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Clinical Study

Validating the Stopping Opioids after Surgery (SOS) score for sustained postoperative prescription opioid use in spine surgical patients

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Abstract

BACKGROUND CONTEXT: The opioid epidemic has increased scrutiny of health-care practices and care episodes, such as surgery, that increase the risk of opioid dependence. The Stopping Opioids after Surgery (SOS) score to predict sustained prescription opioid use was previously developed within a population of patients receiving general surgery, orthopedic, and urologic procedures. Notably, the performance for this score has not been assessed in a spine surgical cohort.

PURPOSE: We sought to validate the SOS score in a series of patients undergoing cervical and lumbar spine surgery, including inpatient and outpatient cohorts.

STUDY DESIGN/SETTING: Retrospective review at two academic medical centers and three community hospitals.

OUTCOME MEASURES: Sustained prescription opioid use was defined as opioid prescription without interruption for 90 days or longer following surgery.

METHODS: The performance of the SOS score was assessed in the study population by calculating the c-statistic, receiver-operating curve, and observed rates of sustained prescription opioid use.

RESULTS: Among 7,027 patients included in this study, 2,374 (33.8%) underwent anterior cervical discectomy and fusion and 4,653 (66.2%) underwent surgery for lumbar disc herniation. The median age was 46 (interquartile range=38.0–53.5). Overall, 604 patients (8.6%) had prolonged opioid prescription. The c-statistic of the risk score was 0.764. The sensitivity of the score at the low risk cutoff of 30 was 0.72. At the high-risk cutoff of 60, the specificity was 0.99. The observed risk (95% confidence interval) of prolonged opioid prescription was 3.6% (3.1–4.2) in the low-risk group (scores <30), 17.2% (15.6–18.7) in the intermediate-risk group (scores 30–60), and 46.0% (36.2–55.9) in the high-risk group (scores >60).

CONCLUSIONS: We have validated the use of a clinically relevant bedside risk score for sustained prescription opioid use after spine surgery. The score's ease of use, combined with its

FDA device/drug status: Not applicable.

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Ethical Statement: This study was approved by our institutional review board.

Level of Evidence: 3.

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exceptional performance, renders it a valuable tool for spine care providers in counseling patients and determining appropriate postdischarge management to prevent sustained opioid use.

Keywords: Anterior cervical discectomy and fusion; Lumbar disc herniation; Opioid dependence; Prediction; Risk score; Spine surgery

Introduction

Drug-overuse deaths in the United States have tripled in the last two decades, with 64,000 deaths attributed to opioid abuse in 2016 alone [1]. The scope of the opioid epidemic has increased regulation of opioid prescribing practices for acute pain [2] and raised public awareness regarding the potential link between sustained opioid use and misuse, abuse and addiction [3–6]. Previous studies have identified several risk factors for prolonged opioid use after spine surgery and, recently, others have developed algorithms to estimate this risk [7–12]. None of these efforts, however, have resulted in a risk assessment tool capable of prognosticating sustained prescription opioid use after surgery.

Recently, Chaudhary et al. presented a bedside utility intended to estimate the risk of sustained opioid use after a procedure, which they have termed the Stopping Opioids after Surgery (SOS) score [13]. The SOS tool considers a variety of clinical and sociodemographic characteristics (Table 1), summing risk factors into a composite score of 0 to 100, and stratifying patients into low- (<30), intermediate- (30–60), and high-risk (>60) subgroups**.** In the cohort used to develop the risk score, patients in the low-, intermediate-, and high-risk groups were found to have sustained opioid use rates of 2.6%, 13.0%, and 25.9%, respectively. Importantly, the score was developed using Tricare claims data for patients aged 18 to 64 who received major general surgery, cardiovascular, urological, or orthopedic procedures. Despite representing one of the surgical cohorts at greatest risk of sustained prescription opioid use [3,7–10], spine surgical patients were not considered in the group used to develop the SOS score.

In this context, we sought to examine the performance of this risk score in a series of patients undergoing cervical and lumbar spine surgery for degenerative conditions. This is a population with a relatively high prevalence of sustained prescription opioid use as documented in prior work [3,7–10]. Secondarily, we also sought to contrast the score's performance in the subset of patients who received cervical or lumbar surgery as outpatients in contrast to those who underwent an inpatient procedure.

