Full Reversal of Anticoagulants Before Cephalomedullary Fixation of Geriatric Hip Fractures May Not Be Necessary

Carlos Maturana, MS,[a] Manak Singh, BS, Aaron M. Perdue, MD,[b,c] Jaimo Ahn, MD, PhD,[b,c] Mark E. Hake, MD,[b,c] and Nathaniel E. Schaffer, MD, PhD[d]

Objectives: To examine the relationship between anticoagulant and antiplatelet drugs and surgical blood loss for geriatric patients undergoing cephalomedullary nail fixation of extracapsular proximal femur fractures.

Design: Multicenter, retrospective, cohort study using bivariate and multivariable regression analyses.

Setting: Two Level-1 trauma centers.

Patients: One thousand four hundred forty-two geriatric (ages 60–105 years) patients undergoing isolated primary intramedullary fixation of nonpathologic extracapsular hip fractures from 2009 to 2018 including 657 taking an antiplatelet drug alone (including aspirin), 99 taking warfarin alone, 37 taking a direct oral anticoagulant (DOAC) alone, 59 taking an antiplatelet drug and an anticoagulant, and 590 taking neither.

Intervention: Cephalomedullary nail fixation.

Main Outcome Measurements: Blood transfusion and calculated blood loss.

Results: More patients taking antiplatelet drugs required a transfusion than controls (43% vs. 33%, $P < 0.001$), whereas patients taking warfarin or DOACs did not (35% or 32% vs. 33%). Median calculated blood loss was increased in patients taking antiplatelet drugs (1275 mL vs. 1059 mL, $P < 0.001$) but not in patients taking warfarin or DOACs (913 mL or 859 mL vs. 1059 mL). Antiplatelet drugs were independently associated with an odds ratio of transfusion of 1.45 [95% confidence interval (CI), 1.1–1.9] in contrast with 0.76 (95% CI, 0.5–1.2) for warfarin and 0.67 (95% CI, 0.3–1.4) for DOACs.

Conclusions: Geriatric patients taking warfarin (incompletely reversed) or DOACs lose less blood during cephalomedullary nail fixation of hip fractures than those taking aspirin. Delaying surgery to mitigate anticoagulant-related surgical blood loss may be unwarranted.

Key Words: hip fractures/surgery, blood loss, surgical/statistics and numerical data, blood transfusion/statistic and numerical data, cephalomedullary nail, retrospective studies, fracture fixation, intramedullary/instrumentation

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

(*J Orthop Trauma* 2023;37:444–449)

INTRODUCTION

In an aging population, hip fractures are among the most common injuries treated by orthopaedic surgeons.[1] Some estimates project more than 5.6 million patients older than 65 years will require surgery for hip fractures each year by 2050,[2] and currently, intertrochanteric (IT) fractures account for approximately 42% of geriatric hip fractures in the United States.[3,4] Many of these patients are taking antiplatelet drugs or anticoagulants at the time of admission, which complicates decisions regarding timing of fracture management.[5–7] For example, it is common in clinical practice to delay surgery for patients taking warfarin until the international normalized ratio (INR) is less than 1.5.[8,9] Delays may be even longer for patients on direct oral anticoagulants (DOACs), such as apixaban (eg, Eliquis), dabigatran (eg, Pradaxa), and rivaroxaban (eg, Xarelto), because drug clearance is affected by renal function and reversal agents may not be readily available. The scarce literature available recommends delaying surgery up to 48 hours for patients taking these drugs.[10–12] Similarly, patients taking antiplatelet therapies (eg, aspirin or clopidogrel) to reduce cardiovascular events may face a choice between increased blood loss and delayed hip fracture surgery.[13–15]

Timely intervention for hip fractures is paramount to permit early ambulation and reduce complications including mortality.[16,17] Although performing surgery within 24 hours has been associated with reduced mortality, morbidity, and hospital length of stay, concerns persist that surgery should be delayed 24–48 hours for patients on DOACs or until INR is reduced for patients on warfarin.[9,18,19] Therefore, the

Accepted for publication April 13, 2023.

From the [a]David Geffen School of Medicine, University of California, Los Angeles, CA; [b]Department of Orthopaedic Surgery, University of Michigan, Ann Arbor, MI; [c]Department of Orthopaedic Surgery, St. Joseph Mercy Ann Arbor Hospital, Ypsilanti, MI; and [d]Department of Orthopaedic Surgery, Vanderbilt University Medical Center, Nashville, TN.

