Clinical Study

Patient-reported allergies predict postoperative outcomes and psychosomatic markers after spine surgery

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Abstract

BACKGROUND CONTEXT: Prior studies have shown that patient-reported allergies can be prognostic of poorer postoperative outcomes.

PURPOSE: The objective of this study was to investigate the correlation between self-reported allergies and outcomes after cervical or lumbar spine surgery.

STUDY DESIGN/SETTING: This is a retrospective cohort study at a single tertiary care institution.

PATIENT SAMPLE: The patient sample included all patients undergoing cervical or lumbar spine surgery from 2009 to 2014.

OUTCOME MEASURES: The primary outcome measure was change in the EuroQol-5 Dimensions (EQ-5D) after surgery. Secondary outcomes included changes in the Pain Disability Questionnaire (PDQ) and in the Patient Health Questionnaire-9 (PHQ-9), achievement of the minimal clinically important difference (MCID) in these measures, and cost of admission.

METHODS: Before and after surgery, EQ-5D, PDQ, and PHQ-9 were recorded for patients with available data. Paired Student t tests were used to compare changes in these measures after surgery. Multivariable linear and logistic regressions were used to assess the relationship between the log transformation of the total number of allergies and outcomes.

RESULTS: A total of 592 cervical patients and 4,465 lumbar patients were included. The median number of reported allergies was two. The EQ-5D index increased from 0.539 to 0.703 for cervical patients and from 0.530 to 0.676 for lumbar patients (p<.01 for both). Patients experienced significant pain improvement by the PDQ (80.1–58.2 for cervical patients and 79.4–58.1 for lumbar patients, p<.01). Using multivariable logistic regression, the log transformation of the number of allergies predicted significantly higher odds of achieving the PDQ MCID (odds ratio [OR]=2.09, 95% confidence interval [CI] 1.05–4.15, p=.02, for cervical patients; OR=1.30, 95% CI 1.03–1.68, p=.03, for lumbar patients). However, this relationship was not durable for patients with follow-up exceeding 1 year. The log transformation of the number of allergies for lumbar patients predicted a significantly increased cost of admission (β=$3,597, p<.01) and trended toward significance among cervical patients (β=$1,842, p=.10).

CONCLUSIONS: Patient-reported allergies correlate with subjective improvement in pain and disability after spine surgery and may serve as a marker of postoperative outcomes. The relationship between allergies and PDQ improvement may be secondary to the short-term expectation-actuality discrepancy, as this relationship was not durable beyond 1 year. © 2018 Elsevier Inc. All rights reserved.

Introduction

Collecting an accurate list of allergies from the medical history is critical for patient care. Importantly, it is unclear whether patient-reported allergies represent true allergic reactions, adverse effects, or other factors. For example, the most common patient-reported drug allergy is penicillin allergy. However, in one hospital cohort, only a minority of patients who have reported or have had a documented penicillin allergy in the medical record have been proven to be positive for penicillin via allergy testing or drug challenge [1]. Even if patient-reported allergies have not been verified through testing, they can still influence patient care. For example, patients who report penicillin allergies have increased broad-spectrum antibiotic use, greater antibiotic costs, and more frequent drug-resistant infections compared with those without the allergy as less optimal antimicrobial therapies may be used in treatment because of this reported allergy. These patients also experience longer hospital stays, more complicated hospital courses, increased likelihood of an intensive care unit admission, and increased risk of mortality during the hospitalization [1–3].

In addition, patient-reported allergies are also correlated with significant underlying psychosomatic burden. In a Canadian cohort, patient-reported allergies correlated with Axis I psychological disorders, including major depression, bipolar and panic disorders, and social phobia [4]. Other studies have shown a correlation between drug hypersensitivity reactions and anxiety [5], as well as between allergies and suicide mortality. The association between allergies and non-fatal suicidal behaviors is still unclear [6]. Finally, a cohort study of patients suffering from drug intolerance or insect venom allergies has shown that patients reporting these reactions have scored significantly higher on questionnaires measuring somatization and have worse health-related quality of life (QOL), frequently reporting higher levels of anxiety relative to the normal population [7].

In the present study, we investigated whether or not patients who self-report more allergies before undergoing cervical or lumbar spine surgery have worse outcomes after surgery. We hypothesized that patient-reported allergies are associated with poorer postoperative outcomes and higher admission costs and thus may serve as a prognostic factor for outcomes after spinal surgery.

