The Impact of Preoperative Spinal Injection Timing on Postoperative Complications of Lumbar Decompression Surgery

Syed I. Khalid, MD*‡, Pranav Mirpuri, BS§, Elie Massaad, MD, MSc‡, Kyle B. Thomson, BS§, Ali Kiapour, PhD‡, John H. Shin, MD‡, Owoicho Adogwa, MD, MPH‖

*Department of Neurosurgery, University of Illinois at Chicago, Chicago, Illinois, USA; ‡Department of Neurosurgery, Massachusetts General Hospital, Boston, Massachusetts, USA; §Chicago Medical School, North Chicago, Illinois, USA; ‖Department of Neurosurgery, University of Cincinnati, Cincinnati, Ohio, USA

Correspondence: Syed I. Khalid, MD, Department of Neurosurgery, University of Illinois at Chicago, 912 S. Wood St, 4N NPI, Chicago, IL 60612, USA. Email: syed.khalid@me.com

Received, October 25, 2023; **Accepted,** December 19, 2023; **Published Online,** February 20, 2024.

Neurosurgery 95:198–206, 2024 https://doi.org/10.1227/neu.0000000000002857

BACKGROUND AND OBJECTIVES: Epidural steroid injections (ESIs) are commonly used for lower back pain management. The effect of these injections on lumbar decompression surgery outcomes is hitherto underexplored. The study objective was to determine the impact of ESIs on postoperative rates of medical and surgical complications and to define the appropriate interval before lumbar decompression surgery.

METHODS: This retrospective all-payer database analysis identified 587 651 adult patients undergoing one- to three-level laminectomies from January 2010 to October 2021. A 2:1 propensity score match accounting for comorbidities, levels of surgery, and demographics was performed to create two cohorts: (1) 43 674 patients who had received an ESI in the 90 days before laminectomy and (2) 87 348 patients who had not received an ESI. The primary outcome was the rates of medical and surgical complications between groups at 30 days postoperatively. Patients were divided into five cohorts based on injection time before surgery: 1 to 30 days, 31 to 45 days, 46 to 60 days, 61 to 75 days, and 76 to 90 days. Logistic regression was performed between groups to identify temporal associations of complication rates. Confidence intervals of 95% are provided when appropriate. *P* values < .01 were considered significant.

RESULTS: Rates of medical complications within 30 days of surgery were significantly higher in those with ESI compared with control (4.83% vs 3.9%, $P < .001$). Cerebrospinal fluid (CSF) leak rates were increased in the ESI group at 0.28% vs 0.1% ($P < .001$), but surgical site infection rates were not significantly different between groups (1.31% vs 1.42% $P = .11$). ESI performed within 30 days was associated with increased odds of CSF leak (OR: 5.32, 95% CI: 3.96-7.15).

CONCLUSION: Preoperative ESI increases the risk of CSF leak and medical complications after lumbar decompression. Because these complications were significantly associated with ESIs given 1 to 30 days before surgery, avoiding ESIs at least 30 days before surgery may be advisable.

KEY WORDS: Laminectomy, Epidural steroid injection, Decompression, ESI, Pain interventions, Spine quality

Lumbar back pain is a leading cause of disability and functional impairment, with a combined population prevalence of 1% to 3% in US adults.[1-3] While back pain can be managed through various treatment methods, many patients eventually receive a spinal epidural steroid injection (ESI). ESIs have historically been used for diagnostic and therapeutic purposes but are now primarily used to treat pain.[4] Spinal injections exert their analgesic effect by delivering steroids or local anesthetics to the affected area, thereby reducing nerve root inflammation and local ischemia.[4] Interestingly, despite the significant controversy regarding the clinical effectiveness of ESIs for chronic pain, there has been explosive growth in their utilization; from 2000 to 2011, uptake for lumbar/sacral transforaminal epidural injections increased by 665% in the Medicare population.[5]

Some believe that with proper patient selection, ESIs can provide meaningful pain relief and reduce the need for spinal surgery. However, others argue that current research has not supported the efficacy of ESIs for these purposes.[6,7] At this time, studies have demonstrated that ESI might have some benefits in patients with

ABBREVIATIONS: CAD, coronary artery disease; **CHF,** congestive heart failure; **CPT,** Current Procedural Terminology; **ESI,** epidural steroid injection; **ICD,** International Classification of Diseases; **PE,** pulmonary embolism; **PVD,** peripheral vascular disease; **SSI,** surgical site infection.

Supplemental digital content is available for this article at neurosurgery-online.com.

radiculopathy for pain relief, but the effects are short-term (<2 weeks) and less remarkable in patients with spinal stenosis. Furthermore, meta-analyses have demonstrated significant inconsistency and heterogeneity between trials regarding the type of control used, including soft tissue vs epidural injection and volume-mediated effects on inflammation, making it difficult to appreciate the actual value of ESIs in practice.[8,9] These findings have resulted in the updated 2020 North American Spine Society guideline on diagnosis and treatment of low back pain, which states that there is insufficient evidence to recommend for or against caudal or interlaminar ESIs in patients with low back pain.[10]

Further complicating the picture are the genuine risks of ESIs—although rare—including headaches, cerebrospinal fluid (CSF) leaks, adhesive arachnoiditis, intravascular injections, local hematoma formation, injection site abscess, and infection.[11,12] Recognizing these complications, the US Food and Drug Administration issued a formal warning on April 23, 2014, alerting medical professionals to additional risks for loss of vision, stroke, paralysis, and death after epidural corticosteroid injection.[13] Recent studies have additionally suggested that ESIs may compromise subsequent spine surgery by precipitating medical and surgical complications, notably surgical site infection. This study aimed to determine the impact of preoperative lumbar ESI on the rates of postoperative medical and surgical complications after one-, two-, and three-level laminectomies in patients with low back pain.

