Research Article

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Traumatic Orthopaedic Injury Is Not an Independent Risk Factor for High Postdischarge Opioid Consumption

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Abstract

Introduction: The purpose of this study was to quantify how opioid use in patients with traumatic injury compared with opioid use in patients undergoing elective arthroplasty.

Methods: In a retrospective review, 235 adult trauma patients treated surgically for fracture were compared with 98 patients undergoing elective total hip or knee arthroplasty. Inpatient, discharge, and postdischarge opioid use were recorded in oral morphine equivalents (OMEs).

Results: There were no differences between trauma and elective arthroplasty patients for inpatient opioid use (OME/day: 70.2 vs. 67.3; P = 0.53), discharge prescription (OME: 542 vs. 594; P = 0.13), or postdischarge opioid use (OME: 986 vs. 1,147; P = 0.29). Postdischarge opioid use was positively correlated with Caucasian race, intensive care unit admission, baseline alcohol or opioid use, and higher discharge prescriptions ($P < 0.0001$; adjusted R^2 = 0.127). Discharge prescription amount was the most significant predictor.

Discussion: Traumatic injury is not a predictor of high post-discharge opioid use. Demographic, social, and physician prescribing behaviors contribute to higher postdischarge opioid consumption.

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Prescription opioid use, dependence, and abuse have reached epidemic proportions.[1] Opioid analgesia sales quadrupled from 1999 to 2010.[2] In the period 2011 to 2012, 6.9% of adults used prescription opioid analgesia in the past 30 days, an increase from 5% in the 1999 to 2002 period.[3] Sustained use of opioid analgesia can result in tolerance and physical dependence, sometimes resulting in opioid addiction.[4] In addition, these medications can be diverted for illicit use, thus making prescription opioids more readily available in the general population.[5–8] The increased supply of both prescription and illicit opioid drugs has correlated with a tripling of opioid-related deaths over the past two decades.[6]

With the use of prescription opioid medications increasing, research studies have focused on identifying risk factors for opioid abuse.[9–12]

Much of the literature has focused on patients with chronic pain. Studies within this population suggest that risk factors for opioid abuse fall into two general categories: nonmodifiable and modifiable. Nonmodifiable risk factors are often demographic factors, including younger age and substance use disorders; modifiable risk factors are often prescriber related and include prescriptions for short-acting opioids at high daily doses. Although significant literature exists regarding opioid use in chronic pain populations, less is known regarding orthopaedic injury and the risk of high levels of opioid use.

Patients with trauma represent a patient cohort with unanticipated surgical needs in whom social factors are often unable to be optimized prior to necessary intervention. By contrast, elective orthopaedic operations first require consultation with an orthopaedic surgeon, who can defer surgical management in candidates deemed unsuitable based on medical or social factors. In addition, many elective procedures require patient clearance by a perioperative medicine provider, providing ample opportunities for patient optimization prior to intervention. Therefore, although both populations undergo surgical intervention, the medical and psychological settings in which the surgery proceeds are considerably different.

Given these concerns, the main goal of this study was to determine whether traumatic orthopaedic injury was a risk factor for high levels of postdischarge opioid consumption. In addition, this study characterized demographic differences between the groups and identified risk factors for greater inpatient and postdischarge opioid consumption.

Methods

Design and Setting

This retrospective comparative study was performed at a single level 1 trauma center in a major metropolitan area in the Midwest United States. As the only level 1 trauma center in the metropolitan area during the data acquisition period, all significant trauma activations were treated at this institution. Institutional review board approval was obtained for the study.

Selection Criteria

A total of 305 potential patients with trauma were identified. Trauma patient selection was limited to adult patients who presented with fractures requiring surgical management and who were admitted to the hospital for at least one midnight. Based on these criteria, 235 patients were selected for study inclusion. Of 235 patients included in this study, 202 had isolated orthopaedic injuries. The most common concomitant injuries were rib fractures and closed head injuries. Thirty-three patients with non-isolated orthopaedic injuries were included in the analysis to adequately capture more severe orthopaedic injuries. Patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) were selected to represent the elective orthopaedic procedure, given the significant preoperative clearance often required by this group. A total of 50 patients undergoing THA and 50 undergoing TKA were identified; incomplete information was found in two patients, resulting in a total of 98 elective surgery patients for inclusion in the study.