The authors report no conflict of interest.

Presented in part as a poster at the Annual Meeting of the American Academy for Orthopaedic Surgeons, March 2022, Chicago, IL.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.jorthotrauma.com).

Reprints: Nathaniel E. Schaffer, MD, PhD, Department of Orthopaedic Surgery, Vanderbilt University Medical Center, 1215 21st Ave South, Suites 3200 and 4200, Nashville, TN 37232 (e-mail: nathaniel.e.schaffer@vumc.org).

DOI: 10.1097/BOT.0000000000002620

literature is conflicting on the merits and risks of early versus delayed surgery in this population. To help clarify the potential hazards associated with early surgical fixation of geriatric extracapsular hip fractures in patients taking anticoagulants or antiplatelet drugs, this study evaluates the association between preoperative use of these medications and perioperative blood loss, hospital length of stay (LOS), need for transfusion, and 30-day mortality. We hypothesize that despite being considered more worrisome than aspirin, for which surgery is not commonly delayed, warfarin and DOACs do not meaningfully alter blood loss and mortality. If true, this finding would suggest delaying fixation to permit clearance or reversal of these anticoagulants is unnecessary.

METHODS

A retrospective cohort analysis was conducted for all patients 60 years of age or older with acute extracapsular hip fractures (OTA/AO 31A, 31B3, and 32 fractures within 5 cm of the lesser trochanter[20]) treated with a cephalomedullary nail from January 1, 2009, to December 31, 2018, at 2 institutions. Internal review board approval was obtained at both institutions. Patients with nonosteoporotic pathologic fractures or no recorded preoperative or postoperative hematocrit, height, or weight were excluded. Also excluded were subjects undergoing revision surgeries or multiple simultaneous procedures under one anesthetic event. For bivariate comparisons of the effects of antiplatelet medications, the sample was divided into those subjects taking a medication of that class (including aspirin, clopidogrel, and dipyridamole), excluding all patients taking anticoagulants. Similarly, for bivariate analyses of the effects of anticoagulant medications, patients were grouped according to whether they were taking a direct oral anticoagulant (including apixaban, dabigatran, edoxaban, and rivaroxaban), warfarin, or none of the above after excluding all patients taking antiplatelet drugs. Any potential interactions or cumulative effects in patients taking both classes of medications were addressed using multivariable regression analyses. Preoperative height, weight, hematocrit, international normalized ratio (INR), American Society of Anesthesiologists (ASA) class, and comorbid conditions were abstracted by chart review along with postoperative hematocrit, hospital length of stay, time to last follow-up, and death date if applicable. Blood loss was calculated as previously described.[21] In brief, calculated blood loss (CBL) is the total blood volume multiplied by the change between preoperative and postoperative hematocrits normalized to the mean hematocrit over that time and adjusted for the volume of blood transfused, if any.

Continuous variables were compared across treatment groups using Kruskal–Wallis tests, and, for those variables for which a difference was found, the specific groups responsible were subsequently identified using pairwise Mann–Whitney U tests with Bonferroni multiple-test correction. Gaussian continuous variables were summarized by mean and SD, and non-Gaussian continuous variables were summarized by median and interquartile range (IQR). The Pearson χ^2 test was used for dichotomous variables. The correlation between continuous variables was assessed using the Spearman rank correlation coefficient. Linear regression was used to determine the effect of INR on CBL among patients taking warfarin, and logistic regression was used to determine the effect of the medications of interest on postoperative transfusion while controlling for potential observed confounders (age, sex, ASA class, weight, operative time, use of a short nail, tobacco use, chronic kidney disease, and preoperative hemoglobin). Goodness-of-fit was evaluated using the area under the receiver operating characteristic (AUROC). Thirty-day mortality was analyzed using a multivariable Cox hazard model with anticoagulants, antiplatelet drugs, age, sex, body mass index (BMI), ASA class, operative time, tobacco use, preoperative creatinine, and hemoglobin as independent variables. Variables with a P value less than 0.2 in bivariate analysis were included in regression models. Statistical analysis was performed using STATA 17.0 (StatCorp, TX), and a threshold of $P < 0.05$ was selected for statistical significance.

