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Original Research Article

Association of Opioid Usage with Spinal Cord Stimulation Outcomes

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Abstract

Study Design. Observational study using insurance claims.

Objective. To quantify opioid usage leading up to spinal cord stimulation (SCS) and the potential impact on outcomes of SCS.

Setting. SCS is an interventional therapy that often follows opioid usage in the care continuum for chronic pain.

Methods. This study identified SCS patients using the Truven Health MarketScan databases from January 2010 to December 2014. The index event was the first occurrence of a permanent SCS implant. Indicators of opioid usage at implant were daily morphine equivalent dose (MED), number of unique pain drug classes, and diagnosis code for opioid abuse. System explant was used as a measure of ineffective SCS therapy. Multivariate logistic regression was used to analyze the effect of pre-implant medications on explants.

Results. A total of 5,476 patients (56 ± 14 years; 60% female) were included. SCS system removal occurred in 390 patients (7.1%) in the year after implant. Number of drug classes (odds ratio [OR] = 1.11, $P = 0.007$) and MED level (5–90 vs < 5 mg/d: OR = 1.32, $P = 0.043$; $\geq$90 vs < 5 mg/d: OR = 1.57, $P = 0.005$) were independently predictive of system explant. Over the year before implant, MED increased in 54% (stayed the same in 21%, decreased in 25%) of patients who continued with SCS and increased in 53% (stayed the same in 20%, decreased in 27%) of explant patients ($P = 0.772$). Over the year after implant, significantly more patients with continued SCS had an MED decrease (47%) or stayed the same (23%) than before ($P < 0.001$).

Conclusions. Chronic pain patients receive escalating opioid dosage prior to SCS implant, and high-dose opioid usage is associated with an increased risk of explant. Neuromodulation can stabilize or decrease opioid usage. Earlier consideration of SCS before escalated opioid usage has the potential to improve outcomes in complex chronic pain.

Key Words. Spinal Cord Stimulation; Opiates; Opioids; Explant; Neuromodulation; Outcomes

Introduction

Despite the important role of opioids in alleviating acute pain, the misuse of opioids has reached epidemic levels in the United States [1]. From 1999 to 2015, the number of opioid prescriptions quadrupled while the number of opioid-related overdose deaths more than quadrupled, reaching 10.4 per 100,000 in 2015 [1–4]. There have been no controlled studies of the effectiveness of prolonged opioid usage lasting more than one year [5]. Prescription drugs, specifically pain-related prescriptions (analgesics, anticonvulsants, muscle relaxants, nonsteroidal anti-inflammatory drugs, and opioids), are a major contributor to health care resource utilization for chronic pain management [6]. Estimated national health expenditures for spine problems have grown 82% from 1997 to 2006, with expenditures for opioid medications growing 660%, reaching $1.9 billion in 2006, while the number of users increased only 39.9% [7]. The escalating reliance on opioids displays that the current algorithm for treatment of chronic spine pain is not effective and demonstrates a need for nonpharmaceutical therapies.

Evidence from randomized controlled trials and single-center studies shows spinal cord stimulation (SCS) to be a safe, cost-effective, and efficacious treatment for chronic spine pain, in comparison with medical management alone [8–11]. Delay between diagnosis of chronic pain and implant of SCS has been shown to correlate with increased opioid prescriptions [12]. Nationwide insurance claims databases allow for the study of real-world outcomes from larger patient populations. This study investigates the effect of opioid usage on SCS outcomes in a large, real-world population to test the hypotheses: 1) SCS patients are high-dose opioid users at the time of implant, 2) opioid usage is reduced in patients after SCS implant, and 3) pain-related health care resource utilization (HCRU) before SCS implant is predictive of SCS system explant.

Methods

Patient Selection

An observational, retrospective study was performed by identifying patients undergoing SCS implant using the Truven Health MarketScan databases with private and Medicare insurance from January 2010 to December 2014. The data sets include duration of enrollment in health insurance as well as insurance claims for inpatient and outpatient services and for prescription drugs. The index event was defined when an implantable pulse generator (IPG) for SCS was implanted and accompanied or preceded by a lead implantation procedure within 0–90 days (Supplementary Table S1), both with corresponding chronic pain diagnosis (Supplementary Table S2).