Table 1
Opioid risk score

Characteristic	Score
Age	
18–24	0
25–34	4
35–44	7
45–54	7
55–64	7
Sex	
Male	0
Female	4
Discharge status	
Home	0
Nonhome discharge	14
Socioeconomic status	
High	0
Low	7
Procedure category	
Minor	0
Major	5
Length of stay (d)	
≤3	0
>3	1
Diabetes mellitus	2
Depression	6
Anxiety	7
Prior opioid use	29
Total score	100

Materials and methods

Guidelines

The Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis guidelines were followed [14].

Data source

Our institutional review board approved this retrospective review. Patient data from two academic medical centers and three community hospitals in the Partners Healthcare System were reviewed from January 1, 2000 to March 1, 2018. The means by which these data are obtained and accessed have been described in prior publications [7]. The inclusion criteria for the study were as follows: (1) age 18 to 64 years; (2) inpatient or outpatient spine surgery; and (3) anterior cervical discectomy and fusion (ACDF) for cervical disc herniation, disc degeneration, stenosis, and/or other spondylotic conditions OR decompression and/or fusion for a diagnosis of lumbar disc herniation (LDH). Exclusion criteria for the study included trauma cases, malignancy, infections, pseudoarthrosis, spinal stenosis, spondylolisthesis, and scoliosis. The age range was restricted from 18 to 64 years because the risk score was previously developed for adult patients under the age of 65 [13].

Outcome

Sustained postoperative opioid prescriptions were defined as uninterrupted prescriptions for opioid agonists, partial agonists, and/or synthetic opioids filled for a period of 90 days or longer following the index procedure [5,15,16]. The complete list of eligible medications included in the opioid definition was based on prior studies, including the work of Chaudhary et al. that described the SOS score, and is available upon request from the authors [7,13]. We selected the 90-day observation period to establish our definition of sustained prescription opioid use based on prior studies, which have documented that individuals continuously using opioids for a period of 3 months are likely to become dependent [3,17].

Variables

Variables needed to calculate the risk score for each patient were collected via chart abstraction. These included (1) age (years), sex (female, male), Medicaid insurance status, surgical environment (inpatient, outpatient), length of stay (days), receipt of prior opioid prescription in the 6 months before surgery, comorbidities (diabetes, depression, anxiety), and discharge disposition (home, nonhome). Within the context of the SOS score, Medicaid insurance was considered a proxy of lower socioeconomic status. The original SOS score as described by Chaudhary et al. [13] delineated major and minor surgery based on the extent of the procedure and the need to access major organ spaces or resection of osseous structures. In the context of orthopedic, neurosurgery or spine surgery, only arthroscopic or endoscopic procedures would qualify as minor interventions based on the definitions used by Chaudhary's group. Thus, in this analysis, all spine procedures were classified as major surgical interventions. The variables needed to calculate the risk score did not have any missing data in this study.

Risk score assessment

The performance of the risk score in the validation cohort was measured by calculating the c-statistic (area under the curve) using receiver-operating characteristic curves. The risk score ranges from 0 to 100 and point values for risk factors are shown in Table 1. Specificity and sensitivity of the score were further calculated at thresholds of 30 and 60. Next, the rates of observed opioid prescription in each strata of the risk score (low risk=scores <30, medium risk=scores 30–60, high risk=scores >60) were calculated along with 95% confidence intervals (CI). Sensitivity analyses were conducted by repeating the above analyses for subpopulations of patients undergoing ACDF, surgery for LDH, inpatient surgery, and outpatient surgery. R version 3.5.1 (The R Foundation, Vienna, Austria), RStudio version 1.1.453 (RStudio, Boston, MA, USA), and Python version 3.6 (Python Software Foundation, Wilmington, DE, USA) were used for data analysis.

Results

Among 7,027 patients included in this study, 2,374 (33.8%) underwent ACDF for degenerative conditions and 4,653 (66.2%) underwent surgery for LDH (Fig. 1). The median age was 46 (interquartile range=38.0–53.5) years and 3,360 patients (47.8%) were female. At baseline, 2,159 (30.7%) had prior opioid prescriptions in the 6 months before surgery and 5,605 patients (79.8%) underwent inpatient surgery (Table 2). Overall, 604 patients (8.6%) met our definition of sustained prescription opioid use following surgery.

