

Table 6
Risk Factors for Revision Surgery.

Risk Factors	Age Group (years)	Relative Risk	Confidence Interval	p-Value
HIV	18-49	0.49	0.08-3.2	0.422
	≥50	1.64	0.50-5.40	0.445
Diabetes	18-49	0.76	0.30-1.90	0.540
	≥50	0.08	0.49-1.35	0.414
Peripheral Neuropathy	18-49	1.69	0.81-3.54	0.194
	≥50	0.7	0.30-1.64	0.400
Immunosupressive Drugs	18-49	0	–	0.182
	≥50	0.32	0.05-2.19	0.193
HTN	18-49	1.41	0.96-2.08	0.087
	≥50	1.27	0.80-2.01	0.314
Other comorbidities	18-49	0.78	0.53-1.16	0.213
	≥50	1.04	0.64-1.67	0.878
Tobacco Use	18-49	0.62	0.43-0.90	0.011
	≥50	1.74	1.11-2.73	0.017
Alcohol use	18-49	0.9	0.64-1.28	0.562
	≥50	1.09	0.69-1.71	0.716
Substance Use	18-49	0.76	0.45-1.29	0.297
	≥50	0.29	0.04-1.98	0.151
COPD	18-49	0.55	0.087-3.54	0.505
	≥50	1.11	0.52-2.35	0.795
CHF	18-49	1.12	0.33-3.84	0.862
	≥50	1.35	0.56-3.29	0.516
Other pulmonary disorders	18-49	1.53	0.96-2.44	0.089
	≥50	0.8	0.4-1.45	0.450
Chronic Kidney Disease	18-49	1.12	0.33-3.84	0.862
	≥50	0.94	0.44-2.02	0.871

No confidence interval; RR of 0.

Table 7
Risk Factors for Non-Union.

Risk Factors	Age Group (years)	Relative Risk	Confidence Interval	p-Value
HIV	18-49	4.61	0.65-32.66	0.105
	≥50	0	–	0.488
Diabetes	18-49	1.71	0.23-12.87	0.600
	≥50	1.48	0.66-3.31	0.340
Peripheral Neuropathy	18-49	3.04	0.42-22.24	0.260
	≥50	1.8	064-5.00	0.266
Immunosupressive Drugs	18-49	0	–	0.681
	≥50	0	–	0.270
HTN	18-49	0.39	0.05-3.01	0.347
	≥50	1.56	0.66-3.69	0.311
Other comorbidities	18-49	0.72	0.19-2.68	0.622
	≥50	1.02	0.43-2.42	0.957
Tobacco Use	18-49	1	0.31-3.24	0.997
	≥50	1.73	0.76-3.94	0.190
Alcohol use	18-49	0.52	0.15-1.75	0.283
	≥50	0.87	0.38-1.99	0.739
Substance Use	18-49	0.52	0.07-4.01	0.523
	≥50	0	–	0.287
COPD	18-49	0	–	0.680
	≥50	1.06	0.26-4.29	0.938
CHF	18-49	0	–	0.640
	≥50	2.21	0.57-8.57	0.257
Other pulmonary disorders	18-49	0	–	0.247
	≥50	0.38	0.09-1.60	0.167
Chronic Kidney Disease	18-49	0	–	0.640
	≥50	1.36	0.43-4.36	0.605

No confidence interval; RR of 0.

not specifically analyzed. Abidi et al. (1998) assessed wound healing in a retrospective study of patients who underwent ORIF of calcaneal fractures, and found that patients who actively smoked had increased healing time [16]. A systematic review and meta-analysis by Sorensen (2012) found that odds of healing delay and wound dehiscence were 2.07 times greater for smokers than non-smokers across multiple surgical specialties [17]. It should be expected that wound dehiscence would occur commonly among patients who smoke, based on the proposed pathophysiology that smoking alters collagen metabolism and proliferative healing [17]. These impaired healing mechanisms may also explain the increased risk for revision surgery among patients who smoke. No literature to date draws these comparisons between 50 years and older than 50 years.