The pre-implant period was defined as the 12 months prior to lead implant date, and the postimplant period was defined as the IPG implant date until 12 months following IPG implant. Patients were included if they were at least 18 years old at index event, had at least one year of pre- and postimplant follow-up, and if their prescription drug information was contained in the database. A subanalysis was performed for patients with two years of postimplant follow-up.

Clinical Covariates

Basic characteristics, including age and gender, were derived from pre-implant data. Key comorbidities and the Charlson Comorbidity Index were extracted from diagnosis codes of inpatient and outpatient services in the year prior to implant (Supplementary Table S3) [13]. Opioid abuse, alcohol abuse, and tobacco use were also noted based on diagnosis codes (Supplementary Table S2). Outpatient prescription drug claims were used to derive average daily morphine equivalent dose (MED) as an indicator of opioid usage and number of unique pain drug classes (Supplementary Table S4). All clinical measures were calculated within the year prior to lead implant. MED for each prescription was calculated by multiplying the quantity (number of units) of each prescription by the strength (milligrams of opioid per unit) and by the morphine equivalent conversion factor (Supplementary Table S5) to estimate the milligrams of morphine equivalent in each prescription (Supplementary Table S4) [14]. Daily MED was calculated by dividing the MED for the prescription by the prescribed days of supply for that prescription. Average daily MED was calculated by summing the daily MED for all prescriptions over a given time period and dividing by the number of days in that period.

Outcomes

Outcome measures included system explant as an indicator of ineffective SCS therapy and change in opioid usage within the year following IPG implant. SCS system explants were identified as a lead removal procedure and an IPG revision procedure within seven days of each other, to avoid counting battery replacements or lead revisions (Supplementary Table S1). Explants for infection were identified as the subgroup with a diagnosis code for infection from the same case (inpatient) or on the same day of service (outpatient procedures) (Supplementary Table S2). Patients were divided into two groups: “explant” if there was a system explant within the year after IPG implant or “continued SCS” if no explant was observed for at least one year. For the regression analysis, average daily MED in the year prior to implant was categorized in three levels (off: <5 mg, moderate: 5–90 mg, high: ≥ 90 mg) [15]. In addition, average daily MED was calculated by month and by yearly quarter, and changes by quarter were compared. Each patient’s change in MED was labeled as a decrease if MED decreased by at least 10%, labeled as an increase if MED increased by at least 10%, or labeled as the same if there was less than 10% difference.

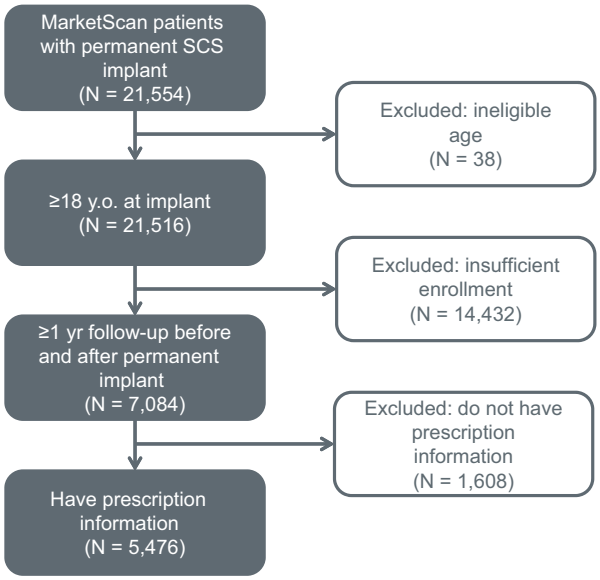

Figure 1 Consort diagram. SCS = spinal cord stimulation.

Statistical Analysis

For patient demographics, analysis of variance was used to test for differences among continuous variables, and the chi-squared test was used to test for differences between categorical variables. Survival free from explant was estimated using the Kaplan-Meier method. The Wilcoxon rank sum test was used to compare MED between continued SCS and explant patients at each month. The paired Wilcoxon rank sum test was used to compare differences in MED within patients across time. Univariate and multivariate logistic regression with binomial distribution and logit link function were used to analyze the effect of covariates in the year prior to implant on explant rate. Covariates included age at implant, sex, presence of alcohol, tobacco, or opioid abuse diagnosis, comorbidities that were significantly different between continued SCS and explant patients with $P < 0.25$, number of back surgeries, number of unique pain drug classes, and MED level calculated over the year prior to implant. The level of significance was 0.05. Bonferroni correction was used when multiple comparisons were made.