Data Collection

Data were retrospectively collected on consecutive patients with trauma who presented, starting January 1, 2012, for the evaluation of traumatic injury and were found to have sustained fractures requiring surgical fixation. Similar collection was completed for elective surgery patients. Chart review was completed using the electronic medical record system (Epic Systems). Patient demographic information was recorded, including age, sex, race, insurance type, employment status, number of medical comorbidities, and the use of alcohol, tobacco, or opioids prior to admission. Insurance type was subdivided into classes of Medicare, Medicaid, uninsured (self-pay), commercial insurance, managed care plans, and workers' compensation. Employment status was broadly defined into two categories: currently employed or currently unemployed (retired, disabled, students, and dependents). Patients were considered positive for substance use if they reported current or prior use or had evidence of use on urine toxicology or serum alcohol testing. Urine toxicology was obtained only in patients with trauma. Opioid and benzodiazepine medications on urine toxicology screens were excluded in determining prior use due to

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potential confounding from medically appropriate use in the acute trauma setting prior to study acquisition. Evidence of prior use in patients with arthroplasty was assessed based on patient self-reporting to the orthopaedic surgeon, prior hospital notes, prior prescriptions for opioids, and information obtained during the presurgical medical provider assessment. For patients with trauma, injury characteristics were also collected, including fracture location and Injury Severity Score. For both trauma and elective surgery patients, hospital stay features, including the presence of a complication and the presence of an intensive care unit (ICU) admission, were recorded.

All opioid medications administered to a patient, from the time of admission to discharge, were recorded. Opioid medication was defined using FDA classifications and included morphine, oxycodone, hydromorphone, meperidine, fentanyl, oxymorphone, codeine, methadone, and tramadol. Although codeine and tramadol are regulated differently from the other medications, the FDA defines both as opioid pain relievers.[13,14,15] For oral and non–patient-controlled analgesia (PCA) intravenous medications, a medication was determined to have been administered if it was recorded as such in the Medication Administration Record. Intraoperative and PCA-delivered pain medications were not recorded on the Medication Administration Record, and thus the amount of this medication used was determined from a separate Flowsheet organizer. Discharge opioid prescription amount was also recorded. Postdischarge opioid use was determined based on the total amount of opioid medication prescribed to the patient after the initial discharge prescription, from discharge to the final follow-up. Postdischarge opioid use calculations did not include the discharge prescription; only refill data were included. All opioid use was converted into oral morphine equivalents (OMEs) using a standard equianalgesic opioid dose conversion chart.[16]

During the data collection period, the standard postoperative pain management protocol for THA was as follows: hydromorphone PCA, no NSAIDs (ie, ketorolac), and ice packs if patient requested. The TKA protocol was as follows: femoral nerve peripheral block, if patient consented; hydromorphone PCA; ACE bandage wrap for control of swelling; no NSAIDs (ie, ketorolac); and ice packs if a patient requested. Patients with trauma had no standard postoperative pain management protocol. Pain management regimes generally involved the following: oral opioid medications; ice packs, if patient requested; and no NSAIDs.

Overall, 44 of 49 patients with TKA received a femoral nerve peripheral block. None of the trauma cases in this series received a peripheral nerve block. No standardized protocol was in place for other modalities, either medical or accessory. Medication adjuncts such as NSAIDs, gabapentin, or pregabalin were not part of standard postoperative plans. Ice machines were not in routine use.

Main Outcome

The primary goal of this study was to evaluate differences in inpatient, discharge, and postdischarge opioid use between trauma and elective orthopaedic surgery patients. In addition, this study attempted to describe demographic differences between groups and to identify factors predictive of inpatient and postdischarge opioid use.

Analysis

Opioid use was converted into OMEs. Inpatient opioid use was adjusted for length of stay and is presented as OME per day ± SD; discharge and postdischarge opioid use are presented as mean OME ± SD. Univariate analysis was completed with Prism 7.0a software (GraphPad Software). Student *t*-tests with Welch corrections in the setting of unequal variance, one-way analysis of variance, Tukey multiple comparison test in the setting of significant analysis of variance results, chi-squared and Fisher exact tests, and Pearson correlation coefficients were generated in the appropriate setting. Paired *t* tests were used for matched data. Logistic regression was used to identify demographic features most predictive of trauma patient status, and multiple linear regression was used in predictive modeling of inpatient, discharge, and postdischarge opioid use with MATLAB R2016b software (Mathworks).

Factors analyzed as potential predictors of inpatient opioid use were as follows: patient type (trauma vs. elective), age, sex, race, insurance type, employment status, number of comorbidities, use of alcohol, tobacco, or narcotics prior to admission, presence of a complication, and ICU admission. Discharge prescription analysis included these factors plus inpatient opioid use, and postdischarge opioid use included all the aforementioned variables plus discharge prescription amount. Two analyses were performed: whole-group and matched comparisons. Patients were matched on factors that were found to be most different between groups in logistic regression analysis, specifically, sex, race, insurance status, age, and baseline alcohol, tobacco, and opioid use. Residual analysis using Cook distance was used to identify outliers in regression models. Observations with Cook distance greater than three times the mean Cook distance were identified as potential outliers, and models were adjusted accordingly.