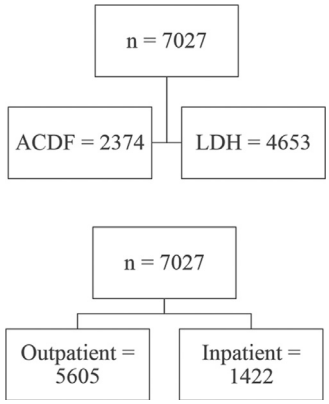

Fig. 1. Flow chart of patients in each subpopulation within study. ACDF, anterior cervical discectomy and fusion; LDH, lumbar disc herniation.

Table 2
Baseline characteristics of validation cohort, n=7,027

Variable	n (%), median (IQR)
Total	7,027 (100)
Age	46.0 (38.0–53.5)
Sex	
Female	3,360 (47.8)
Male	3,667 (52.2)
Procedure/diagnosis	
Anterior cervical discectomy and fusion	2,374 (33.8)
Lumbar disc herniation	4,653 (66.2)
Medicaid insurance	562 (8.0)
Disposition	
Inpatient	5,605 (79.8)
Outpatient	1,422 (20.2)
Length of stay (d)	2 (1–3)
Prior opioid prescription	2,159 (30.7)
Comorbidities	
Diabetes	533 (7.6)
Depression	1,026 (14.6)
Anxiety	873 (12.4)
Discharge disposition	
Home	6,829 (97.2)
Nonhome	198 (2.8)
Prolonged postoperative opioid prescription	604 (8.6)

IQR, interquartile range.

In the total study population (n=7,027), the c-statistic of the risk score (area under the receiver-operating curve) was 0.764 (Fig. 2). The sensitivity and specificity of the risk score at the low risk cutoff of 30 were 0.72 and 0.70, respectively (Table 3). At the high-risk cutoff of 60, the specificity was 0.99. The observed risk (95% CI) of prolonged opioid prescription in the low-risk group (scores <30) was 3.6% (3.1–4.2), in the intermediate-risk group (scores 30–60) it was 17.2% (15.6–18.7), and in the high-risk group (scores >60) the risk was 46.0% (36.2–55.9; Table 4).

In patients who underwent ACDF (n=2,374), the c-statistic of the SOS score was 0.773. The observed risk of sustained prescription opioid use in the low-, intermediate-, and high-risk groups were 4.1%, 23.0%, and 47.2%, respectively. In those who received surgery for a diagnosis of lumbar disc herniation (n=4,653), the c-statistic of the score was 0.758. The observed risk of sustained prescription opioid use in the low-, intermediate-, and high-risk cohorts were 3.4%, 14.5%, and 45.5%, respectively.

In patients who underwent inpatient surgery (n=5,605), the c-statistic of the SOS score was 0.757. The observed risk of sustained prescription opioid use in the low-, intermediate-, and high-risk groups were 4.2%, 18.4%, and 46.2%, respectively. In patients who underwent outpatient surgery (n=1,422), the c-statistic of the score was 0.776. The observed risk of sustained prescription opioid use in the low-, intermediate-, and high-risk categories were 1.7%, 10.8%, and 44.4%, respectively.

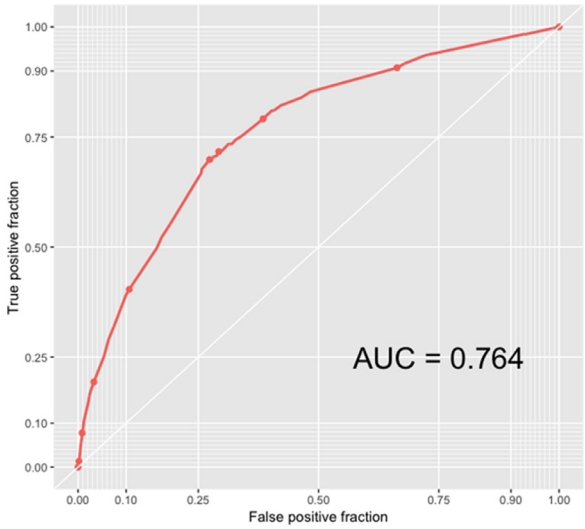

Fig. 2. Receiver-operating curve for discrimination of score in validation cohort. AUC, area under the curve.