Results

Study Population

The MarketScan database contained 21,554 patients with a permanent SCS implant (Figure 1). The study cohort contained 5,476 patients who were age 18 years or older, had two years of medical and drug insurance coverage, of which 59.7% were female, and age at SCS implant was 56.0 ± 13.6 years. Within one year after SCS implant, 390 patients (7.1%) had their entire SCS system removed (Figure 2), while 5,086 had continued SCS. Continued SCS patients were significantly older and were less likely to be tobacco users than explant patients (Table 1). Of the 390 patients with SCS system explants, 93 (23.8% of explant patients, 1.7% of all study patients) had a diagnosis code indicating an infection during hospitalization or on the day of explant.

Opioid Usage and SCS Explant Rate

Opioid usage before SCS implant was measured by calculating the average daily MED for prescription drug claims (Figure 3). In the month immediately before implant, average daily MED was not different between continued SCS and explant patients ($P = 0.139$) (Table 2). In the 12th month after SCS implant, average daily MED was significantly lower in continued SCS than in explant patients ($P < 0.001$). In the month after implant, mean daily MED was 98 mg/d in the continued SCS group and 99 mg/d in the explant group. In the continued SCS group, average daily MED declined to 73 mg/d for the remaining 11 months of the year, while it remained an average of 94 mg/d for explant patients.

Within individual patients, opioid usage tended to increase over the 12 months before SCS implant both for continued SCS (median = 3.9, IQR = –2.0 to 28.6 mg/d, $P < 0.001$) and explant patients (median = 4.9, IQR, = –6.9 to 27.6 mg/d, $P < 0.001$). Over the 12 months after implant, MED had a statistically significant decrease within continued SCS patients (median = 0.0, IQR = –21.7 to 5.9 mg/d, $P < 0.001$) but was not statistically different in explant patients (median = 0.0, IQR = –14.0 to 21.8, $P = 0.181$). In explant patients, opioid usage increased significantly in the first month after explant compared to the first month before implant (median = 5.0, IQR = –7.0 to 31.4, $P < 0.001$).

Patients were categorized into three levels based on MED in the year prior to implant: 1,372 (25.1%) patients were off opioids, 2,958 (54.0%) were moderate-dose users, and 1,146 (20.9%) were high-dose users. Of the patients who had their SCS systems explanted in the year after implant, 78 (5.6%) were off opioids, 214 (7.2%) were moderate-dose users, and 98 (8.6%) were high-dose users.

The impact of opioid use and clinical covariates in the year prior to SCS implant on the SCS system explant rate was compared using univariate and multivariate regression (Table 3). Patients who used tobacco (odds ratio [OR] = 1.37, 95% confidence interval [CI] = 1.03–1.79, $P = 0.027$), were younger (OR = 0.99 per year, 95% CI = 0.98–1.00, $P = 0.030$), or were prescribed more unique drug classes (OR = 1.11, 95% CI = 1.03–1.19, $P = 0.007$) were more likely to have their SCS system explanted. Patients prescribed average daily MED of at least 90 mg/d (OR = 1.55, 95% CI = 1.14–2.12, $P = 0.005$) were also more likely to have an explant. A previous diagnosis code for opioid abuse was not a