Table 1

Patient Demographics

	Trauma (N = 235)	Elective (N = 98)	*P*
Age (yr)			<0.0001
Mean (SD)	49.9 (20.8)	62.1 (9.00)	
Median	48.0	62	
Range	18.0–97.0	33.0–82.0	
Sex			<0.0001
Male	140 (59.6%)	31 (31.6%)	
Female	95 (40.4%)	67 (68.4%)	
Race			<0.0001
White	164 (69.8%)	45 (45.9%)	
Black or African American	61 (26.0%)	53 (54.1%)	
Other or unknown	10 (4.3%)	0 (0%)	

Table 2

Patient Financial Profile

Factor	Trauma (N = 235)	Elective (N = 98)	*P*
Payer			<0.0001
Medicare	64 (27.2%)	43 (43.9%)	
Medicaid	29 (12.3%)	31 (31.6%)	
Self-pay	58 (24.7%)	5 (5.1%)	
Commercial	17 (7.2%)	7 (7.1%)	
Managed care	49 (20.9%)	10 (10.2%)	
Workers' compensation	9 (3.8%)	2 (2.0%)	
Employment status			0.021
Unemployed	128 (54.5%)	67 (68.4%)	
Employed	107 (45.5%)	31 (31.6%)	

Table 3

Baseline Health and Substance Use

Factor	Trauma (N = 235)	Elective (N = 98)	*P*
Comorbidities			0.0012
Mean (SD)	2.04 (2.16)	2.76 (1.67)	
Median	1	3	
Range	0–9	0–7	
Substance use			
Alcohol	115 (48.9%)	29 (29.6%)	0.0012
Tobacco	100 (42.6%)	34 (34.7%)	0.18
Opioids (any)	45 (19.1%)	41 (41.8%)	0.0001
Opioid source			0.0027
Prescribed	28 (62.2%)	37 (90.2%)	
Recreational	17 (37.8%)	4 (9.8%)	

Variance inflation factors were reported to demonstrate the severity of multicollinearity in the least square regression models. All statistical analyses were two tailed. Statistical significance was set to $P < 0.05$ for all outputs.

Results

Demographics and Baseline Substance Use Characteristics of Trauma and Elective Orthopaedic Patients

Compared with patients with THA or TKA, patients with trauma were younger (49.9 ± 20.8 vs. 62.1 ± 9.0; $P < 0.0001$) and more often male (59.6% vs. 31.6%; $P < 0.0001$), Caucasian (69.8% vs. 45.9%; $P < 0.0001$), self-pay payers (24.7% vs. 5.1%; $P < 0.0001$), and currently employed (45.5% vs. 31.6%; $P < 0.0001$). Patients with trauma also had fewer medical comorbidities (2.04 ± 2.16 vs. 2.67 ± 1.67; $P < 0.0012$). In terms of baseline substance use, patients with trauma more often had a history of alcohol use (48.9% vs. 29.6%; $P = 0.0012$) but less often had self-reported or documented history of opioid use (19.1% vs. 41.8%; $P = 0.0001$). Patients with trauma more often had opioid use histories consistent with recreational use; elective surgery patients generally used opioids with a prescription from a medical provider (recreational opioid use: trauma, 37.8%, and elective, 9.8%; $P = 0.0027$) (Tables 1–3).

Baseline substance use in patients with trauma was prevalent, with 48.9% and 42.6% of patients reporting some form of alcohol or tobacco use, respectively. Current or former opioid use was self-reported or present in prior records in 19.1% of patients. Urine toxicology test results were obtained in 29.8% of patients. The most common positive finding was for opioids, which was positive in 34.3% of patients. Alcohol and tetrahydrocannabinol were also frequently present on urine toxicology, positive in 32.9% and 24.3% of studies, respectively. Benzodiazepine and cocaine use were also prevalent, present in 24.3% and 24.3% of patients screened, respectively. Overall, urine toxicology was positive for alcohol or a narcotic in 84.3% of patients, with 44.3% of patients having positive results for more than one substance. Serum alcohol levels were obtained in 42.7% of patients. the Like urine toxicology screen, the specific indication for obtaining serum alcohol levels in some patients and not others was not well documented. Although 73.0% of patients who were tested for serum alcohol had undetectable levels (<5 mg/dL), these levels were greater than the legal limit (80 mg/dL) in 22.5% of the studies obtained (Table 4).

A logistic regression analysis to identify factors most predictive of trauma patient status produced a significant model (Chi-square vs. constant model, 113; $P < 0.0001$; pseudo-$R^2 = 0.3286$). Significant predictors of trauma patient status were male sex (odds ratio [OR], 2.87), Caucasian race (OR, 4.30), and non-Medicaid insurance (OR, 3.62). Patients with trauma were also predicted to be younger (β coefficient, −0.05) and less likely to have a history of opioid use (OR, 0.28).