Methods

Data collection

Institutional review board approval was obtained before study initiation. No patient consent was required, given the retrospective nature of the present study. A retrospective cohort study of all patients undergoing cervical or lumbar spine surgery at a tertiary care center between January 2009 and December 2014 was performed. Queried data were collected from institutional audited data warehouses and included demographics, comorbidities, insurance status, length of hospital stay, and operative data. Data on patient-reported allergies were collected from institutional audited data warehouses and included all allergies recorded in the medical chart, including allergies without confirmatory testing (eg, skin or patch testing). Patient comorbidities were used to derive the Charlson Comorbidity Index (CCI) using established International Classification of Diseases, Ninth Revision (ICD-9) coding algorithms [8]. Quality of life data were collected both preoperatively and through the last follow-up. To represent costs of admission corresponding with spine surgery, we collected charge data from the institution's financial database. Charges reflect patient-level resource use and include all components of care, including imaging, laboratory diagnostics, and therapies. To represent costs from the payer's perspective, billed charges were normalized to Medicare reimbursement rates based on institutional cost-to-charge ratios [9,10] and were presented in 2016 US dollars.

Quality of life measures

Quality of life data were prospectively collected in an institutional database of patient-reported health status measures, including validated questionnaires administered at each outpatient visit. These questionnaires include the EuroQol-5 Dimensions (EQ-5D) [11–13], the Pain Disability Questionnaire (PDQ) [14,15], and the Patient Health Questionnaire-9 (PHQ-9) [16–18]. The EQ-5D contains five dimensions of a patient's health state: mobility, self-care, completion of usual activities, pain or discomfort, and anxiety or depression, with each dimension scored on a scale from 1 to 3. An EQ-5D index is subsequently derived from the five subscores and represents the patient's overall health state ranging from 0 (death) to 1 (perfect health). The minimal clinically important

difference (MCID) for the EQ-5D index after spine surgery has been reported to be 0.1 [19,20]. The PDQ is used to evaluate chronic disabling musculoskeletal and spinal disorders, focusing on disability and patients' abilities to perform activities of daily living. It records functional and psychosocial components of pain for a total score between 0 and 150. The MCID for the PDQ has been reported to be 20 [21]. The PHQ-9 assesses for depression based on nine criteria for major depressive disorder established in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-V) [22]. Each of the nine questions is scored from 0 to 3 for a total score ranging from 0 to 27. The MCID for the PHQ-9 has been reported to be 5 [23].

Statistical analysis

All statistical analyses were performed using R statistical software version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria) [24]. Quantitative statistics are presented as means with standard deviations or medians with interquartile ranges, whereas qualitative statistics are represented as counts with percentages. Continuous variables were compared using Student t tests. Multivariable linear regression was used to model postoperative change in QOL questionnaires, cost of admission, and length of hospital stay, whereas multivariable logistic regression was used to model changes in QOL measures greater than the MCID. For each of these models, pertinent covariates were included to adjust for confounding and to minimize bias. Only covariates demonstrating association ($p<.20$ via simple regression) with outcome variables of interest were evaluated in multivariable models. Backward stepwise regression was used to arrive at the final model, with $p<.10$ as the stopping criterion. Additional separate multivariable regressions were performed with the number of allergies included as a continuous variable using restricted cubic splines with five knots to represent a nonlinear relationship between the number of allergies and modeled outcomes [25]. Regression coefficients (β) and odds ratios were reported for linear and logistic models, respectively. All values of $p<.05$ were considered statistically significant.

Results

Five hundred ninety-two cervical spine patients and 4,465 lumbar spine patients were included in the present study (Table 1). Patients had an average age of 56.2 and 60.8 years for cervical and lumbar procedures, respectively. The patient demographics were slightly predisposed toward men in both cervical (43% women) and lumbar (48% women) patient groups. However, when subset by the presence of allergies, women less often had no allergies among cervical (26%) and lumbar (29%) patients (Supplementary Tables S1 and S2). The most common spine conditions in cervical spine patients were degenerative disc disease (31%), spondylosis (29%), stenosis (24%), disc herniation (16%), and spondylolisthesis (15%), whereas the most common lumbar spine

conditions were stenosis (60%), degenerative disc disease (60%), spondylosis (53%), disc herniation (20%), and spondylolisthesis (33%). Patients with at least one allergy consistently were diagnosed with multiple spine pathologies (Supplementary Tables S1 and S2); cervical patients with at least one allergy more often were diagnosed with degenerative disc disease (35% vs. 23%) and spondylosis (32% vs.

