Risk factors for post-discharge complications and readmissions in home-discharges after elective posterior lumbar fusions

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ABSTRACT

Objectives: Previous literature has studied overall post-operative outcomes following lumbar fusions. We examined the rates and risk factors for adverse outcomes in patients who are being discharged home.
Patients and methods: The 2012–2016 ACS-NSQIP database was used to query for patients undergoing 1- to 2-level posterior lumbar fusions (PLFs) for degenerative spinal pathology. Patients discharged to a destination other than home were removed from the database.
Results: Out of a total of 19,179 home-discharge patients, 546 (2.8%) experienced any adverse event (AAE), 276 experienced a severe adverse event (SAE) and 321 (1.7%) experienced a minor adverse event (MAE). Overall re-admission and re-operation rate in home-discharged patients was 4.4% and 2.5%. Multivariate analysis identified the following predictors for experiencing an AAE – Bleeding disorder (OR 2.25), BMI ≥ 35.0 vs. BMI < 25 (OR 1.96), chronic steroid use (OR 1.89), a LOS > 3 days (OR 1.53), insulin-dependent diabetes mellitus (OR 1.44), hypertension (OR 1.28) and female gender (OR 1.24). Patients with a pre-discharge complication (OR 2.12), bleeding disorders (OR 1.84), chronic steroid use (OR 1.55), age > 75 (OR 1.49), age > 65 (OR 1.26), history of severe COPD (OR 1.43), total operative time > 210 min. (OR 1.26), ASA > II (OR 1.26) and undergoing a 2-level fusion (OR 1.21) were likely to be re-admitted from home.
Conclusions: Providers should utilize the data to risk-stratify and better understand the need of provision of supplemental health-care services, in home-discharged patients, and/or regular clinic follow-up to minimize the rate of adverse events and reduce costs in a bundled-payment environment.

1. Introduction

Concurrent with expanding indications and technological innovations, there has been a dramatic increase in the utilization of lumbar fusions for the management of degenerative spinal pathologies in the elderly. From an economic point-of-view, according to a recent national report, the annual number of elective lumbar fusions has risen more than 62%, with aggregate hospital costs associated with surgery increasing by 177% from 2004 to 2015 [1]. Given the unsustainable trajectory associated with healthcare spending for this surgery, there has been a recent push towards identifying areas where costs can be optimized or reduced in order to bring about value in care [2].

Post-acute care following spine surgery has been shown to not only be a significant driver of cost-variation in 90-day payments following elective spine surgery [3–5], but also have a negative impact on post-discharge outcomes [6]. As providers begin to realize the marginal cost-impacts associated with the utilization of post-acute care facilities in spine surgical bundled episodes of care, it is anticipated that the construction of tailored care-pathways will allow an increasing number of patients to go home after elective spinal fusions. However, the success of such home-discharge care pathways rely on careful patient selection and appropriate pre-operative planning to avoid the occurrences of untoward adverse events in a home-setting, that may lead to costly readmissions and/or emergency department visits.

In the light of the latter observations, the current study uses a national surgical database to quantify the rates and risk factors associated with adverse post-discharge 30-day outcomes in patients being sent home following elective 1-to 2-level posterior lumbar fusions for degenerative spine pathology. Understand these risk factors will allow providers to identify individuals who may not benefit from a home-discharge and would be more suitable for receiving supervised inpatient care in a facility.

2. Materials and methods

2.1. Database and patient selection

This was a retrospective review of prospectively collected data from the 2012–2016 American College of Surgeons – National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP is a comprehensive surgical registry contained outcomes-based data from more than 500 participating hospitals across the United States [7]. The database is known to have a high accuracy and/or validity due to a strict audit/review process, the details of which can be found on the official ACS-NSQIP website (https://www.facs.org/quality-programs/acs-nsqip).

The 2012–2016 ACS-NSQIP was queried using *Current Procedural Terminology* codes 22612, 22,630 and 22633to retrieve records of patients undergoing posterior lumbar fusions. CPT codes 22614, 22,632 and 22,634 were used to identify 2-level fusion. Patients undergoing a fusion due to deformity, malignancy and/or fracture were removed from the study sample as these patients would likely have different post-acute care needs as compared to elective patients undergoing a 1- to 2-level posterior lumbar fusion for degenerative spine pathology. Only patients being discharged home following the surgery were included in the final cohort.