Table 3
Model performance in validation cohort

Metric	Overall	ACDF	LDH	Inpatient	Outpatient
C-statistic	0.764	0.773	0.758	0.757	0.776
Cutoff=0.3					
Sensitivity	0.72	0.72	0.72	0.72	0.71
Specificity	0.70	0.74	0.68	0.69	0.75
Cutoff=0.6					
Sensitivity	0.08	0.07	0.08	0.08	0.06
Specificity	0.99	0.99	0.99	0.99	0.99

ACDF, anterior cervical discectomy and fusion; LDH, lumbar disc herniation.

Discussion

In light of the opioid epidemic plaguing communities across the nation, a variety of efforts have attempted to impact the potential for prolonged prescription opioid use, misuse, and addiction [1-3,6–10]. Most initiatives have focused on restricting the number of opioid tablets issued to patients at any one time, or using behavioral patterns to flag individuals at high risk for opioid misuse or diversion [1–3,6]. Very few investigations have been able to generate an assessment tool that is generalizable to clinical practice and has the ability to accurately quantify the risk of prescription opioid use using clinical criteria available at the point of care. Recently, Chaudhary et al. proposed the SOS score, an accessible and intuitive risk assessment that its developers maintain can be incorporated into electronic record platforms to generate real-time alerts [13]. To the best of our knowledge, however, the SOS score has not been independently validated in patients outside of the Tricare population from which it was developed. Moreover, the score's utility has not been assessed in a cohort undergoing elective spine surgery, a demographic known to be at exceptionally high risk of sustained prescription opioid use and dependence [3,7–12].

This study relied on clinically granular information stored in the Partners Healthcare Clinical Registry and obtained from two tertiary academic centers and three community hospitals. We chose this select group of patients undergoing spine surgical intervention to ensure adequate variation in the rates of pre- and postoperative prescription use to detect meaningful differences in the validation of the

Table 4
Observed rate (95% confidence interval) of sustained prescription opioid use by strata of risk score in validation cohort

Risk score category	Overall	ACDF	LDH	Inpatient	Outpatient
Low	3.6 (3.1–4.2)	4.1 (3.2–5.1)	3.4 (2.7–4.0)	4.2 (3.5–4.8)	1.7 (0.9–2.5)
Intermediate	17.2 (15.6–18.7)	23.0 (19.9–26.2)	14.5 (12.8–16.3)	18.4 (16.7–20.2)	10.8 (7.6–14.0)
High	46.0 (36.2–55.9)	47.2 (30.1–64.4)	45.5 (33.1–57.8)	46.2 (35.9–56.6)	44.4 (3.9–85.0)

ACDF, anterior cervical discectomy and fusion; LDH, lumbar disc herniation.

SOS score. The demographic characteristics of our study population as well as the prevalence of preoperative opioid exposure and postsurgical sustained use are similar to those reported in other contexts, including the Tricare data used to develop the SOS score [7–11,13]. Our investigation was able to externally validate the SOS score in this independent population of patients undergoing cervical and lumbar spine surgery. The score's discriminative capacity, as delineated by the c-statistic, was 0.764 indicating that about 76% of the variation in sustained prescription opioid use was explained by the scoring system. Moreover, the various risk strata (low, intermediate, and high) were closely tied to the observed rates of sustained prescription opioid use, with mutually exclusive 95% CIs indicating three distinct categories of patients. If the low-risk score of 30 is used as a threshold, the sensitivity for identifying sustained prescription opioid use is 72%. If one relies on the high-risk estimate of 60, the specificity of the SOS is remarkably high, at 99%.

The score's performance proved durable among the subpopulations analyzed, including procedures performed on an outpatient basis. Patients receiving outpatient, or less-invasive surgical procedures, have been thought to be at lower risk of sustained prescription opioid use [3,6,8,9]. Although that was the case here as well, only in the low-risk strata were meaningful differences in sustained opioid use encountered between inpatient (4.2%) and outpatient (1.7%) procedures. In the high-risk category, although the rate of sustained use was lower within the outpatient group (44.4%) as compared with inpatients (46.2%), the marginal difference in sustained prescription opioid use is not likely clinically important.