RESULTS

Patient Population

Demographics data are summarized in Table 1. Of the 1442 patients included, 657 (45.6%) were on antiplatelet medications alone, 99 (6.9%) were on warfarin alone with a mean immediate preoperative INR of 1.40 (SD 0.40), and 37 (2.6%) patients were on a DOAC alone before surgery. The control group comprised 590 (40.9%) patients taking neither anticoagulants nor antiplatelet drugs. Another 59 patients (4.1%) taking both an anticoagulant and an antiplatelet medication were included only in multivariable regression analysis. The median postoperative follow-up time in the entire cohort was 651 days (IQR, 118 to 1349) and did not statistically differ between groups. Most of the patients (93%) were white, compared with 69% among the general population in the geographic area of the hospitals,[22] and this did not differ significantly across groups. The mean patient age was clinically similar across treatment groups, although patients taking antiplatelet drugs were statistically older than those who were not (82.8 vs. 80.3 years, $P < 0.001$). Similarly, their BMI was statistically greater than controls (25.1 vs. 24.4 kg/m^2, $P < 0.01$). Compared with controls, patients taking antiplatelet medications also had higher ASA classes (67% ASA 3 and 21% ASA 4 vs. 60% and 14%; $P < 0.001$) and more comorbid chronic kidney disease (CKD) (33% vs. 21%, $P < 0.001$).

Subjects on DOACs or warfarin also were of higher ASA class than controls (78% and 77% ASA 3, 16% ASA 4 vs. 60% and 14%). Sex distribution differed from controls with more women taking DOACs and fewer taking warfarin (87% and 64% vs. 75%, $P < 0.05$), and anticoagulated patients had a higher mean BMI (25.8 and 26.5 vs. 24.4 kg/m^2, $P < 0.01$). Patients on anticoagulants more commonly had CKD (38% DOACs, 30% warfarin vs. 21% controls, $P < 0.05$), and they had higher mean preoperative INRs than controls (1.2 DOACs, 1.4 warfarin vs. 1.0 controls, $P < 0.001$). Among patients taking warfarin, 31% had an immediate preoperative INR >1.5 with a maximum of 3.1.

Blood Loss and Transfusion

Bivariate analysis demonstrated increased blood loss and need for transfusion in patients taking antiplatelet drugs

TABLE 1. Baseline Comparison of Treatment Groups

	Antiplatelet Treatment Versus Control		Anticoagulation Treatment Versus Control			Control
	Antiplatelet (n = 657)	*P*	DOAC (n = 37)	Warfarin (n = 99)	*P*	(n = 590)
Age [mean (SD)], y	82.8 (9.3)	<0.001	80.9 (9.3)	82.1 (8.5)	0.367	80.3 (10.4)
Sex, n (%)		0.139			0.011	
Male	187 (28.5%)		5 (13.5%)	36 (36.4%)		146 (24.8%)
Female	470 (71.5%)		32 (86.5%)	63 (63.6%)		444 (75.2%)
Height [mean (SD)], cm	163.7 (10.8)	0.694	159.8 (6.9)	165.4 (11.2)	<0.01	163.3 (10.5)
Weight [mean (sd)], kg	67.6 (17.7)	0.015	65.9 (15.5)	72.9 (19.8)	<0.001	65.4 (17.7)
BMI [mean (SD)], kg/m^2	25.1 (5.6)	0.007	25.8 (5.9)	26.5 (6.4)	0.002	24.4 (5.9)
Est. blood volume [mean (sd)], mL	4121.9 (915.5)	0.061	3882.3 (668.8)	4378.7 (988.9)	<0.01	4018.9 (887.3)
ASA, n (%)		<0.001			<0.001	
1	0		0	0		4 (0.7%)
2	79 (12.0%)		2 (5.4%)	7 (7.1%)		150 (25.4%)
3	440 (66.9%)		29 (78.4%)	76 (76.7%)		351 (59.5%)
4	138 (21.0%)		6 (16.2%)	16 (16.1%)		85 (14.4%)
Race/ethnicity, n (%)		0.243			0.831	
Asian	7 (1.1%)		0	1 (1.01%)		15 (2.5%)
Black	21 (3.3%)		1 (2.7%)	2 (2.02%)		23 (3.9%)
White	622 (94.7%)		36 (97.3%)	96 (96.97%)		540 (91.5%)
Native American	1 (0.1%)		0	0		1 (0.1%)
Other	3 (0.4%)		0	0		6 (1.0%)
Unknown	3 (0.4%)		0	0		5 (0.8%)
Chronic kidney disease, n (%)	215 (32.7%)	<0.001	14 (37.8%)	30 (30.3%)	0.014	125 (21.2%)
Tobacco use, n (%)	54 (8.2%)	0.372	1 (2.7%)	7 (7.07%)	0.277	57 (9.7%)
Use of short nail, n (%)	360 (54.8%)	0.481	29 (78.4%)	48 (48.5%)	0.007	335 (56.8%)
Preoperative hemoglobin [mean (sd)], g/dL	10.9 (1.7)	0.113	10.5 (1.6)	10.6 (1.7)	0.016	11.1 (1.8)
Preoperative hematocrit [mean (sd)] (%)	32.7 (5.2)	0.121	32.1 (4.7)	31.8 (5.0)	<0.05	33.2 (5.4)
Preoperative platelet count [mean (sd)], 1000/μL	203.6 (73.0)	0.331	202.7 (74.3)	178.6 (53.8)	0.002	209.2 (83.8)
Preoperative INR [mean (SD)]	1.0 (0.1)	0.789	1.2 (0.2)	1.4 (0.4)	<0.001	1.0 (0.1)
Preoperative creatinine [mean (sd)], mg/dL	1.17 (1.01)	<0.001	0.94 (0.3)	1.09 (0.72)	0.074	0.9 (0.7)
Preoperative estimated glomerular filtration rate [mean (SD)], mL/min/1.73 m^2	64.3 (27.4)	<0.001	67.8 (23.1)	66.8 (26.6)	<0.05	73.7 (28.6)

