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Increasing Patient Complexity Is Associated With Longer In-Hospital Lengths of Stay and Higher Rates of Medical Complications Following Primary 1- to 2-Level Lumbar Fusion

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ABSTRACT

Background: The Elixhauser Comorbidity Index (ECI) is a stratification tool to predict adverse surgical outcomes. No studies have explored the relationship between ECI and outcomes following primary 1- to 2-level lumbar fusion (1-2LF). The purpose was to determine whether an ECI score greater than 1 correlated with (1) longer in-hospital length of stay (LOS) and (2) greater odds of developing 90-day medical complications.

Methods: A retrospective review from 2004 to 2015 was performed using the Medicare Standard Analytical Files for patients undergoing primary LF. Patients with ECI scores from 2 to 5 served as the study cohorts (1 for each ECI score), and patients with an ECI score of 1 served as the control cohort. In-hospital LOS and 90-day medical complications were compared between cohorts. A P value of <0.001 was statistically significant.

Results: A total of 105,120 patients were equally distributed between the 5 cohorts. Patients with an ECI score of 2 (6.00 ± 4.51), ECI 3 (6.22 ± 4.67), ECI 4 (7.35 ± 5.05), or ECI 5 (8.99 ± 5.67) had longer in-hospital LOS compared with patients with an ECI score of 1 (4.28 ± 4.36) (all $P < 0.001$). Patients with an ECI score of 2 (OR: 1.17, 95% CI: 1.05–1.30, $P = 0.003$; 2.85% vs 2.45%), ECI 3 (OR: 1.22, 95% CI: 1.10–1.36, $P < 0.001$; 2.98% vs 2.45%), ECI 4 (OR: 1.26, 95% CI: 1.13–1.40, $P < 0.001$; 3.10% vs 2.45%), or ECI 5 (OR: 1.18, 95% CI: 1.06–1.31, $P = 0.001$; 2.89% vs 2.45%) had greater incidence and odds of 90-day medical complications such as pneumonia, deep vein thrombosis, cerebrovascular accidents, and myocardial infarctions than patients in the control group (all $P < 0.0001$).

Conclusions: Increasing ECI score was associated with longer in-hospital LOS and increased 90-day medical complication rates following 1-2LF. This study is the first to establish a correlation between ECI score, in-hospital LOS, and complication rates following lumbar fusion.

Clinical Relevance: ECI score may assist physicians in adjusting pre- and postoperative care for complex patients undergoing 1-2LF.

Level of Evidence: 3.

Lumbar Spine

Keywords: Elixhauser Comorbidity Index, lumbar fusion, patient complexity, complications, length of stay, spine

INTRODUCTION

Lumbar fusion (LF) procedures are being performed at a higher rate and on an older patient population than ever before.[1–3] The increasing age of patients undergoing LF is accompanied by increasing complexity and comorbidity burden.[3] This is an extremely important trend to explore, as patient complexity significantly influences complication rates as well as overall hospital costs.[4–12] The accuracy of comorbidity indices that rely on administrative data is therefore frequently evaluated, and both national and international studies have shown that comorbidity indices can predict complication rates and adverse outcomes.[4–10,13–23] As the volume of LF procedures performed, patient age and patient complexity increase, it is necessary for hospitals to implement risk stratification methods to accurately predict patient outcomes.[1–3]

Perhaps the most widely utilized comorbidity index for administrative database studies is the Elixhauser Comorbidity Index (ECI). The ECI, developed in 1998, consists of 30 comorbidity measures associated with increased length of stay (LOS), hospital charges, and perioperative complications.[24] The ECI is unique in that it includes comorbidities not addressed in other indices such as mental health disorders, drug and alcohol abuse,