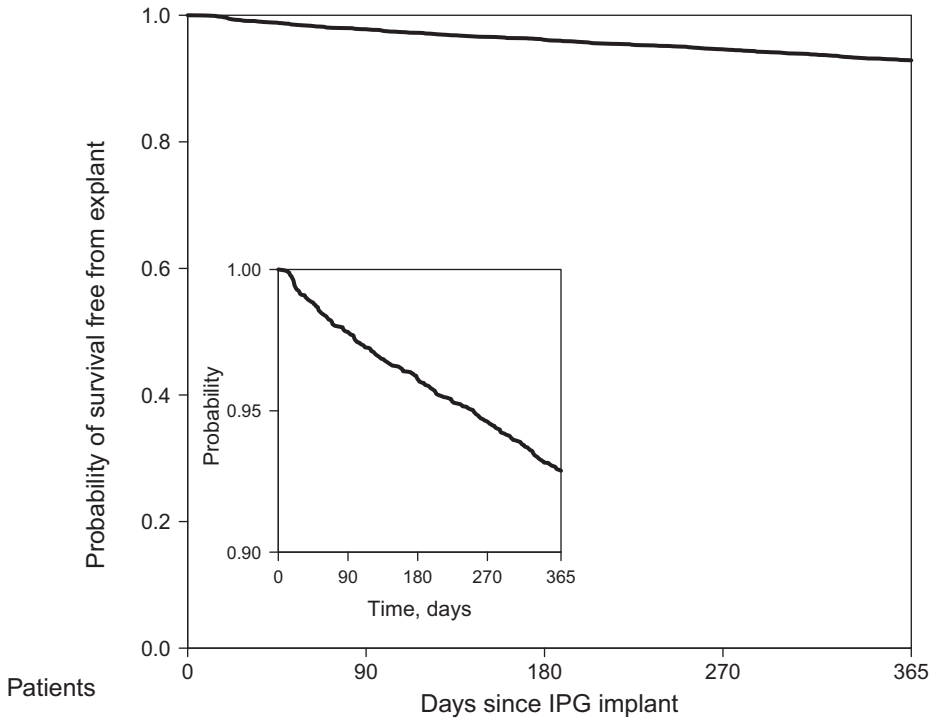

Figure 2 Survival free from SCS system explant. Kaplan-Meier estimator indicates survival free from SCS system explant up to 1 year. Inset: Detail of Kaplan-Meier estimator. Table below shows the number of patients at risk and the cumulative number of patients with SCS system explant at each quarter. IPG = implantable pulse generator.

predictor of system explant. In a multivariate analysis accounting for all covariates (Table 3), only cerebrovascular disease ($P = 0.028$) and MED of at least 90 mg/d ($P = 0.042$) were significant predictors of system explant. In a subanalysis excluding the 93 explants with an associated infection diagnosis, an average daily MED of at least 90 mg/d was still an independent predictor of explant (OR = 1.48, 95% CI = 1.04–2.11, $P = 0.029$) and trended toward but did not reach significance in multivariate analysis (OR = 1.38, 95% CI = 0.96–1.99, $P = 0.08$).

Opioid Usage Before and After SCS

The outcome of SCS therapy was also measured by MED change over the year after implant (Figure 4). In the year before implant, MED decreased in 25% (N = 1,283), stayed the same in 21% (N = 1,074), and increased in 54% (N = 2,729) of continued SCS patients. The distribution of MED changes over the year before implant was not different between continued SCS and explant patients ($P = 0.772$), but was significantly different over the year after implant ($P < 0.001$). After implant, more continued SCS patients had an MED decrease (47%, N = 2,397) or had MED stay the same (23%, N = 1,167) than before implant ($P < 0.001$). Over this time, the proportion of explant patients whose MED decreased (38%, N = 147) or for whom MED stayed the same (19%, N = 73) was significantly lower in the explant patients than continued SCS patients ($P < 0.001$).

Two-Year Cohort Subanalysis

A total of 2,697 patients met inclusion criteria with two-year postimplant follow-up. In this subset, the explant rate was 6.9% at one year and 11.6% at two years, and 38 explants at two years had a corresponding infection diagnosis (12% of explant patients, 1.4% of all study patients). MED was not different between the 2,385 continued SCS and 312 explant patients immediately before implant ($P = 0.076$) but was lower in the continued SCS patients at one year ($P < 0.001$) and two years ($P = 0.009$). As in the one-year cohort, tobacco use (OR = 1.48, 95% CI = 1.05–2.04, $P = 0.022$), cerebrovascular disease (OR = 1.67, 95% CI = 1.13–2.43,