METHODS

Data Source

An analysis of the Mariner database was conducted to examine the impact of preoperative spinal injection on complications after lumbar decompression. The Mariner database is an all-payer claims database of 157 million persons developed and maintained by PearlDiver Inc. The deidentified database contains Health Insurance Portability and Accountability Act–compliant patient information across the United States and its territories. Patient information, ranging from diagnoses to procedures, is recorded using medical coding including Current Procedural Terminology (CPT) and International Classification of Diseases (ICD) codes. Our institution's Institutional Review Board approved this study with a waiver of patient informed consent because the nature of this analysis posed minimal risk to participating individuals and the data were presented in aggregate to minimize risk of loss of confidentiality.

Cohort Selection

Patients undergoing one-, two-, and three-level lumbar laminectomies were identified using the well-validated ICD-9 and ICD-10 and CPT coding algorithm updated for the 2010 to 2021 coding years (**Supplemental Digital Content 1**, http://links.lww.com/NEU/E124), and patients undergoing interventions between January 2010 and October 2021 were identified.[14-16] Laminectomy was defined using code CPT-22633, and additional levels were defined with codes CPT-63044, CPT-63035, and CPT-63048. Inclusion criteria were (1) age between 18 and 85 years, (2) undergoing elective lumbar decompression procedures, and (3) at least 1-year continuous health plan enrollment for longitudinal tracking. Patients undergoing laminectomy secondary to neoplasm, spinal abscess, osteomyelitis, discitis, trauma, fractures, and spinal metastases were excluded. These patients were then further stratified by the interval in which they received an ESI within 90 days preoperatively.

Patient Matching and Comorbidity Selection

Propensity matching of 2:1 was performed based on comorbidities and demographics independently associated with the complications analyzed in this study to eliminate potential confounders and to optimize the balance between groups. For a complete list of the confounders accounted for in the matching process, refer to Table 1.

The Mariner database provided aggregate records of age ranges. Covariates and comorbidities were extracted using ICD-9 and ICD-10 diagnosis codes. These included demographics (age, sex, year of surgery, smoking status, alcoholism history, procedure information (anatomic location, levels involved), and comorbidities (hypertension, chronic obstructive pulmonary disease [COPD], asthma, congestive heart failure [CHF], coronary artery disease [CAD], gastroesophageal reflux disease, osteoarthritis, diabetes mellitus, hyperlipidemia, morbid obesity, depression, hypothyroidism, peripheral vascular disease [PVD], liver disease).

Outcomes

This study's main objective was to evaluate ESI's impact on rates of medical and surgical complications at 30 days after lumbar laminectomy. Medical complications included urinary tract infection (UTI), pneumonia, deep vein thrombosis, pulmonary embolism (PE), cardiac arrest, and acute kidney injury. Surgical complications included hematoma, wound disruption, surgical site infection, and CSF leak. Surgical site infection was identified using ICD codes (ICD-10-D-T8140XA, ICD-10-D-T8149XA, ICD-10-D-T814XXA, ICD-9-D-99851, ICD-9-D-99859, 10-D-T8141XA, ICD-10-D-T8142XA, ICD-10-D-T8144XA).

In addition, groups based on the time from injection to surgery were constructed: less than 30 days, <45 days, <60 days, <75 days, and <90 days. The secondary outcome was the rates of surgical and medical complications over these periods.

Statistical Analysis

Descriptive statistics were calculated for age, sex, and comorbidities and compared between the ESI and control groups. Patient populations were propensity-matched in a 2:1 fashion based on age, sex, number of surgery levels, and comorbidities (smoking status, peripheral vascular disease, osteoarthritis, morbid obesity, liver disease, hypothyroidism, hypertension, hyperlipidemia, gastroesophageal reflux disease, alcohol use disorder, diabetes, depression chronic pulmonary disease, coagulopathy, chronic kidney disease, chronic heart failure, coronary artery disease, and asthma). χ^2 tests were performed to compare categorical variables: age ranges, sex, comorbidities, and outcomes. Odds ratios were calculated based on logistic regressions performed for each complication over the predefined time intervals. Ninety-five percent confidence intervals are calculated and provided when appropriate. Data were analyzed using R (Version 4.1, R Foundation, Vienna, Austria). *P* values <.01 were considered significant.