Patients with trauma presented with injuries of the chest, abdomen, or head, and fractures of the upper extremity, lower extremity, pelvis, and/or spine, resulting in a wide range of Injury Severity Scores. Elective surgery patients were admitted for either total hip or TKA. The management of these different patient types resulted in different lengths of stay, rates of admission to the ICU, and rates of complications (Tables 5 and 6). After

Table 4

Trauma Patient Baseline Substance Use

Factor	Total
Urine toxicology test results	70
Alcohol	23 (32.9%)
Amphetamines	3 (4.3%)
Benzodiazepines	17 (24.3%)
Cocaine	10 (14.7%)
Opioids	24 (34.3%)
Phencyclidine	1 (1.4%)
Tetrahydrocannabinol	17 (24.3%)
Any substance	59 (84.3%)
Multiple substances	31 (44.3%)
Serum alcohol test results, mg/dL	129
<5	94 (73.0%)
5–80	6 (4.7%)
>80	29 (22.5%)

Table 5

Injury and Elective Arthroplasty Characteristics

Factor	Trauma (N = 235)	Elective (N = 98)	
Fracture type			NA
Upper extremity	62 (26.4%)	NA	
Lower extremity	163 (69.4%)	NA	
Pelvis	35 (14.9%)	NA	
Spine	8 (3.4%)	NA	
Multiple sites	75 (31.1%)	NA	
Arthroplasty			NA
Total hip arthroplasty	NA	50 (51.0%)	
Total knee arthroplasty	NA	48 (49.0%)	

NA, not applicable.

Table 6

Hospital Admission Profile

Factor	Trauma (N = 235)	Elective (N = 98)	*P*
Length of stay			<0.0001
Mean (SD)	7.17 (8.0)	3.92 (1.8)	
Median	4	3.5	
Range	1–54	2–10	
Complication			<0.0001
No	176 (74.9%)	78 (79.6%)	
Yes	59 (25.1%)	20 (20.4%)	
Intensive care unit admission			<0.0001
No	178 (75.7%)	97 (99.0%)	
Yes	57 (24.3%)	1 (1.0%)	

Table 7

In-patient Opioid Medication Use

Factor	Trauma	Elective	*P*
Total opioid use (oral morphine equivalent/day)			0.53
Mean (SD)	70.21 (48.7)	67.3 (32.9)	
Median	63.6	66.4	
Range	0–230	12–174.7	
Type of opioid prescribed			
Inpatient			<0.0001
Morphine	120 (51.1%)	14 (14.3%)	
Oxycodone	219 (93.2%)	94 (95.9%)	
Hydromorphone	199 (84.7%)	80 (81.6%)	
Meperidine	44 (18.7%)	8 (8.2%)	
Fentanyl	45 (19.2%)	1 (1.0%)	
Oxymorphone	1 (0.43%)	0 (0%)	
Codeine	1 (0.43%)	0 (0%)	
Hydrocodone	10 (4.30%)	6 (6.12%)	
Methadone	2 (0.85%)	1 (1.02%)	
Tramadol	7 (2.98%)	7 (7.14%)	
Patient-controlled analgesia—in-patient			<0.0001
Yes	69 (29.4%)	93 (94.9%)	
Morphine	19 (27.5%)	2 (2.2%)	
Hydromorphone	50 (72.5%)	91 (97.8%)	

discharge, there no was difference in the length of follow-up between patients with trauma and elective surgery (193 ± 196 days vs. 217 ± 161 days; *P* = 0.26).

Inpatient Opioid Use

In-patient pain management differed between groups. Standard arthroplasty postoperative pain management consisted of PCA followed by oral opioid pain medication. There was no standardized pain management protocol in patients with trauma. Patients with trauma had lower use of PCA than did elective surgery patients (29.4% vs. 94.9%; $P < 0.0001$). In addition, the prevalence of each type of opioid analgesic prescribed differed between groups. However, there was no difference between trauma and elective patients in terms of inpatient opioid use (70.2 ± 48.7 OME/day vs. 67.3 ± 32.9 OME/day; *P* = 0.53) (Table 7). When matched for sex, race, insurance status, age, and baseline alcohol, tobacco, and opioid use, there continued to be no significant difference between groups (91.3 ± 82.2 vs. 85.3 ± 59.5; *P* = 0.55).

Analyzed together, univariate analysis demonstrated that inpatient opioid use was negatively correlated with age (r = −0.395; $P < 0.0001$) and positively associated with ICU admission (71.0 ± 50.6 vs. 139 ± 162.3; *P* = 0.0027), baseline tobacco use (68.5 ± 74.5 vs. 104 ± 95.0; *P* = 0.0004), and baseline alcohol use (70.4 ± 76.4 vs. 98.8 ± 92.9; *P* = 0.0032) (Figure 1). Stepwise multiple linear regression produced a significant model ($F(7,309) = 21$; $P < 0.0001$; adjusted $R^2 = 0.275$) identifying negative correlations between trauma patient status, age, and African American race, and positive correlations between ICU admission and tobacco use, and inpatient opioid use (β-coefficients = −22.3, −1.08, −13.9, 43.7, and 15.9, respectively). Variance inflation factors for patient type, age, race, ICU admission, and tobacco use were 1.25, 1.23, 1.09, 1.09, and 1.10, respectively. Age was the greatest predictor of inpatient opioid use.

