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Epidemiologic study of epidural analgesia for lung cancer surgery from 2011 to 2018 in South Korea: a National Health Insurance Database cohort study

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Background: Epidural analgesia is commonly used for pain control during lung cancer surgery. However, the clinical trends in epidural analgesia, associated factors, and their association with clinical outcomes remain controversial. Therefore, we aimed to investigate the trends, associated factors, and their association with the clinical outcomes of epidural analgesia for lung cancer surgery.

Methods: The National Health Insurance Database was used as the data source in a nationwide cohort study. All adult patients who underwent lung cancer surgery between 2011 and 2018 were included.

Results: A total of 60,031 adult patients who underwent surgery for lung cancer were included. Of these, a total of 24,786 patients (41.3%) received epidural analgesia with a mean value of 1.5 days (standard deviation: 2.0 days). Male sex, increased Charlson comorbidity index (CCI), concurrent musculoskeletal disease, and a wider surgical extent were associated with higher odds of epidural analgesia for lung cancer surgery. Compared to open thoracotomy, video-assisted thoracoscopic surgery (VATS) was associated with lower odds of epidural analgesia for lung cancer surgery. Moreover, epidural analgesia was not associated with 30-day mortality, fatal respiratory events, or one-year mortality after lung cancer surgery.

Conclusions: From 2011 to 2018, 41.3% of patients with lung cancer in South Korea received epidural analgesia for lung cancer surgery. Some factors (male sex, increased CCI, concurrent musculoskeletal disease, wider surgical extent, and VATS) were associated with the use of epidural analgesia in lung cancer surgery. However, epidural analgesia was not associated with clinical outcomes after lung cancer surgery.

Keywords: Analgesia; Cohort studies; Epidemiology; Lung neoplasms; Pain management; Population; Postoperative pain; Thoracic surgery.

Introduction

Lung cancer is the leading cause of cancer-related mortality worldwide [1]. According to global cancer statistics from 185 countries in 2020 [2], 2,206,771 individuals were newly diagnosed with lung cancer, and 1,796,144 patients died due to lung cancer in 2020. As the global incidence, death, and economic burden of lung cancer have increased [3], effective management of lung cancer remains a significant public health issue.

For the treatment of lung cancer, surgical procedures are first considered with curative intent [4]. Patients who undergo lung cancer surgery are known to experience severe postoperative pain that might affect their quality of life [5,6]. Epidural analgesia has been widely used for clinical benefits, such as effective postoperative pain control during thoracotomy and attenuation of the inflammatory response during lung cancer surgery [7,8]. Thus, epidural analgesia is considered an optimal technique for effective pain control in lung cancer surgery, especially for open thoracotomy cases [9]. However, video-assisted thoracoscopic surgery (VATS), which is a minimally invasive surgical technique, has emerged as the standard surgical procedure for lung cancer surgery [10], and there is no clear gold standard for regional analgesia in lung cancer surgery [11]. For example, intravenous (IV) analgesia, thoracic paravertebral block, and intercostal nerve block have been used for postoperative pain control to replace epidural analgesia in lung cancer surgery [11]. Thus, the trend in the application of epidural analgesia has changed over time. However, no study has been conducted on the epidemiology of epidural analgesia for lung cancer surgery using a nationwide registration database.

Therefore, the present study aimed to investigate trends, associated factors, and their association with the clinical outcomes of epidural analgesia for lung cancer surgery using the South Korean national registration database.

Materials and Methods

Study design and ethical statement

The study protocol was approved by the Institutional Review Board (IRB) (IRB approval number: X-2008-630-902). The National Health Insurance Scheme (NHIS) approved the data sharing protocol for this study (NHIS approval number: NHIS-2021-1-041). The requirement for informed consent was waived by the IRB because the data were analyzed retrospectively in an anonymous form after masking the individual and sensitive information of the study population.

Data source and study population

The NHIS database was used as the national registration database. The NHIS database contains all disease diagnoses and prescription information regarding the procedures and/or drugs in South Korea. The government supports financial expenses for treatment or medical examinations after registration of disease diagnoses and prescriptions. Moreover, the NHIS database contains demographic and socio-economic information of the South Korean population. The 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) codes is used to register any disease in the NHIS database.