obesity, weight loss, and fluid and electrolyte disorders.[24] Since its inception, the ECI has consistently been shown to be a better predictor of adverse outcomes than the Charlson Comorbidity Index (CCI), Modified Frailty Index, and American Society of Anesthesiologists (ASA) physical status score.[4,13–23] As it pertains specifically to spine surgery, the ECI has outperformed the CCI and other comorbidity indices at predicting adverse events following cervical fusion and LF procedures.[16,17,21,22] Although there is much literature comparing comorbidity indices, there is insufficient research on how ECI scores correlate with perioperative outcomes following LF.[4,8,9,13–23] Higher ECI scores have been associated with a greater likelihood of 90-day medical complications and longer LOS after total knee arthroplasty.[5] This trend has also been demonstrated following total hip arthroplasty, as higher ECI scores correlated with longer LOS, increased 90-day medical complications, higher 90-day readmissions, and more prostheses-related complications.[10] While this relationship has been studied within the total joint arthroplasty literature, the association of increasing ECI scores with in-hospital LOS and adverse events within the episode of care interval following primary 1- to 2-level LF (1-2LF) has not been thoroughly elucidated.

Given the increase in LF surgeries being performed on increasingly complex patients, it is important that we understand the impact of comorbidities on patient outcomes following these procedures.[1–3] The purpose of this study is to determine whether higher patient complexity, determined by an ECI score of 2 to 5, is associated with worse outcomes compared with less complex patients with an ECI score of 1 following 1-2LF. Specifically, this retrospective study compared: (1) in-hospital LOS and (2) rates of 90-day medical complications.

MATERIALS AND METHODS

Data Source

A retrospective level III case-control study using the Parts A and B 100% Medicare Standard Analytical Files from 1 January 2005 to 31 March 2014, of the PearlDiver database (PearlDiver Technologies, Fort Wayne, Indiana) was performed. The syntax-based language is a subscription-based platform, which provides principal investigators and researchers access to more than 120 million patients within the Medicare and private payer claims database known as Mariner. Investigators can choose to query from either cohort. Due to the large housing of patients within the database, PearlDiver has been used previously for spine-related studies. Information from the database is aggregated using *I*nternational Classification of Diseases, Ninth Revision codes. The information is then downloaded as a Microsoft Excel spreadsheet for future analyses. Because the downloaded information does not contain any patient information, the study was exempt from our institution's Institutional Review Board approval process.

Cohorts

Patients undergoing primary LF were identified using International Classification of Diseases, Ninth Revision, procedural codes 81.04 to 81.08. From this cohort, patients who underwent 1 to 2 levels of fusion were identified using procedural code 81.62. Patients who underwent LF for traumatic injuries, infections, or malignancies were excluded. From this sample, using the "FILTER" command of PearlDiver patients with an ECI score of 1 to 5 was filtered using 1-point increments. As such, a total of 5 different cohorts were formed with patients having an ECI score of 1 being the comparison cohort, and patients with higher scores being the study cohorts. Each study group was individually matched in a 1:1 ratio by age and sex to the ECI 1 cohort. After the matching process, there were a total of 105,120 patients (women = 56,216; men = 48,232; unknown = 672) equally distributed between the 5 cohorts (Table 1).

Variables of Interest

Primary endpoints of this study were to compare in-hospital LOS and 90-day medical complications between the study cohorts and comparison cohort. The 90-day medical complications analyzed included the following: acute kidney injuries, cerebrovascular accidents (CVAs), deep vein thromboses (DVTs), ileus episodes, myocardial infarctions (MIs), pneumoniae, pulmonary emboli, respiratory failure, transfusion of blood products, urinary tract infections, and venous thromboemboli. A comprehensive

Table 1. Demographics of patients undergoing primary 1- to 2-level lumbar fusion with an Elixhauser Comorbidity Index score of 1 to 5 within the Medicare database.

Demographics	*n* (%)
Age, y	
<64	23,040 (21.91%)
65–69	44,660 (42.48%)
70–74	21,160 (20.12%)
75–79	10,760 (10.23%)
80–84	3952 (3.75%)
>85	876 (0.83%)
Unknown	672 (0.63%)
Sex	
Women	56,216 (53.47%)
Men	48,232 (45.88%)
Unknown	672 (0.63%)

Table 2. Comparison of in-hospital length of stay among patients with an ECI score of 1 to 5 undergoing primary 1- to 2-level lumbar fusion within the Medicare database.

