A commentary by Patricia Lipson, BS, and Philip K. Louie, MD, is linked to the online version of this article.

Effect of Preoperative Acupuncture and Epidural Steroid Injection on Early Postoperative Infection After Lumbar Spinal Fusion

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Background: Acupuncture and epidural steroid injection (ESI) are frequently performed in patients with degenerative lumbar disease. The purpose of this study was to explore preoperative acupuncture and ESI as risk factors for postoperative infection after elective lumbar fusion.

Methods: Patients >50 years of age who underwent spinal fusion due to degenerative lumbar disease from 2010 to 2019 were identified by diagnostic and procedural codes using a nationwide database. The incidence of spinal infection within 90 days after surgery was identified. Patients who underwent acupuncture and/or ESI within 90 days prior to spinal surgery were identified using procedural codes. The infection rate was analyzed by dividing patients into 4 groups as follows: patients who underwent neither acupuncture nor ESI (unexposed group), patients who underwent acupuncture only (acupuncture group), patients who underwent ESI only (ESI group), and patients who underwent both acupuncture and ESI (combined group). Cox regression analysis was performed to identify risk factors for postoperative spinal infection.

Results: A total of 207,806 patients were included in this study. The postoperative infection rate among all patients was 4.29%. The infection rates in the unexposed, acupuncture, ESI, and combined groups were 4.17% (4,342 of 104,106 patients), 3.90% (340 of 8,726 patients), 4.48% (3,761 of 83,882 patients), and 4.26% (473 of 11,092 patients), respectively. Increasing age, male sex, and ESI were demonstrated to be risk factors for postoperative spinal infection. ESI was no longer a risk factor when patients who received acupuncture or ESI within 2 weeks of spinal surgery were excluded. Preoperative acupuncture was not associated with postoperative spinal infection.

Conclusions: Acupuncture and ESI performed >2 weeks prior to spinal surgery did not increase the risk of postoperative infection.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

Although the efficacy of acupuncture is controversial, it is a widely used alternative treatment. Over 3 million people in the United States received acupuncture in 2007, and this number has continued to increase with time[1]. Back pain is experienced by >70% of people at least once in their lifetime[2,3]. Acupuncture is a frequently employed alternative medicine for treating lower back pain. It is known to alleviate pain by regulating endogenous neuropeptides by

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TABLE I International Classification of Diseases (ICD) Diagnosis Codes for Postoperative Spinal Infection

Diagnosis	ICD Diagnosis Code
Osteomyelitis of vertebra	M46.20-29
Infection of intervertebral disc (pyogenic)	M46.30-39
Other infective spondylopathies	M46.50-59
Disruption of operative wound	T81.3
Infection following a procedure	T81.4
Complications of internal orthopaedic prosthetic devices, implants, and grafts	T84.2-9
Infection and inflammatory reaction due to other internal prosthetic devices, implants, and grafts	T85.7

stimulating the trigger point of pain[4-7]. There have been reports on several complications of acupuncture, and a few of those complications have been fatal[8-11]. MacPherson et al. reported a complication rate of 0.13% among approximately 34,000 cases of acupuncture treatment, as assessed using a self-reported survey of practitioners[8]. Hematoma and infection are common complications[9,10,12], and there have been several reports of infection after acupuncture treatment for the lower back and radiating pain[13,14].

Epidural steroid injection (ESI) is a widely used non-operative treatment method for pain control in patients with degenerative spinal disorders[15-19]. Recently, several studies have reported that preoperative ESI is a risk factor for postoperative infection after spinal surgery[20-22]. However, few studies have investigated whether preoperative acupuncture increases the risk of postoperative infection after spinal surgery.

The National Health Insurance system of our country covers almost the entire national population[23] and also has covered alternative medicine such as acupuncture and herbal medicine since 1987[24]. Therefore, many patients receive acupuncture to treat back pain because the treatment is covered by the national insurance. Approximately 30% of all acupuncture treatments are performed for the treatment of back pain. The claims data provide the dates that acupuncture and ESIs were performed. Therefore, this study aimed to investigate preoperative acupuncture and ESI as risk factors for postoperative infection after lumbar fusion using nationwide claims data.

