Characterizing trauma patients with delays in orthopedic process measures

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INTRODUCTION: Early operative intervention in orthopedic injuries is associated with decreased morbidity and mortality. Relevant process measures (e.g., femoral shaft fixation <24 hours) are used in trauma quality improvement programs to evaluate performance. Currently, there is no mechanism to account for patients who are unable to undergo surgical intervention (i.e., physiologically unstable). We characterized the factors associated with patients who did not meet these orthopedic process measures.

METHODS: A retrospective cohort study of patients from 35 American College of Surgeons Committee on Trauma–verified level 1 and level 2 trauma centers was performed using quality collaborative data (2017–2022). Inclusion criteria were adult patients (18 years or older), Injury Severity Score ≥5, and a closed femoral shaft or open tibial shaft fracture classified via the Abbreviated Injury Scale version 2005. Relevant factors (e.g., physiologic) associated with a procedural delay >24 hours were identified through a multivariable logistic regression, and the effect of delay on inpatient outcomes was assessed. A subanalysis characterized the rate of delay in "healthy patients."

RESULTS: We identified 5,199 patients with a femoral shaft fracture, and 87.5% had a fixation procedure, of which 31.8% had a delay, and 47.1% of those delayed were "healthy." There were 1,291 patients with an open tibial shaft fracture, 92.2% had fixation, 50.5% had an irrigation and debridement, and 11.2% and 18.7% were delayed, respectively. High Injury Severity Score, older age, and multiple medical comorbidities were associated with a delay in femur fixation, and those delayed had a higher incidence of complications.

CONCLUSION: There is a substantial incidence of surgical delays in some orthopedic trauma process measures that are predicted by certain patient characteristics, and this is associated with an increased rate of complications. Understanding these factors associated with a surgical delay, as well as effectively accounting for them, is key if these process measures are to be used appropriately in quality improvement programs. (*J Trauma Acute Care Surg.* 2024;97: 918–927. Copyright © 2024 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic/Care Management; Level IV.

KEY WORDS: Orthopedic; process measures; quality improvement; trauma outcomes.

Early operative intervention of orthopedic injuries has been proven to result in decreased mortality,[1–6] reduced complication rates,[2,7,8] and lower total health care–related costs.[9–11] Subsequently, appropriate orthopedic process measures have been incorporated into both the American College of Surgeons (ACS) Trauma Quality Improvement Program (TQIP)[12,13] and the American College of Surgeons Committee on Trauma verification process.[14] Currently, there are seven orthopedic process measures, including three that are assessed within 24 hours of patient arrival: (1) fixation of midshaft femur fractures, (2) fixation of open tibia shaft fractures, and (3) operative irrigation and debridement of open tibia fractures. American College of Surgeons TQIP performance reports are generated and fed back to the participating trauma centers so that local stakeholders can know where they stand in relation to their peers as well as identify and understand outlier patients who did not receive a timely operative intervention at their own institution. To accomplish these measures, it is essential to have the coordination of multiple stakeholders (e.g., trauma surgeons, anesthesiologists, orthopedic surgeons, etc.) along with robust systems in place (e.g., operating room availability, surgical staff, etc.).[9,15] Because orthopedic outcomes are currently not measured by ACS TQIP, measurement of care processes represents the best alternative means to evaluate quality, in line with the Donabedian[16–18] model.

However, current reporting of orthopedic process measures does not account for patients who are physiologically unstable or who have other extenuating issues (e.g., hemorrhagic shock, subarachnoid hemorrhage) that could preclude operative intervention within 24 hours. While the presence of resources (e.g., the availability of appropriate surgeons, operating rooms) can be addressed through performance improvement mechanisms, the existing health status of the patient at the time of injury is something that cannot be modified. As a goal of ACS TQIP is to provide credible reports with actionable information for all relevant stakeholders, it is unclear how individual centers respond to these outlier patients in their reports, especially those who might have been deemed "too unstable" for surgery. In addition, these metrics are also used during trauma center verification site visits to evaluate the overall orthopedic care provided. Interestingly, when evaluating the door-to-balloon time in patients with a myocardial infarction, the issue of which patients to include, as well as exclude, in this process measure has been discussed, and treating centers are allowed some leeway in their patient selection.[19,20] Subsequently, it might be appropriate to have a more nuanced approach to how we measure these orthopedic process measures (e.g., times to operative interventions) in these patients and possibly consider the relevant factors that might delay care and that are beyond the control of the treating center and care team.