In both age groups, hypertension was associated with significant risk of implant failure. Relative risk for older patients was almost twice that of younger patients. These results are consistent with published literature, which suggests that high blood

pressure—in a similar manner to chronic kidney disease— is associated with calcium metabolism abnormalities and bone loss [18,19]. As a result, patients with hypertension may have poor bone quality and consequential hardware failure. Cappuccio et al. (1999) found that among women with osteoporosis, rate of bone mineral density loss at the femoral neck increased with increasing systolic blood pressure [20]. All patients with hypertension undergoing ORIF of the ankle should be extensively counseled regarding the risks of hardware failure, with emphasis among patients 50 and older.

Patients in both age groups with hypertension were also at significantly increased risk of infection, although risk was higher among patients 50 years and older. Previous studies have not demonstrated this relationship. In fact, our results contradict those of a retrospective study by Sun et al., which demonstrated no significant correlation between hypertension and surgical site infection among patients undergoing ORIF for ankle fractures [21]. The mechanism by which hypertension may play a role in postoperative infection has not been clearly elucidated and warrants further investigation.

HIV has not been previously assessed as a risk factor for ankle fracture healing in any age group. Results from the current study demonstrated that patients younger than 50 with HIV were at 4.3 times greater risk of implant failure than patients without HIV; no patients 50 years or older in this study had HIV. In contrast to these results, Xu et al. (2017) found no significant difference in union rate between patients with and without HIV among all orthopaedic fractures at a single institution [22]. Similarly, Gardner et al. (2013) found a non-union rate of only 4% among HIV patients undergoing ORIF of any traumatic fracture [23]. However, none of the aforementioned studies assess outcomes for ankle fracture patients specifically, nor do they distinguish level of risk between younger and older patients. The results of the current study support the theory that HIV interferes with healing via metabolic alterations and increased cytokine level [24]. Additionally, bone toxicity is a well-known adverse effect of nucleoside/tide reverse transcriptase inhibitors, which likely contributes to implant failure [25].

This is the first study to assess risk factors for complications among ankle fracture patients with chronic kidney disease. Older patients with chronic kidney disease were 18.8 times more likely to develop postoperative sepsis than those without. The literature reports acute kidney injury incidence of 20–25% among orthopaedic surgery patients, [26] and some studies report increased risk of sepsis following acute kidney injury [27]. Bell et al. found lower glomerular filtration rate, use of angiotensin-converting enzyme inhibitors, and angiotensin receptor blockers to be independent predictors of acute kidney injury [28]. Therefore, we postulate that chronic kidney disease predisposes orthopaedic surgery patients to acute kidney injury, increasing sepsis risk. However, the exact mechanism of the development of sepsis in these patients is not clearly understood.

Pulmonary conditions (excluding COPD) were also associated with significantly increased risk of sepsis and DVT among older patients, but not among patients younger than 50. Griffin et al. (2013) concluded that obstructive sleep apnea had no significant bearing on risk of perioperative complications; however, this study only assessed in-hospital morbidity and mortality in shoulder arthroplasty patients [29]. In contrast, D'Apuzzo and Browne (2012) found increased risk of pulmonary embolism and wound hamartomas or seromas among revision arthroplasty patients with OSA [30]. A database study by Lin et al. (2016) demonstrated increased risk of septicemia among patients with asthma [31]. However, only inpatient surgeries were assessed. The aforementioned studies did not specifically assess pulmonary diseases as risk factors for foot and ankle surgeries, nor did they identify whether risk factors may impact specific age groups more than others.

There is a paucity of literature which describes CHF as a risk factor for postoperative outcomes, particularly among ankle ORIF patients. Curtis et al. found a significant association between comorbid heart failure and wound dehiscence; however, this was following total knee arthroplasty [32]. The current study is the first to quantify a risk relationship between congestive heart failure and infection, wound dehiscence, DVT, and implant failure.

Several weaknesses of this study should be considered. Results of retrospective studies are dependent upon thoroughness and accuracy of medical documentation and data collection. However, because most patients are part of the study institution's healthcare system, chances of any comorbidities not being recorded after seeing multiple providers are low. Additionally, differences in internal fixation technique may impact outcomes. All surgeries were performed by board-certified orthopaedic surgeons, however, from which it can be assumed that procedures were performed according to standard of care. Union was assessed using x-rays, which are not as sensitive as CT scans. However, do not routinely undergo CT scans; rather, x-rays are standard for postoperative imaging. It should also be noted that "revision surgeries" included syndesmotic screw removal, which does not necessarily imply complication. Despite these shortcomings, this is the first study which provides a comparison of potential risk factors for adverse outcomes between younger and older patients undergoing open reduction and internal fixation of ankle fractures.