RESULTS

A total of 587 651 patients undergoing one- to three-level lumbar fusion were identified. A total of 726 patients were

TABLE 1. Matched Descriptive Patient Characteristics

Factor	Control, n = 87 348	ESI intervention, n = 43 674	*P* value
Age, years, n (%)			.99
15-19	98 (0.11%)	55 (0.13%)	
20-24	468 (0.54%)	249 (0.57%)	
25-29	954 (1.09%)	492 (1.13%)	
30-34	2193 (2.51%)	1099 (2.52%)	
35-39	3523 (4.03%)	1743 (3.99%)	
40-44	4661 (5.34%)	2339 (5.36%)	
45-49	6213 (7.11%)	3069 (7.03%)	
50-54	8106 (9.28%)	4086 (9.36%)	
55-59	10 772 (12.33%)	5301 (12.14%)	
60-64	12 219 (13.99%)	6094 (13.95%)	
65-69	12 021 (13.76%)	6003 (13.75%)	
70-74	15 148 (17.34%)	7591 (17.38%)	
75-79	9104 (10.42%)	4595 (10.52%)	
80+	1868 (2.14%)	958 (2.19%)	
Sex, n (%)			
Female	42 397 (48.54%)	21 149 (48.42%)	.7
Male	44 951 (51.46%)	22 525 (51.58%)	
Comorbidity, n (%)			
Hypertension	42 885 (49.1%)	21 335 (48.85%)	.4
COPD	11 341 (12.98%)	5993 (13.72%)	<.001
Asthma	3289 (3.77%)	1802 (4.13%)	<.05
Chronic heart failure	1049 (1.2%)	655 (1.5%)	<.001
Coronary artery disease	10 496 (12.02%)	5462 (12.51%)	<.05
Smoking	14 468 (16.56%)	7429 (17.01%)	<.05
Gastroesophageal reflux disease	44 301 (50.72%)	22 282 (51.02%)	.31
Osteoarthritis	15 157 (17.35%)	7623 (17.45%)	.65
Diabetes mellitus	16 238 (18.59%)	8222 (18.83%)	.31
Hyperlipidemia	64 417 (73.75%)	32 214 (73.76%)	.97
Morbid obesity	5449 (6.24%)	2922 (6.69%)	<.05
Depression	12 924 (14.8%)	6615 (15.15%)	.09
Hypothyroidism	10 141 (11.61%)	5214 (11.94%)	.08
Peripheral vascular disease	5594 (6.4%)	3005 (6.88%)	<.05
Liver disease	2571 (2.94%)	1556 (3.56%)	<.001
Alcohol use disorder	945 (1.08%)	577 (1.32%)	<.001

TABLE 1. Continued.

Factor	Control, n = 87 348	ESI intervention, n = 43 674	*P* value
Laminectomy levels, n (%)			
One level	44 190 (50.59%)	22 118 (50.64%)	.86
Two level	19 793 (22.66%)	9850 (22.55%)	.67
Three level	23 365 (26.75%)	11 706 (26.8%)	.84
ESI days before surgery, n (%)			
1-30	0 (0%)	18 251 (41.79%)	<.001
31-45	0 (0%)	8581 (19.65%)	<.001
46-60	0 (0%)	6979 (15.98%)	<.001
61-75	0 (0%)	5620 (12.87%)	<.001
76-90	0 (0%)	4243 (9.72%)	<.001

COPD, chronic obstructive pulmonary disease; ESI, epidural steroid injection.

excluded because they were not in the appropriate age range (18-85) or had incomplete details of their medical history. Similarly, 50 155 patients were excluded for diagnoses of neoplasm, spinal abscess, osteomyelitis, discitis, trauma, fractures, and spinal metastases (Figure). Descriptive statistics for the unmatched population are reported in **Supplemental Digital Content 1** (http://links.lww.com/NEU/E124).

After 2:1 propensity score matching using patient demographic and comorbidity data, 43 674 ESI-treated patients were matched with 87 348 controls. Each cohort consisted of a majority of individuals over age 50 years, and the age distribution was identical between groups ($P > .99$). ESI intervention and control cohorts were 51.5% and 51.6% males, respectively. Comorbidities that were equally matched between groups included hypertension, gastroesophageal reflux disease, osteoarthritis, diabetes mellitus and HLD, depression, and hypothyroidism. Rates of COPD, asthma, CHF, CAD, history of smoking, morbid obesity, depression, hypothyroidism, PVD, liver disease, and history of alcoholism were significantly increased in the ESI group (Table 1).

Rates of Complications in Matched Cohorts

At 30 days after surgery, complications were calculated for the matched cohort. Medical complication rates were increased in the ESI group at 4.83% vs 3.9% ($P < .001$), likely secondary to increased rates of UTI (2.68% vs 1.95%, $P < .001$) and pneumonia (1.01% vs 0.79%, $P < .001$). Rates of CSF leak were increased in the ESI cohort at 0.28% vs 0.1% ($P < .001$). On the other hand, wound disruption rates were more significant in the control group (0.75% vs 0.62%, $P < .05$). No differences were found between groups in deep vein thrombosis, PE, acute kidney injury, cardiac arrest, surgical complications, hematoma, wound disruption, or surgical site infection rates. Refer to Table 2.