Materials and Methods

This study was approved by the institutional review board of the corresponding author's hospital. The requirement for informed consent was waived because the study involved the retrospective use of anonymized and publicly available data.

Data Selection and Definition of Postoperative Infection

The Health Insurance Review and Assessment (HIRA) service of our country is a public agency that evaluates the adequacy of insurance claims. The claims data include prescribed medications, procedures, diagnoses, demographic data, and comorbidities[23,25-27]. Data of insurance claims were collected from January 2010 to December 2019. Patients >50 years of age who underwent elective lumbar fusion surgery for degenerative diseases were included. Patients who received treatment for specific diseases,

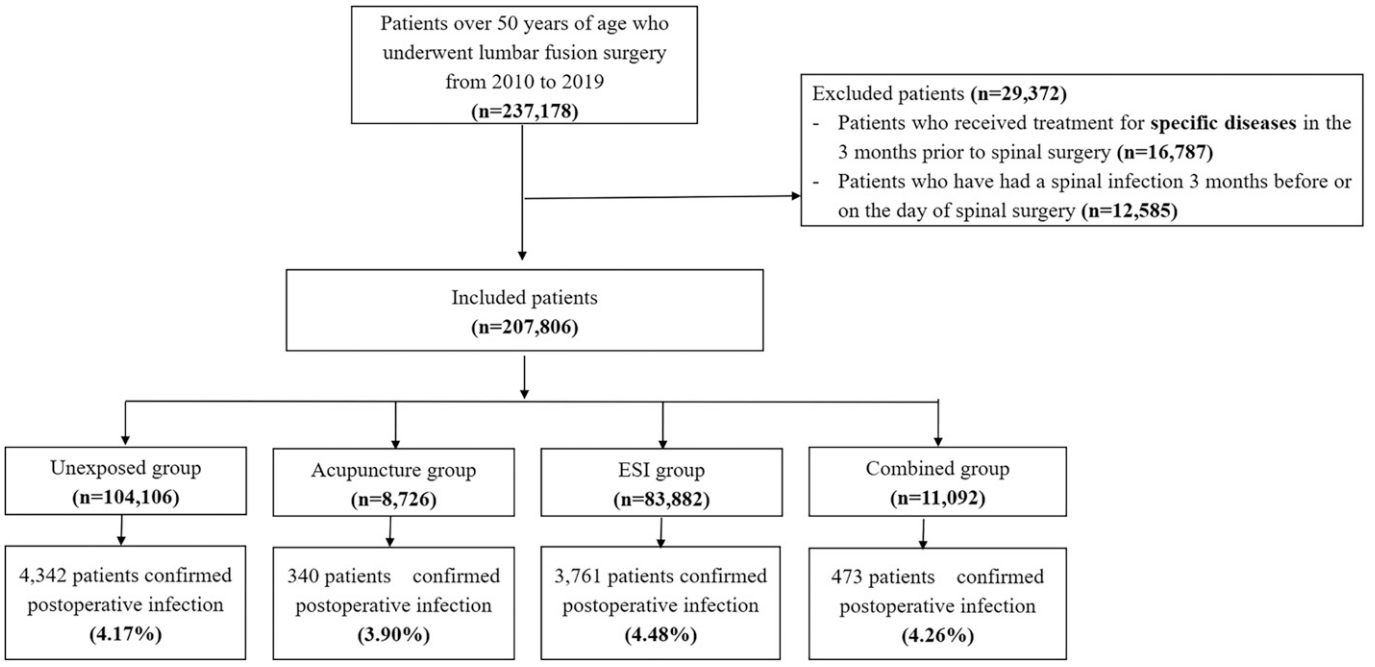

Fig. 1

Diagram of patient groups and corresponding infection rates from our analysis of nationwide claims data from the Health Insurance Review and Assessment (HIRA) service. ESI = epidural steroid injection.