2.2. Outcomes studied

Complications and/or adverse events were categorized into two groups – pre-discharge and post-discharge. For ease of referral, 30-day post-discharge outcomes were grouped in the following categories – severe adverse event (SAE), minor adverse event (MAE) or any adverse event (AAE). SAEs included occurrences of deep surgical site infections (SSIs), organ/space SSIs, wound dehiscence, unplanned intubation, pulmonary embolism, deep venous thrombosis, post-operative ventilator use > 48 h, progressive renal insufficiency, acute renal failure, stroke, cardiac arrest, myocardial infarction, sepsis and/or septic shock. MAEs included incidents of superficial SSIs, urinary tract infection, pneumonia and bleeding requiring transfusions. AAE recorded the presence of either a SAE or MAE within 30 days of the surgery. Readmissions and re-operations within 30-days of the surgery were also analyzed as part of the study.

2.3. Statistical analysis

Descriptive analysis was performed to report the frequencies/rates of AAEs, SAEs and MAEs following elective 1-to 2-level posterior lumbar fusions. Uni-variate analysis using Pearson-chi square tests were used to identify significant associations between baseline clinical characteristics of the study population and occurrences of adverse events. All variables with a p-value of less than 0.1 were then included in a multi-variate logistic regression model to identify significant independent predictors associated with adverse outcomes. Results from regression models have been reported as adjusted odds ratio (OR) and 95% confidence intervals (CI). For statistical purposes, a p-value of less than 0.05 was considered significant. All analysis was performed using SPSS v24 (IBM, Armonk, NY).

3. Results

3.1. Baseline characteristics

Following application of inclusion/exclusion criteria, a total of 19,179 elective 1-to 2-level posterior lumbar fusions were found to have been discharged to home. More than 65% of patients undergoing a home discharge were below the age of 65 years. Nearly 50% of home-discharge patients had a BMI < 30 kg/m². Majority of patients undergoing a home-discharge underwent a 1-level fusion (76.1%), and

Table 1
Pre-Operative, Operative and Post-operative clinical characteristics of the study population.

Clinical Characteristics of patients being discharged 'Home'	Frequency (%)
Age(years)	
0–50	4945 (25.8%)
51–65	7842 (40.9%)
66–75	4871 (25.4%)
> 75	1521 (7.9%)
Gender	
Male	9189 (47.9%)
Female	9990 (52.1%)
Race	
White	16094 (83.9%)
Black or African-American	1478 (7.7%)
American Indian or Alaska Native	117 (0.6%)
Native Hawaiian or Pacific	303 (1.6%)
Unknown/Not Reported	1187 (6.2%)
Body Mass Index/BMI(kg/m2)	
≤24.99	3186 (16.6%)
25.0–29.99	6367 (33.2%)
30.0–34.99	5351 (27.9%)
≥35.00	4275 (22.3%)
Co-Morbidities	
Diabetes Mellitus	
- IDDM	917 (4.8%)
- NIDDM	2178 (11.4%)
Smoking within the past one year	4299 (22.4%)
Dypsnea	
- At Rest	35 (0.2%)
- With moderate exertion	953 (5.0%)
Functional health status prior to surgery	
- Independent	18883 (98.5%)
- Partially Dependent	192 (1.0%)
- Totally Dependent	6 (~0%)
- Unknown	98 (0.5%)
Ventilator Dependent	3 (~0%)
History of Severe COPD	797 (4.2%)
CHF in 30 days before surgery	27 (0.1%)
Hypertension requiring medication	10419 (54.3%)
Acute Renal failure	1 (~0%)
Currently on Dialysis	16 (0.1%)
Disseminated Cancer	18 (0.1%)
Chronic Steroid Use	672 (3.5%)
> 10% weight loss in last 6 months	19 (0.1%)
Bleeding disorders	225 (1.2%)
Transfusion ≥1 units of Packed RBCS before surgery	13 (0.1%)
Type of Anesthesia	
General (GA)	19,098 (99.6%)
Spinal/Epidural/Other	81 (0.4%)
Admission Status	
Inpatient	18479 (96.4%)
Outpatient	700 (3.6%)
ASA Class	
I-II	10543 (55.0%)
> II	8636 (45.0%)
Number of levels fused	
1 – Level	14592 (76.1%)
2 – Level	4587 (23.9%)
Posterior Instrumentation	13016 (67.9%)
Total Operative Time(mins)	
0–120	4110 (21.4%)
121–210	8584 (44.8%)
> 210	6485 (33.8%)
Length of stay(days)	
0–3 days	13609 (71.0%)
> 3 days	5570 (29.0%)
Any Pre-Discharge Complication	250 (1.3%)