Table 1
Patient characteristics

Characteristics	Cervical	Lumbar
N	592	4,465
Age at surgery (y)	56.2±12.1	60.8±14.5
Women, n (%)	252 (43)	2,123 (48)
Race, n (%)		
White	520 (88)	4,011 (90)
Black	55 (9)	281 (6)
Other	17 (3)	173 (4)
Marital status, n (%)		
Single	106 (18)	694 (16)
Married	403 (68)	3,063 (69)
Separated	50 (8)	388 (9)
Widowed	26 (4)	300 (7)
Unknown	7 (1)	20 (1)
BMI	28.9±5.9	29.6±6.1
CCI	0 (0–1)	0 (0–1)
Spine conditions, n (%)		
Degenerative disc disease	184 (31)	2,671 (60)
Spondylosis	171 (29)	2,362 (53)
Stenosis	142 (24)	2,690 (60)
Disc herniation	92 (16)	1,806 (40)
Spondylolisthesis	86 (15)	1,461 (33)
Scoliosis	55 (9)	906 (20)
Kyphosis	28 (5)	304 (7)
Lordosis	4 (1)	42 (1)
Length of stay (d)	1 (1–2)	3 (1–4)
Cost of hospital admission	15,105±10,239	19,123±15,466
Presence of allergy, n (%)		
Animals	12 (2)	84 (2)
Food	49 (8)	367 (8)
Insects	16 (3)	111 (2)
Medication	351 (59)	2,846 (64)
Environmental	46 (8)	395 (9)
Skin	54 (9)	524 (11)
Other	6 (1)	64 (1)
Any	398 (67)	3,181 (71)
Number of allergies		
Animals	0 (0–0)	0 (0–0)
Food	0 (0–0)	0 (0–0)
Insects	0 (0–0)	0 (0–0)
Medication	1 (0–3)	1 (0–3)
Environmental	0 (0–0)	0 (0–0)
Skin	0 (0–0)	0 (0–0)
Other	0 (0–0)	0 (0–0)
Total	2 (0–4)	2 (0–4)
Follow-up time (mo)	7.8 (4.3–14.5)	7.8 (4.3–14.7)
95% Range (mo)	(3.0–36.1)	(3.0–41.4)
90-d follow-up, n (%)	581 (98)	4359 (98)
180-d follow-up, n (%)	373 (63)	2850 (64)

N, number; BMI, body mass index; CCI, Charlson Comorbidity Index.

Continuous variables are reported as mean±standard deviation or median (interquartile range) unless otherwise specified; categorical variables are reported as count (percent).
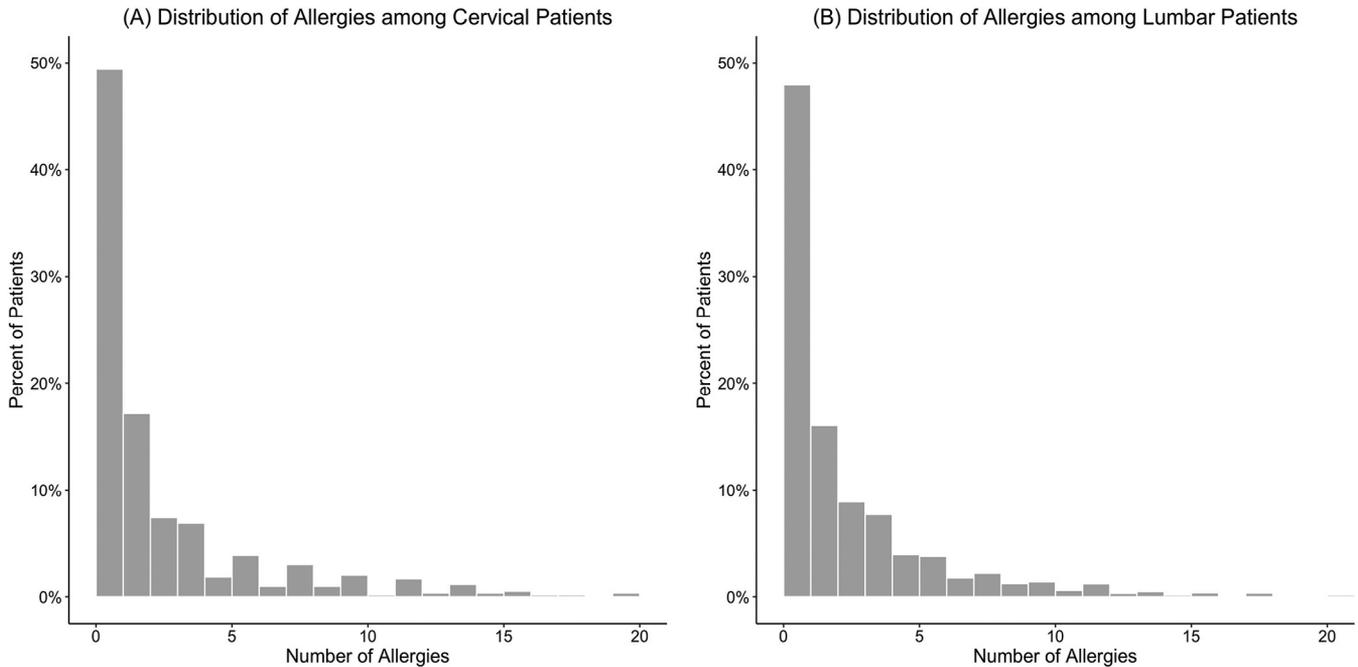
Fig. 1. Distribution of allergies. Among patients with reported allergies, the provided histograms illustrate the distribution of the number of allergies per patient among (Left) cervical and (Right) lumbar patients.