TABLE II Patient Characteristics, Comorbidities, and Infection-Related Variables for Each Group*

	Total (N = 207,806)	Unexposed (N = 104,106)	Acupuncture (N = 8,726)	ESI (N = 83,882)	Combined (N = 11,092)	P Value
Age at surgery† *(yr)*	65.52 ± 8.09	64.79 ± 8.13	67.01 ± 7.83	65.96 ± 8.01	67.89 ± 7.63	**<0.0001**
<65 yr	93,719 (45.10)	51,062 (49.05)	2,994 (34.31)	36,271 (43.24)	3,392 (30.58)	**<0.0001**
≥65 yr	114,087 (54.90)	53,044 (50.95)	5,732 (65.69)	47,611 (56.76)	7,700 (69.42)	**<0.0001**
Sex						**<0.0001**
Male	74,467 (35.83)	37,161 (35.70)	2,656 (30.44)	31,076 (37.05)	3,574 (32.22)	
Female	133,339 (64.17)	66,945 (64.30)	6,070 (69.56)	52,806 (62.95)	7,518 (67.78)	
Infection	8,916 (4.29)	4,342 (4.17)	340 (3.90)	3,761 (4.48)	473 (4.26)	**0.0022**
Age at surgery						**<0.0001**
<65 yr	3,876 (43.47)	2,087 (48.07)	109 (32.06)	1,559 (41.45)	121 (25.58)	
≥65 yr	5,040 (56.53)	2,255 (51.93)	231 (67.94)	2,202 (58.55)	352 (74.42)	
Sex						**0.0126**
Male	3,923 (44.00)	1,899 (43.74)	134 (39.41)	1,706 (45.36)	184 (38.90)	
Female	4,993 (56.00)	2,443 (56.26)	206 (60.59)	2,055 (54.64)	289 (61.10)	
Reoperation	160 (0.08)	65 (0.06)	12 (0.14)	71 (0.08)	12 (0.11)	**0.0285**
CCI†	2.00 ± 1.86	1.84 ± 1.82	2.00 ± 1.82	2.16 ± 1.89	2.32 ± 1.90	**<0.0001**
Myocardial infarction	2,615 (1.26)	1,277 (1.23)	103 (1.18)	1,080 (1.29)	155 (1.40)	0.3118
Congestive heart failure	11,650 (5.61)	5,379 (5.17)	461 (5.28)	5,056 (6.03)	754 (6.80)	**<0.0001**
Peripheral vascular disease	46,077 (22.17)	19,855 (19.07)	1,941 (22.24)	21,032 (25.07)	3,249 (29.29)	**<0.0001**
Cerebrovascular disease	24,836 (11.95)	11,917 (11.45)	1,119 (12.82)	10,250 (12.22)	1,550 (13.97)	**<0.0001**
Dementia	3,847 (1.85)	1,528 (1.47)	188 (2.15)	1,812 (2.16)	319 (2.88)	**<0.0001**
Chronic pulmonary disease	55,582 (26.75)	25,648 (24.64)	2,397 (27.47)	24,186 (28.83)	3,351 (30.21)	**<0.0001**
Rheumatic disease	17,412 (8.38)	7,971 (7.66)	680 (7.79)	7,679 (9.15)	1,082 (9.75)	**<0.0001**
Peptic ulcer disease	59,855 (28.80)	27,011 (25.95)	2,542 (29.13)	26,509 (31.60)	3,793 (34.20)	**<0.0001**
Mild liver disease	46,158 (22.21)	21,200 (20.36)	1,855 (21.26)	20,382 (24.30)	2,721 (24.53)	**<0.0001**
Diabetes without chronic complications	60,707 (29.21)	28,024 (26.92)	2,539 (29.10)	26,458 (31.54)	3,686 (33.23)	**<0.0001**
Diabetes with chronic complications	25,237 (12.14)	11,861 (11.39)	1,067 (12.23)	10,817 (12.90)	1,492 (13.45)	**<0.0001**
Hemiplegia or paraplegia	2,100 (1.01)	1,047 (1.01)	93 (1.07)	850 (1.01)	110 (0.99)	0.9531
Renal disease	4,893 (2.35)	2,505 (2.41)	202 (2.31)	1,955 (2.33)	231 (2.08)	0.1686
Any malignancy	9,522 (4.58)	4,697 (4.51)	387 (4.44)	3,873 (4.62)	565 (5.09)	**0.0369**
Moderate or severe liver disease	553 (0.27)	282 (0.27)	21 (0.24)	220 (0.26)	30 (0.27)	0.9491
Metastatic solid tumor	355 (0.17)	175 (0.17)	15 (0.17)	143 (0.17)	22 (0.20)	0.9102
AIDS/HIV‡	—	—	—	—	—	—
Mean onset period† *(days)*	30.60 ± 18.99	29.86 ± 18.58	30.16 ± 19.40	31.26 ± 19.27	32.42 ± 19.91	**0.0013**