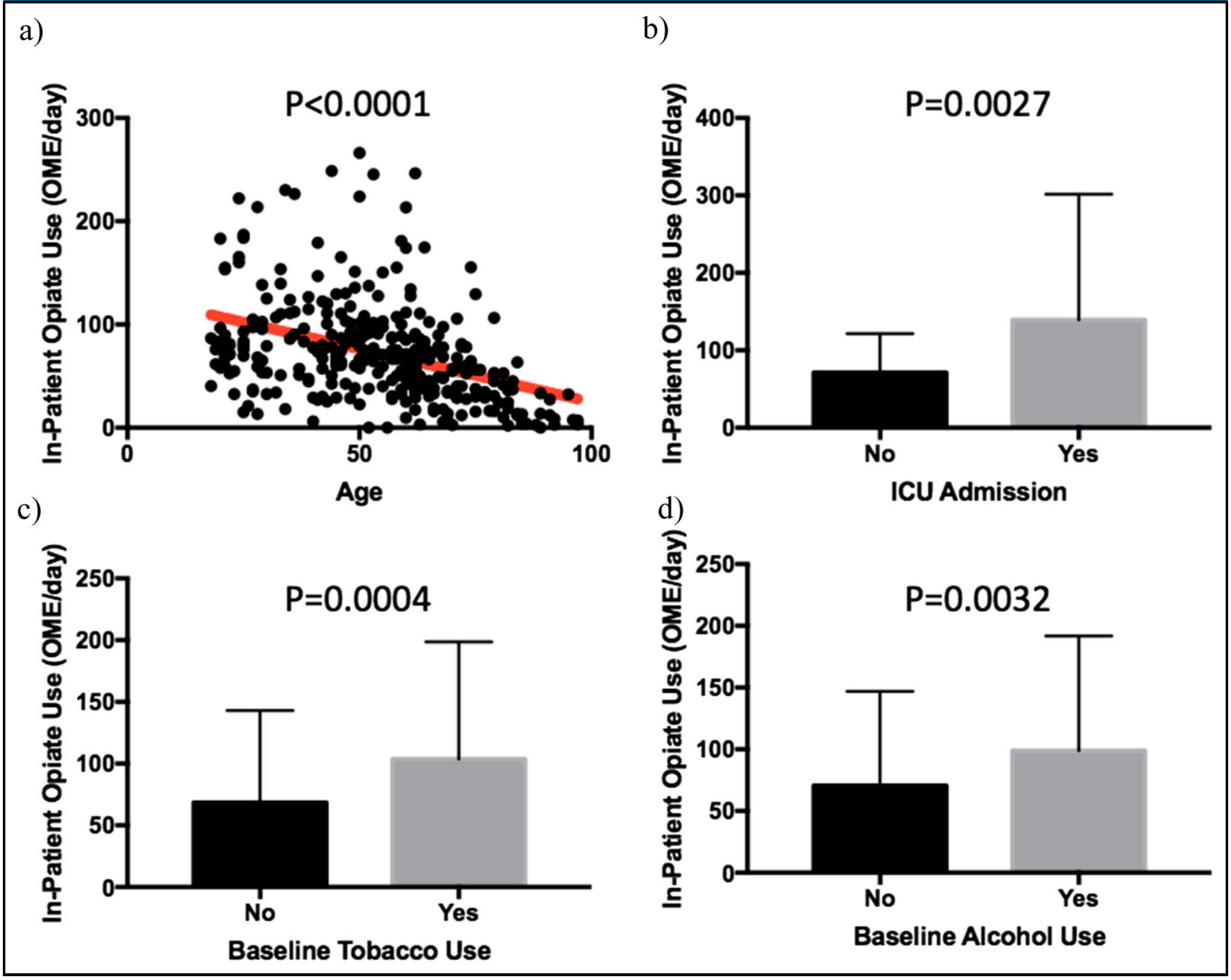
Discharge Prescription

In both trauma and elective surgery patients, oxycodone was the most commonly prescribed opioid analgesia at discharge. There was no significant difference between groups in terms of prevalence of specific opioid prescribed at discharge. In addition, there was no significant difference between groups in terms of discharge opioid prescription amount (542 ± 442 vs. 594 ± 169; *P* = 0.13) (Table 8).

Postdischarge Opioid Use

Elective surgery patients received a greater number of opioid prescriptions after discharge (5.0 ± 6.2 vs. 3.4 ± 5.8; *P* = 0.031), with 83.7% receiving at least one refill, compared with 66.8% for patients with trauma. Follow-up was high in each group, with 94.0% and 99.0% of trauma and elective surgery patients, respectively, returning for at least one follow-up visit (*P* = 0.077). After discharge, the prevalence of opioid analgesia type prescribed to patients with trauma and elective surgery was significantly different. However, on univariate analysis, there was no difference between groups in terms of total postdischarge opioid use (986 ± 1,411 vs. 1,147 ± 1,159; *P* = 0.29) (Tables 9 and 10). When matched for sex, race, insurance status, age, and baseline alcohol, tobacco, and opioid use, again, no difference was seen between groups

Figure 1



In-patient opioid use was lower in (**A**) older patients and higher with (**B**) ICU admission, (**C**) baseline tobacco use, and (**D**) baseline alcohol use. ICU = intensive care unit, OME = oral morphine equivalent.