In addition, the performance of the SOS score in our study was remarkably similar to the investigation of Chaudhary et al. from which it developed [13]. For example, the c-statistic for the score in the work of Chaudhary et al. was 0.73, compared with 0.76 documented here. The rates of sustained opioid use within the risk strata reported by Chaudhary et al. were as follows: low=2.6%, intermediate=13.0%, and high=25.9%. These are somewhat lower than the estimates encountered here (eg, low=3.6%, intermediate=17.2%, and high=46.0%.), which is likely reflective of the previously documented higher prevalence of sustained prescription opioid use in patients receiving spine surgery as opposed to those undergoing general surgery or other elective orthopedic procedures. Chaudhary's group also focused largely on general surgery, vascular and urologic procedures in the development of the SOS score, including appendectomy, inguinal herniorrhaphy, and transurethral resection of prostate, colectomy, coronary artery bypass grafting, nephrectomy and radical cystectomy [13]. The prevalence of preoperative opioid exposure and risks for postoperative opioid use and dependence may be dramatically different in these populations, which could also account for some of the differences in our estimates and those of Chaudhary et al. The disparity may also be caused by a difference in our definition of sustained prescription opioid use (90 days) as compared with that used by Chaudhary et al. (180 days). We chose the 90-day interval for our definition of sustained used based on prior literature indicating that this time period is an important threshold for long-term addiction to prescription pain medications [3,17].

The good performance of the SOS score within a population of spine surgery patients can be understood in the context of previous work around opioid use in the spine literature [7–11,18]. Preoperative opioid use is the most serious risk factor in the SOS score (29 points) and this measure has been previously established as a valid predictor for sustained use after spine surgery in numerous studies including patients receiving cervical and lumbar procedures [7,8,10,11,18]. Similarly, other factors important to the risk score, such as surgical intensity, discharge disposition, diabetes mellitus, depression, and anxiety have also been identified as factors driving sustained prescription opioid use after surgical interventions [3,7,9,19].

There are several limitations to this study. Foremost, the population used to externally validate the SOS score came from a retrospective review of experiences at five hospitals affiliated with one health-care system and likely many shared institutional practices. Restricted variation in opioid prescribing practices, clinical factors associated with administration of opioids and the choice of opioids provided, may impact our determinations. Second, determinations regarding sustained prescription opioid use in this study are based on pharmacy and electronic health record documentation as opposed to toxicology testing of patients or self-reported surveys. As the SOS is intended to serve as an easily calculated and accessible tool, it does not stratify preoperative use by duration or morphine equivalents, which are notoriously difficult to attain or quantify from patient histories. This study assumes opioids were used as prescribed and opioids obtained through other means (eg, misuse, diversion, or use of illegal drugs) were not captured in this analysis. Similarly, provider prescribing practices and willingness to prescribe opioids in the postoperative period vary significantly and this study did not capture these subtleties. Finally, this study focused on external validation of the SOS score in degenerative spinal conditions; the utility of this system in other spinal disorders including trauma, infections, and revision procedures remains to be determined. Score performance should also be assessed separately in patients over the age of 65, populations with high rates of pre- and postoperative prescription opioid dependence, and conditions that are associated with a greater prevalence of instrumented fusion and/or interbody procedures such as scoliosis and spondylolisthesis. Further research is necessary to externally validate the SOS score using prospective means that span multiple institutions across regions of the United States. In addition, such an approach would be the only one capable of demonstrating the impact of any intervention based on the SOS score on mitigating sustained opioid use after surgery.

Conclusion

In conclusion, this study has validated the use of a clinically relevant bedside risk score for sustained prescription opioid use after spine surgery. The score performs equally well in inpatient and outpatient populations. The score's ease of use, combined with its good performance in this validation study, renders it a valuable tool for spine care providers in counseling patients and determining appropriate postdischarge management to prevent the long-term consequences of sustained opioid use. The SOS can provide clinicians with objective evidence on which to bolster their clinical judgment, both when rendering decisions to patients on issuing opioid prescriptions and cessation with patients. The tool could also be used as a quantification of the overall risk of prescription opioid dependence in patient populations for the purposes of negotiations with healthcare systems for better resource support, including approval of higher cost opiate alternatives and staffing for the often labor-intensive processes of contracting with patients and maintaining antidiversion oversight.

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