The goal of this study is to characterize trauma patients undergoing operative intervention (e.g., fixation, irrigation and debridement) of either closed femoral or open tibia shaft fractures and determine if there are factors (e.g., demographic, physiologic, injury) associated with delays in care. These injuries were chosen because they are each associated with substantial complications (e.g., femoral shaft fracture: mortality, acute respiratory distress syndrome; open tibia shaft fracture: infection, nonunion), and their subsequent process measures are associated with these

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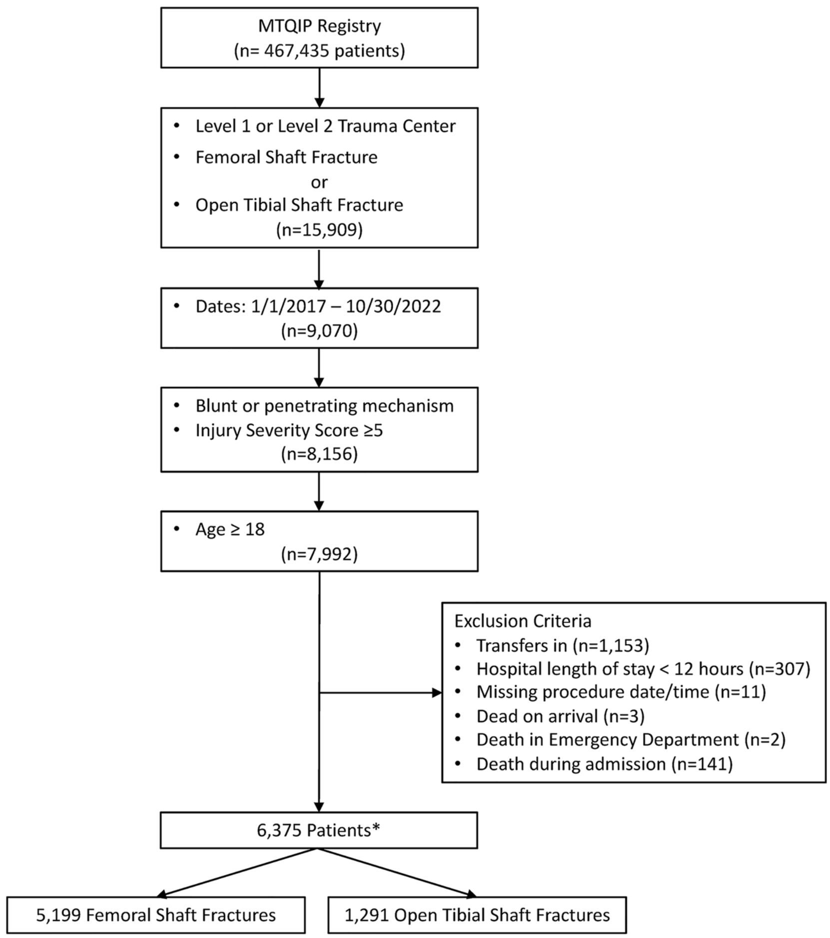

MTQIP, Michigan Trauma Quality Improvement Program
*Some patients had both types of fractures

Figure 1. Patient cohort inclusion and exclusion criteria.

outcomes. The secondary goal is to assess whether patients who have a delay to surgery have an increased rate of complications. Using ACS TQIP criteria, we will examine patients in a statewide trauma collaborative to answer these two questions. We hypothesize that there are patient factors (e.g., higher injury severity, increased age) associated with delays in care. Our aim is to frame the conversation toward "risk adjusting" of these process measures to acknowledge the heterogeneity of these patients and design an evaluation system that accounts for nonmodifiable factors beyond the control of the trauma center.

PATIENTS AND METHODS

Study Design and Setting

This is a retrospective cohort study of trauma patients treated at 35 American College of Surgeons Committee on Trauma–verified level 1 and level 2 trauma centers participating in the Michigan Trauma Quality (MTQIP). MTQIP is a collaborative quality initiative, funded by the Blue Cross Blue Shield of Michigan, which uses enhanced trauma registry data collection.[21] In addition to standard trauma registry data, MTQIP collects additional information on outcomes, processes of care, and uses a robust data validation program.[22]

Data and Participants

Patients with a closed femoral shaft or open tibial shaft fracture were identified using Abbreviated Injury Scale version 2005 codes described in the Fall 2022 ACS TQIP reporting code set. Associated fixation and irrigation and debridement procedures were based on *International Classification of Diseases, Tenth Revision, Procedure Coding System*, codes also defined in the same reporting codes set (Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/D760). Patients 18 years or older with an Injury Severity Score (ISS) of ≥5 who presented to a MTQIP participant trauma center between January 2017 and October 2022 with a relevant fracture were included in the study. Patients were excluded if they had been entered into the database prior to the center enrolling in MTQIP. Patients with burns, patients with no signs of life at initial evaluation in the emergency department (ED) (systolic blood pressure, 0; pulse, 0; Glasgow Coma Scale score, 3), patients who died in the ED or died during their hospital admission, those who were not admitted, and those who were transferred from another hospital were excluded.[23] In addition, patients with a hospital length of stay less than 12 hours were also excluded.