Comparison	Mean ± SD		*P* Value
	Control Group	Study Group	
ECI 1 vs ECI 2	4.28 ± 4.36	6.00 ± 4.51	<0.001
ECI 1 vs ECI 3	4.28 ± 4.36	6.22 ± 4.67	<0.001
ECI 1 vs ECI 4	4.28 ± 4.36	7.35 ± 5.05	<0.001
ECI 1 vs ECI 5	4.28 ± 4.36	8.99 ± 5.67	<0.001

Abbreviation: ECI, Elixhauser Comorbidity Index.

comparison on the rates of these complications was analyzed, and individual rates of the 3 leading complications were also assessed. Ninety days was chosen as the time interval for adverse events to be compliant with the bundled payment care initiative set in place by the Centers for Medicare and Medicaid Services.

Data Analyses

Baseline demographics of the individual cohorts were compared using χ^2 analyses or Fisher's exact test, when applicable. To determine the association of ECI on 90-day medical complications, logistic regression analyses were used to calculate the OR and 95% CI on the individual complications. Due to the ease of finding statistical significance in large database registries, a Bonferroni correction was performed to reduce the probability of a type I error. As such, a *P* value less than 0.001 was considered to be statistically significant.

RESULTS

In-Hospital LOS

Patients with an ECI score of 2 (6.00 ± 4.51 vs 4.28 ± 4.36, $P < 0.001$), ECI 3 (6.22 ± 4.67 vs 4.28 ± 4.36, $P < 0.001$), ECI 4 (7.35 ± 5.05 vs 0.28 ± 4.36, $P < 0.001$), or ECI 5 (8.99 ± 5.67 vs 4.28 ± 4.36, $P < 0.001$) were found to have significantly longer in-hospital LOS compared with patients with an ECI score of 1 (Table 2).

Rates of 90-Day Medical Complications

Patients undergoing primary 1-2LF with an ECI score of 3 (OR: 1.22, 95% CI: 1.10–1.36, $P < 0.001$; 2.98% vs 2.45%), ECI 4 (OR: 1.26, 95% CI: 1.13–1.40, $P < 0.001$; 3.10% vs 2.45%), or ECI 5 (OR: 1.18, 95% CI: 1.06–1.31, $P = 0.001$; 2.89% vs 2.45%) were significantly more likely to develop 90-day medical complications compared with patients with an ECI score of 1 (Table 3). Patients with an ECI of 2 (OR: 1.17, 95% CI: 1.05–1.30, $P = 0.003$; 2.85% vs 2.45%) trended toward significance.

The incidence of acute posthemorrhagic anemia, DVT, urinary tract infection, and postoperative infection all increased with increasing ECI scores. The most common medical complications seen in patients included in analyses were pneumoniae, DVTs, CVAs, and MIs. When comparing incidence of adverse events, there was a significant difference in rates of developing pneumonia ($P < 0.0001$), DVTs ($P < 0.0001$), CVAs ($P < 0.0001$), and MIs ($P < 0.0001$) in patients with ECI scores greater than 1 compared with patients with an ECI score of 1 (Table 4).

DISCUSSION

The volume of LF procedures is drastically increasing, and these procedures are being performed on older, more complex patients.[1–3] Despite this trend and the evidence that ECI may be the most accurate comorbidity index in terms of predicting adverse outcomes, there has been no research evaluating the relationships between increasing ECI scores, in-hospital LOS, and adverse events following 1-2LF.[5,7–10,13–22] Using a large, nationwide database, this study demonstrates that patients with ECI scores greater than 1 have a higher in-hospital LOS and are at an increased risk of developing complications within 90 days of 1-2LF compared with patients with an ECI score of 1.

Our findings are consistent with the previous total joint arthroplasty studies that have demonstrated a correlation between patient complexity, LOS, and 90-day complication rates.[5,10] In a study of 715,398 patients who underwent total knee arthroplasty, Anis et al[5] found that patients with an ECI score greater than 1 were more likely to develop medical complications within 90 days of the procedure and had significantly longer LOS than patients with an ECI score of 1. Guntaka et al[10] had similar results in a study evaluating patients undergoing total hip arthroplasty. They

Table 3. Comparison of 90-d medical complications of patients with an ECI score of 1 to 5 undergoing primary 1- to 2-level lumbar fusion in the Medicare database.

