Development and Validation of a Clinical Risk Calculator for Prolonged Opioid Use After Shoulder Surgery

Allen D. Nicholson¹, Hafiz F. Kassam¹, Jacqueline L. Steele¹, Natalie Passarelli¹, Theodore A. Blaine¹, David Kovacevic¹

¹Department of Orthopaedics and Rehabilitation, Yale School of Medicine, New Haven, CT.

INTRODUCTION

- Opioid addiction is an escalating problem in the United States, with 33,091 reported deaths due to opioid overdose in 2015.
- Opioids are an integral part of postoperative pain control but can have significant side effects including physical dependence, development of tolerance, respiratory depression, and death.
- Orthopaedic surgeons are the third highest prescribers of opioids among physicians in the United States.
- Proper identification of patients at greater risk for prolonged postoperative opioid use can help direct patients towards ancillary treatments such as behavioral therapy, pain management, and should ultimately reduce the risk of serious harm.
- A tool that can effectively predict prolonged opioid use after shoulder surgery may identify patients benefitting from referral to pain management specialists and reduce risk of opioid abuse and addiction

GOAL

To develop and internally validate a preoperative predictive nomogram for opioid use longer than 6 weeks after shoulder surgery

We hypothesized that patient-specific covariates are responsible for opioid use longer than 6 weeks after shoulder surgery. If sufficiently accurate, such a nomogram would be valuable for defining which patients would benefit from additional treatments such as behavioral therapy or pain management referral.

Table 1. Demographics and Prior Opioid Use

	Opioid use 6 weeks after surgery		
	Yes (n = 153)	No (n = 395)	Total (N = 548)
Age at time of surgery in years			
Mean (SD)	55.6 (13.7)	51.9 (18)	52.9 (16.9)
Median (Range)	57 (18 – 85)	54 (18 – 91)	55 (18 – 91)
Gender			
Female	82 (53.6%)	159 (40.3%)	241 (44%)
Male	71 (46.4%)	236 (59.7%)	307 (56%)
BMI			
< 25	104 (22.2%)	118 (29.9%)	152 (27.7%)
25-30	147 (30.7%)	135 (34.2%)	182 (33.2%)
30-35	108 (24.9%)	93 (23.5%)	131 (23.9%)
≥ 35	104 (22.2%)	149 (37.4%)	203 (37.2%)
Prior opioid prescriptions in the three years prior to surgery			
Yes	127 (83%)	181 (45.8%)	308 (56.2%)
No	26 (17%)	214 (54.2%)	240 (43.8%)
Oral Morphine Milligram Equivalent for Opioid Prescriptions Filled Within 6 Weeks of Surgical Date			
Mean (SD)	2483.2 (2857)	665.2 (534.1)	1172.8 (1772)
Median (Range)	1425 (1-16575)	645 (0-4350)	675 (0-16575)
Oral Morphine Milligram Equivalent for Opioid Prescriptions Filled After 6 Weeks of Surgical Date			
Mean (SD)	11105 (29413)	0 (0)	3100.5 (16287)
Median (Range)	1162.5 (90-248614.3)	0 (0)	0 (0-248614.3)
Is patient a current smoker?			
Yes	128 (84.1%)	109 (27.6%)	237 (43.5%)
No	24 (15.9%)	286 (72.4%)	310 (56.5%)
Insurance Status			
Medicaid or Medicare	107 (70.0%)	103 (26.1%)	210 (38.5%)
Worker's compensation	22 (14.4%)	102 (25.8%)	124 (22.6%)
Private	24 (15.6%)	190 (48.1%)	214 (39.1%)
Procedure Type			
Labral Repair	113 (73.9%)	185 (46.8%)	298 (54.5%)
Shoulder Arthroplasty	38 (24.8%)	121 (30.6%)	159 (29.0%)
Rotator Cuff Repair	105 (69.3%)	190 (48.1%)	295 (53.9%)
Fracture Repair	117 (76.5%)	107 (27.1%)	224 (41.1%)
Hepatobiliary and Intestinal Disorders			
Yes	105 (68.7%)	117 (29.6%)	222 (40.6%)
No	48 (31.3%)	278 (70.4%)	326 (59.4%)
Cardiopulmonary Disease			
Yes	105 (68.7%)	117 (29.6%)	222 (40.6%)
No	48 (31.3%)	278 (70.4%)	326 (59.4%)
Psychiatric Disease			
Yes	105 (68.7%)	117 (29.6%)	222 (40.6%)
No	48 (31.3%)	278 (70.4%)	326 (59.4%)
Neurologic Disorders			
Yes	105 (68.7%)	117 (29.6%)	222 (40.6%)
No	48 (31.3%)	278 (70.4%)	326 (59.4%)