22%), as were lumbar patients who more often had degenerative disc disease (63% vs. 53%) and spondylosis (57% vs. 44%). The median length of stay was 1 day for cervical patients and 3 days for lumbar patients. The average cost of hospital admission was $15,105 for cervical patients and $19,123 for lumbar patients. For both groups of patients, the most common type of reported allergy was a medication allergy (median of one reported allergy), with a median number of two total reported allergies. Approximately two-thirds of both cervical and lumbar spine surgeries patients reported at least one allergy (cervical patients, 67%; lumbar patients, 71%). The distribution of the number of allergies for both cervical and lumbar patients is illustrated in Fig. 1. The median follow-up time was 7.8 months for both cervical and lumbar patients, with 98% of all patients meeting at least 90 days' follow-up and 63% of cervical patients and 64% of lumbar patients meeting at least 180 days' follow-up.

For unadjusted QOL outcomes, both cervical and lumbar patients improved in several factors as measured with the EQ-5D, the PDQ, and the PHQ-9 (Table 2). Both patient groups showed significant postoperative improvement in all five dimensions of their health status in the EQ-5D after surgery, with the EQ-5D index increasing from 0.539 to 0.703 for cervical patients and from 0.530 to 0.676 for lumbar patients (p<.01 for both). Additionally, both patient groups showed a significant decrease in their pain symptoms as measured by the PDQ. The conditions of the cervical spine surgery patients improved from an average score of 80.1 to 58.2 after surgery (p<.01), whereas the condition of the lumbar spine surgery patients improved from 79.4 to 58.1 after surgery (p<.01). Depressive symptoms as measured by PHQ-9 scores

also significantly decreased in both cervical (eight to four) and lumbar (seven to four) patients (p<.01 for both).

For both cervical and lumbar patients, multivariable linear regression was used to adjust for covariates associated with modeled outcomes. Preoperative PDQ and follow-up time were included in our models for change in PDQ burden, whereas age and CCI were included in our models predicting admission cost and length of stay. We first performed these models using restricted cubic splines to represent the number of allergies as a continuous variable with a non-linear relationship with modeled outcomes (Fig. 2). Despite the general trend toward increased allergies predicting a larger improvement in PDQ, this trend was not significant for cervical or lumbar patients (Fig. 2A and E). However, when modeling achievement of PDQ MCID with multivariable logistic regression, the number of allergies became a significant predictor of increased odds of PDQ MCID for cervical spine patients with greater than seven allergies and for lumbar patients with greater than six allergies (Fig. 2B and F). A larger number of allergies were found to be associated with increased cost of admission, although this was only found to be consistently significant for lumbar patients (Fig. 2C and G). Similarly, a larger number of allergies predicted a longer length of stay, but this was only consistently significant for lumbar patients (Fig. 2D and H). Despite the observed relationship between the number of allergies and outcomes reported earlier, no significant relationship was observed between the total number of allergies and changes in postoperative EQ-5D or PHQ-9.

Based on the shapes of the curves obtained using restricted cubic splines, we chose to also model these outcomes

Table 2
Unadjusted quality of life outcomes

Characteristic	Cervical				Lumbar		
	Preop	Postop	p-Value*		Preop	Postop	p-Value*
EQ-5D (n=562)				N=4,161			
Mobility	2 (2–2)	2 (1–2)	<.01[†]		2 (2–2)	2 (1–2)	<.01[†]
Self-care	1 (1–2)	1 (1–2)	<.01[†]		1 (1–2)	1 (1–2)	<.01[†]
Usual activities	2 (2–2)	2 (1–2)	<.01[†]		2 (2–2)	2 (1–2)	<.01[†]
Pain or discomfort	2 (2–3)	2 (2–2)	<.01[†]		2 (2–3)	2 (2–2)	<.01[†]
Anxiety or depression	2 (1–2)	1 (1–2)	<.01[†]		2 (1–2)	1 (1–2)	<.01[†]
Index	0.539±0.220	0.703±0.202	<.01[†]		0.530±0.222	0.676±0.218	<.01[†]
MCID		298 (53%)				2,090 (50%)	
PDQ (n=268)				N=1,782			
Function	51.7±18.7	38.1±24.1	<.01[†]		51.1±19.6	37.8±23.4	<.01[†]
Psychosocial	28.5±13.0	20.0±14.8	<.01[†]		28.4±13.5	20.3±15.5	<.01[†]
Total	80.1±30.0	58.2±37.0	<.01[†]		79.4±31.1	58.1±37.2	<.01[†]
MCID		123 (50%)				889 (50%)	
PHQ-9 (n=217)				N=1,854			
Total	8 (4–14)	4 (2–9)	<.01[†]		7 (3–12)	4 (1–9)	<.01[†]
MCID		80 (37%)				602 (32%)	

EQ-5D, EuroQol 5-Dimensions; N, number; MCID, minimal clinically important difference; PDQ, Pain Disability Questionnaire; PHQ-9, Patient Health Questionnaire-9; preop, preoperative; postop, postoperative.