This study included all adult patients (≥ 18 years old) who were diagnosed with lung cancer (C34 of ICD-10 code) and underwent lung cancer surgery between January 1, 2011, and December 31, 2018, in South Korea. In South Korea, the government covers almost all expenses (approximately 95%) involved in the treatment and examination of lung cancer after the registration of ICD-10 codes (C34); thus, all patients with lung cancer who underwent lung cancer surgery were included in the NHIS database.

Epidural analgesia for lung cancer surgery

As the main independent variable, information on the administration of epidural analgesia during lung cancer surgery for pain control was collected. The prescription code for epidural patient-controlled analgesia (PCA) was used to extract data. Patients who received epidural PCA after lung cancer surgery were considered the epidural analgesia group, and the other patients were considered the control group.

Study outcomes

First, the proportion of patients who received epidural analgesia from 2011 to 2018 after lung cancer surgery was examined. Second, the factors associated with epidural analgesia in patients who underwent lung cancer surgery were examined. Third, the association of epidural analgesia with 30-day mortality, development of fatal respiratory events, and one-year mortality after lung cancer surgery was investigated. A fatal respiratory event was defined as a diagnosis of acute respiratory distress syndrome (ARDS) (J80 of ICD-10 code) or respiratory failure (J96 of ICD-10 code) during hospitalization following lung cancer surgery.

Collected variables

Age and sex were collected as demographic information. To reflect socioeconomic status, household income level, employment status, and residence locality at the time of lung cancer surgery were collected. The annual household income level in South Korea is registered by considering the individual's annual income and property to determine their insurance premium. All patients were divided into four groups based on the quartile ratio of the household income level. Employment status did not include self-employed people, and all patients were divided into two groups according to their residence: urban areas (capital or other metropolitan cities) and rural areas (all other areas). For sur-

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gery-related information, the type of surgery, use of VATS or open thoracotomy, and a redo-case of surgery were collected for this study. Surgery type was divided into five groups: wedge resection, segmentectomy, lobectomy, bilobectomy, and pneumonectomy. If a patient underwent wedge resection in addition to segmentectomy, the patient was included in the segmentectomy group, whereas a patient who underwent segmentectomy in addition to lobectomy was included in the lobectomy group. As a high case volume was strongly associated with improved survival outcomes after lung cancer surgery [12], the annual number of lung cancer surgery cases in each hospital in South Korea was calculated. The patients were then divided into four groups using quartile ratios, based on the case load of the hospital in which the lung cancer surgery was performed (Q1: ≤ 74, Q2: 75– 276, Q3: 277–921, and Q4: ≥ 922). In addition, all patients were divided into two groups according to the hospital in which the lung cancer surgery was performed: a tertiary general hospital group and a general hospital group. The total cost of hospitalization (United States Dollar [USD]) and length of hospital stay (days) were recorded. For comorbid stats related information, the Charlson comorbidity index (CCI) at the time of lung cancer surgery was calculated using the ICD-10 codes of individual diseases (Supplementary Table 1), which were registered within one year before the date of the lung cancer surgery. Concurrent musculoskeletal disease (M* of ICD-10 code) and preoperative chronic analgesic (opioid, paracetamol, non-steroidal anti-inflammatory drugs, gabapentin, or pregabalin) use (≥ 90 days) were collected as covariates. In addition, the underlying disability before lung cancer surgery was collected because all individuals with any disability should be registered in the NHIS database to receive various benefits from the social welfare system in South Korea. The disabilities were divided into six grades based on severity (grade 1, most severe; grade 6, mildest). Patients with grades 1, 2, or 3 constituted the severe disability group, while those with grades 4, 5, or 6 constituted the mild-to-moderate disability group.

Statistical analysis

The clinicopathological characteristics of all patients are presented as mean values with standard deviations (SDs) for continuous variables and numbers with percentages for categorical variables. For comparison of clinicopathological characteristics between the epidural analgesia and control groups, t-test and chi-square test were used. Next, we constructed a multivariable logistic regression model to examine the factors associated with epidural analgesia. All variables were included in the multivariable model for adjustment, and the Hosmer–Lemeshow test was used to confirm if the goodness of fit in the model was appropriate.