Data Collection and Data Definitions

Data collection was performed using the existing trauma registry at participating hospitals with a modular add-on for MTQIP specific data. MTQIP publishes a data definitions dictionary, based upon the National Trauma Data Standard, which is available online and updated annually. Trauma registrars and data abstractors from participating centers undergo training in MTQIP and National Trauma Data Standard data definitions. Data are transmitted to the coordinating center at 2-month intervals. Each MTQIP center undergoes an annual data validation audit.[22]

Analysis

The primary outcome of this study was the proportion of patients who had a delay of a relevant orthopedic procedure (e.g., fixation or irrigation and debridement) greater than 24 hours. For each linked diagnosis-surgery group (e.g., midshaft femur fractures-fixation), the time to surgery was calculated based on the patient's arrival at the ED to the start of surgery. Patients who had both a femur fracture and an open tibia fracture were analyzed separately in each appropriate category. A univariate analysis was performed to describe differences between the delay and nondelayed groups. A multivariable logistic regression was used to evaluate any relevant factors that were associated with a delay to surgery. This model included 25 covariates: age, sex, race, insurance, admission during weekend, trauma center level, admitting service, ISS, AIS regions, ED systolic blood pressure, ED heart rate, Glasgow Coma Scale motor, intubation, smoking status, hypertension, anticoagulant usage, functionally dependent health status, prehospital cardiac arrest, disseminated cancer, blood transfusion, and chronic renal failure. The variables for the regression were chosen after we analyzed the univariate analyses and used a forward stepwise selection process with the variables that were potentially correlated with delay ($p < 0.2$). We then added covariates that are clinically and demographically important that could be expected to be on the causal pathway. These covariates chosen are consistent with the stated hypothesis and are consistent with other trauma outcomes studies.[4,24–30]

A subanalysis was also performed to assess the proportion of patients delayed to surgery who were deemed to be "healthy," that is, patients who were physiologically stable and likely able to undergo an operative intervention. This subanalysis was designed to capture patients who were presumably delayed because of trauma center structural issues, for example, surgeon staffing, and operating room availability. These patients were defined as being nonhypotensive (ED systolic blood pressure, >90 mm Hg), lacking serious head injury (head AIS, < 3), ISS <15, no preinjury use of anticoagulant medication, no procedures within first 24 hours, and no intensive care unit (ICU) stay.

The secondary outcome was to determine if the patients who had a delay to surgery had a higher rate of complications (e.g., pneumonia, acute respiratory distress syndrome, deep vein thrombosis, pulmonary embolism, stroke/cerebral vascular accident, ventilator-associated pneumonia, unplanned return to ICU, unplanned intubation) or overall hospital length of stay compared with those who were not delayed.

Average values were expressed as the mean ± SD. All statistical tests were two-sided. Statistical significance was defined as a p value of <0.05. Statistical analyses were performed using Stata 15.1 (StataCorp., College Station, TX).

This study was submitted to the University of Michigan Medical School Institutional Review Board and given a determination of "not regulated" status as secondary use of existing data from a quality assurance and quality improvement clinical activity. Secondary use of MTQIP data has been approved by the Michigan Medicine Institutional Review Board under application HUM00041947. We followed the STROBE guidelines in this retrospective, cross-sectional study using observational cohort data (Supplemental Digital Content, Supplementary Data 2, http://links.lww.com/TA/D761).[31]

RESULTS

There were 467,435 trauma patients in the MTQIP database, and after inclusion/exclusion criteria were applied, 6,375 patients were left for the final analysis. We identified 5,199 patients with a femoral shaft fracture and 1,291 patients with an open tibial shaft fracture (some patients had both injuries) (Fig. 1). Of the patients with a femoral shaft fracture, 4,550 (87.5%) had a fixation procedure, and of those who underwent surgery, 1,445 (31.8%) had an operative delay >24 hours (Table 1). Of the patients who had a surgical delay, 681 (47.1%) were deemed to be "healthy" by our criteria. Of the patients with an open tibial shaft fracture, 1,190 (92.2%) had a fixation procedure, and 652 (50.5%) had an irrigation and debridement, and of those who underwent surgery, 133 (11.2%) and 122 (18.7%) had an operative delay >24 hours of their respective procedures. Of the open tibia fracture patients who had a surgical delay, 27 who had fixation procedures (20.3%) and 13 who had irrigation and debridement (10.7%) were deemed to be "healthy" by our criteria.