with a median of 1275 mL (IQR, 798–1783) versus 1059 mL (IQR, 667–1660) for controls ($P < 0.001$). Of patients taking these medications, 43% required a blood transfusion versus 33% of controls ($P < 0.001$). By contrast, anticoagulants were not associated with increased blood loss or transfusion (Table 2). Logistic regression (Table 3) corroborated these results, indicating that patients taking antiplatelet drugs were at increased risk of transfusion (OR, 1.45; 95% CI, 1.11–1.89; $P < 0.05$), whereas patients taking anticoagulants were not (warfarin OR, 0.76; 95% CI, 0.49–1.17; DOAC OR, 0.67; 95% CI, 0.31–1.40) after accounting for age, sex, weight, ASA class, operative time,

TABLE 2. Bivariate Analysis of Outcome Variables Stratified by Anticoagulants and Antiplatelet Medications

	Antiplatelet Treatment Versus Control		Anticoagulation Treatment Versus Control			Control
	Antiplatelet (n = 657)	*P*	DOAC (n = 37)	Warfarin (n = 99)	*P*	(n = 590)
Calculated blood loss [median (IQR)], mL	1275 (798–1783)	<0.001	859 (500–1483)	913 (608–1462)	*0.189*	1059 (667–1660)
Hospital length of stay [median (IQR)], d	5 (4–6)	0.560	5 (3–7)	6 (4–8)	*<0.001*	5 (4–6)
Transfused, n (%)	281 (42.8%)	<0.001	12 (32.4%)	35 (35.4%)	*0.897*	195 (33.1%)
pRBCs transfused [median (IQR)], mL	700 (350–700)	0.955	350 (350–700)	700 (350–900)	*0.833*	680 (350–700)
Operative time (SD) [CI], minutes	52.5 (25.4)	0.307	44.5 (17.5)	52.6 (23.3)	*0.174*	52.1 (26.4)
Estimated blood loss [mean (sd)], mL	133.0 (134.9)	0.687	107.8 (65.6)	141.6 (141.9)	*0.525*	129.9 (122.4)
30-d mortality, n (%)	48 (7.3%)	0.006	2 (5.4%)	4 (4.0%)	*0.872*	22 (3.7%)

TABLE 3. Logistic Regression Predicting the Risk of Transfusion

	Odds Ratio	95% Confidence Interval	*P*
Anticoagulant			0.291
Warfarin	0.76	0.49–1.17	
DOAC	0.67	0.31–1.40	
Antiplatelet	1.45	1.11–1.89	<0.01
Age	1.02	1.00–1.02	<0.05
Male	0.72	0.53–0.97	<0.05
Operative time	1.01	1.01–1.02	$<10^{-5}$
Short nail	0.48	0.36–0.64	$<10^{-6}$
Chronic kidney disease	1.42	1.07–1.90	<0.05
Preoperative hemoglobin	0.46	0.42–0.51	$<10^{-15}$

Area under receiver operating characteristic = 0.825.

tobacco use, chronic kidney disease, use of a short nail, and preoperative hemoglobin.