(959 ± 2,832 vs. 1,330 ± 2,457; *P* = 0.34). Elective surgery patients received a greater number of opioid prescriptions after discharge (5.0 ± 6.2 vs. 3.4 ± 5.8; *P* = 0.031).

Postdischarge opioid use was higher in baseline alcohol users (863 ± 1,421 vs. 2,400 ± 4,638; *P* = 0.0002), baseline opioid users (1,009 ± 2,120 vs. 3,019 ± 5,184; *P* = 0.0007), and those receiving more opioid medication on discharge (r = 0.1684; *P* = 0.0024) (Figure 2). Multiple linear regression to model postdischarge opioid use produced a significant model (F(7,316) = 8.81; *P* < 0.0001; adjusted R^2 = 0.127). In this model, postdischarge opioid use was predicted to be positively associated with Caucasian race, ICU admission, baseline alcohol use, baseline narcotic use, and amount of narcotic medication prescribed at discharge (β-coefficients = 364, 502, 457, 838, and 0.71, respectively). Variance inflation factors for race, ICU admission, baseline alcohol use, baseline narcotic use, and discharge prescription amount were 1.05, 1.03, 1.08, 1.10, and 1.06, respectively. The most significant predictor of postdischarge narcotic use was discharge prescription amount (Figure 3). Patient status as elective or trauma was not a significant predictive factor.

Discussion

Increased availability of prescription opioid medication in the general population has correlated with increased opioid-related morbidity and mortality. Certain populations are more susceptible to opioid abuse, including younger patients and those with substance use disorders. There is

Table 8

Discharge Opioid Medication

Factor	Trauma	Elective	*P*
Total opioid use (oral morphine equivalent)			0.13
Mean (SD)	542 (442)	594 (169)	
Median	600	675	
Range	0-5,040	100–900	
Type of opioid prescribed			
Discharge			0.51
Morphine	5 (2.13%)	0 (0%)	
Oxycodone	204 (86.8)	92 (93.9%)	
Hydromorphone	2 (0.85%)	0 (0%)	
Hydrocodone	12 (5.11%)	5 (5%)	
Codeine	2 (0.85%)	0 (0%)	
Methadone	1 (0.43%)	0 (0%)	
Tramadol	2 (0.85%)	1 (1.02%)	

Table 9

Postdischarge Opioid Medication Refills and Follow-Up

Factor	Trauma	Elective	*P*
Number of refills			0.031
Mean	3.4 (5.8)	5.0 (6.2)	
Median	2	2.5	
Range	0–23	0–23	
Patients receiving			0.016
0 refill	78 (33.2%)	16 (16.3%)	
1 refill	36 (15.3%)	19 (19.4%)	
2 refills	23 (9.8%)	15 (15.3%)	
3+ refills	98 (41.7%)	48 (49.0%)	
Follow-up			0.077
No follow-up	14 (6.0%)	1 (1.0%)	
At least 1 follow-up	221 (94.0%)	97 (99.0%)	

also concern that traumatic injury itself may predict high postdischarge opioid use levels, given the inability to fully optimize baseline social and psychological factors prior to intervention. As such, the main goal of this study was to compare trauma patients with elective orthopaedic patients to determine whether traumatic injury was an independent risk factor for high levels of opioid use. In addition, this study looked to determine demographic and social differences between groups to evaluate factors that may predict high levels of opioid use.

Compared with elective arthroplasty patients in this series, factors most predictive of trauma patient status were male sex, younger age, Caucasian race, non-Medicaid insurance, and no current or prior use of opioid medication. This finding was consistent with those of other large series, which reported male-to-female disparity and younger age ranges in patients with trauma.[17,18] The racial disparity reflected that of the city and county in which the hospital system was located. According to the United States Census Bureau, the city's racial demographics were 53.3% African American and 37.3% Caucasian in 2010 compared with the county's demographics of 29.7% African American and 63.6% Caucasian.[19,20] Although one of many elective orthopaedic practices in the county, the study institution was the only level 1 trauma center in the county; therefore, the racial difference in elective and trauma orthopaedic patients is consistent with the city's and county's demographics. With regard to opioid use history, it is known that knee and hip osteoarthritis generally follows a chronic course. Although the American Academy of Orthopaedic Surgeons has released guidelines on appropriate use criteria for nonarthroplasty management of knee osteoarthritis advocating against opioid use,[21] many primary care physicians use opioid medication,[22] possibly secondary to concerns related to NSAID use in older populations.[23] It is, therefore, logical that patients with arthroplasty may have had exposure to opioid medications at increased rates compared with patients with trauma. The fact that the majority of patients with elective arthroplasty had used opioids as prescribed by physicians prior to surgical management further supports this conclusion.