TABLE 1. Orthopedic Procedures Performed and Surgical Delays

Total Injuries (n) and Associated Procedures	Total Procedures Performed, n (%)	Surgical Patients With Delay >24 h, n (% of Total Procedures)	"Healthy" Surgical Patients With Delay >24 h, n (% of Delayed Patients)
Femoral shaft fracture (5,199)			
Operative stabilization	4,550 (87.5)	1,445 (31.8)	681 (47.1)
Open tibial shaft fracture (1,291)			
Operative stabilization	1,190 (92.2)	133 (11.2)	27 (20.3)
Irrigation and debridement	652 (50.5)	122 (18.7)	13 (10.7)

TABLE 2. Femoral Shaft Fracture Patients Undergoing Surgical Fixation (n = 4,550)

Variable	Patients Without Surgical Delay (n = 3,105)	Patients With Surgical Delay >24 h (n = 1,445)	p
Age, mean (SD), y	51.4 (24.7)	66.9 (22.4)	<0.001
Age, %			<0.001
18–25 y	19.2	7.3	
26–45 y	28.2	13.0	
46–65 y	17.7	16.6	
65–75 y	11.8	17.8	
>75 y	23.1	45.3	
Male, %	53.5	41.5	<0.001
Race, %			<0.001
White	69.5	80.9	
Black	25.9	15.9	
Other	4.6	3.2	
Uninsured, %	6.4	3.2	<0.001
Trauma center level, %			<0.001
1	44.5	38.0	
2	55.5	62.0	
ISS, %			<0.001
5–15	81.5	85.8	
15–24	11.9	5.8	
24–35	5.2	5.1	
>35	1.4	3.3	
AIS head/neck >2, %	4.1	5.5	0.038
AIS face >2, %	0.3	0.6	0.12
AIS chest >2, %	10.2	8.9	0.19
AIS abdomen >2, %	3.9	4.2	0.64
AIS extremity >2, %	100.0	100.0	
AIS external >2, %	0.2	0.2	0.73
ED heart rate, %			0.002
51–120, bpm	90.8	88.9	
>120	5.9	5.3	
0–50	0.7	1.2	
Missing	2.6	4.6	
ED systolic blood pressure, %			<0.001
>90, mm Hg	93.7	91.2	
61–90	3.3	3.3	
≤60	0.5	0.4	
Missing	2.5	5.1	
Glasgow Coma Scale motor, %			<0.001
1	1.1	2.3	
2–5	3.0	3.5	
6	90.5	84.8	
Missing	5.4	9.4	
Intubated, %	4.5	6.9	<0.001
Comorbid diseases, %			
Active chemotherapy	0.5	1.2	0.003
Advanced directive limiting care	3.3	7.5	<0.001
Alcohol use disorder	6.1	6.0	0.83
Angina	0.3	1.0	0.005
Bleeding risk	8.2	21.5	<0.001
Cerebrovascular accident	1.8	4.2	<0.001
COPD	5.5	9.1	<0.001
Chronic renal failure	0.5	2.2	<0.001
Congestive heart failure	4.1	11.1	<0.001
Current smoker	26.6	16.3	<0.001
Dementia	7.3	15.3	<0.001
Diabetes mellitus	10.2	17.6	<0.001
Disseminated cancer	0.5	1.8	<0.001
Drug use disorder	26.0	14.6	<0.001
Functionally dependent health status	18.7	40.4	<0.001
History of myocardial infarction	0.4	0.8	0.065
Hypertension requiring medication	31.1	55.1	<0.001
Liver disease	0.6	0.7	0.75
Major psychiatric illness	22.5	24.4	0.16
Obesity	2.4	1.8	0.17
Peripheral vascular disease	1.8	3.7	<0.001
Steroid use	2.0	3.5	0.004

AIS, Abbreviated Injury Scale; COPD, chronic obstructive pulmonary disease.