Continuous variables are reported as mean±standard deviation or median (interquartile range); categorical variables are reported as count (percent).

* Paired *t* tests and Wilcoxon signed-rank tests were used to compare preop measurements with postop measurements for parametric and non-parametric continuous variables, respectively.

[†] Statistically significant: p<.05.

using the log transformation of the total number of allergies (Tables 3 and 4). To adjust for the "ceiling effect," higher preoperative PDQ was significantly associated with postoperative decreases in both patient groups (cervical β=−0.34, p<.01; lumbar β=−0.36, p<.01). Longer follow-up time was also associated with worse postoperative improvement in both patient groups (cervical β=0.50, p=.02; lumbar β=0.28, p<.01). Similar to our findings using restricted cubic splines, the log trans-

formation of the total number of allergies in both patient groups trended toward predicting greater postoperative improvement in PDQ, but this was not significant (cervical β=−6.36, p=.21; lumbar β=−3.32, p=.11). Furthermore, again after adjusting for numerous covariates, higher total costs during the hospital admission were significantly associated with the log transformation of the total number of allergies for lumbar patients (β=$3,597, p<.01) and trended toward statistical

Table 3
Admission cost and quality of life improvement multivariable regression models

Location	Outcome*	Covariate	β Coefficient	p-Value
Cervical	ΔPDQ	Preoperative PDQ	−0.34	<.01[†]
		Follow-up (mo)	0.50	.02[†]
		Log (total number of allergies)	−6.36	.21
	Admission cost ($)	Age	93	<.01[†]
		CCI	855	.02[†]
		Log (total number of allergies)	1,842	.10
	Length of stay (d)	Age	0.04	<.01[†]
		CCI	0.13	.05[†]
		Log (total number of allergies)	0.36	.08
Lumbar	ΔPDQ	Preoperative PDQ	−0.36	<.01[†]
		Follow-up (mo)	0.28	<.01[†]
		Log (total number of allergies)	−3.32	11
	Admission cost ($)	Age	101	<.01[†]
		CCI	786	<.01[†]
		Log (total number of allergies)	3,597	<.01[†]
	Length of stay (d)	Age	0.04	<.01[†]
		CCI	0.25	<.01[†]
		Log (total number of allergies)	1.01	<.01[†]

PDQ, Pain Disability Questionnaire; BMI, body mass index; CCI, Charlson Comorbidity Index.

* Decrease in PDQ represents improvement.

[†] Statistically significant: p<.05.
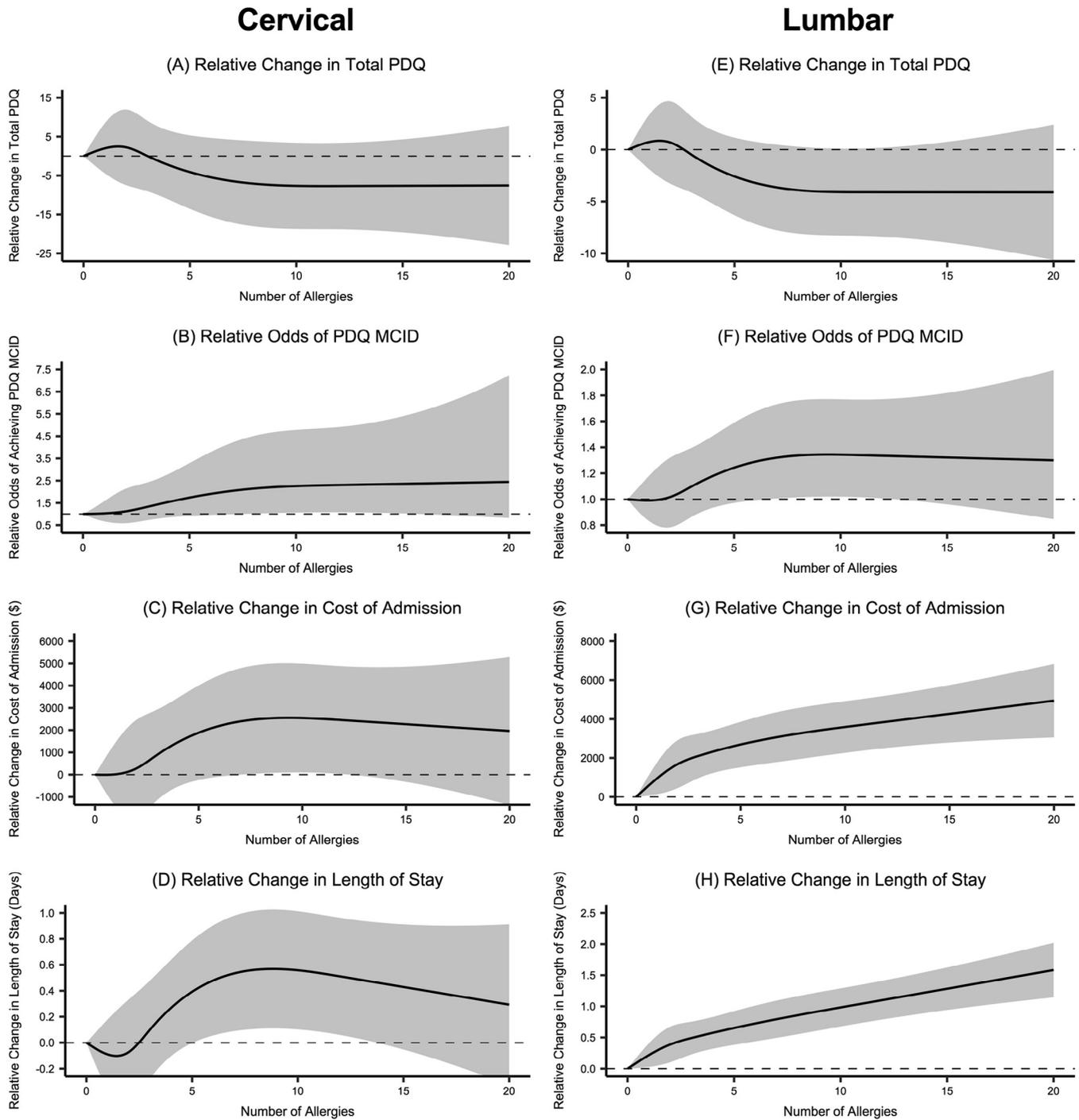
Cervical