had an ASA Classification of I or II (55.0%). A complete description of baseline demographic and clinical characteristics of the study population can be found in Table 1.

Table 2
Frequency of post-discharge adverse events in patients being discharge home following elective 1-to-2 level PLFs.

Post-discharge complications	Frequency (%)
Any adverse event (AAE)	546 (2.8%)
Severe adverse event (SAE)	276 (1.4%)
Deep SSI	86 (0.4%)
Organ/Space SSI	35 (0.2%)
Wound dehiscence	27 (0.1%)
Unplanned intubation	8 (~0%)
Pulmonary embolism	30 (0.2%)
Deep venous thrombosis	48 (0.3%)
Post-operative ventilator use > 48 hours	7 (~0%)
Progressive renal insufficiency	12 (0.1%)
Acute renal failure	4 (~0%)
Stroke	8 (~0%)
Cardiac arrest	7 (~0%)
Myocardial infarction	10 (0.1%)
Sepsis	67 (0.3%)
Septic Shock	14 (0.1%)
Minor adverse event (MAE)	321 (1.7%)
Superficial SSI	151 (0.8%)
Urinary tract infection	135 (0.7%)
Pneumonia	35 (0.1%)
Bleeding requiring transfusions	7 (~0%)
Readmission	836 (4.4%)
Re-operation	475 (2.5%)

Table 3
Multivariate analysis of risk factors for adverse events, re-operations and re-admissions in home-discharged patients.

Post-discharge event	Adjusted OR (95% CI)	P-value
Any adverse event		
- Female gender	1.24 [1.04–1.48]	0.016
- BMI ≥ 35 vs. BMI < 25	1.96 [1.46–2.64]	< 0.001
- IDDM	1.44 [1.04–1.99]	0.026
- Hypertension	1.28 [1.05–1.56]	0.017
- Chronic steroid use	1.89 [1.34–2.65]	< 0.001
- Bleeding disorder	2.25 [1.34–3.75]	0.002
- Length of stay > 3 days	1.53 [1.28–1.83]	< 0.001
Severe adverse event		
- BMI ≥ 35 vs. BMI < 25	2.35 [1.52–3.61]	< 0.001
- Hypertension	1.37 [1.04-1.79]	0.024
- Chronic steroid use	2.36 [1.53–3.63]	< 0.001
- 2-level vs. 1-level fusion	1.45 [1.12–1.87]	0.005
- Length of stay > 3 days	1.63 [1.27–2.09]	< 0.001
Minor adverse event		
- Female gender	1.42 [1.13–1.79]	0.003
- BMI ≥ 35 vs. BMI < 25	1.48 [1.03–2.12]	0.033
- IDDM	1.92 [1.30–2.84]	0.001
- Hypertension	1.36 [1.06–1.75]	0.017
- Chronic steroid use	1.96 [1.27–3.01]	0.002
- Bleeding disorder	2.19 [1.13–4.23]	0.020
- Black/African-American vs. White	0.53 [0.32–0.88]	0.014
- Length of stay > 3 days	1.50 [1.19–1.88]	0.001
Readmission		
- Chronic steroid use	1.55 [1.14–2.09]	0.005
- Bleeding disorders	1.84 [1.16–2.93]	0.010
- Age > 65 vs. age < 51	1.26 [1.01–1.57]	0.038
- Age > 75 vs. age < 51	1.49 [1.12–1.98]	0.006
- ASA > II	1.26 [1.07–1.47]	0.004
- Length of stay > 3 days	1.20 [1.03–1.40]	0.020
- history of severe COPD	1.43 [1.06–1.92]	0.018
- 2-level vs. 1-level fusion	1.21 [1.03–1.41]	0.017
- Operative time > 210 min.	1.26 [1.03–1.55]	0.027
- Pre-discharge complication	2.12 [1.40–3.22]	< 0.001
Re-operation		
- Chronic steroid use	1.60 [1.18–2.16]	0.002
- Bleeding disorders	1.89 [1.19–3.01]	0.007
- ASA > II	1.40 [1.20–1.63]	< 0.001
- Length of stay > 3 days	1.25 [1.07–1.46]	0.005
- Operative time > 210 min.	1.28 [1.06–1.58]	0.016
- Predischarge complication	2.22 [1.48–3.36]	< 0.001