In a univariate analysis of patients with a femur fracture who had a surgical delay >24 hours, patients tended to be older, female, White, insured, and intubated and have a significant head or neck injury along with more medical comorbidities compared with those who did not have a surgical delay (Table 2). For patients with open tibia fractures, patients who had a surgical delay tended to have higher ISSs and be intubated but largely did not show a difference in medical comorbidities compared with those without a surgical delay (Table 3).

The multivariable analysis of patients with a femoral shaft fracture yielded a *C* statistic of 0.73 and identified characteristics associated with a delay to surgery (Table 4). Having an ISS of >35 (odds ratio, 2.64; $p = 0.012$) and being intubated (odds ratio, 2.59; $p < 0.001$) was associated with having a surgical delay, while an ISS below 35 was not a significant factor. In patients older than 45 years, there was a significant risk of a delayed surgery with odds increasing from 2.32 ($p < 0.001$) (46–65 years old) to 3.37 ($p < 0.001$) (older than 75 years). Multiple medical comorbidities were also relative factors in patients with a delay, including hypertension, anticoagulant use, functionally dependent health status, cancer, and chronic renal failure. Interestingly, receiving a blood transfusion was more likely in patients who did not have a delay in their femur fixation surgery.

In the multivariable analysis of patients with an open tibia fracture, those who were 65 to 75 years old and of other race and had received a blood transfusion were associated with delays to fixation, while those who were uninsured were less likely to have a delay to surgery. In open tibia patients undergoing a debridement, ages 26 to 45 years and 65 to 75 years, male sex, receiving a blood transfusion, and having functionally dependent health status were associated with a delay to surgery. The *C* statistic of these

TABLE 3. Open Tibia Shaft Fracture Patients Undergoing Surgical Fixation (n = 1,190) or Irrigation and Debridement (n = 652)

	Surgical Fixation (n = 1,190)			Irrigation and Debridement (n = 652)		
Variable	Patients Without Surgical Delay (n = 1,057)	Patients With Surgical Delay >24 h (n = 133)	*p*	Patients Without Surgical Delay (n = 530)	Patients With Surgical Delay >24 h (n = 122)	*p*
Age, mean (SD), y	41.3 (17.4)	42.6 (18.4)	0.45	41.7 (18.1)	42.9 (16.1)	0.50
Age, %			0.083			0.25
18–25 y	20.7	16.5		21.9	13.9	
26–45 y	41.5	45.1		39.2	46.7	
46–65 y	28.4	23.3		27.9	27.9	
65–75 y	4.7	9.8		5.5	7.4	
>75 y	4.6	5.3		5.5	4.1	
Male, %	72.3	70.7	0.70	70.4	79.5	0.043
Race, %			0.19			0.36
White	62.9	54.9		59.4	54.1	
Black	32.6	39.1		35.1	41.8	
Other	4.4	6.0		5.5	4.1	
Uninsured, %	11.0	8.3	0.34	10.2	9.0	0.70
Trauma center level, %			0.046			0.34
1	48.7	57.9		59.2	63.9	
2	51.3	42.1		40.8	36.1	
ISS, %			0.002			0.014
5–15	78.1	66.2		74.0	61.5	
15–24	14.1	16.5		17.2	20.5	
24–35	5.4	12.0		5.7	11.5	
>35	2.4	5.3		3.2	6.6	
AIS head/neck >2, %	7.0	16.5	<0.001	8.5	14.8	0.035
AIS face >2, %	0.2	1.5	0.014	0.4	0.8	0.52
AIS chest >2, %	12.0	17.3	0.084	14.3	23.0	0.019
AIS abdomen >2, %	4.2	6.8	0.17	4.9	7.4	0.27
AIS extremity >2, %	100.0	100.0		100.0	100.0	
AIS external >2, %	0.3	0.0	0.54	0.4	0.8	0.52
ED heart rate, %			0.16			0.12
51–120, bpm	89.3	82.7		88.7	82.0	
>120	8.7	14.3		9.1	16.4	
0–50	0.9	1.5		1.1	0.8	
Missing	1.1	1.5		1.1	0.8	
ED systolic blood pressure, %			0.40			0.95
>90, mm Hg	93.8	94.7		92.6	93.4	
61–90	4.6	3.0		5.5	4.9	
≤60	0.6	0.0		0.6	0.8	
Missing	1.0	2.3		1.3	0.8	
Glasgow Coma Scale motor, %			0.050			0.43
1	1.8	5.3		2.3	4.9	
2–5	3.5	3.8		4.5	4.9	
6	91.8	86.5		90.4	86.9	
Missing	2.9	4.5		2.8	3.3	
Intubated, %	7.8	15.8	0.002	9.6	16.4	0.030
Comorbid diseases, %						
Active chemotherapy	0.1	0.8	0.081	0.2	0.8	0.26
Advanced directive limiting care	0.2	2.3	<0.001	0.6	0.8	0.75
Alcohol use disorder	10.9	15.0	0.15	11.1	11.5	0.91
Angina	0.3	0.0	0.54	0.0	0.8	0.037
Bleeding risk	3.8	5.3	0.41	4.5	4.9	0.85
Cerebrovascular accident	0.5	0.8	0.67	0.8	1.6	0.36