For secondary analyses, multivariable logistic models were constructed to investigate whether epidural analgesia was associated with 30-day mortality or development of fatal respiratory events after lung cancer surgery. We also fitted a multivariable Cox regression model to examine whether epidural analgesia was associated with the one-year mortality risk after lung cancer surgery. The results of logistic regression were presented as odds ratios (ORs) with 95% CIs, whereas those of Cox regression were presented as hazard ratios (HRs) with 95% CIs. There was no multicollinearity between the variables in the model with variance inflation factors < 2.0. All statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., USA) and R software (version 3.6.2; R Foundation for Statistical Computing, Austria). Statistical significance was set at $P < 0.05$.

Results

Study population

A total of 60,031 adult patients who were diagnosed with lung cancer and underwent lung cancer surgery between January 1, 2011, and December 31, 2018, were included in the analysis. Clinicopathological characteristics of the patients are shown in Table 1. The mean age of the patients was 65.6 years (SD: 9.9 years), and 61.3% (36,778/60,031) were men. The epidural analgesia group included 24,786 patients (41.3%), and they received epidural analgesia for a mean duration of 1.5 days (SD: 2.0 days).

Trend of epidural analgesia for lung cancer surgery in South Korea

Fig. 1 shows the trends in epidural analgesia use for lung cancer surgery in South Korea. In 2011, 45.2% (2,477/5,479) of patients received epidural analgesia, which gradually increased until 2016 (64.7%, 5,406/8,360). However, the proportion of epidural analgesics decreased by 20.8% (1,889/9,076) in 2017 and 12.0% (1,198/9,959) in 2018. Table 2 shows the results of the comparison of clinicopathological characteristics between the epidural analgesia and control groups. The epidural analgesia group had a higher proportion of lobectomy (17,055/24,786; 68.8% vs. 23,733/35,245; 67.3%), bilobectomy (972/24,786; 3.9% vs. 985/35,245; 2.8%), and pneumonectomy (928/24,786; 3.7% vs. 828/35,245; 2.3%) than the control group ($P < 0.001$).

Table 1. Clinicopathological Characteristics of the Patients

Variable	
Age (yr)	65.6 ± 9.9
Sex (M)	36,778 (61.3)
Household income level	
Q1 (lowest)	12,207 (20.3)
Q2	9,149 (15.2)
Q3	13,361 (22.3)
Q4 (highest)	24,057 (40.1)
Unknown	1,257 (2.1)
Having a job at surgery	37,808 (63.0)
Residence at surgery	
Urban area	23,803 (39.7)
Rural area	36,228 (60.3)
Type of surgery	
Wedge resection	11,489 (19.1)
Segmentectomy	4,041 (6.7)
Lobectomy	40,788 (67.9)
Bilobectomy	1,957 (3.3)
Pneumonectomy	1,756 (2.9)
VATS	48,888 (81.4)
CCI at surgery	6.2 ± 3.0
Concurrent musculoskeletal disease	4,532 (7.5)
Preoperative chronic analgesics use	
Opioid	3,291 (5.5)
Paracetamol	236 (0.4)
NSAIDs	220 (0.4)
Gabapentin or pregabalin	1,725 (2.9)
Having a disability at surgery	
Mild to moderate	5,433 (9.1)
Severe	1,784 (3.0)

Variable	
Redo case	2,786 (4.6)
Annual case volume of lung cancer surgery	
Q1: ≤ 74	15,108 (25.2)
Q2: 75–276	13,807 (23.0)
Q3: 277–921	14,868 (24.8)
Q4: ≥ 922	16,248 (27.1)
Type of hospital	
Tertiary general hospital	46,648 (77.7)
General hospital	13,383 (22.3)
Epidural analgesia	24,786 (41.3)
Duration of epidural analgesia, day	1.5 ± 2.0
Fatal respiratory event	285 (0.5)
Postoperative ARDS	156 (0.3)
Postoperative respiratory failure	135 (0.2)
Total cost for hospitalization (USD)	8,890.5 ± 4,334.4
LOS (day)	11.6 ± 7.9
Postoperative 30-day mortality	446 (0.7)
Postoperative one-year mortality	4,407 (7.3)
Year of surgery	
2011	5,479 (9.1)
2012	6,164 (10.3)
2013	6,640 (11.1)
2014	7,050 (11.7)
2015	7,303 (12.2)
2016	8,260 (13.9)
2017	9,076 (15.1)
2018	9,959 (16.6)

Values are presented as mean ± SD or number (%). VATS: video-assisted thoracoscopic surgery, CCI: Charlson comorbidity index, NSAIDs: non-steroidal anti-inflammatory drugs, ARDS: acute respiratory distress syndrome, USD: United States dollars, LOS: length of hospital stays.