Lumbar

Fig. 2. Non-linear relationships between the number of allergies and patient outcomes. Restricted cubic splines were used to represent the number of allergies as a continuous variable with a non-linear relationship with modeled outcomes in both cervical and lumbar patients. (A, E) Increased allergies trended toward predicting larger improvement in PDQ for cervical and lumbar patients. (B, F) Greater than seven allergies predicted increased odds of PDQ MCID for cervical patients, whereas greater than six allergies predicted increased odds for PDQ MCID. (C, G) More allergies predicted increased cost of admission, consistently found to be significant among lumbar patients. (D, H) More allergies also predicted a longer length of stay, consistently significant among lumbar patients. PDQ, Pain Disability Questionnaire; MCID, minimal clinically important difference.

significance among cervical patients (β=$1,842, p=.10). Similar findings were observed when modeling length of stay, as the log transformation of the total number of allergies significantly predicted longer length of stay for lumbar patients

(β=1.01, p<.01) and trended toward significance among cervical patients (β=0.36, p=.08).

Notably, the log transformation of the total number of allergies was found to be correlated with an improvement in

Table 4
PDQ minimal clinically important difference multivariable regression models

Location	Subgroup	Covariate	OR (95% CI)	p-Value
Cervical	All patients (N=268)	Preoperative PDQ	1.01 (1.00–1.02)	<.01*
		Follow-up (mo)	0.98 (0.94–1.01)	.13
		Log (total number of allergies)	2.09 (1.05–4.15)	.02*
	<1-y follow-up (n=167)	Preoperative PDQ	1.01 (1.00–1.03)	<.01*
		Follow-up (m)	1.08 (0.94–1.23)	.27
		Log (total number of allergies)	2.38 (1.02–5.58)	.04*
	>1-y follow-up (n=101)	Preoperative PDQ	1.01 (1.00–1.03)	.14
		Follow-up (mo)	0.97 (0.92–1.02)	.29
		Log (total number of allergies)	1.70 (0.51–5.65)	.38
Lumbar	All patients (N=1,782)	Preoperative PDQ	1.01 (1.01–1.02)	<.01*
		Follow-up (mo)	0.98 (0.97–0.99)	<.01*
		Log (total number of allergies)	1.30 (1.03–1.68)	.03*
	<1-y follow-up (n=1,109)	Preoperative PDQ	1.01 (1.01–1.02)	<.01*
		Follow-up (mo)	1.03 (0.98–1.09)	.20
		Log (total number of allergies)	1.57 (1.02–1.92)	.04*
	>1-y follow-up (n=673)	Preoperative PDQ	1.02 (1.01–1.02)	<.01*
		Follow-up (mo)	0.97 (0.95–0.98)	<.01*
		Log (total number of allergies)	1.20 (0.78–1.83)	.41

OR, odds ratio; CI, confidence interval; PDQ, Pain Disability Questionnaire; MCID, minimal clinically important difference.
* Statistically significant: $p<.05$.