Continued next page

TABLE 3. *(Continued)*

Variable	Surgical Fixation (n = 1,190) Patients Without Surgical Delay (n = 1,057)	Surgical Fixation (n = 1,190) Patients With Surgical Delay >24 h (n = 133)	p	Irrigation and Debridement (n = 652) Patients Without Surgical Delay (n = 530)	Irrigation and Debridement (n = 652) Patients With Surgical Delay >24 h (n = 122)	p
COPD	4.0	3.0	0.59	3.2	4.9	0.36
Chronic renal failure	0.6	0.0	0.38	0.4	0.0	0.50
Congestive heart failure	2.6	2.3	0.79	2.8	4.1	0.46
Current smoker	37.7	38.3	0.88	35.7	41.8	0.20
Dementia	0.7	0.8	0.91	0.6	0.0	0.40
Diabetes mellitus	7.1	6.0	0.64	5.8	9.8	0.11
Disseminated cancer	0.0	0.8	0.005	0.0	0.8	0.037
Drug use disorder	36.2	45.1	0.046	36.4	47.5	0.023
Functionally dependent health status	4.8	7.5	0.18	4.7	7.4	0.23
History of myocardial infarction	0.2	0.0	0.62	0.4	0.0	0.50
Hypertension requiring medication	17.4	18.0	0.86	18.5	19.7	0.76
Liver disease	0.7	0.0	0.35	0.9	0.8	0.90
Major psychiatric illness	19.9	18.0	0.62	18.1	23.0	0.22
Obesity	2.8	2.3	0.70	3.8	4.1	0.87
Peripheral vascular disease	1.7	1.5	0.87	1.9	1.6	0.85
Steroid use	1.3	0.0	0.18	0.8	0.8	0.94

AIS, Abbreviated Injury Scale; COPD, chronic obstructive pulmonary disease.

models were 0.66 and 0.72, respectively (Supplemental Digital Content, Supplementary Data 3, http://links.lww.com/TA/D762).

In patients with a femur fracture, those who had a delay in care had more complications (Table 5). Compared with those without a delay, these patients had a significantly higher rate of pneumonia (3.5% vs. 1.5%, $p < 0.001$), ventilator-assisted pneumonia (2.1% vs. 0.9%, $p < 0.001$), unplanned ICU admission (4.2% vs. 2.1%, $p < 0.001$), and a longer length of stay (8.4 days vs. 6.7 days, $p < 0.001$). While femur fracture fixation patients with a delay did have a higher complication rate of acute respiratory distress syndrome, venothromboembolic events, stroke, and unplanned intubation, these differences were not statistically significant.

DISCUSSION

In this study, we found that a substantial portion of patients (31.8%) with a femur fracture had a delay to surgical fixation of greater than 24 hours. Of those who had a surgical delay, almost half of them were deemed to be "healthy" or otherwise should have been able to undergo a fixation procedure. Highly injured patients, older age, and multiple medical comorbidities were factors predictive of femur fracture patients not undergoing surgical fixation within 24 hours. In open tibia fracture patients, having an older age receiving a blood transfusion were the common factors that predicted a delay in either operative fixation or a formal irrigation and debridement procedure. Patients with a delay to surgery were also more likely to develop some serious complications and have a longer hospital length of stay.

The ACS TQIP orthopedic process measures were designed to evaluate major orthopedic injuries based on widely accepted interventions and their respective timeframes. Multiple studies have shown that the early fixation (within 24 hours) of a femoral shaft fracture results in decreased mortality.[1,5,8,32] and fewer complications.[2,7,8] In this study, almost one third of patients with a femur fracture did not have surgery within a day, and those with a delay also had a higher rate of complications. While only half of the patients with an open tibia fracture had a documented irrigation and debridement of their injury, it is possible that this procedure was performed during the fixation surgery but not coded. It should also be noted that newer evidence is shifting more toward the importance of early antibiotic administration and less on urgent irrigation and debridement;[33–35] however, the majority of these patients were not delayed in their procedures. Nevertheless, it is essential that we understand the reasons for these delays if we are to improve the care that is delivered.