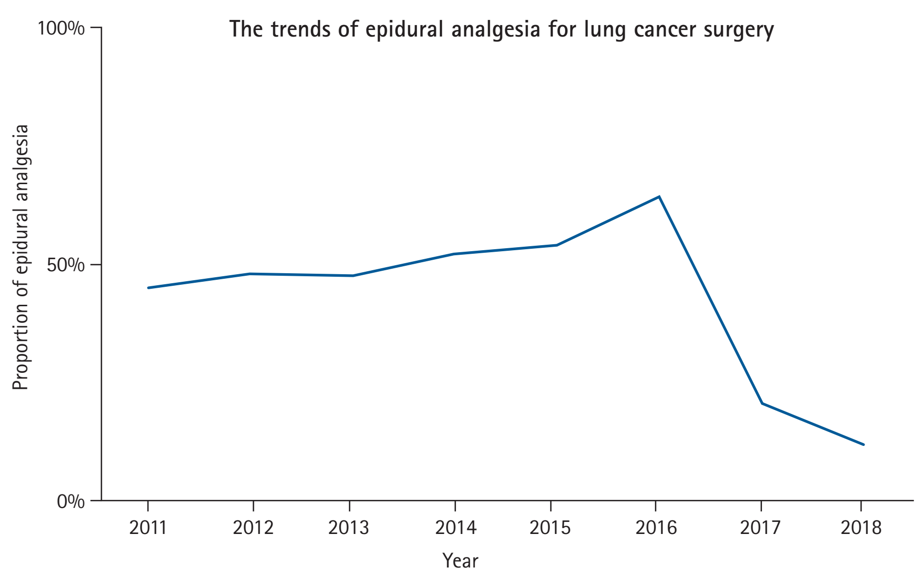

Fig. 1. The trends of epidural analgesia for lung cancer surgery from 2011 through 2018 in South Korea.

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Table 2. Comparison of Clinicopathological Characteristics between the Epidural Analgesia and Control Groups

Variable	Epidural analgesia (n = 24,786)	Control group (n = 35,245)	P value
Age (yr)	65.7 ± 9.8	65.6 ± 10.0	0.034
Sex (M)	15,885 (64.1)	20,893 (59.3)	< 0.001
Household income level			0.006
Q1 (lowest)	5,118 (20.6)	7,089 (20.1)	
Q2	3,857 (15.6)	5,292 (15.0)	
Q3	5,566 (22.5)	7,795 (22.1)	
Q4 (highest)	9,713 (39.2)	14,344 (39.2)	
Unknown	532 (2.1)	725 (2.1)	
Having a job at surgery	15,297 (61.7)	22,511 (63.9)	< 0.001
Residence at surgery			0.145
Urban area	9,914 (40.0)	13,889 (39.4)	
Rural area	14,872 (60.0)	21,356 (60.6)	
Type of surgery			< 0.001
Wedge resection	4,336 (17.5)	7,153 (20.3)	
Segmentectomy	1,495 (6.0)	2,546 (7.2)	
Lobectomy	17,055 (68.8)	23,733 (67.3)	
Bilobectomy	972 (3.9)	985 (2.8)	
Pneumonectomy	928 (3.7)	828 (2.3)	
VATS	1,8948 (76.4)	29,940 (84.9)	< 0.001
CCI at surgery	6.5 ± 3.1	5.9 ± 3.0	< 0.001
Concurrent musculoskeletal disease	2,116 (8.5)	2,416 (6.9)	< 0.001
Preoperative chronic analgesics use			
Opioid	1,407 (5.7)	1,884 (5.3)	0.079
Paracetamol	84 (0.3)	152 (0.4)	0.075
NSAIDs	74 (0.3)	146 (0.4)	0.021
Gabapentin or pregabalin	665 (2.7)	1,060 (3.0)	0.019
Having a disability at surgery			< 0.001
Mild to moderate	2,375 (9.6)	3,058 (8.7)	
Severe	790 (3.2)	994 (2.8)	
Redo case	996 (4.0)	1,790 (5.1)	< 0.001
Annual case volume of lung cancer surgery			< 0.001
Q1: ≤ 74	7,257 (29.3)	7,851 (22.3)	
Q2: 75–276	5,743 (23.2)	8,065 (22.9)	
Q3: 277–921	5,799 (23.4)	9,069 (25.7)	
Q4: ≥ 922	5,988 (24.2)	10,260 (29.1)	
Type of hospital			< 0.001
Tertiary general hospital	20,236 (81.6)	26,412 (74.9)	
General hospital	4,550 (18.4)	8,833 (25.1)	
Fatal respiratory event	140 (0.6)	145 (0.4)	0.007
Total cost for hospitalization (USD)	8,981.7 ± 4,718.2	8,826.3 ± 4,041.6	< 0.001
LOS (day)	12.5 ± 8.7	11.0 ± 7.2	< 0.001
Postoperative 30 days mortality	218 (0.9)	228 (0.6)	0.001
Year of surgery			< 0.001
2011	2,477 (10.0)	3,002 (8.5)	
2012	2,976 (12.0)	3,188 (9.0)	
2013	3,181 (12.8)	3,459 (9.8)	
2014	3,696 (14.9)	3,354 (9.5)	
2015	3,963 (16.0)	3,340 (9.5)	
2016	5,406 (21.8)	2,954 (8.4)	
2017	1,889 (7.6)	7,187 (20.4)	
2018	1,198 (4.8)	8,761 (24.9)	