*The values are given as the number (percentage) of patients, except where otherwise noted. †The values are given as the mean and standard deviation. ‡Because AIDS/HIV status is a sensitive issue, data are not available.

such as ankylosing spondylitis or spinal tumors, in the 3 months prior to spinal surgery and patients who had a spinal infection within 3 months or on the day of spinal surgery were excluded.

Identification of ESI and Acupuncture

ESI and acupuncture were identified using procedural codes. Patients who underwent epidural, root, and facet blocks in the thoracolumbar region and those who underwent intervertebral acupuncture within 90 days prior to lumbar fusion surgery were identified. Patients who underwent acupuncture and nerve blocks after spinal surgery were excluded from this study. The patients were divided into 4 groups on the basis of the type(s) of preoperative procedure they received: those who received neither acupuncture nor ESI ("unexposed group"), those who

TABLE III Comparison of Infection Rates According to the Number of Treatments by ESI and Acupuncture Procedure in the 3 Months Before Surgery*

	0 ESI		1 ESI		2 ESI		3 ESI		>3 ESI		
	Total No. (%)	No. (%) with Infection	Total No. (%)	No. (%) with Infection	Total No. (%)	No. (%) with Infection	Total No. (%)	No. (%) with Infection	Total No. (%)	No. (%) with Infection	P Value
0 acupuncture	104,106 (50.10)	4,342 (4.17)	31,969 (15.38)	1,343 (4.20)	18,757 (9.03)	849 (4.53)	12,442 (5.99)	575 (4.63)	20,714 (9.97)	994 (4.80)	**<0.0001**
1 acupuncture	2,845 (1.37)	122 (4.29)	1,246 (0.60)	56 (4.49)	822 (0.40)	24 (2.92)	598 (0.29)	23 (3.85)	1,077 (0.52)	54 (5.01)	0.3694
2 acupuncture	1,446 (0.70)	60 (4.15)	654 (0.31)	33 (5.05)	403 (0.19)	19 (4.71)	296 (0.14)	8 (2.70)	538 (0.26)	20 (3.72)	0.2130
3 acupuncture	952 (0.46)	34 (3.57)	428 (0.21)	23 (5.37)	273 (0.13)	16 (5.86)	204 (0.10)	8 (3.92)	365 (0.18)	14 (3.84)	0.3696
>3 acupuncture	3,483 (1.68)	124 (3.56)	1,379 (0.66)	51 (3.70)	885 (0.43)	42 (4.75)	684 (0.33)	27 (3.95)	1,240 (0.60)	55 (4.44)	0.0591
P value		**0.0348**		0.4984		0.3679		0.0776		0.1493	

*Percentages in the "Total No. (%)" columns are of the total cohort (N = 207,806). Percentages in the "No. (%) with Infection" columns are of the total number for the indicated treatments.

underwent acupuncture only ("acupuncture group"), those who underwent ESI only ("ESI group"), and those who underwent both procedures before spinal surgery ("combined group").

Incidence of and Risk Factors for Postoperative Infection After Spinal Surgery

The primary outcome of this study was the occurrence of postoperative infection. Postoperative infection was considered present if diagnostic codes relating to spinal infection were registered within 90 days of the date of spinal surgery (Table I). Risk factors associated with postoperative infection after lumbar fusion surgery were evaluated. The Charlson Comorbidity Index (CCI) was used to identify underlying diseases.