Based on the multivariable analysis, we can characterize a phenotype of a femur fracture patient (e.g., older, high ISS, medical comorbidities) that is likely to have a delay in surgical fixation. Subsequently, it might be reasonable to assume that these patients were deemed "too sick to operate," even for a temporizing damage-control type procedure (e.g., external fixator).[3,32,36,37] Including these patients in the reporting for this measure, together with those who are stable for surgery, is problematic because it creates a heterogeneous group for the analysis. This issue has been acknowledged in myocardial infarction patients receiving a percutaneous coronary intervention within 90 minutes, as some patients are excluded from the denominator of this process measure based on their risk factors.[19,20] It might be reasonable to have a similar approach to trauma process measures and exclude the patients who are known to not be candidates for timely operative intervention. Also, by defining a homogenous cohort from the start, this might encourage more stakeholder buy-in and lessen the risk of creating a set-up-to-fail situation where the vested

TABLE 4. Characteristics of Femoral Shaft Fracture Patients With a Surgical Fixation Delay

Variable	Odds Ratio and 95% CI	*p*
Age		
18–25 y	(Reference)	
26–45 y	1.32 (0.93–1.85)	0.117
46–65 y	2.32 (1.64–3.28)	<0.001
65–75 y	3.14 (2.24–4.40)	<0.001
>75 y	3.37 (2.23–5.10)	<0.001
Male	1.07 (0.93–1.24)	0.328
Race		
White	(Reference)	
Black	0.90 (0.73–1.10)	0.293
Other	0.86 (0.55–1.35)	0.522
Uninsured	0.77 (0.51–1.17)	0.225
Trauma center level		
1	(Reference)	
2	0.98 (0.69–1.39)	0.903
Admitting service		
Trauma	(Reference)	
Orthopedics	0.67 (0.44–1.02)	0.064
Other	1.32 (0.95–1.84)	0.104
Weekend admission	0.95 (0.80–1.13)	0.568
ISS		
5–15	(Reference)	
15–24	0.80 (0.54–1.18)	0.252
24–35	1.30 (0.72–2.35)	0.392
>35	2.64 (1.24–5.61)	0.012
AIS head/neck >2	1.27 (0.81–1.98)	0.304
AIS face >2	0.98 (0.41–2.38)	0.970
AIS chest >2	1.00 (0.65–1.54)	0.983
AIS abdomen >2	1.53 (0.96–2.42)	0.073
AIS external >2	1.55 (0.22–11.00)	0.659
ED systolic blood pressure		
>90, mm Hg	(Reference)	
61–90	1.07 (0.78–1.47)	0.679
≤60	0.90 (0.30–2.69)	0.846
Missing	1.89 (0.78–4.57)	0.156
ED heart rate		
51–120, bpm	(Reference)	
>120	1.26 (0.92–1.71)	0.150
0–50	1.28 (0.68–2.41)	0.442
Missing	0.63 (0.30–1.31)	0.217
Glasgow Coma Scale motor, %		
1	(Reference)	
2–5	0.65 (0.38–1.11)	0.114
6	0.69 (0.40–1.20)	0.192
Missing	0.76 (0.41–1.40)	0.375
Intubated	2.59 (1.72–3.90)	<0.001
Current smoker	0.88 (0.71–1.08)	0.212
Hypertension requiring medication	1.32 (1.10–1.58)	0.003
Anticoagulant use	1.70 (1.39–2.07)	<0.001
Functionally dependent health status	1.59 (1.34–1.88)	<0.001
Pre-hospital cardiac arrest	3.30 (0.41–26.41)	0.260
Disseminated cancer	2.13 (1.19–3.83)	0.011
Blood transfusion	0.54 (0.41–0.72)	<0.001
Chronic renal failure	2.43 (1.09–5.41)	0.029

AIS, Abbreviated Injury Scale.

parties are asked to do something beyond their control (i.e., operate on a patient who cannot tolerate surgery).[38]