Complication Rates Over Time: Definition of an Optimal Interval

At 30 days after surgery, complication rates were calculated for each time-stratified ESI group. In the intervention group, medical complications were increased at 1 to 30 days (OR 1.31, 95% CI 1.22-1.41), 31 to 45 days (OR 1.22, 95% CI 1.1-1.35), 46 to 60 days (OR 1.21, 95% CI 1.07-1.36), and 76 to 90 days (OR 1.16, 95% CI 1.01-1.32). UTI was similarly increased in the 1- to 30-day (OR 1.44), 31- to 45-day (OR 1.45), 46- to 60-day (OR 1.39), and 76- to 90-day (OR 1.34) group. Pneumonia was increased in the 1- to 30-day (OR 1.33) and 46- to 60-day ESI groups (OR 1.32). PE was increased in the 1- to 30-day ESI group (OR 1.33). In the ESI group, surgical complications were increased at 1 to 30 days (OR 1.15, 95% CI 1.04-1.27), as was CSF leak (OR 5.32, 95% CI 3.96-7.15). Wound disruption was decreased at 1-30 days (OR 0.75, 95% CI 0.59-0.95) but increased in the ESI group at 76-90 days (OR 1.58, 95% CI 1.12-2.17). Refer to Table 3.

DISCUSSION

Interest in the impact of preoperative ESI on surgical outcomes is growing. Despite their promise, ESIs remain controversial and may cause significant harm. This study sought to explore the effects of preoperative ESI on medical and surgical outcomes after one-, two-, and three-level laminectomies with a secondary analysis to define an optimal interval for ESI administration before surgery. In this study, rates of medical and surgical complications were significantly increased in the ESI group at 30 days. CSF leak, in particular, was drastically increased in undergoing surgery within 30 days of receiving an ESI. Interestingly, there was no discernible difference in surgical site infection rates between groups, in contrast to the literature.