Number of Procedures and the Date of the Last Procedure Prior to Spinal Surgery

We investigated whether the number of preoperative acupuncture and ESI sessions had an effect on the postoperative infection rate. We divided the number of treatment sessions into 0, 1, 2, 3, and >3 each for acupuncture and for ESI, and analyzed whether the number of sessions was associated with an increase in the risk of infection. Moreover, the duration between the last procedure and spinal surgery was calculated, and it was divided into ≤2 weeks, >2 weeks to 4 weeks, and >4 weeks to 12 weeks before surgery.

Statistical Analysis

One-way analysis of variance (ANOVA) was performed for continuous variables, and the chi-square test was performed for categorical variables, when comparing characteristics between groups. Univariate and multivariable Cox regression analyses were performed to identify the factors associated with the risk of postoperative infection. All statistical tests were 2-sided, and p values of <0.05 were considered significant. SAS software (version 9.4; SAS Institute) was used for the statistical analyses.

Results

A total of 237,178 patients >50 years of age underwent elective lumbar spinal surgery between 2010 and 2019. Of the 207,806 patients who met the inclusion criteria, 104,106 were in the unexposed group, 8,726 were in the acupuncture group, 83,882 were in the ESI group, and 11,092 were in the combined group (Fig. 1).

Postoperative infection occurred in 8,916 patients, resulting in a total infection rate of 4.29%, with a mean onset period (and standard deviation) of 30.60 ± 18.99 days. The infection rate in each group was as follows: 4.17% (4,342 of 104,106) in the unexposed group, 3.90% (340 of 8,726) in the acupuncture group, 4.48% (3,761 of 83,882) in the ESI group, and 4.26% (473 of 11,092) in the combined group (p = 0.0022). The pairwise comparisons showed that there was a significant difference in the infection rate between the unexposed group and the ESI group (p = 0.0027).

The mean age at surgery was the highest in the combined group (67.89 ± 7.63 years), followed by the acupuncture (67.01 ± 7.83 years), ESI (65.96 ± 8.01 years), and unexposed (64.79 ± 8.13 years) groups (p < 0.0001) (Table II). The proportion of female patients in the acupuncture group was significantly higher than in the other groups (p < 0.0001) (Table II).

The rate of infection increased with the number of ESIs received prior to surgery (p < 0.0001) (Table III). There was no association between the number of procedures and the rate of infection in the acupuncture group and combined group.

In addition, we identified differences in the postoperative infection rate on the basis of the duration between the last procedure and spinal surgery. The incidence of postoperative infection increased as the duration between the

TABLE IV Comparison of Infection Rates According to the Time of the Last Preoperative Procedure

	Duration Between Last Procedure and Surgery			
	≤2 Wk	>2 to 4 Wk	>4 to 12 Wk	P Value
Acupuncture group				0.4250
Total no. (%) of patients	2,327 (26.67)	1,745 (20.00)	4,654 (53.33)	
No. (%) with infection	88 (3.78)	60 (3.44)	192 (4.13)	
ESI group				**<0.0001**
Total no. (%) of patients	24,490 (29.20)	20,009 (23.85)	39,383 (46.95)	
No. (%) with infection	1,226 (5.01)	893 (4.46)	1,642 (4.17)	
Combined group				0.5510
Total no. (%) of patients	5,161 (46.53)	2,947 (26.57)	2,984 (26.90)	
No. (%) with infection	223 (4.32)	116 (3.94)	134 (4.49)	

procedure and surgery decreased in the ESI group ($p < 0.0001$) (Table IV). There were no significant differences in the acupuncture and combined groups on the basis of the timing of the last procedure.

Univariate Cox Regression Analysis

In the univariate analysis, the risk of infection increased with age (crude hazard ratio [HR], 1.006; 95% confidence interval [CI], 1.003 to 1.008), and it was shown that female patients were at a lower risk compared with male patients (HR, 0.705; 95% CI, 0.676 to 0.735). A 1-point increase in the CCI was demonstrated to increase the risk of postoperative infection by 1.052 times (95% CI, 1.041 to 1.063). Congestive heart failure, peripheral vascular disease, cerebrovascular disease, chronic pulmonary disease, rheumatic disease, peptic ulcer disease, mild liver disease, diabetes without chronic complications,

TABLE V Risk Factors for Postoperative Spinal Infection Using Cox Regression Analysis