the postoperative PDQ score above the MCID (Table 4). For cervical patients, again after adjusting for the ceiling effect with preoperative PDQ and follow-up time, the log transformation of the total number of allergies predicted significantly higher odds of an improvement in PDQ greater than the MCID (odds ratio [OR]=2.09, 95% confidence interval [CI] 1.05–4.15, p=.02). After identical adjustments in lumbar patients, log transformation of the total number of allergies was again significantly predictive of higher odds of improvement in PDQ greater than the MCID (OR=1.30, 95% CI 1.03–1.68, p=.03). However, when repeat analyses were performed among patient subsets by follow-up time (less than or greater than 1 year), log transformation of the total number of allergies was inconsistently associated with achieving the PDQ MCID. For both cervical (OR=2.38, 95% CI 1.02–5.58, p=.04) and lumbar (OR=1.57, 95% CI 1.02–1.92, p=.04) patients with less than 1 year of follow-up, log transformation of the total number of allergies predicted achievement of the PDQ MCID. In contrast, both cervical (OR=1.70, 95% CI 0.51–5.65, p=.38) and lumbar (OR=1.20, 95% CI 0.78–1.83, p=.41) patients with more than 1 year of follow-up did not demonstrate this relationship.

Discussion

In the present study of over 5,000 patients undergoing cervical and lumbar spine surgeries, we identified numerous patients with extensive self-reported allergies. In this cohort, the number of patient-reported allergies was associated with superior postoperative improvements in pain-related QOL as measured by the PDQ. Additionally, the total number of allergies significantly correlated with higher admission costs and longer lengths of stay.

Previous studies have identified potential relationships between patient-reported allergies and outcomes after surgery. Within spine surgery, one previous study reported an association between patient-reported allergies and poorer postoperative pain and disability after surgery for degenerative lumbar spine diseases [26]. Within Kay et al.'s [26] study, the increasing numbers of patient-reported medication allergies demonstrated worse outcomes by the Oswestry Disability Index, the Short Form-12 Physical Composite Score, and the visual analog scale for back and leg pain. The increased number of self-reported allergies was also significantly correlated with depression and anxiety in this cohort as measured by the Zung Depression Scale and the Modified Somatic Perception Questionnaire. Previous studies have shown that patient-reported allergies correlate with poorer functional outcomes in both hip and knee arthroplasties. Patients with self-reported allergies who have undergone total knee arthroplasty reported inferior postoperative outcomes in knee function as measured by the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index and the Knee Society Score (KSS) scores compared with patients who did not report any allergies, although this effect was not associated with depression [27]. Patients with multiple (>3) reported allergies in the medical record experienced poorer patient-reported functional outcomes in both knee and hip arthroplasties as measured by the physical component of the 36-Item Short Form Health Survey (SF-36) and the functional WOMAC scores, as well as increased lengths of hospital admissions [28,29].

In addition to affecting hospital admission and postoperative outcomes in surgical patients, self-reported allergies have also been associated with various psychiatric comorbidities. Patient-reported allergies correlate with a significant burden

of various psychosomatic processes across studies, including major depression, bipolar and panic disorders, social phobia, anxiety, suicide mortality, and somatization [4–7]. Patient-reported allergies are also correlated with other clinical considerations and conditions, such as psychogenic non-epileptic seizures [30–32] and drug intolerance [7], which may be reflective of higher levels of somatization in these patients.

Regarding somatization, the DSM-V currently includes somatoform disorders under the category of somatic symptom and related disorders and aims to redefine somatic disorders as typically having multiple somatic complaints that significantly impact QOL (eg, pain, fatigue, and lethargy) rather than the absence of an organic medical cause of the symptoms. The prevalence of somatoform disorders is significant at nearly 10%, similar to that of other well-known psychiatric disorders, such as depression and anxiety, which are often comorbid with somatoform disorders [33]. Given the association between somatoform disorders and medical conditions, it is possible that patient-reported allergies may be a proxy for somatization and somatoform disorders. With this increased burden of psychiatric conditions, there should also be a significant overlap between patient-reported allergy burden and somatic symptoms and related disorders. In fact, these patients may seek out care with greater expectations or desires for therapies to benefit their condition, although this may be a double-edged sword, as individuals with a tendency toward somatization are oftentimes more likely to develop the nocebo response and report more adverse effects from therapy, possibly because of hyperawareness of adverse effects [34,35].

Recent studies and meta-analyses have shown that patient expectations of spine surgery contribute significantly to surgical outcomes. Higher preoperative expectations are associated with improved postoperative outcomes. This finding may be related to a placebo-like effect. However, unrealistic patient expectations are associated with poorer postoperative outcomes in patients undergoing elective spine surgery [36,37]. This finding may be the phenomenon underlying patient response to surgical therapies, with the best outcomes achieved at a healthy balance of patient expectations.