Values are presented as mean ± SD or number (%). VATS: video-assisted thoracoscopic surgery, CCI: Charlson comorbidity index, NSAIDs: non-steroidal anti-inflammatory drugs, USD: United States dollars, LOS: length of hospital stays.

Associated factors with application of epidural analgesia

Table 3 shows the results of the multivariate logistic regression model for the application of epidural analgesia. Male sex (OR: 1.17, 95% CI [1.12, 1.21], P < 0.001), increased CCI (OR: 1.06, 95% CI [1.06, 1.07], P < 0.001),, and concurrent musculoskeletal disease (OR: 1.46, 95% CI [1.36, 1.57], P < 0.001) were associated with higher odds of epidural analgesia for lung cancer surgery. Compared to wedge resection, segmentectomy (OR: 1.13, 95% CI [1.04, 1.23], P = 0.003), lobectomy (OR: 1.21, 95% CI [1.16, 1.27], P < 0.001), bilobectomy (OR: 1.52, 95% CI [1.37, 1.69], P < 0.001), and pneumonectomy (OR: 1.68, 95% CI [1.50, 1.88], P < 0.001) were associated with higher odds of epidural analgesia for lung cancer surgery. Compared with open thoracotomy, VATS was associated with lower odds of epidural analgesia for lung cancer surgery (OR: 0.73, 95% CI [0.70, 0.77], P < 0.001).

Thirty-day mortality, fatal respiratory event, and one-year mortality

Table 4 shows the results of the analyses regarding 30-day mortality, fatal respiratory events, and one-year mortality associated with epidural analgesia for lung cancer surgery. The epidural analgesia group showed no significant difference in the odds of 30-day mortality (OR: 1.07, 95% CI [0.87, 1.32], P = 0.522), fatal respiratory events (OR: 1.12, 95% CI [0.87, 1.45], P = 0.388), and one-year mortality risk (HR: 1.01, 95% CI [0.94, 1.07], P = 0.840). However, epidural analgesia might influence the management of acute and chronic pain control and patient satisfaction following lung cancer surgery. Unfortunately, these details are not available in the NHIS dataset.

Discussion

According to the results of this population-based cohort study in South Korea, 41.3% patients received epidural analgesia for lung cancer surgery. Even though there has been a recent decreased rate of epidural analgesia with the increase of VATS, our study suggested that epidural analgesia might still be a good option in case of increased CCI, concurrent musculoskeletal disease, and wider surgical extent. Moreover, clinical outcomes were assessed, such as 30-day mortality, fatal respiratory events, and one-year mortality.