	Crude HR (95% CI)	P Value	Adjusted HR (95% CI)	P Value
Age	1.006 (1.003-1.008)	**<0.0001**	1.004 (1.001-1.007)	**0.0045**
Sex				
Male	1 (ref.)		1 (ref.)	
Female	0.705 (0.676-0.735)	**<0.0001**	0.701 (0.672-0.731)	**<0.0001**
CCI	1.052 (1.041-1.063)	**<0.0001**		
Myocardial infarction	1.149 (0.965-1.368)	0.1186	0.989 (0.829-1.180)	0.9051
Congestive heart failure	1.154 (1.061-1.257)	**0.0009**	1.074 (0.985-1.172)	0.1068
Peripheral vascular disease	1.101 (1.049-1.156)	**0.0001**	1.054 (1.002-1.108)	**0.0406**
Cerebrovascular disease	1.079 (1.014-1.148)	**0.0165**	1.013 (0.950-1.080)	0.6951
Dementia	0.950 (0.811-1.112)	0.5211	0.913 (0.778-1.070)	0.2588
Chronic pulmonary disease	1.061 (1.013-1.111)	**0.0118**	1.021 (0.974-1.070)	0.3883
Rheumatic disease	1.226 (1.144-1.314)	**<0.0001**	1.237 (1.154-1.326)	**<0.0001**
Peptic ulcer disease	1.126 (1.077-1.178)	**<0.0001**	1.102 (1.053-1.153)	**<0.0001**
Mild liver disease	1.122 (1.069-1.178)	**<0.0001**	1.057 (1.006-1.111)	**0.0292**
Diabetes without chronic complications	1.121 (1.073-1.173)	**<0.0001**	1.046 (0.996-1.098)	0.0721
Diabetes with chronic complications	1.158 (1.091-1.230)	**<0.0001**	1.071 (1.004-1.144)	**0.0388**
Hemiplegia or paraplegia	1.234 (1.023-1.488)	**0.0279**	1.142 (0.946-1.378)	0.1676
Renal disease	1.280 (1.133-1.447)	**<0.0001**	1.135 (1.003-1.286)	**0.0453**
Any malignancy	0.943 (0.852-1.045)	0.2629	0.860 (0.775-0.955)	**0.0046**
Moderate or severe liver disease	1.411 (1.003-1.986)	**0.0479**	1.275 (0.905-1.795)	0.1642
Metastatic solid tumor	1.325 (0.855-2.054)	0.2084	1.403 (0.898-2.191)	0.1369
AIDS/HIV	—	—	—	—
Acupuncture	0.951 (0.885-1.022)	0.1733	0.946 (0.880-1.017)	0.1307
ESI	1.075 (1.032-1.121)	**0.0006**	1.048 (1.005-1.093)	**0.0273**

TABLE VI Risk Factors for Postoperative Spinal Infection Using Cox Regression Analysis, Excluding Patients Who Received Acupuncture or ESI within 2 Weeks Prior to Spinal Surgery

	Adjusted HR (95% CI)	P Value
Age	1.004 (1.001-1.007)	**0.0050**
Sex		
Male	1 (ref.)	
Female	0.701 (0.669-0.734)	**<0.0001**
CCI		
Myocardial infarction	0.979 (0.806-1.190)	0.8321
Congestive heart failure	1.089 (0.990-1.199)	0.0797
Peripheral vascular disease	1.052 (0.995-1.112)	0.0749
Cerebrovascular disease	0.995 (0.928-1.068)	0.8990
Dementia	0.914 (0.764-1.093)	0.3231
Chronic pulmonary disease	1.019 (0.967-1.073)	0.4832
Rheumatic disease	1.228 (1.137-1.326)	**<0.0001**
Peptic ulcer disease	1.093 (1.039-1.150)	**0.0005**
Mild liver disease	1.058 (1.001-1.118)	**0.0467**
Diabetes without chronic complication	1.045 (0.990-1.103)	0.1124
Diabetes with chronic complication	1.073 (0.998-1.153)	0.0559
Hemiplegia or paraplegia	1.189 (0.971-1.456)	0.0933
Renal disease	1.132 (0.990-1.294)	0.0709
Any malignancy	0.827 (0.736-0.929)	**0.0013**
Moderate or severe liver disease	1.514 (1.075-2.134)	**0.0177**
Metastatic solid tumor	1.478 (0.911-2.399)	0.1140
AIDS/HIV	—	—
Acupuncture	0.972 (0.887-1.064)	0.5372
ESI	1.003 (0.956-1.052)	0.9012