Among the subset of patients taking warfarin, INR was correlated with CBL (Spearman $\rho = 0.18$; 95% CI, 0.01–0.34; $P < 0.05$). Within that group, linear regression of CBL demonstrated INR was statistically predictive of CBL ($\beta = 520$ mL; 95% CI, 149–891 mL; $P < 0.01$; $R^2 = 0.16$) (see **Table**, **Supplemental Digital Content 1**, http://links.lww.com/JOT/C11). However, increased INR in those patients was not associated with increased risk of transfusion by logistic regression (OR, 1.53; 95% CI, 0.53–4.57) (see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/C12).

Hospital Length of Stay

The hospital length of stay was correlated to anticoagulant use, and this finding was mediated by the warfarin subgroup with a median of length of stay of 6 days (IQR, 4–8) versus 5 days (IQR, 4–6 and IQR, 3–7) for controls and patients on DOACs ($P < 0.001$). Patients taking antiplatelet medications had a similar LOS to controls at a median of 5 days (IQR, 4–6) (Table 2).

Thirty-Day Mortality

Although 30-day mortality was higher in the antiplatelet group than in controls (7.3% vs. 3.7%, $P < 0.01$) (Table 2), after controlling for the significant effects of age, ASA class, preoperative creatinine, and BMI using Cox proportional hazard regression, neither antiplatelet drugs (HR, 1.49; 95% CI, 0.92–2.43) nor warfarin (HR, 0.89; 95% CI, 0.40–1.98) nor DOACs (HR, 0.85; 95% CI, 0.20–3.52) were associated with increased early postoperative mortality (Table 4).

DISCUSSION

Given the known mortality benefit of early operative intervention for geriatric hip fractures and the historical correlation between surgical delay and use of preoperative anticoagulants, a better understanding of the effects of these medications on blood loss and mortality is required.[9,16–18] To the best of our knowledge, this is the first study comparing blood loss effects of DOACs, warfarin, and antiplatelet drugs in patients undergoing intramedullary fixation of geriatric extracapsular hip fractures, and in our sample, antiplatelet medications rather than anticoagulants were associated with increased blood loss and need for transfusion. Our findings that patients in the warfarin group did not experience increased blood loss contrasts with the results of Caruso et al.[9] This is likely because of more frequent or robust warfarin reversal in our study population, evidenced by the increased LOS and mean INR <1.5 among patients taking warfarin. Mattisson et al[23] corroborated our results that for nail fixation of extracapsular hip fractures, warfarin does not increase blood loss, at least with warfarin reversal to INR <1.5. This raises the question as to how high the INR can be before increased blood loss in these patients becomes clinically significant. Despite 31% of the patients in the warfarin group having an INR >1.5 at the time of surgery, transfusion requirements were not increased, and blood loss was only weakly correlated to INR. Based on the linear regression correlating a 1-point increase in INR with 520 mL of blood loss, it is estimated that a mean INR of 1.8 would be associated with the same blood loss as that observed in patients taking antiplatelet drugs (209 mL higher). This suggests that it may be reasonable, at least, to proceed with surgery with an INR <1.8.

Our results contribute to a growing body of literature suggesting that DOACs do not meaningfully increase blood loss in this patient population.[11] This is particularly important for these drugs that can have relatively long half-lives and high-cost reversal agents with limited availability.[24] Importantly, the length of stay in this group did not differ from patients not taking anticoagulants, implying that blood loss in this group was not artificially depressed by delaying surgery until the effect of these medications had worn off.

By contrast, patients taking antiplatelet drugs before surgery lost more blood and more often required a blood transfusion (Table 2). Although this finding contrasts with a prior report by Collinge et al stating that patients taking