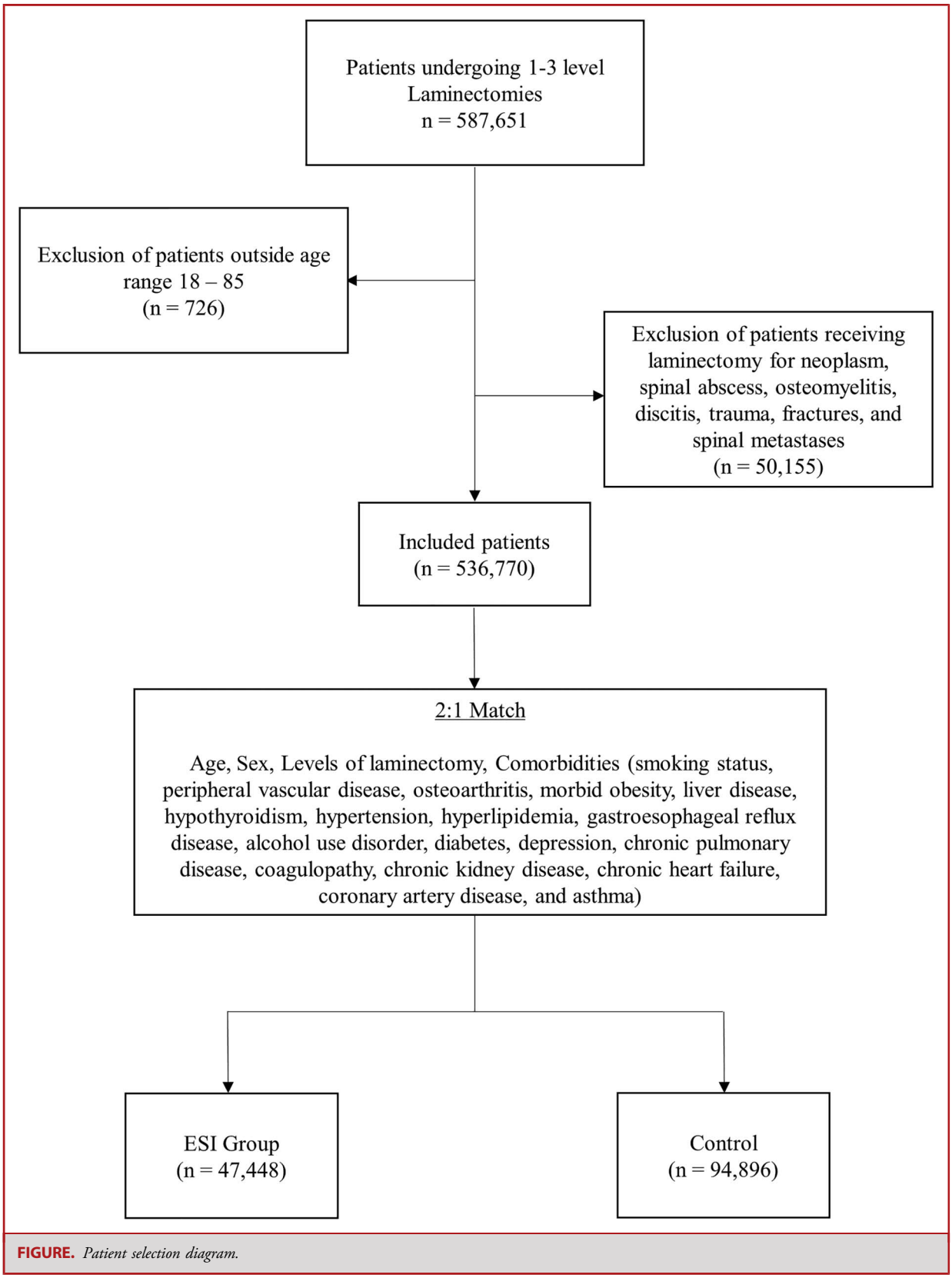

FIGURE. *Patient selection diagram.*

TABLE 2. Rates of Postoperative Complications

Outcomes	Control, n = 87 348	ESI intervention, n = 43 674	*P* value	95% CI OR
Medical complications	3403 (3.9%)	2108 (4.83%)	<.001	1.25 (1.18-1.32)
Urinary tract infection	1700 (1.95%)	1172 (2.68%)	<.001	1.38 (1.28-1.49)
Pneumonia	692 (0.79%)	443 (1.01%)	<.001	1.28 (1.14-1.45)
Deep vein thrombosis	187 (0.21%)	102 (0.23%)	.52	1.09 (.086-1.39)
Pulmonary embolism	266 (0.3%)	151 (0.35%)	.23	1.14 (0.93-1.39)
Cardiac arrest	72 (0.08%)	25 (0.06%)	.14	0.69 (0.44-1.09)
Acute kidney injury	944 (1.08%)	458 (1.05%)	.61	0.97 (0.87-1.09)
Surgical complications	2032 (2.33%)	1048 (2.4%)	.42	1.03 (0.96-1.11)
Wound	497 (0.57%)	231 (0.53%)	.38	0.93 (0.79-1.09)
Hematoma	573 (0.66%)	294 (0.67%)	.74	1.03 (0.89-1.18)
Cerebrospinal fluid leak	84 (0.1%)	123 (0.28%)	<.001	2.93 (2.22-3.87)
Surgical site infection	1238 (1.42%)	570 (1.31%)	.11	0.92 (0.83-1.02)

ESI, epidural steroid injection.

The discussion thus far on the incidence of postoperative CSF leak after ESI has been limited because this complication is rare. A series by Botwin et al[17] found an incidence of 0.3% for dural tears after cervical ESI with fluoroscopic guidance. Instead, dural tears resulting in CSF leak are a more common complication of spine surgery, with incidence ranging from 0.6% to 14% for various lumbar procedures.[18,19] We could find only two relevant studies of note: Koltsov et al performed a retrospective database analysis investigating whether preoperative ESI was associated with postoperative complications. No significant association with CSF leak was observed in their propensity-matched analysis. In a more related study, Shakya et al recently explored the impact of preoperative lumbar ESI on dural tears during minimally invasive lumbar discectomy in a single-center prospective analysis with a sample size of 315. They found that patients receiving an ESI were more likely to suffer from intraoperative dural tears, a relationship especially prevalent in those who received an ESI within 3 months of surgery.[20] Similarly, our results demonstrated that CSF leaks were especially likely in those who received an ESI within 30 days of the procedure.

The anti-inflammatory effects of corticosteroids likely mediate the higher incidence of CSF leak in the ESI group. ESIs are intended to diminish inflammation and thus reduce pain, but inflammation is a critical part of wound healing that becomes impaired by their administration.[21,22] This effect is profound on the meninges because they are mainly composed of collagen. While studies have not shown a direct compromise to the material strength of the dura from local steroid injection, electron microscopy has shown a significant decrease in the number of intracytoplasmic mitochondria of dural fibroblasts in steroid-injected animals, suggesting an inhibitory effect to the dura mater.[23] The effects of ESI are thus similar to those of chronic corticosteroid use, another factor implicated as a risk factor for dural tears in elective spine surgery.[24] Unfortunately, our result is unclear because there were differences in our control and ESI group baseline comorbid conditions. While certain conditions such as COPD likely had no bearing on the results, higher levels of morbid obesity, in particular, were observed and have been previously recorded as a risk factor for postoperative CSF leak.[25]

The literature is more nuanced regarding the effect of ESI on postoperative surgical site infection. A meta-analysis from 2022 demonstrated that preoperative ESI within 30 days of lumbar spine surgery was associated with a high risk of postoperative infection. In a subgroup analysis, they found that fusion specifically was associated with higher site infection rates, whereas no association between ESI and decompression was identified. It is worth noting that within the meta-analysis, there was significant heterogeneity in study design, definition of surgical site infection, and age distribution, such that their conclusions leave more questions than answers.[26]

Seavey et al[27] examined the impact of ESI on patients undergoing single-level lumbar decompression in a retrospective analysis with the military health system repository but found no relationship between preoperative ESI and postoperative surgical site infection. Similarly, Kreitz et al[28] performed a single-institution retrospective study and concluded that there was no relationship between site infection and preoperative ESI. By contrast, using the PearlDiver database, Yang et al[29] analyzed a larger population undergoing single-level decompression for the same end point. Their matched analysis found that preoperative