Table 1 Patient demographics

Characteristic	Continued SCS (N = 5,086)	Explant (N = 390)	*P* Value
Age at implant, mean ± SD, y	56.16 ± 13.57	54.60 ± 14.53	**0.030**
Lead to IPG time, mean ± SD, d	30.62 ± 24.34	31.58 ± 24.60	0.452
Sex (female), No. (%)	3,028 (59.5)	241 (61.8)	0.411
Implant diagnosis (can be multiple per patient), No. (%)			
Postlaminectomy syndrome	1,888 (37.1)	149 (38.2)	0.710
CRPS	359 (7.1)	30 (7.7)	0.713
Neuritis	2,096 (41.2)	161 (41.3)	1.000
Degenerative disc disease	1,141 (22.4)	89 (22.8)	0.910
Other back pain	1,165 (22.9)	91 (23.3)	0.896
Limb pain	328 (6.4)	24 (6.2)	0.903
Other chronic pain	2,205 (43.4)	172 (44.1)	0.815
Charlson comorbidity index, mean ± SD	1.07 ± 1.43	1.10 ± 1.39	0.701
Congestive heart failure, No. (%)	203 (4)	15 (3.8)	0.994
Peripheral vascular disease, No. (%)	366 (7.2)	31 (7.9)	0.652
Cerebrovascular disease, No. (%)	399 (7.8)	41 (10.5)	0.077
Chronic pulmonary disease, No. (%)	1,427 (28.1)	122 (31.3)	0.192
Rheumatic disease, No. (%)	243 (4.8)	16 (4.1)	0.630
Mild liver disease, No. (%)	233 (4.6)	20 (5.1)	0.711
Diabetes without chronic complication, No. (%)	1,013 (19.9)	82 (21)	0.644
Diabetes with chronic complication, No. (%)	256 (5)	19 (4.9)	0.984
Opioid abuser, No. (%)	203 (4)	21 (5.4)	0.228
Tobacco user, No. (%)	660 (13)	66 (16.9)	**0.033**
Alcohol abuser, No. (%)	82 (1.6)	9 (2.3)	0.407
Prior surgeries, No. (%)			
0	4,641 (91.3)	350 (89.7)	
1	376 (7.4)	30 (7.7)	0.150
>1	69 (1.4)	10 (2.6)	

Demographics of spinal cord stimulation (SCS) patients. Charlson comorbidity index, opioid, tobacco, and alcohol abuse, and prior surgeries were calculated over the year prior to SCS implant. *P* values show differences between continued SCS and explant patients, as measured by one-way analysis of variance or chi-square test. Bold *P* values are significantly different. Comorbidities with counts ≤10 were excluded from the table.
IPG = implantable pulse generator.

$P = 0.009$), and MED of at least 90 mg/d (OR = 1.71, 95% CI = 1.17–2.5, $P = 0.006$) were significant factors in a multivariate regression for explant rate. In addition, female gender (OR = 1.3, 95% CI = 1.01–1.68, $P = 0.045$) and MED prescription of 5–90 mg/d (OR = 1.47, 95% CI = 1.06–2.06, $P = 0.025$) were associated with higher explant rates.

Discussion

This claims data study examined a large, real-world cohort of SCS patients to quantify prescription opioid use before and after SCS therapy. Opioid dosage across the population increased significantly over the year prior to SCS implant. Patients with continued SCS saw their prescribed opioid dosage stabilize or decrease in the year after device implant, while patients who had a system explant in the year postimplant did not change their opioid dosage. For patients in whom SCS was ineffective, as measured by system explant, opioid dosage was even higher at the time of explant than before receiving SCS. Cerebrovascular disease and opioid dosage of at least 90 mg/d prior to implant were significant predictors of SCS system explant in multivariate analysis.

Hayek et al. [16] reported a higher one-year explant rate of 11.7% in percutaneous implants performed by pain physicians, while this study found 7.1% explants at one year across all implant and physician types. SCS system removals for infection (23.8% of explants) tended to occur early, with 1.7% in the one-year cohort compared with 1.4% in the two-year cohort, but rates were similar to Hayek (4.3% over an average of 3.7 years) [16] or Cameron (3.4%, unknown follow-up) [9].