3.2. Post-discharge 30-day adverse events

A total of 546 (2.8%) patients experienced an AAE following a home-discharge, with 276 (1.4%) experiencing a SAE and 321 (1.7%) experiencing a MAE. (Some patients experienced multiple SAEs and MAEs.) The most common SAEs was deep SSI (N = 86; 0.4%) followed by deep venous thrombosis (N = 48; 0.3%) and sepsis (N = 67; 0.3%). The most common MAEs were superficial SSI (N = 151; 0.8%) and UTI (N = 151; 0.7%). Frequencies of all MAEs and SAEs can be found in Table 2. Univariate analysis for risk factors associated with AAEs, MAEs and SAEs can be found in Supplementary Table 1. Following adjustment in multivariate logistic regression, significant risk factors associated with experiencing an AAE following discharge to a home were as follows (in decreasing order of effect size):- bleeding disorder (OR 2.25; p = 0.002), BMI ≥ 35 (OR 1.96; p < 0.001), chronic steroid use (OR 1.89; p < 0.001), length of stay > 3 days (OR 1.53; p < 0.001), 35 (OR 1.96; p < 0.001), chronic steroid use (OR 1.89; p < 0.001), length of stay > 3 days (OR 1.53; p < 0.001), presence of insulin-dependent diabetes mellitus (OR 1.44; p = 0.026), hypertension (OR 1.28; p = 0.017) and female gender (OR 1.24; p = 0.016) (Table 3).

Significant risk factors associated with occurrence of a SAE were chronic steroid use (OR 2.36; p < 0.001), BMI ≥ 35 (OR 2.35; p < 0.001), length of stay > 3 days (OR 1.63; p < 0.001), undergoing a 2-level vs. 1-level fusion (OR 1.45; p = 0.005) and hypertension (OR 1.37; p = 0.024). Significant risk factors associated with a MAE were bleeding disorder (OR 2.19; p = 0.020), chronic steroid use (OR 1.96; p = 0.002), insulin-dependent diabetes mellitus (OR 1.92; p = 0.001), length of stay > 3 days (OR 1.50; p = 0.001), BMI ≥ 35 (OR 1.48; p = 0.033), female gender (OR 1.42; p = 0.003) and hypertension (OR 1.36; p = 0.017) (Table 3).

3.3. Readmissions and reoperations

A total of 836 (4.4%) patients were readmitted from home, whereas 475 (2.5%) patients underwent a re-operation. Univariate analysis of risk factors associated with a readmission or reoperation can be found in Supplementary Table 2. Following multivariate analysis, independent risk factors associated with a readmission following a home discharge were (in decreasing order of effect size:- occurrence of a pre-discharge complication (OR 2.12; p < 0.001), bleeding disorders (OR