TABLE 3. Epidural Steroid Injection Complications Over Time With Odds Ratios

Factor	ESI 1-30 d	ESI 31-45 d	ESI 46-60 d	ESI 61-75 d	ESI 76-90 d
Medical complications	921	404	326	248	209
Odds ratio (95% CI)	1.31 (1.22-1.41)	1.22 (1.1-1.35)	1.21 (1.07-1.36)	1.14 (0.995-1.3)	1.28 (1.1-1.47)
UTI	507	240	188	127	110
Odds ratio (95% CI)	1.44 (1.3-1.59)	1.45 (1.26-1.66)	1.39 (1.19-1.62)	1.16 (0.97-1.39)	1.34 (1.1-1.62)
Pneumonia	197	77	73	56	45
Odds ratio (95% CI)	1.33 (1.13-1.56)	1.13 (0.89-1.43)	1.32 (1.03-1.67)	1.26 (0.95-1.64)	1.34 (0.98-1.8)
DVT	39	22	13	17	11
Odds ratio (95% CI)	1 (0.7-1.39)	1.2 (0.75-1.82)	0.87 (0.47-1.46)	1.41 (0.83-2.25)	1.21 (0.62-2.12)
PE	74	33	22	14	123
Odds ratio (95% CI)	1.33 (1.02-1.72)	1.26 (0.86-1.79)	1.04 (0.65-1.56)	0.82 (0.46-1.35)	0.62 (0.28-1.17)
Cardiac arrest	11	[a]	[a]	[a]	[a]
Odds ratio (95% CI)	0.73 (0.37-1.32)	0.42 (0.1-1.14)	1.04 (0.4-2.21)	0.65 (0.16-1.74)	0.57 (0.09-1.82)
Acute kidney injury	196	76	66	62	58
Odds ratio (95% CI)	0.99 (0.85-1.16)	0.82 (0.64-1.03)	0.87 (0.67-1.11)	1.02 (0.78-1.31)	1.27 (0.96-1.64)
Surgical complications	487	182	152	123	104
Odds ratio (95% CI)	1.15 (1.04-1.27)	0.91 (0.78-1.06)	0.93 (0.79-1.1)	0.94 (0.78-1.12)	1.05 (0.86-1.28)
Hematoma	138	44	44	36	32
Odds ratio (95% CI)	1.15 (0.95-1.39)	0.78 (0.57-1.05)	0.96 (0.7-1.29)	0.98 (0.68-1.35)	1.15 (0.79-1.62)
Wound	78	44	37	34	38
Odds ratio (95% CI)	0.75 (0.59-0.95)	0.9 (0.65-1.21)	0.93 (0.66-1.28)	1.06 (0.74-1.48)	1.58 (1.12-2.17)
Surgical site infection	243	107	89	72	59
Odds ratio (95% CI)	0.94 (0.82-1.08)	0.88 (0.72-1.07)	0.9 (0.72-1.11)	0.9 (0.7-1.14)	0.98 (0.75-1.26)
CSF leak	93	11	12	[a]	[a]
Odds ratio (95% CI)	5.32 (3.96-7.15)	1.33 (0.71-2.5)	1.79 (0.98-3.28)	0.93 (0.38-2.28)	0.49 (0.12-1.99)

CSF, cerebrospinal fluid; DVT, deep vein thrombosis; ESI, epidural steroid injection; PE, pulmonary embolism; UTI, urinary tract infection.
[a]Values too small to report.

ESI within 90 days of surgery was significantly associated with a high risk of infection. Donally et al[30] also conducted a study with the PearlDiver database but found that preoperative ESI within 30 to 180 days of decompression increased the risk for postoperative infection. Studies investigating single- and multilevel fusion have somewhat more consistently demonstrated an increased risk for postoperative surgical site infection (SSI).[29,31-34]

Rates of SSI in the literature have ranged from 0.0% to 1.8%. Our event rate was 1.3%. In this study, SSI was defined by medical codes that account for those used by previous authors, including Yang et al and Singla et al.[29,35] Given that our sample size is larger than theirs and several years have passed since their studies, we are inclined to believe that the difference between their observed rates of SSI and ours reflects greater power and changing times. Furthermore, we also used a more robust propensity match accounting for comorbidities, demographics, and surgical procedures (levels performed) in contrast to their analyses.

Limitations

This study has certain limitations that warrant consideration. First, patients who used ESIs were more likely to have comorbid conditions, including COPD, Asthma, CHF, CAD, morbid obesity, depression, hypothyroidism, PVD, liver disease, and

alcoholism history. Notably, despite a robust matching process, we were unable to achieve comparisons between groups without significant baseline differences in comorbidity prevalence. In this case, these comorbid conditions likely led these patients to elect to have an ESI: possibly their pain tolerance was lower, their disease had progressed further, or they simply wished to be more comfortable before surgery. These differences might have affected our secondary outcome as well. We had numerous significant findings that are likely not clinically relevant. For example, rates of UTI were increased in the ESI group, no matter the timing of the ESI, whereas pneumonia, PE, and wound disruption were increased in those receiving ESI 1 to 30 days preoperatively. These findings are likely unrelated to ESI administration but suggest that the population receiving an ESI 1 to 30 days preoperatively is particularly comorbid. Future studies should focus on corroborating these findings and matching comorbidities that increase the risk of surgical site infection and CSF leak to diminish the likelihood of type 1 error. Second, we did not distinguish the patient indications for receiving an ESI or lumbar laminectomy beyond the exclusion of certain conditions, nor were we able to distinguish the particulars of the ESI technique (eg transforaminal vs interlaminar, use of fluoroscopy) or the type of steroid used. This is a known limitation of using a deidentified database although our analysis's large sample size and high power somewhat compensate for this constraint. Finally, the study's retrospective nature and nonuniform procedures introduced heterogeneity in each group that the variables included in our analysis might not have accounted for entirely. All clinical information from this database, diagnoses, and adverse events were identified using CPT, ICD-9, and ICD-10 codes and were thus subject to misclassification errors.