diabetes with chronic complications, hemiplegia or paraplegia, renal disease, and moderate or severe liver disease were identified as the risk factors (Table V). ESI was associated with an increase in the postoperative infection rate (crude HR, 1.075; 95% CI, 1.032 to 1.121); however, acupuncture was not (crude HR, 0.951; 95% CI, 0.885 to 1.022).

Multivariable Cox Regression Analysis

Multivariable analysis was performed after adjusting for age, sex, comorbidities, acupuncture, and ESI procedures. As age increased by 1 year, the postoperative infection rate increased by 1.004 times (95% CI, 1.001 to 1.007). Females were at lower risk of infection compared to males (adjusted HR, 0.701; 95% CI, 0.672 to 0.731). Peripheral vascular disease, rheumatic disease, peptic ulcer disease, mild liver disease, diabetes with chronic complications, renal disease, and any malignancy were identified as risk factors (Table V). ESI was a risk factor for postoperative infection among the preoperative procedures but acupuncture was not (ESI: adjusted HR, 1.048; 95% CI, 1.005 to 1.093; acupuncture: adjusted HR, 0.946; 95% CI, 0.880 to 1.017) (Table V). When the patients who received procedures within 2 weeks prior to surgery were excluded, ESI was no longer a risk factor for postoperative infection. (ESI: adjusted HR, 1.003; 95% CI, 0.956 to 1.052; acupuncture: adjusted HR, 0.972; 95% CI, 0.887 to 1.064) (Table VI).

Discussion

To our knowledge, this is the first study to investigate the effect of acupuncture on infection following lumbar spinal fusion using a nationwide database. We compared early infection rates (within 90 days following spinal surgery) among patients who underwent spinal fusion who had a history of ESI and/or acupuncture within 3 months before surgery, as identified using insurance claims data. Acupuncture was not associated with an increased infection rate. Although ESI was identified as a risk factor for postoperative infection, it was no longer a risk factor when patients who received acupuncture or ESI within 2 weeks prior to surgery were excluded. In addition to ESI, increasing age, male sex, and several comorbidities, including peripheral vascular disease, rheumatic disease, peptic ulcer disease, mild liver disease, diabetes with chronic complications, renal disease, and any malignancy, were identified as risk factors for postoperative infection after spinal surgery.

Several studies have demonstrated that preoperative ESI is associated with an increased infection rate after fusion surgery, similar to the results of this study[20,21,28]. The total infection rate in this study was 4.29% (8,916 of 207,806 patients), which is considered relatively high compared with the infection rate of other studies (1.60% to 3.6%)[29-31]. It is difficult to make a direct comparison since there are discrepancies among the studies in the methodology and the definition of postoperative infection.

Our study included cases of infection that occurred within 90 days after spinal surgery. Postoperative infection is considered infection that occurs up to 1 year postoperatively in cases of spinal surgery with instrumentation[32]. However, the later the onset of postoperative infection, the less likely it is to be affected by invasive procedures performed preoperatively and the more likely it is to be influenced by patient-related risk factors. Previous studies on the association between ESI and postoperative infection also included cases that occurred within 90 days postoperatively[20,21]. Early postoperative infection is often defined as that occurring within 90 days, and delayed onset is defined as infection occurring after 90 days postoperatively. This 90-day threshold also serves as a standard for deciding whether to remove an implant for the treatment of infection[33,34].