The most clinically relevant points in this study were the associated factors for the application of epidural analgesia because it reflects the favoring of epidural analgesia among anesthesiologists and surgeons for pain control of lung cancer surgery using re-

Table 3. Multivariate Logistic Regression Model for the Application of Epidural Analgesia

Variable	OR (95% CI)	P value
Age (yr)	1.00 (1.00, 1.00)	0.858
Sex (M)	1.17 (1.12, 1.21)	< 0.001
Household income level		
Q1 (lowest)	1	
Q2	1.02 (0.96, 1.09)	0.484
Q3	0.98 (0.93, 1.04)	0.520
Q4 (highest)	0.95 (0.91, 1.00)	0.048
Unknown	1.01 (0.89, 1.15)	0.906
Having a job at surgery	0.95 (0.91, 0.99)	0.006
Residence at surgery		
Urban area	1	
Rural area	0.99 (0.96, 1.03)	0.725
Type of surgery		
Wedge resection	1	
Segmentectomy	1.13 (1.04, 1.23)	0.003
Lobectomy	1.21 (1.16, 1.27)	< 0.001
Bilobectomy	1.52 (1.37, 1.69)	< 0.001
Pneumonectomy	1.68 (1.50, 1.88)	< 0.001
VATS (vs. open thoracotomy)	0.73 (0.70, 0.77)	< 0.001
CCI at surgery, point	1.06 (1.06, 1.07)	< 0.001
Concurrent musculoskeletal disease	1.46 (1.36, 1.57)	< 0.001
Preoperative chronic analgesics use		
Opioid	1.06 (0.97, 1.15)	0.208
Paracetamol	0.99 (0.72, 1.34)	0.926
NSAIDs	0.64 (0.47, 0.87)	0.004
Gabapentin or pregabalin	0.78 (0.70, 0.88)	< 0.001
Having a disability at surgery		
Mild to moderate	1.01 (0.95, 1.07)	0.814
Severe	0.94 (0.84, 1.04)	0.237
Redo case (vs. first case)	0.95 (0.92, 0.88)	0.009
Annual case volume of lung cancer surgery		
Q1: ≤ 74	1	
Q2: 75–276	0.68 (0.65, 0.72)	< 0.001
Q3: 277–921	0.59 (0.56, 0.62)	< 0.001
Q4: ≥ 922	0.45 (0.42, 0.47)	< 0.001
Type of hospital		
Tertiary general hospital	2.52 (2.40, 2.65)	< 0.001
General hospital	1	
Year of surgery		
2011	1	
2012	1.09 (1.01, 1.17)	0.029
2013	1.10 (1.02, 1.18)	0.017
2014	1.35 (1.26, 1.46)	< 0.001
2015	1.42 (1.32, 1.53)	< 0.001
2016	2.23 (2.07, 2.40)	< 0.001
2017	0.29 (0.27, 0.32)	< 0.001
2018	0.15 (0.14, 0.17)	< 0.001

Hosmer Lemeshow test: Chi-square, 9.4, df = 8, P = 0.310. OR: odds ratio, VATS: video-assisted thoracoscopic surgery, CCI: Charlson comorbidity index, NSAIDs: non-steroidal anti-inflammatory drugs.

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Table 4. Analyses regarding 30-day Mortality, Fatal Respiratory Events, and One-year Mortality Associated with Epidural Analgesia for Lung Cancer Surgery

Variable	OR, HR (95% CI)	P value
30-day mortality (model 1)		
Control group	1	
Epidural analgesia group	1.07 (0.87, 1.32)	0.522
Fatal respiratory event (model 2)		
Control group	1	
Epidural analgesia group	1.12 (0.87, 1.45)	0.388
One-year mortality (model 3)		
Control group	1	
Epidural analgesia group	1.01 (0.94, 1.07)	0.840

All covariates were adjusted. OR: odds ratio, HR: hazard ratio.

al-world data. Although the risks and benefits of thoracic epidural analgesia for pain control have been documented [13], there was insufficient information on the cases in which epidural analgesia was frequently performed for pain control of lung cancer surgery. Moreover, we also showed that epidural analgesia might not affect important clinical outcomes after lung cancer surgery such as 30-day mortality, fatal respiratory events, and one-year mortality. This is the first study to describe the factors associated with the use of epidural analgesia for lung cancer surgery using real-world data based on a national registration database.