CONCLUSION

This study leveraged a large data set to examine the impacts of ESI on complications after spine surgery. The analysis found that preoperative ESI was associated with an increased risk of medical and surgical complications within 30 days postoperatively. Although this observation may be partly attributable to more medically complex patients opting for preoperative ESI, a notable increase in cerebrospinal fluid leaks was seen among patients receiving ESI 1 to 30 days preoperatively. However, regardless of timing, ESI was not associated with higher surgical site infection rates. Given the observed correlation between recent ESI and postoperative complications, avoiding ESI within 30 days before lumbar decompression may be advisable to minimize complication risk. Further study is warranted to establish causal relationships and refine clinical guidelines.

Funding

This study did not receive any funding or financial support.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

References

1. Lee MJ, Cassinelli EH, Riew KD. Prevalence of cervical spine stenosis. Anatomic study in cadavers. *J Bone Jt Surg Am Vol.* 2007;89(2):376-380.
2. Kalichman L, Cole R, Kim DH, et al. Spinal stenosis prevalence and association with symptoms: the Framingham study. *Spine J.* 2009;9(7):545-550.
3. Kalichman L, Kim DH, Li L, Guermazi A, Berkin V, Hunter DJ. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. *Spine.* 2009;34(2):199-205.
4. Cohen SP, Hurley RW. The ability of diagnostic spinal injections to predict surgical outcomes. *Anesth Analg.* 2007;105(6):1756.
5. Manchikanti L, Pampati V, Falco FJE, Hirsch JA. Assessment of the growth of epidural injections in the medicare population from 2000 to 2011. *Pain Physician.* 2013;16(4):e349-e364.
6. MacVicar J, King W, Landers MH, Bogduk N. The effectiveness of lumbar transforaminal injection of steroids: a comprehensive review with systematic analysis of the published data. *Pain Med.* 2013;14(1):14-28.
7. Carette S, Leclaire R, Marcoux S, et al. Epidural corticosteroid injections for sciatica due to herniated nucleus pulposus. *N Engl J Med.* 1997;336(23):1634-1640.
8. Chou R, Hashimoto R, Friedly J, et al. Epidural corticosteroid injections for radiculopathy and spinal stenosis: a systematic review and meta-analysis. *Ann Intern Med.* 2015;163(5):373-381.
9. Manchikanti L, Knezevic NN, Boswell MV, Kaye AD, Hirsch JA. Epidural injections for lumbar radiculopathy and spinal stenosis: a comparative systematic review and meta-analysis. *Pain Physician.* 2016;19(3):e365-e410.
10. Ridge B. *Diagnosis & Treatment of Low Back Pain*. North American Spine Society; 2020.
11. Epstein NE. The risks of epidural and transforaminal steroid injections in the Spine: commentary and a comprehensive review of the literature. *Surg Neurol Int.* 2013;4(suppl 2):S74-S93.
12. Pountos I, Panteli M, Walters G, Bush D, Giannoudis PV. Safety of epidural corticosteroid injections. *Drugs RD.* 2016;16(1):19-34.
13. U.S. Food and Drug Administration (FDA). FDA Drug Safety Communication: FDA requires label changes to warn of rare but serious neurologic problems after epidural corticosteroid injections for pain. FDA; 2019. Accessed April 14, 2023. https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-fda-requires-label-changes-warn-rare-serious-neurologic-problems-after.
14. Kazberouk A, Martin BI, Stevens JP, McGuire KJ. Validation of an administrative coding algorithm for classifying surgical indication and operative features of spine surgery. *Spine.* 2015;40(2):114-120.
15. Gray DT, Deyo RA, Kreuter W, et al. Population-based trends in volumes and rates of ambulatory lumbar spine surgery. *Spine.* 2006;31(17):1957-1964.
16. Omoto D, Bederman SS, Yee AJ, Kreder HJ, Finkelstein JA. How do validated measures of functional outcome compare with commonly used outcomes in administrative database research for lumbar spinal surgery? *Eur Spine J.* 2010;19(8):1369-1377.
17. Botwin KP, Castellanos R, Rao S, et al. Complications of fluoroscopically guided interlaminar cervical epidural injections. *Arch Phys Med Rehabil.* 2003;84(5):627-633.
18. Smorgick Y, Baker KC, Herkowitz H, et al. Predisposing factors for dural tear in patients undergoing lumbar spine surgery. *J Neurosurg Spine.* 2015;22(5):483-486.
19. Bosacco SJ, Gardner MJ, Guille JT. Evaluation and treatment of dural tears in lumbar spine surgery: a review. *Clin Orthopaedics Relat Res.* 2001;389:238-247.
20. Shakya A, Sharma A, Singh V, et al. Preoperative lumbar epidural steroid injection increases the risk of a dural tear during minimally invasive lumbar discectomy. *Int J Spine Surg.* 2022;16(3):505-511.
21. Wicke C, Halliday B, Allen D, et al. Effects of steroids and retinoids on wound healing. *Arch Surg.* 2000;135(11):1265-1270.
22. Anderson K, Hamm RL. Factors that impair wound healing. *J Am Coll Clin Wound Spec.* 2012;4(4):84-91.
23. Slucky AV, Sacks MS, Pallares VS, Malinin TI, Eismont FJ. Effects of epidural steroids on lumbar dura material properties. *J spinal Disord.* 1999;12(4):331-340.
24. Murphy ME, Kerezoudis P, Alvi MA, et al. Risk factors for dural tears: a study of elective spine surgery. *Neurol Res.* 2017;39(2):97-106.