TABLE 4. Multivariable Cox Regression of 30-D Mortality

	Hazard Ratio	95% Confidence Interval	*P*
Anticoagulant			0.755
Warfarin	0.89	0.40–1.98	
DOAC	0.85	0.20–3.52	
Antiplatelet	1.49	0.92–2.43	0.100
Age	1.04	1.01–1.07	0.009
Female	0.91	0.86–0.96	0.001
BMI	1.05	0.61–1.79	0.845
ASA class	3.08	2.01–4.75	<0.001
Operative time	0.99	0.98–1.00	0.089
Tobacco use	0.17	0.02–1.21	0.077
Chronic kidney disease	1.19	1.04–1.37	0.022
Preoperative hemoglobin	0.88	0.77–1.01	0.082

antiplatelet agents were not at an increased risk of bleeding or transfusion,[13] that study used estimated blood loss (EBL), which has been shown to be inaccurate.[25–27] In addition, more than 55% of patients in that study received a transfusion, and the likely more liberal use of blood transfusions at that time may have masked the difference in transfusion percentage found here. More recent studies corroborate our finding that antiplatelet medications increase bleeding in this patient population.[14,15] Despite the increased blood loss, these medications did not increase mortality, suggesting the benefit of early surgical intervention, with its known mortality reduction, may outweigh the risks of increased blood loss. In this context, early surgical intervention for patients on warfarin may be reasonable with an INR of 1.8, the level at which the impact on blood loss would be similar to that of aspirin use in our cohort.

Our study has several limitations, including its retrospective design, which risks confounding and selection bias. As would be expected for a nonrandomized design, our groups were unbalanced with patients taking the medications being older and of poorer health. However, it would not be feasible to conduct a study in which patients were randomly assigned to receive chronic preoperative antiplatelet drugs, and conclusions can still be drawn from our data as our regression analyses account for this confounding. Furthermore, these retrospective data assessing the outcomes of surgery on patients with an elevated INR provide needed justification and equipoise to ethically conduct prospective studies on the outcomes of fixing these fractures in patients with limited or no reversal of their anticoagulation. This growing body of knowledge is especially helpful when treating patients for whom reversing anticoagulation may pose especially high risks. Because it remains possible that our study was underpowered to detect a real difference in blood loss and need for transfusion among patients taking anticoagulants, our study is not definitive, and larger sample sizes in future studies motivated by this work will be required to confirm this finding.

Owing to limitations of the medical records and incomplete histories provided by many of these patients, the specific timing of the injuries and last administration of the medications was not available. Some medications may have been subtherapeutic at the time of surgery, and mortality data may have been affected by the time between injury and surgery. However, many of these medications have long half-lives and would still be at least partially effective if the patient had missed a dose, and, for warfarin, laboratory data provided a direct measure of the medication effect.

The data presented support a growing literature that surgical intervention for extracapsular geriatric hip fractures should not be delayed for patients taking anticoagulants.[11,17] Surprisingly, antiplatelet drugs including aspirin were more strongly associated with increased blood loss than anticoagulants. Because the increased blood loss from antiplatelet medications did not increase early postoperative mortality and anticoagulants did not meaningfully increase blood loss, early hip fracture fixation for patients taking anticoagulant drugs without reversal may be warranted to avoid the known risks of surgical delay. This may be particularly true for DOACs, but even for patients on warfarin, an immediate preoperative INR of 1.8 may be as safe as preoperative aspirin use. Of sample replication of our findings is required, but complete reversal of anticoagulation may be less important before cephalomedullary fixation of geriatric extracapsular hip fractures than once believed.