RESULTS

Figure 1. Preoperative prediction of Prolonged Opioid Use After Shoulder Surgery. Locate the procedure type on the y-axis then draw a line directly upward to the "points" axis to determine how many points toward the probability of opioid use longer than 6 weeks after surgery. Repeat this process for remaining predictors. Add the points for all predictors and locate the total point value on the "total points" axis, then draw a line straight downward to find the patient's probability of post-surgical opioid use longer than 6 weeks.

Figure 2. Calibration error of the model using the development sample. Area under curve (AUC) from receiver operative characteristic curve (ROC) analysis is 0.766 with 95% confidence interval at (0.736, 0.820). Smoothed curves between predicted and actual probability are generated using original dataset (apparent) and all resampled datasets (bias-corrected). The calibration graph shows us that the current prediction model overestimates prolonged opioid use in patients with high conglomerate risk factors.

METHODS

- Patient cohort: 563 patients that underwent shoulder surgery from January 2015 to February 2017 at a tertiary healthcare system by six orthopedic surgeons. The cohort was separated into two groups – those that used opioid less than six weeks following shoulder surgery, and those that used opioids longer than six weeks following shoulder surgery. Inclusion criteria were patient age over 18 and exclusion criteria were patients not registered on Connecticut Prescription Monitoring and Reporting System (CPMRS).
- Opioid prescription data was collected from the CPMRS. Opioid prescription data was collected for up to 3 years prior to surgery. Quantities of opioids prescribed were documented. Chart review identified demographic information, active medications, and medical comorbidities.
- 51 factors were identified from the chart. Simple logistical regression was used to calculate the odds ratios of patients using opioids longer than 6 weeks. Group comparisons were conducted using Chi-square tests for categorical variables and t-tests for continuous variables. Statistical significance was set as $p < 0.05$, two-sided.
- Ten variables were selected for inclusion in multivariate analysis based on which variables independently had the significantly highest odds ratios of prolonged opioid use after shoulder surgery. The coefficients from these ten chosen predictor variables was used to construct a preoperative predictive risk calculator nomogram as described by Yang et al.
- The nomogram was validated by the bootstrapping method, and a calibration plot was used to examine agreement between observed outcomes and predicted probability. Internal recalibration of the data set using bootstrapping was done by resampling the dataset with replacement 1000 times and running the model.

- Principal Outcome: Opioid prescription refills beyond six weeks after shoulder surgery
- Secondary Outcome: Oral morphine equivalents filled before six weeks and after six weeks following shoulder surgery.

CONCLUSIONS

- We developed and internally validated a nomogram for predicting opioid use longer than 6 weeks following shoulder surgery.
- We identify patient-specific covariates that are significantly associated with prolonged opioid use following shoulder surgery.
- These results show that prior opioid use within the last 3 years is the greatest risk factor for prolonged opioid use following shoulder surgery, followed by insurance type, smoking status, BMI, and presence of psychiatric disease.
- This predictive nomogram may be a practical and valuable clinical decision making tool for preoperatively planning a patient's perioperative opioid needs, managing patient expectations, and implementing an interdisciplinary opioid-sparing pain management regimen with pain management and anesthesia.

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