Historically, patients who receive SCS tend to be high-dose opioid users because the stepladder approach placed neurostimulation after opioid therapy; SCS patients were using on average 68–77 mg/d (SD = 139–146 mg/d) MED in the PROCESS trial [8] and 131

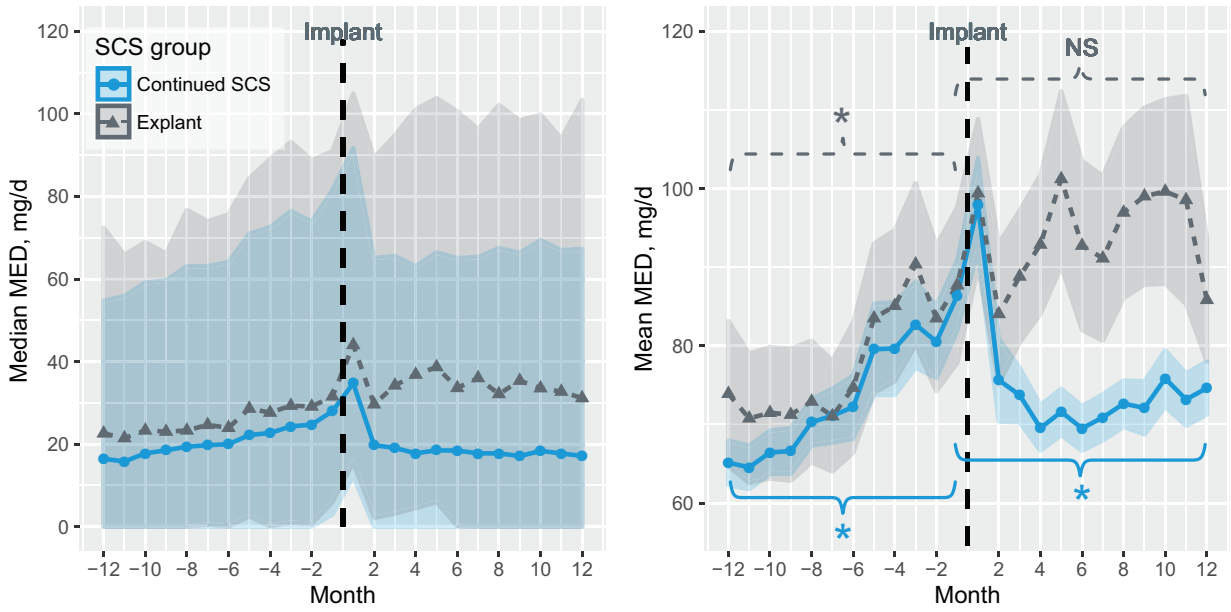

Figure 3 Morphine equivalent dose by month. MED over time for patients with continued SCS (solid, circle) and explant (dashed, triangle) before and after SCS implant. Left: solid lines are medians and shaded areas are interquartile ranges. Right: solid lines are means and shaded areas are standard errors. Brackets represent within-patient comparisons in MED between the 12th month before and the first month before implant, and between the first month before and the 12th month after implant. Asterisk (*) indicates $p<0.001$, NS is not significant. MED = morphine equivalent dose; NS = not significant; SCS = spinal cord stimulation.

Table 2 Between-group differences in morphine equivalent dose

	MED, mg/d		
Time period	Continued SCS	Explant	*P* Value
12th mo before implant	16.4 (0–54.7)	22.6 (0–72.4)	0.015
1st mo before implant	28.0 (3.0–81.6)	31.6 (5.9–91.0)	0.139
12th mo after implant	17.1 (0–67.3)	31.2 (0–103.3)	<0.001
1st mo before explant		41.8 (13.1–117.1)	
1st mo after explant		43.6 (14.8–115.2)	

Median daily morphine equivalent dose and interquartile range across the patient population. *P* values show significant differences between continued SCS and explant groups, as measured by the Wilcoxon rank sum test.
MED = morphine equivalent dose; SCS = spinal cord stimulation.

mg/d (SD = 149 mg/d) MED in the SENZA-RCT trial [17]. Opioid usage over the year before implant was on average 73 mg/d (SD = 235 mg/d) in this study, similar to previous trials, with 50% of patients increasing their dosage over that year. Currently, there is no strong evidence of change or decrease in opioid usage in chronic pain patients with SCS therapy in the literature. Cameron found that 67% of patients reported pain relief across 20 years of SCS literature, while 45% reduced narcotic use after implant [9]. In this study, 44% of patients with continued SCS had a MED decrease by at least 10% after implant, and 26% had stable MED. Implants in this study were performed prior to 2015, which may predate the heightened awareness and interest in weaning or eliminating patients from opioid medications. While there is complexity in chronic pain management, it is reasonable to expect that in the future, the clinician's goal could be to stabilize, reduce, or eliminate opioids after SCS implant.