Conclusions

The results of this study provide valuable information regarding possible risks for adverse outcomes in younger and older patient age groups undergoing ORIF of the ankle. With these results in mind, physicians can better make informed decisions about which patients should err on the side of caution if surgery is not absolutely necessary. Older patients with pulmonary disorders other than COPD may consider nonoperative management of ankle fractures if possible. Younger patients who have HIV should also be conservative when possible for treatment of ankle fractures. Universally, patients who use tobacco or illicit drugs, have hypertension, or have chronic kidney disease should be well-informed of the potential risks of operative management. A multidisciplinary approach is warranted for appropriate management of patients with multiple comorbidities.

Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

References

[1] Zaghloul A, Haddad B, Barksfield R, Davis B. Early complications of surgery in operative treatment of ankle fractures in those over 60: a review of 186 cases. Injury 2014;45(4):780–3, doi:http://dx.doi.org/10.1016/J.INJURY.2013.11.008.
[2] Anderson SA, Li X, Franklin P, Wixted JJ. Ankle fractures in the elderly: initial and long-term outcomes. Foot Ankle Int 2008;29(12):1184–8, doi:http://dx.doi.org/10.3113/FAI.2008.1184.
[3] Miller AG, Margules A, Raikin S. Risk factors for wound complications after ankle fracture surgery. J Bone Jt Surg Am 2012;94(22):2047–52, doi:http://dx.doi.org/10.2106/JBJS.K.01088.
[4] Aigner R, Salomia C, Lechler P, Pahl R, Frink M. Relationship of prolonged operative time and comorbidities with complications after geriatric ankle fractures. Foot Ankle Int 2016;38(1):41–8, doi:http://dx.doi.org/10.1177/1071100716667315.
[5] Varenne Y, Curado J, Asloum Y, Salle de Chou E, Colin F, Gouin F. Analysis of risk factors of the postoperative complications of surgical treatment of ankle fractures in the elderly: a series of 477 patients. Orthop Traumatol Surg Res 2016;102(4, Supplement):S245–8, doi:http://dx.doi.org/10.1016/j.otsr.2016.03.004.