In the present study, patients with higher levels of self-reported allergy burden may have greater levels of behavioral health comorbidities and therefore greater expectations of surgical management alleviating their disability and pain. Patients with more self-reported allergies showed greater improvements in perceived postoperative pain and disability burden as measured by the PDQ without corresponding improvement of the underlying psychiatric burden (PHQ-9) or other QOL measures (EQ-5D). However, this relationship between allergy burden and perceived pain improvement was predominantly observed in the brief follow-up window of less than 1 year after surgery, as patients with follow-up exceeding 1 year did not consistently demonstrate the same significant relationship. These patients may not be aware of their underlying psychiatric burden and may not see any significantly different biologic or mechanical difference in postoperative outcomes. Interestingly, the fact that patients with psychiat-

ric burden may not see any differences in biologic or mechanical outcomes seems to align with aspects of the expectation-actuality discrepancy. Thus, patients report a short-term subjective improvement in their pain and disability postoperatively, even if this improvement may not be reflected in other behavioral or QOL measures and ultimately may not remain durable over extended follow-up. As spine surgery is oftentimes performed on an elective basis for the goal of improving specific symptoms such as pain and overall QOL, spine surgery may be uniquely subject to patient expectations of pain and disability relief. Thus, patient-reported allergies may serve as a predictor of short-term subjective improvements in pain and disability postoperatively, although they may not be as useful for predicting outcomes in other QOL measures.

Of course, significant correlations with increased cost of care and longer lengths of stay also reflect the greater complexities of caring for patients who report allergies in general. As medication allergies were the most common self-reported allergies in the present study, and penicillin is the most commonly reported drug allergy, it is reasonable to think that some of the additional costs of admission may be due to more complicated hospital courses with challenging postoperative management and complications caused by these self-reported allergies, as has been previously reported in patients who self-report both confirmed and unconfirmed penicillin allergies [1–3]. Furthermore, although patients with allergies did not have any notable differences in overall medical comorbidities as measured by the CCI, nearly all of our recorded spine conditions and indications were more commonly diagnosed among our patients with listed allergies. Thus, it is possible that patients' histories of neck or back pain, along with multiple spine conditions, could alter both patient expectations and perceived treatment at a tertiary referral center.

Our study is limited by several factors. The chief limitation of the present study was that it was retrospective, and thus limited in its ability to directly assess patient somatization levels. Going forward, future prospective studies could directly interrogate the link between somatization, patient-reported allergies, and spine surgery outcomes through the use of validated screening instruments, such as the Screening for Somatoform Disorders (SOMS) or the Somatosensory Amplification Scale (SSAS) questionnaires, in addition to structured clinical interviews to determine patient somatization burden [38]. Allergies were assessed without differentiation between unconfirmed allergies and allergies confirmed by objective testing methods, and differences between perceived and confirmed allergies may affect patient perceptions of outcome. Indeed, patients with validated allergies may be affected by biologic processes, such as altered immune regulation or inflammatory states that might alter their responsiveness to surgical therapy as well as lead to different outcomes (ie, inadvertent allergen exposures leading to medical complications), compared with individuals who do not have validated allergies. In addition, patients with validated allergies may also suffer from increased levels of anxiety and depression

as a result of their allergies, perhaps because of various possible immunologic mechanisms, in addition to the psychological stress in avoiding allergens and the corresponding impact on QOL [39,40]. This may serve as a possible confounder in the present study and in future studies, and indeed, many prior studies on this subject have not differentiated between patients with and without validated allergies [40]. Further investigation and analysis of differences in patient outcomes comparing individuals with validated allergies with those without validated allergies would be highly informative in this aspect. Additional analyses of the root causes of increased admission costs and the role of managing complications (ie, prolonged intensive care unit stays and infection) incurred related to the patient's allergies in increased admission costs for spinal surgery may also be valuable in further exploring the impact of allergies on clinical outcomes and health-care systems. In addition, although we examined both lumbar and cervical spine surgery patients, ultimately it is unclear if cervical spine surgery patients have a significantly different profile compared with lumbar spine surgery patients, given the discrepancy. Furthermore, our sample size of patients with longer allergy lists was fairly limited, as most patients had fairly few reported allergies, which resulted in wider CIs at larger allergy numbers. Finally, given that this was a study conducted in a single health-care system, the results may not be generalizable to other systems, especially if patient expectations of surgery differ significantly.

Conclusions

In conclusion, patient-reported allergy burden is significantly correlated with reductions in postoperative pain burden, as well as increased costs of care during the hospital admission and longer lengths of stay, and thus may serve as a useful prognostic factor for these postsurgical outcomes. The relationship between patient-reported allergies and reduction in PDQ may be secondary to the effects of the expectation-actuality discrepancy, as this relationship was observed for patients with shorter follow-up but not durable beyond 1 year. No significant associations were found with changes in mental health or overall QOL.

Supplementary material

Supplementary material related to this article can be found at https://doi.org/10.1016/j.spinee.2018.05.032.

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