Comparison	Control Group, %	Study Group, %	OR	95% CI	*P* Value
ECI 1 vs ECI 2	2.45%	2.85%	1.17	1.05–1.30	0.003
ECI 1 vs ECI 3	2.45%	2.98%	1.22	1.10–1.36	<0.001
ECI 1 vs ECI 4	2.45%	3.10%	1.26	1.13–1.40	<0.001
ECI 1 vs ECI 5	2.45%	2.89%	1.18	1.06–1.31	0.001
Total	9.80%	11.82%	1.22	1.16–1.30	<0.001

Abbreviation: ECI, Elixhauser Comorbidity Index.

Table 4. Incidence trends of most common medical complication among patients with an ECI score of 1 to 5 undergoing primary 1- to 2-level primary lumbar fusion within the Medicare database.

Medical Complication	Incidence of Medical Complications Based on ECI Score, %					*P* Value
	ECI 1	ECI 2	ECI 3	ECI 4	ECI 5	
Pneumoniae	0.13%	0.25%	0.24%	0.31%	0.22%	<0.0001
Deep vein thromboses	0.05%	0.06%	0.06%	0.06%	0.11%	<0.0001
Cerebrovascular accidents	0.28%	0.33%	0.40%	0.46%	0.40%	<0.0001
Myocardial infarctions	0.19%	0.24%	0.27%	0.30%	0.32%	<0.0001
Total	0.65%	0.88%	0.97%	1.13%	1.05%	<0.0001

Abbreviation: ECI, Elixhauser Comorbidity Index.

found that patients with ECI scores greater than 1 had significantly higher in-hospital LOS, 90-day medical complication rates, 90-day readmission rates, and implant-related complications compared with those with an ECI score of 1. These studies both underscore the potential value of using ECI as a predictor of adverse perioperative outcomes following joint arthroplasty, but our study is the first to evaluate the association between ECI, LOS, and complications following 1-2LF.

Several studies have examined the relationship between comorbidity index score and patient outcomes following other surgeries of the spine.[8,9,25] Khechen et al[8] previously established a correlation between CCI score and inpatient complication rate following minimally invasive transforaminal lumbar interbody fusion but found no relationship between CCI scores and LOS. Many studies have shown ECI to be superior to CCI as a predictor of adverse outcomes,[13–23] which may explain the differences between the results of our study and theirs. Additionally, the researchers only included complications during inpatient stays rather than a 90-day complication window, so true complication rates following the procedure may have been underreported. Finally, with a sample size of only 298 patients, the results of their study are less generalizable to the average spine surgeon. In a similar attempt, Mannion et al[9] discovered a correlation between increasing ASA score and complication rates following lumbar or lumbosacral spine surgery. However, the researchers used ASA grade as a comorbidity measure, which, like CCI, has been shown to be a less accurate predictor of adverse outcomes than ECI.[13–23] Additionally, the researchers did not specify the types of surgeries performed, only the region of the spine, so there is no way of knowing the complication rates of specific procedures. Because we used a superior comorbidity burden measure (ECI score) as our independent variable, analyzed complication rates over a period of 90 days, included a generalizable sample size of 105,120 patients, and only evaluated patients who had undergone 1-2LF, our study addresses many of the shortcomings of previous research on this topic.

This study has some limitations for consideration. As with any comorbidity index, the ECI relies on administrative data.[24] With administrative database studies, it is difficult to know the severity of a patient's comorbidity, when a comorbidity first arose, which comorbidities have the greatest influence on patient outcomes, and there may also be inconsistent coding between databases.[24] Additionally, our study population consisted of patients with ECI scores ranging from 1 to 5 even though the full range of ECI scores extends beyond this range , thus limiting the scope of patient complexity included in analyses. Despite these limitations, 90-day complication rates and in-hospital LOS were significantly lower in patients with an ECI score of 1 compared with patients with an ECI score of 2 to 5.

CONCLUSIONS

As the volume of LF procedures performed and patient complexity increase, it is important for providers to understand the relationship between comorbidities and perioperative outcomes so they may appropriately adjust patients' pre- and postoperative care. Our study is the first to establish an association between increasing ECI scores with longer LOS and higher 90-day complication rates following 1-2LF. Future research should focus on identifying specific comorbidities that have the largest effect on patient outcomes and determine which modifications to pre- and postoperative care can lower complication rates in complex patients.

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