There were no differences between groups in terms of inpatient opioid use, although traumatic injury was an independent predictor of lower use. This may have been related to the prevalence of PCA availability in the elective arthroplasty group. Other negative predictors were age and African American race. Age-related differences were likely secondary to provider concerns for postoperative cognitive dysfunction, coupled with a physiologic increased pain threshold in older adults.[24,25] The reason for decreased use in the African American population is unclear, although there is evidence for disparities in pain treatment along racial lines.[26–28] Positive predictors were ICU admission and baseline tobacco use. ICU admission may represent greater degrees of injury, thus requiring greater amounts of opioid medication for acute pain management. Nicotine-induced upregulation of mu-opioid receptors, coupled with inpatient nicotine restriction to facilitate fracture and wound healing, may account for increased use of opioids in nicotine users during admission.[29–32]

In order of significance, predictors of postdischarge opioid use were discharge prescription amount, baseline opioid use, ICU admission, Caucasian race, and baseline alcohol use. Traumatic injury was not an independent risk factor for increased postdischarge opioid use. To avoid the possibility that the full discharge prescription was not consumed, postdischarge opiate use was calculated based on refill data only. Although elective surgery patients received a greater number of refills, these prescriptions were more often for tramadol compared with the trauma patient group (27.5% vs. 11.5%). Given the equianalgesic conversion rate for tramadol to OMEs, this higher number of refills did not translate to higher total postdischarge opiate use. In addition, discharge prescribing protocols do not appear to have been different between elective and trauma surgery groups, given that there were no differences in the amount or type of pain medication prescribed at discharge. Therefore, the amount of postdischarge use between groups was not simply a reflection of one group getting a greater or smaller amount of opioid medication.

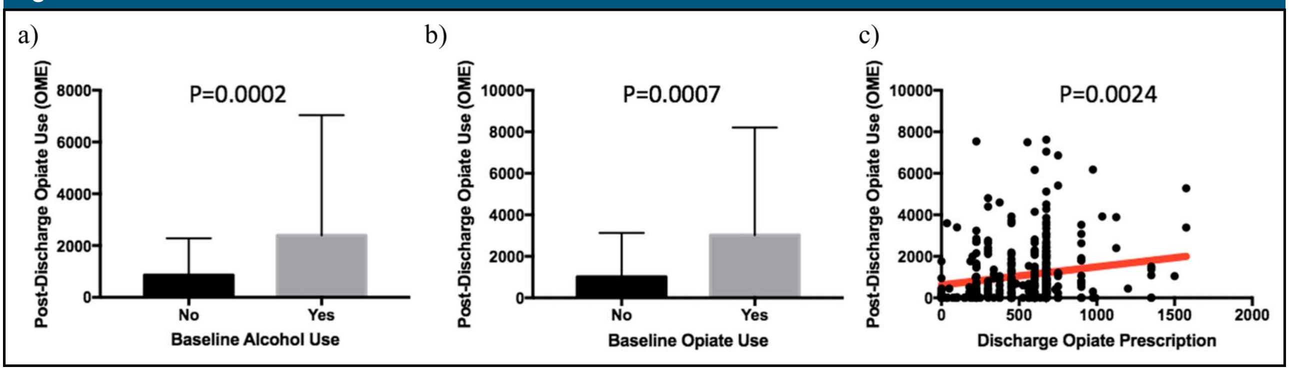
The factors identified in this study as significant predictors of postdischarge opiate use are supported by the literature. Discharge prescription is likely important, as the duration of initial opioid therapy in the nontrauma population has been reported to predict sustained use.[33] Baseline narcotic use can result in physical dependence, necessitating higher levels of opioid use to achieve the same analgesic effect. ICU admission may suggest more severe injury, requiring higher and more sustained doses of opioid medication after discharge. Racial disparities are likely similar to those discussed previously regarding inpatient opioid

Table 10

Postdischarge Opioid Use

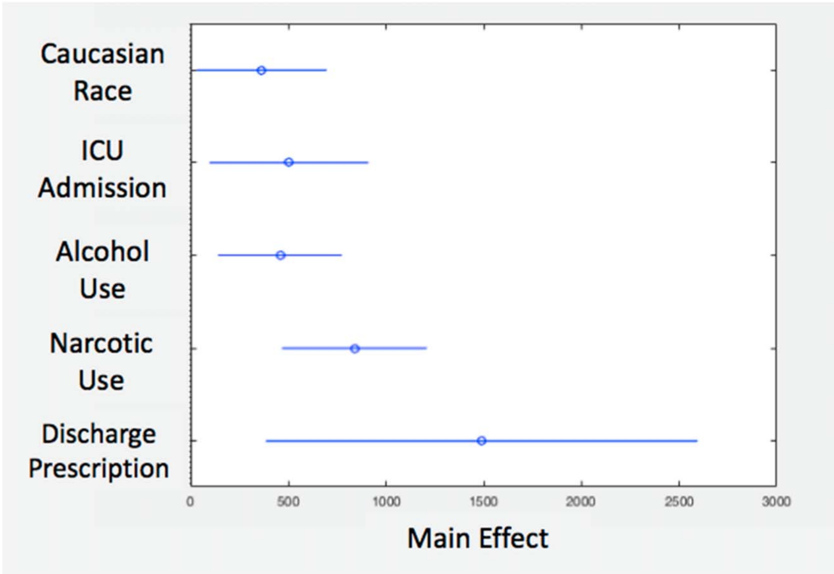
Factor	Trauma	Elective	*P*
Total opioid use (oral morphine equivalent)			0.29
Mean (SD)	986 (1,411)	1,147 (1,159)	
Median	450	735	
Range	0–7,538	0–4,500	
Type of opioid prescribed			
Postdischarge			0.0002
Morphine	6 (2.55%)	0 (0%)	
Oxycodone	128 (54.5%)	75 (76.5%)	
Hydromorphone	2 (0.85%)	1 (1.02%)	
Hydrocodone	83 (35.3%)	11 (11.2%)	
Codeine	5 (2.13%)	2 (2.04%)	
Methadone	2 (0.85%)	0 (0%)	
Tramadol	27 (11.5%)	27 (27.5%)	