[6] Fong W, Acevedo J, Stone R, Mizel M. The treatment of unstable ankle fractures in patients over eighty years of age. Foot Ankle Int 2007;28(12):1256–9, doi:http://dx.doi.org/10.3113/FAI.2007.1256.
[7] Shivarathre DG, Chandran P, Platt SR. Operative fixation of unstable ankle fractures in patients aged over 80 years. Foot Ankle Int 2011;32(6):599–602, doi:http://dx.doi.org/10.3113/FAI.2011.0599.
[8] Macera A, Carulli C, Sirleo L, Innocenti M. Postoperative complications and reoperation rates following open reduction and internal fixation of ankle fracture. Joints 2018;6(2):110–5, doi:http://dx.doi.org/10.1055/s-0038-1653949.
[9] Dodson NB, Ross AJ, Mendicino RW, Catanzariti A. Factors affecting healing of ankle fractures. J Foot Ankle Surg 2013;52(1):2–5.
[10] Lynde MJ. Complications after open reduction and internal fixation of ankle fractures in the elderly. Foot Ankle Surg 2012;18(2):103–7.
[11] Strauss EJ, Egol KA. The management of ankle fractures in the elderly. Injury 2007;38(3):2–9, doi:http://dx.doi.org/10.1016/j.injury.2007.08.005.
[12] Beauchamp CG, Clay NR, Thexton PW. Displaced ankle fractures in patients over 50 years of age. J Bone Jt Surg Br 1983;65(3):329–32.
[13] Matson AP, Hamid KS, Adams SB. Predictors of time to union after operative fixation of closed ankle fractures. Foot Ankle Spec 2016;10(4):308–14, doi:http://dx.doi.org/10.1177/1938640016677813.
[14] Lampley A, Gross CE, Green CL, et al. Association of cigarette use and complication rates and outcomes following total ankle arthroplasty. Foot Ankle Int 2016;37(10):1052–9, doi:http://dx.doi.org/10.1177/1071100716655435.
[15] Saldanha V, Tiedeken N, Gaughan J, Sweitzer B. Complications of open reduction and internal fixation of ankle fractures in patients with positive urine drug screen. Am J Orthop 2015;44(3):118–21.
[16] Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int 1998;19(12):856–61, doi:http://dx.doi.org/10.1177/107110079801901211.
[17] Sorensen LT. Wound healing and infection in surgery: the pathophysiological impact of smoking, smoking cessation, and nicotine replacement therapy: a systematic review. Ann Surg 2012;255(6):1069–79.
[18] Strazzullo P, Nunziata V, Cirillo M, et al. Abnormalities of calcium metabolism in essential hypertension. Clin Sci 1983;65(2):137–41.
[19] Ye Z, Lu H, Liu P. Association between essential hypertension and bone mineral density: a systematic review and meta-analysis. Oncotarget 2017;8(40):68916–27, doi:http://dx.doi.org/10.18632/oncotarget.20325.
[20] Cappuccio FP, Meilahn E, Zmuda JM, Cauley JA. High blood pressure and bone-mineral loss in elderly white women: a prospective study. Lancet 1999;354(9183):971–5, doi:http://dx.doi.org/10.1016/S0140-6736(99)01437-3.
[21] Sun Y, Wang H, Tang Y, et al. Incidence and risk factors for surgical site infection after open reduction and internal fixation of ankle fracture: a retrospective multicenter study. Medicine (Baltimore) 2018;97(7), doi:http://dx.doi.org/10.1097/MD.0000000000009901 e9901-e9901.
[22] Xu G, Zhao J, Sun J, Liu Y. Analysis of the surgical treatment of fracture in HIV positive patients: a clinical study. Pak J Med Sci 2017;33(6):1449–53, doi:http://dx.doi.org/10.12669/pjms.336.13368.
[23] Gardner ROE, Bates JH, Ng'oma E, Harrison WJ. Fracture union following internal fixation in the HIV population. Injury 2013;44(6):830–3, doi:http://dx.doi.org/10.1016/j.injury.2012.11.024.
[24] Richardson J, Hill AM, Johnston CJC, et al. Fracture healing in HIV-positive populations. J Bone Joint Surg Br 2008;90-B(8):988–94, doi:http://dx.doi.org/10.1302/0301-620X.90B8.20861.
[25] Battalora LA, Young B, Overton ET. Bones, fractures, antiretroviral therapy and HIV. Curr Infect Dis Rep 2014;16(2):393, doi:http://dx.doi.org/10.1007/s11908-014-0393-1.
[26] Thakar CV. Perioperative acute kidney injury. Adv Chronic Kidney Dis 2013;20(1):67–75.
[27] Lai T-S, Wang C-Y, Pan S-C, et al. Risk of developing severe sepsis after acute kidney injury: a population-based cohort study. Crit Care 2013;17(5), doi:http://dx.doi.org/10.1186/cc13054 R231-R231.
[28] Bell S, Dekker FW, Vadiveloo T, et al. Risk of postoperative acute kidney injury in patients undergoing orthopaedic surgery—development and validation of a risk score and effect of acute kidney injury on survival: observational cohort study. BMJ 2015;351:h5639, doi:http://dx.doi.org/10.1136/bmj.h5639.
[29] Griffin J, Novicoff W, Browne J, Brockmeier S. Obstructive sleep apnea as a risk factor after shoulder arthroplasty. J Shoulder Elb Surg 2013;22(12):e6–9, doi:http://dx.doi.org/10.1016/j.jse.2013.06.003.
[30] D'Apuzzo MR, Browne JA. Obstructive sleep apnea as a risk factor for postoperative complications after revision joint arthroplasty. J Arthroplasty 2012;27(8):95–8, doi:http://dx.doi.org/10.1016/j.arth.2012.03.025.
[31] Lin C-S, Chang C-C, Yeh C-C, Chung C-L, Chen T-L, Liao C-C. Postoperative adverse outcomes in patients with asthma: a nationwide population-based cohort study. Medicine (Baltimore) 2016;95(3), doi:http://dx.doi.org/10.1097/MD.0000000000002548 e2548-e2548.
[32] Curtis GL, Newman JM, George J, Klika AK, Barsoum WK, Higuera CA. Perioperative outcomes and complications in patients with heart failure following total knee arthroplasty. J Arthroplasty 2018;33(1):36–40, doi:http://dx.doi.org/10.1016/j.arth.2017.07.043.