25. Burks CA, Werner BC, Yang S, Shimer AL. Obesity is associated with an increased rate of incidental Durotomy in lumbar spine surgery. *Spine.* 2015;40(7):500-504.
26. Patel HA, Cheppalli NS, Bhandarkar AW, Patel V, Singla A. Lumbar spinal steroid injections and infection risk after spinal surgery: a systematic review and meta-analysis. *Asian Spine J.* 2022;16(6):947-957.
27. Seavey JG, Balazs GC, Steelman T, Helgeson M, Gwinn DE, Wagner SC. The effect of preoperative lumbar epidural corticosteroid injection on postoperative infection rate in patients undergoing single-level lumbar decompression. *Spine J.* 2017;17(9):1209-1214.
28. Kreitz TM, Mangan J, Schroeder GD, et al. Do preoperative epidural steroid injections increase the risk of infection after lumbar spine surgery? *Spine.* 2021;46(3):e197-e202.
29. Yang S, Werner BC, Cancienne JM, et al. Preoperative epidural injections are associated with increased risk of infection after single-level lumbar decompression. *Spine J.* 2016;16(2):191-196.
30. Donnally CJ, Rush AJ, Rivera S, et al. An epidural steroid injection in the 6 months preceding a lumbar decompression without fusion predisposes patients to postoperative infections. *J Spine Surg.* 2018;4(3):529-533.
31. Hartveldt S, Janssen SJ, Wood KB, et al. Is there an association of epidural corticosteroid injection with postoperative surgical site infection after surgery for lumbar degenerative spine disease? *Spine.* 2016;41(19):1542-1547.
32. Koltsov JCB, Smuck MW, Alamin TF, Wood KB, Cheng I, Hu SS. Preoperative epidural steroid injections are not associated with increased rates of infection and dural tear in lumbar spine surgery. *Eur Spine J.* 2021;30(4):870-877.
33. Pisano AJ, Seavey JG, Steelman TJ, Fredericks DR, Helgeson MD, Wagner SC. The effect of lumbar corticosteroid injections on postoperative infection in lumbar arthrodesis surgery. *J Clin Neurosci.* 2020;71:66-69.
34. Li P, Hou X, Gao L, Zheng X. Infection risk of lumbar epidural injection in the operating theatre prior to lumbar fusion surgery. *J Pain Res.* 2020;13:2181-2186.
35. Singla A, Yang S, Werner BC, et al. The impact of preoperative epidural injections on postoperative infection in lumbar fusion surgery. *J Neurosurg Spine.* 2017;26(5):645-649.

Acknowledgments

Author Contributions: Syed Khalid: Conceptualization, Methodology, Formal analysis, Writing – review & editing, Visualization. Pranav Mirpuri: Methodology, Writing – review & editing, Visualization. Elie Massaad: Writing – review & editing. Kyle Thomson: Methodology, Writing – review & editing. Ali Kiapour: Writing – review & editing. John H. Shin: Writing – review & editing. Owoicho Adogwa: Conceptualization, Supervision.

Supplemental digital content *is available for this article at neurosurgery-online.com.*

Supplemental Digital Content 1. Demographics and outcomes of the unmatched population.

COMMENTS

I have read the manuscript titled "The Impact of Preoperative Spinal Injection Timing on Postoperative Complications of Lumbar Decompression Surgery." Authors' objective was to determine the impact of ESIs on postoperative rates of medical and surgical complications and to define the appropriate interval before lumbar decompression surgery. This is an interesting area. Study is retrospective in nature. They concluded that preoperative ESI increases the risk of CSF leak after lumbar decompression if ESI is given between 1 and 30 days before surgery, but infection rate wasn't noticed to increase. They did a propensity matched analysis and concluded that the ESI will lead to more risk of CSF leak if done within 30 days of the surgery. Analysis looks fine, manuscript easy to read. Questions: why did they limit the surgeries to laminectomies only? Did the authors check if the cases who had CSF leak had calcified ligament that was adherent to the dura? Any bony spurs that were going through the dura? Sometimes if we try to remove them, we will have definite CSF leak regardless of spinal injection or not. Just wanted to know if the authors accounted for those factors before drawing the conclusions. Another question is who did the surgery? Usually, a decompression is performed by more junior residents due to the simplicity of the procedure: was this also accounted for? We do a lot of decompression and fusion, and we don't get much CSF leak after the ESI procedures.

Elias Elias
Dallas, Texas, USA