This study demonstrated that opioid dosage was elevated and on an upward trajectory in the year before

Table 3 Factors associated with SCS system explant

		Univariate			Multivariate		
Covariate		OR	95% CI	*P*	OR	95% CI	*P*
Age at implant, y		0.99	0.98–1.00	**0.030**	0.99	0.99–1.00	0.161
Sex (female)		1.10	0.89–1.36	0.381	1.08	0.87–1.35	0.463
Opioid abuser		1.37	0.84–2.12	0.182	1.16	0.70–1.81	0.539
Tobacco user		1.37	1.03–1.79	**0.027**	1.23	0.92–1.62	0.159
Alcohol abuser		1.44	0.67–2.74	0.303	1.22	0.56–2.36	0.576
Cerebrovascular disease		1.38	0.97–1.92	0.063	1.48	1.03–2.09	**0.028**
Pulmonary disease		1.17	0.93–1.45	0.173	1.13	0.90–1.41	0.288
Renal disease		0.63	0.30–1.17	0.18	0.65	0.30–1.22	0.219
No. back surgeries	0			Reference			
	1	1.06	0.70–1.53	0.776	1.01	0.67–1.46	0.976
	>1	1.92	0.92–3.59	0.057	1.69	0.81–3.19	0.131
No. unique drug classes		1.11	1.03–1.19	**0.007**	1.06	0.98–1.15	0.173
MED level	<5 mg/d			Reference			
	5–90 mg/d	1.32	1.01–1.74	**0.043**	1.19	0.90–1.59	0.227
	≥90 mg/d	1.57	1.15–2.16	**0.005**	1.40	1.01–1.95	**0.042**

Results of the univariate and multivariate logistic regression of spinal cord stimulation system explant within one year. Bold *P* values are significantly different.
CI = confidence interval; MED = morphine equivalent dosage; OR = odds ratio; SCS = spinal cord stimulation.

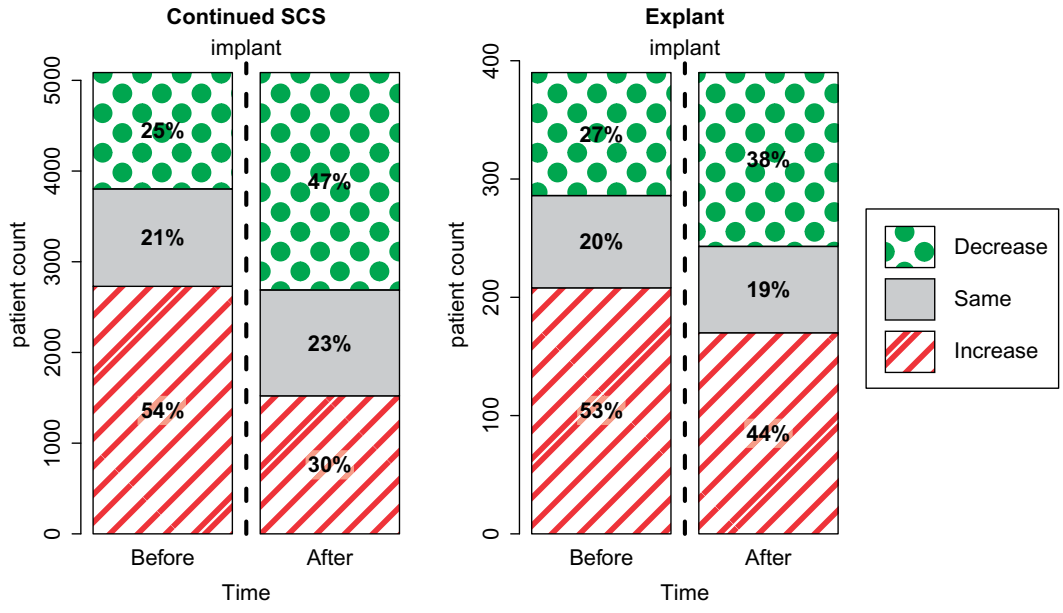

Figure 4 Morphine equivalent dose changes over time. MED changes before and after SCS implant (dashed line). Changes before implant are measured in the 1st quarter before relative to the 4th quarter before implant. Changes after are measured in the 4th quarter after relative to the 1st quarter before implant. Dotted: 10% decrease, lined: 10% increase, solid: less than 10% change in MED. SCS = spinal cord stimulation.