REFERENCES

1. Wu A-M, Bisignano C, James SL, et al. Global, regional, and national burden of bone fractures in 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. *Lancet Healthy Longev*. 2021;2:e580–e592.
2. Cooper C, Campion G, Melton LJ. Hip fractures in the elderly: a worldwide projection. *Osteoporos Int.* 1992;2:285–289.
3. Adeyemi A, Delhougne G. Incidence and economic burden of intertrochanteric fracture. *JBJS Open Access*. 2019;4:e0045.
4. Fox KM, Magaziner J, Hebel JR, et al. Intertrochanteric versus femoral neck hip fractures: differential characteristics, treatment, and sequelae. *J Gerontol A Biol Sci Med Sci*. 1999;54:M635–M640.
5. Palan J, Odutola A, White SP. Is clopidogrel stopped prior to hip fracture surgery-A survey of current practice in the United Kingdom. *Injury*. 2007;38:1279–1285.
6. Thakur NA, Czerwein JK, Butera JN, et al. Perioperative management of chronic anticoagulation in orthopaedic surgery. *Am Acad Orthop Surg*. 2010;18:729–738.
7. Schuetze K, Eickhoff A, Dehner C, et al. Impact of oral anticoagulation on proximal femur fractures treated within 24 h – A retrospective chart review. *Injury*. 2019;50:2040–2044.
8. Sridharan M, Wysokinski WE, Pruthi R, et al. Periprocedural warfarin reversal with prothrombin complex concentrate. *Thrombosis Res*. 2016; 139:160–165.
9. Caruso G, Andreotti M, Marko T, et al. The impact of warfarin on operative delay and 1-year mortality in elderly patients with hip fracture: a retrospective observational study. *J Orthop Surg Res.* 2019;14: 169.
10. Miller CS, Grandi SM, Shimony A, et al. Meta-analysis of efficacy and safety of new oral anticoagulants (dabigatran, rivaroxaban, apixaban) versus warfarin in patients with atrial fibrillation. *Am J Cardiol*. 2012; 110:453–460.
11. Levack AE, Moore HG, Stephan S, et al. Delayed surgery does not reduce transfusion rates in low energy hip fractures on direct oral anticoagulants (DOACs). *J Orthop Trauma*. 2022;36:172–178.
12. Riley TR, Gauthier-Lewis ML, Sanchez CK, et al. Role of agents for reversing the effects of target-specific oral anticoagulants. *Am J Health-System Pharm*. 2017;74:54–61.
13. Collinge CA, Kelly KC, Little B, et al. The effects of clopidogrel (Plavix) and other oral anticoagulants on early hip fracture surgery. *J Orthop Trauma*. 2012;26:568–573.
14. Jang CY, Kwak DK, Kim DH, et al. Perioperative antiplatelet in elderly patients aged over 70 years treated with proximal femur fracture: continue or discontinue? *BMC Musculoskelet Disord.* 2019;20:124.
15. Chechik O, Thein R, Fichman G, et al. The effect of clopidogrel and aspirin on blood loss in hip fracture surgery. *Injury*. 2011;42:1277–1282.
16. Mattisson L, Lapidus LJ, Enocson A. What is the influence of a delay to surgery. 24 hours on the rate of red blood cell transfusion in elderly patients with intertrochanteric or subtrochanteric hip fractures treated with cephalomedullary nails? *J Orthop Trauma*. 2018;32:403–407.
17. Meinig R, Jarvis S, Orlando A, et al. Is anticoagulation reversal necessary prior to surgical treatment of geriatric hip fractures? *J Clin Orthop Trauma*. 2020;11:S93–S99.
18. Tarrant SM, Catanach MJ, Sarrami M, et al. Direct oral anticoagulants and timing of hip fracture surgery. *J Clin Med*. 2020;9:2200.
19. Franklin NA, Ali AH, Hurley RK, et al. Outcomes of early surgical intervention in geriatric proximal femur fractures among patients receiving direct oral anticoagulation. *J Orthop Trauma*. 2018;32:269–273.
20. Meinberg EG, Agel J, Roberts CS, et al. Fracture and dislocation classification compendium-2018. *J Orthop Trauma*. 2018;32:S1–S10.
21. Schaffer NE, Singh M, McHugh MA, Perdue AM, Ahn J, MOTR Collaborative, Hake ME, et al. Comparison of true blood loss between short and long cephalomedullary nail fixation of geriatric hip fractures, a

retrospective cohort study. *Eur J Orthop Surg Traumatol*. 2023. doi: 10.1007/s00590-023-03509-x. [epub ahead of print].
22. U.S. Census Bureau. *Michigan state 2020 census data*. Available at. https://www.census.gov/library/stories/state-by-state/michigan-population-change-between-census-decade.html. Accessed October 16, 2022.
23. Mattisson L, Lapidus LJ, Enocson A. Is fast reversal and early surgery (within 24 h) in patients on warfarin medication with trochanteric hip fractures safe? A case-control study. *BMC Musculoskelet Disord*. 2018;19:203.
24. Cuker A, Burnett A, Triller D, et al. Reversal of direct oral anticoagulants: guidance from the anticoagulation forum. *Am J Hematol*. 2019;94:697–709.
25. Thomas S, Ghee L, Sill AM, et al. Measured versus estimated blood loss: interim analysis of a prospective quality improvement study. *Am Surg*. 2020;86:228–231.
26. Kollberg SE, Häggström ACE, Lingehall HC, et al. Accuracy of visually estimated blood loss in surgical sponges by members of the surgical team. *AANA J*. 2019;87:277–284.
27. Rothermel LD, Lipman JM. Estimation of blood loss is inaccurate and unreliable. *Surgery*. 2016;160:946–953.