The efficacy of epidural analgesia in lung cancer surgery remains controversial [14]. As the thoracic epidural technique is a high-risk procedure that may cause dural puncture, epidural hematoma, or nerve damage [15], IV analgesia has been used for postoperative pain control in VATS as a less invasive technique. Kim et al. [16] reported that IV and epidural analgesia are equally effective for pain control in VATS lobectomy. Moreover, paravertebral block could be used instead of epidural analgesia for effective pain control in VATS [17]. In South Korea, the proportion of VATS among lung cancer surgeries has increased from 64.5% (3,535/5,479) in 2011 to 91.4% (9,106/9,959) in 2018 (Supplementary Fig. 1). The increasing trend of VATS in South Korea may have affected the decrease in epidural analgesia since 2016.

A wider surgical extent, such as pneumonectomy, bilobectomy, and lobectomy, might affect the preference for epidural analgesia in South Korea. In addition to postoperative pain control, epidural analgesia protects against pneumonia after lung cancer surgery [18]. Pneumonectomy for lung cancer is a high-risk procedure, and epidural analgesia lowers the risk of respiratory complications after pneumonectomy [19]. Thus, the anesthesiologists and thoracic surgeons used epidural analgesia for lobectomy, bilobectomy, and pneumonectomy more than for wedge resection and segmentectomy. Similarly, increased CCI with comorbid status might affect the clinician's preference for epidural analgesia because patients with many underlying diseases have a high risk of pneumonia after lung cancer surgery [20]. Therefore, patients with lung cancer in addition to many other underlying diseases need epidural analgesia to prevent pneumonia after lung cancer surgery.

Importantly, epidural analgesia was not associated with clinical outcomes after lung cancer surgery, such as 30-day mortality, fatal respiratory events, or one-year mortality. This is a clinically important result because epidural analgesia is known to reduce pulmonary complications after lung cancer surgery [19,20]. A retrospective cohort study from a single medical center in Taiwan reported that thoracic epidural analgesia was not associated with better recurrence-free or overall survival in patients who underwent lung cancer surgery [21]. Moreover, in a recent randomized trial by Xu et al. [22] epidural analgesia did not improve overall, recurrence-free, or cancer-specific survival after major lung cancer surgery. In addition to the previous reports [21,22], the present epidemiological study conducted in South Korea also showed that the impact of epidural analgesia on clinical outcomes after lung cancer surgery was not significant.

This study had several limitations. First, preoperative lung function was not evaluated because of a lack of data in the NHIS database. For example, the forced expiratory volume per second was not used in this study. Second, lifestyle factors, such as alcohol consumption and smoking history, were not evaluated due to a lack of data sources. Third, the tumor stage of lung cancer was not provided in this study, which could have affected the use of epidural anesthesia and mortality after lung cancer surgery. Finally, generalizability might be limited because medical and insurance systems differ according to the country. For example, patients with lung cancer in South Korea had to pay approximately 5% of the total treatment expense, including epidural analgesia, due to financial support from the NHIS.

In conclusion, from 2011 to 2018, 41.3% of patients with lung cancer in South Korea received epidural analgesia for lung cancer surgery. Some factors (male sex, increased CCI, concurrent musculoskeletal disease, wider surgical extent, and VATS) were associated with the use of epidural analgesia in lung cancer surgery. Moreover, epidural analgesia was not associated with clinical outcomes (30-day mortality, fatal respiratory events, or one-year mortality) after lung cancer surgery. However, considering the limitations of this study, it is not clearly known if the effect could be similar to that of epidural analgesia if appropriate pain control is performed in patients who did not receive epidural analgesia. Therefore, future study is needed for evaluating the effect of epidural analgesia on clinical outcomes after lung cancer surgery.

Funding

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Author Contributions

Tak Kyu Oh (Conceptualization; Data curation; Formal analysis; Writing – original draft)
In-Ae Song (Conceptualization; Methodology; Project administration; Writing – review & editing)

Supplementary Materials

Supplementary Table 1. The ICD-10 codes
Supplementary Fig. 1. The trends of VATS from 2011 through 2018 in South Korea