Figure 2



Postdischarge opioid use was higher in patients with (**A**) baseline alcohol use, (**B**) baseline opioid use, and (**C**) larger opioid prescriptions at discharge.

Figure 3



Factors most predictive of postdischarge opioid use. RELIEFF feature selection algorithm demonstrates that the most important variables (in descending order) were discharge prescription amount, baseline opioid use, ICU admission, Caucasian race, and baseline alcohol use. ICU = intensive care unit.

use. The complex interaction between alcohol, endogenous opioid receptors, and the dopamine reward system likely accounts for the predictive value of baseline alcohol use for higher postdischarge opioid use.[34–37]

The ability to quantify in-patient opioid use is a major advantage of this study; large database studies, while beneficial, rarely are able to capture these data. Taken together, this study suggests several important results. First, traumatic orthopaedic injury itself is not a risk factor for higher amounts of opioid use. Similar results were seen in patients who sustained abdominal trauma,[38] and such evidence supports that providers can provide appropriate analgesia with opioid medications without promoting sustained opioid use. More important than the actual indication for surgical management (eg, elective vs. traumatic), several demographic factors appear to influence high levels of opioid use after discharge. These factors include Caucasian race and baseline substance use of opioids or tobacco. These risk factors fall into the category of unmodifiable; however, prescribers should take note of the increased risks in these populations and advocate for nonopioid pain control strategies to reduce long-term use. A potentially major modifiable risk factor is the amount of opioid medication prescribed at discharge, and another is the number of refills. This could be largely prescriber dependent, with some prescribers reporting continued the amount of opioid medication needed at discharge to provide adequate analgesia. Prescribers must balance the analgesic needs of the patient with the risk of high postdischarge opioid use. Using multimodal pain strategies to reduce discharge opioid prescriptions could provide adequate pain management while reducing the risk of long-term opioid dependence.

This study has several limitations. First, some patients included in this study did not have isolated orthopaedic injuries. Thirty-three patients with nonisolated orthopaedic injuries were included in the analysis to adequately capture more severe orthopaedic injuries. That is, more severe orthopaedic injuries (ie, pelvic ring) often are not isolated injuries. One might expect that the additional injuries would result in increased pain medication use compared with the elective surgery group. This would suggest that the results presented in this study overestimate the actual pain medication use secondary to orthopaedic trauma. Therefore, the main result, that traumatic orthopaedic injury is not an independent risk factor for increased opioid use, would continue to be valid. Second, although an ideal resource for capturing out-patient prescription opioid use, our state did not have a centralized Controlled Substance Monitoring Database during the study period. To account for this, we limited our opioid consumption count to patients with at least one follow-up visit to our center, as we could not account for patients who did not follow-up and may have been prescribed opioids elsewhere. In addition, there was no difference between groups in terms of the length of follow-up. It is possible that patients with trauma were obtaining opioid prescriptions from outside providers. However, it cannot be excluded that patients with arthroplasty were exhibiting the same behavior. Recent evidence has demonstrated that many patients with arthroplasty continue to use opioids even 6 months after surgery, with 53.3% of patients with TKA and 34.7% of patients with THA who reported opioid use the day of surgery reporting continued use at 6 months. Therefore, our results appear consistent with these prior findings. Third, a prescription for an opioid medication does not necessarily mean that the patient took the full medication dose; it is possible that patients took less than the prescribed amount or that some of the medication was diverted and sold for financial gain. However, we attempted to minimize this limitation by considering only refills in our analysis.

In conclusion, traumatic orthopaedic injury is not an independent risk factor for high levels of in-patient or postdischarge opioid use. Although elective hip or knee arthroplasty patients differ significantly regarding demographics, certain characteristics present in each population can predict higher levels of in-patient or postdischarge opioid use. In general, baseline substance use predicts higher levels of opioid use, and evidence of this use in patients with orthopaedic trauma should prompt providers to explore multimodal pain strategies. In addition, providers may be able to reduce postdischarge opioid use by reducing the amount of opioid medication prescribed at discharge. Prospective studies are needed to validate these models.

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