We also evaluated the effect of the number and timing of preoperative procedures on infection. The frequency and timing of preoperative acupuncture did not affect the infection rate. However, the postoperative infection rate increased as the number of preoperative ESIs increased, and as the duration between the last injection and surgery decreased. The appropriate frequency and timing of ESI remains controversial[16,35-37]. It is recommended by the North American Spine Society that ESIs should be performed <6 times per year in the same site[38]. Even in

our country, a medical institution usually performs injection treatment 2 or 3 times at an interval of 1 to 2 weeks and advises the patient to avoid additional injection for several months. However, it is common for many patients who report pain to receive an ESI >3 times in a short period of time by visiting other clinics for treatment. In the current study, we found that 24.69% of the patients who underwent ESI alone received it >3 times within 3 months. Acupuncture is often performed more frequently than ESI. We found that 39.92% of the patients received acupuncture alone >3 times within 90 days.

Surgeons tend to avoid invasive procedures before surgery because they are concerned about the possibility of postoperative infection. However, 29.20% of the patients in the ESI group and 26.67% in the acupuncture group underwent the procedure within 2 weeks prior to surgery, and this shows that, in clinical practice, many patients receive invasive procedures immediately before the operation. In the ESI group, patients who received the injection within 2 weeks of surgery showed an infection rate of 5.01% (1,226 of 24,490), which was higher than the average rate of in the ESI group across the time periods (Table IV). However, when we excluded patients who received acupuncture or ESI within 2 weeks of surgery, ESI was not a risk factor for postoperative infection (Table VI). Therefore, on the basis of our results, we recommend avoiding invasive procedures within 2 weeks prior to surgery in order to reduce the risk of postoperative infection.

Acupuncture is widely practiced as an alternative treatment in our country. More than 3 million acupuncture procedures are performed annually for back pain[39]. Alternative medicine, including acupuncture, has been covered by the National Health Insurance system since 1987[24]. If an alternative medicine practitioner submits a claim for the acupuncture treatment they have performed, HIRA verifies the procedural code and reimburses the institution for the medical cost. Most acupuncture procedures, except for noninsured procedures such as pharmacopuncture, which is a combination of herbal medicine and acupuncture therapy, can be verified through a nationwide database by the date, number, and treatment site. Because procedures such as acupuncture and ESI are performed multiple times in various institutions, it is difficult to accurately identify them through medical records or history taking. It is more difficult to verify the history in the case of acupuncture because patients often attempt to hide their treatment history before undergoing surgery. Such omissions can be avoided when the claims data are used, since all procedures with claims can be identified in the national insurance system.

We discovered that preoperative acupuncture was not associated with an increased risk of postoperative infection. In contrast to ESI, in which the needle is placed directly into the epidural space, most acupuncture needles are placed only subcutaneously in the fascia or muscle layer[7]. Additionally, patients with a high risk of postoperative infection, who have severe chronic underlying diseases or who were scheduled for multilevel surgery, may have avoided receiving acupuncture. If it was confirmed that acupuncture was performed immediately before surgery in a high-risk patient, it is possible that the surgery was cancelled or postponed by the surgeon.

We found that female sex was associated with a lower risk of postoperative infection than male sex. There are conflicting results from previous studies. Some have reported a lower incidence of infections in females, which is similar to the finding in our study[40]. In contrast, others have reported that there is no sex-based difference[41].

This study had several limitations. We used claims data and were unable to review the medical records to confirm diagnoses and treatments. When a superficial infection is suspected, incision and drainage are often performed at the bedside without registering a diagnosis or procedure code. If no claim is reported, treatments cannot be identified in the national insurance data. Such cases may have resulted in the underestimation of the incidence of postoperative infection. In addition, the severity of the infection could not be identified because there are no diagnostic codes to differentiate the severity, and it can only be confirmed through medical chart review. Another limitation is that non-reimbursed procedures, such as acupuncture involving insertion of foreign material inside the body, could not be identified. Most patients receive ESIs several times, and they often involve different types of injections. Therefore, it was not possible to divide them into subgroups according to the type of ESI injection. Also, the claims data do not provide surgical details such as the number of fusion levels and the surgical approach.

Conclusions

This study is the first to investigate the effect of alternative medicine on lumbar spinal surgery using a nationwide insurance claims database. Acupuncture and ESI performed >2 weeks prior to spinal surgery did not increase the risk of postoperative infection. However, ESI performed within 2 weeks before surgery was associated with increased risk. Therefore, we recommend that invasive procedures immediately before surgery should be avoided to prevent postoperative complications. ■

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