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References

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2018; 68: 394-424.
2. Barta JA, Powell CA, Wisnivesky JP. Global epidemiology of lung cancer. Ann Glob Health 2019; 85: 8.
3. Wang Z, Hu L, Li J, Wei L, Zhang J, Zhou J. Magnitude, temporal trends and inequality in global burden of tracheal, bronchus and lung cancer: findings from the Global Burden of Disease Study 2017. BMJ Glob Health 2020; 5: e002788.
4. Jones GS, Baldwin DR. Recent advances in the management of lung cancer. Clin Med (Lond) 2018; 18(Suppl 2): S41-6.
5. Bendixen M, Jørgensen OD, Kronborg C, Andersen C, Licht PB. Postoperative pain and quality of life after lobectomy via video-assisted thoracoscopic surgery or anterolateral thoracotomy for early stage lung cancer: a randomised controlled trial. Lancet Oncol 2016; 17: 836-44.
6. Handy JR Jr, Asaph JW, Skokan L, Reed CE, Koh S, Brooks G, et al. What happens to patients undergoing lung cancer surgery? Outcomes and quality of life before and after surgery. Chest 2002; 122: 21-30.
7. Obuchi T, Yoshida Y, Moroga T, Miyahara N, Iwasaki A. Postoperative pain in thoracic surgery: re-evaluating the benefits of VATS when coupled with epidural analgesia. J Thorac Dis 2017; 9: 4347-52.
8. Okuda J, Suzuki T, Wakaizumi K, Kato J, Yamada T, Morisaki H. Effects of thoracic epidural anesthesia on systemic and local inflammatory responses in patients undergoing lung cancer surgery: a randomized controlled trial. J Cardiothorac Vasc Anesth 2022; 36: 1380-6.
9. Ng A, Swanevelder J. Pain relief after thoracotomy: is epidural analgesia the optimal technique? Br J Anaesth 2007; 98: 159-62.
10. Dziedzic D, Orlowski T. The role of VATS in lung cancer surgery: current status and prospects for development. Minim Invasive Surg 2015; 2015: 938430.
11. Steinthorsdottir KJ, Wildgaard L, Hansen HJ, Petersen RH, Wildgaard K. Regional analgesia for video-assisted thoracic surgery: a systematic review. Eur J Cardiothorac Surg 2014; 45: 959-66.
12. Lüchtenborg M, Riaz SP, Coupland VH, Lim E, Jakobsen E, Krasnik M, et al. High procedure volume is strongly associated with improved survival after lung cancer surgery. J Clin Oncol 2013; 31: 3141-6.
13. Freise H, Van Aken HK. Risks and benefits of thoracic epidural anaesthesia. Br J Anaesth 2011; 107: 859-68.
14. Goto T. What is the best pain control after thoracic surgery? J Thorac Dis 2018; 10: 1335-8.
15. Giebler RM, Scherer RU, Peters J. Incidence of neurologic complications related to thoracic epidural catheterization. Anesthesiology 1997; 86: 55-63.
16. Kim JA, Kim TH, Yang M, Gwak MS, Kim GS, Kim MJ, et al. Is intravenous patient controlled analgesia enough for pain control in patients who underwent thoracoscopy? J Korean Med Sci 2009; 24: 930-5.
17. Ding X, Jin S, Niu X, Ren H, Fu S, Li Q. A comparison of the analgesia efficacy and side effects of paravertebral compared with epidural blockade for thoracotomy: an updated meta-analysis. PLoS One 2014; 9: e96233.
18. Popping DM, Elia N, Marret E, Remy C, Tramer MR. Protective effects of epidural analgesia on pulmonary complications after abdominal and thoracic surgery: a meta-analysis. Arch Surg 2008; 143: 990-9.
19. Licker M, Spiliopoulos A, Frey JG, Robert J, Höhn L, de Perrot M, et al. Risk factors for early mortality and major complications following pneumonectomy for non-small cell carcinoma of the

 https://doi.org/10.4097/kja.22089

lung. Chest 2002; 121: 1890-7.
20. Simonsen DF, Søgaard M, Bozi I, Horsburgh CR, Thomsen RW. Risk factors for postoperative pneumonia after lung cancer surgery and impact of pneumonia on survival. Respir Med 2015; 109: 1340-6.
21. Wu HL, Tai YH, Chan MY, Tsou MY, Chen HH, Chang KY. Effects of epidural analgesia on cancer recurrence and long-term mortality in patients after non-small-cell lung cancer resection: a propensity score-matched study. BMJ Open 2019; 9: e027618.
22. Xu ZZ, Li HJ, Li MH, Huang SM, Li X, Liu QH, et al. Epidural anesthesia-analgesia and recurrence-free survival after lung cancer surgery: a randomized trial. Anesthesiology 2021; 135: 419-32.