The limitations of this study should be acknowledged. This was a retrospective review of previously collected trauma registry data. It is unclear why all femoral shaft fractures did not receive a fixation procedure because this injury is almost never treated nonoperatively. It is possible that some of these patients were coded as a shaft fracture; however, they might have had some involvement of either the proximal or distal component, such that the coded operative procedure pertained to the nonshaft portion of the injury. While a small proportion of open tibia fractures did not have an associated fixation procedure, it is reasonable that some of these fractures were treated without surgical fixation. It is also reasonable to believe that the reason that roughly half of open tibia fractures did not have a formal irrigation and debridement coded is because that happened in conjunction with the fixation procedure. We also did not assess complications in the open tibia group (e.g., infections, nonunions) because these outcomes almost always occur after discharge and are not captured in the current trauma registry structure. We were also limited by the granularity of the data, and thus, there could be other factors not included in the trauma registry data that could have better delineated a "healthy" patient. Lastly, while mortality is an important outcome, we excluded patients who died during their admission from the analysis, as we felt that we would be unable to discern whether their injuries or other confounding factors influenced nonoperative or delayed treatment.

A strength of this study is that it uses the diagnosis and procedure codes that are used by ACS TQIP so that these results should be similar to the reports that are fed back to participating trauma centers and should describe the patients captured in these process measures. Also, these data are from 35 level 1 and level 2 ACS COT–verified trauma centers that represent multiple health systems across a state and are dispersed across rural and urban environments in both academic and nonacademic practice settings. Furthermore, these two diagnoses and their respective treatments are both very common and relevant orthopedic conditions that often affect the cadence of the patient's care and their length of stay. However, it is reasonable that some of these patients simply will

TABLE 5. Complications in Patients With a Femoral Shaft Fracture

Complication, n (%)	Patients With Surgical Delay >24 h (n = 1,445)	Patients Without Surgical Delay >24 h (n = 3,105)	*p*
Pneumonia	51 (3.5)	47 (1.5)	<0.001
ARDS	11 (0.8)	11 (0.4)	0.065
DVT/PE	29 (2.0)	39 (1.3)	0.052
Stroke/CVA	8 (0.6)	13 (0.4)	0.53
VAP	31 (2.1)	27 (0.9)	<0.001
Return to ICU	61 (4.2)	66 (2.1)	<0.001
Unplanned intubation	13 (0.9)	17 (0.5)	0.17
Outcome			
Hospital LOS, mean (SD), d	8.4 (7.5)	6.7 (6.7)	<0.001

ARDS, acute respiratory distress syndrome; CVA, cerebrovascular accident; DVT, deep vein thrombosis; LOS, length of stay; PE, pulmonary embolism; VAP, ventilator-assisted pneumonia.

not be medically stable or able to tolerate these procedures within the first 24 hours of their admission. Thus, if we are to include all patients (stable and unstable) in these process measures, we are creating a situation whereby centers and their respective care teams are being evaluated and scored based on factors outside their control, that is, including patients who cannot have a procedure within 24 hours. Furthermore, because some entities are beginning to use process measures in pay-for-performance initiatives, this might be another reason to consider which patients are included in the denominator of these calculations. We should also examine mechanisms to adjudicate the reasons when patients do not meet these timed measures and potentially further elucidate a trauma patient phenotype that is too sick to include.

In conclusion, this study showed that a substantial proportion of patients with a femoral shaft fracture had a delay to fixation beyond 24 hours and had an increased rate of complications. A high ISS, increasing age, and medical comorbidities were predictive factors for a patient having a delay to surgery with the first day; however, we also found a substantial number of patients who did not have discernable reason for their delay, likely indicating a local system issue at the trauma center that could be addressed through performance improvement audit mechanisms. As we continue to use process measures to evaluate the quality of orthopedic care delivered at trauma centers, we should pause and evaluate which patients we include in the denominator of this calculation.

AUTHORSHIP

N.G., P.K., and B.W.O. contributed in the literature search. L.G., A.N.M., P.W., M.J., R.V., M.R.H., and B.W.O. contributed in the study design. L. G., M.R.H., and B.W.O. contributed in the data collection. L.G., M.R.H., and B.W.O. contributed in the data analysis. L.G., A.N.M., P.W., M.J., J. W.S., R.V., M.R.H., and B.W.O. contributed in the data interpretation. N. G., P.K., L.G., and B.W.O. contributed in the writing. N.G., P.K., L.G., A. N.M., P.W., M.J., J.W.S., R.V., M.R.H., and B.W.O. contributed in the critical revision. J.W.S., M.R.H., and B.W.O. contributed in the funding.

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DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (Supplementary Data 4, http://links.lww.com/TA/D763).
Although BCBSM and the MTQIP work collaboratively, the opinions, beliefs, and viewpoints expressed by the authors do not necessarily reflect the opinions, beliefs, and viewpoints of BCBSM or any of its employees.

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