SCS implant. This could be related to the inherent complexity of chronic pain management [6], to worsening pain symptoms, opioid-induced hyperalgesia or psychological distress from dose withdrawal [18], or to the stepladder approach to escalate medications considerably before considering a medical device. High-dose opioid use before implant was a significant predictor of SCS system explant in both univariate and multivariate analyses. These results suggest that excessive opioid usage before SCS implant has a negative effect

on outcomes. Madineni et al. [19] observed longer hospital stays at SCS implant procedure in patients on high doses of opioids preoperation, while Pope et al. [20] observed that explants tended to occur earlier in patients exceeding 100 mg/d MED prior to implant. Similarly, patients undergoing anterior cervical arthrodesis had worse outcomes if they regularly used opioids before the procedure [21], and patients undergoing total knee arthroplasty had worse long-term outcomes if they regularly used opioids after the procedure [22]. Weaning patients down off of high-dose opioids could improve SCS outcomes, as was seen in total joint arthroplasty [23]. Alternatively, clinicians could intervene with SCS earlier, before opioid use has reached extreme levels, to improve outcomes [12]. In recent years, there has been a heightened awareness to the consequences of overprescribing opioids. In 2016, the Centers for Disease Control and Prevention's recommendations for opioid usage suggested avoidance of MED $\geq$90 mg/d [15]. This paper demonstrates that utilizing SCS as a treatment option, as opposed to escalating doses of opioids, may in many cases lead to stabilization or reduction in opioid use. The data in this study also reveal that SCS insertion as an index event statistically correlates with opioid dosing.

Limitations

This was a retrospective study of insurance claims and is limited to the data submitted for medical billing between 2010 and 2014. Opioids obtained in any way other than through the patient's or family member's health insurance would not be present in the data set. This study only included patients with continuous health insurance coverage for two years and therefore may not capture chronic pain patients who are not working, use Medicaid, or do not have insurance. In recent years, clinicians and government officials have recognized the opioid epidemic and may have changed standard practice, but this database was limited to claims through December 2014. Morphine equivalent dosages were derived from the outpatient prescription drugs table, which contains information about prescriptions filled, but not actual adherence by the patient. Inpatient medication usage was not included in this analysis. In addition, 22.7% of the patients were excluded because their prescription information was not contained in the database.

Clinical measures of pain were not available to measure effectiveness of SCS therapy, so effectiveness was inferred from continuation of care past one year. The primary reason for SCS system explant, whether for inadequate pain relief, infection, or other reasons, was not known and could only be deduced from diagnosis and procedure codes. Infection that leads to explant may also cause increased pain, which could partially explain the finding that explant patients require higher doses of opioids than those with continued SCS. Similarly, reduced mobility associated with stroke leading to difficulty programming or charging the SCS system, cognitive impairment, and even the emergence of central poststroke pain may have contributed to the higher rate of explant for patients with cerebrovascular disease. Tobacco use and increasing opioid use were independent predictors of explant and have previously been shown to be predictors of poor outcomes of SCS [24]. Future investigation identifying a causative link between these risk factors and explants would confirm them as valid targets on which patients could be counseled preoperatively to decrease the risk of poor outcomes.

Conclusion

In this large, real-world cohort, SCS patients were prescribed increasing opioid dosages over the year prior to SCS implant, with 20% exceeding 90 mg MED per day. Risk of SCS explant was related to tobacco use, cerebrovascular disease, taking multiple medications, and higher-dose opioid use. SCS was effective across all levels of opioid dosage, as measured by explant rates ranging from 5.6% for MED $<$5 mg/d to 8.7% for MED $\geq$90 mg/d. The data show more than 91% of patients retain the SCS system at one year, even at the highest opioid dosage. With neuromodulation therapy, opioid dosage stabilized or decreased. There is potential to improve outcomes by implanting SCS earlier, before high-dose opioid usage. Additional opioid reduction techniques, such as preprocedural weaning and low-dose postprocedural plans, should also be considered.

Supplementary Data

Supplementary Data may be found online at http://painmedicine.oxfordjournals.org.

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