1.86; p = 0.010), chronic steroid use (OR 1.55; p = 0.005), age > 75 years (OR 1.49; p = 0.006), history of severe COPD (OR 1.43; p = 0.018), ASA > II (OR 1.26; p = 0.004), age > 65 years (OR 1.26; p = 0.038), operative time > 210 min. (OR 1.26; p = 0.027), undergoing a 2-level vs. a 1-level fusion (OR 1.21; p = 0.017) and a length of stay > 3 days (OR 1.20; p = 0.020). Significant risk factors associated with re-operations were occurrence of a pre-discharge complication (OR 2.22; p < 0.001), bleeding disorders (OR 1.89; p = 0.007), chronic steroid use (OR 1.60; p = 0.002), ASA > II (OR 1.40; p < 0.001), operative time > 210 min. (OR 1.28; p = 0.016) and a length of stay > 3 days (OR 1.25; p = 0.005) (Table 3). The top 3 most common reasons of reoperations were for incision/drainage procedures of skin/soft tissue/subcutaneous tissue/abscesses (28.6%), revision fusions (24.0%) and spinal decompressions (14.5%).

4. Discussion

When compounded together, the increasing utilization and costs of spine surgeries [8–10], as well as an anticipated growth in the population of elderly individuals requiring surgery due to low back pain, such a cost-burden is unsustainable for national healthcare system in the long run [1]. Reducing stays in post-acute care facilities, such as skilled nursing facilities and/or inpatient rehabilitation units, by discharging patients to home offers providers an easy way to reduce costs. However, appropriate patient selection will be a key factor underlying

the success of home-discharges. A majority of past studies analyzing risk factors for 30 day complications and readmissions following elective lumbar fusions do not distinguish/stratify outcomes based on the discharge destination [11–16]. Recent literature by Malik et al [6,17] and Khormaee et al [18] have not only shown that patients being discharged to post-acute care facilities to be distinct from home-discharge patients, but have also delineated that discharge to non-home facilities to be independently associated with higher rates of complications and readmissions. These findings call for a more stratified analysis focusing on outcomes in PLFs undergoing a home-discharge only, to better understand this low-risk, yet ever-growing, population. By analyzing a national cohort of 19,179 patients going home after an elective posterior lumbar fusion, our results show that 2.8% of patients experience an adverse event within a home-setting following discharge. Furthermore, a number of patient-level and operative-level factors are associated with higher odds of experience adverse outcomes within a home-discharge cohort.

A number of patient-level factors, such as presence of bleeding disorder, history of chronic steroid use, presence of hypertension, insulin-dependent diabetes mellitus (IDDM), higher BMI levels and female gender, were associated with experience an AAE following a home-discharge. Careful control of International Normalized Ratio (INR) levels, in patients with bleeding disorder, both pre-operatively and post-operatively, will be an effective way in mitigating risks of adverse outcomes. However, it is important to note that the NSQIP database does not provide further granular detail on bleeding disorders (i.e. was the patient on anti-coagulant or anti-platelet medications? Was the patient diagnosed with a genetic coagulation factor deficiency?). Prior literature has shown that female gender, presence of IDDM [19] and and higher BMI levels [20] were associated with adverse outcomes following elective posterior lumbar fusions [21]. A more enhanced surveillance follow-up, through supplementation of home-health services and/or dissemination of information regarding early signs of complications, particularly in the acute peri-operative period may be helpful in mitigating the rates of these untoward adverse events. Conversely, providers may also consider discharging these patients to inpatient-care facilities where they can undergo a higher level of supervised care, to ensure better outcomes.

It is interesting to note that among procedure-level and hospital-level factors, undergoing a more extensive/complex fusion (as evidenced by longer operative times/additional levels of fusion) and experiencing a pre-discharge complication were associated with higher rates of readmissions and re-operations. While these findings are intuitive in nature, providers should not over-look the need of inpatient care in these patients. Furthermore, occurrence of pre-discharge complications are mostly avoidable events that can be reduced by enhanced in-patient surveillance, pre-operative optimization of modifiable factors and/or pre-operative risk-stratification of patients. As the current healthcare system moves towards the implementation of bundled-payment models, the findings also notion the need of delaying elective PLFs in these high-risk patients, to ensure that several of the modifiable risk factors can be optimized before the surgery takes place. For instance, weaning patients off chronic steroid use, controlling HbA1C levels in diabetic individuals [22] and/or considering weight-loss strategies in obese patients will be an effective way of saving costs [23], through mitigation of post-operative complications and readmissions, in a value-based and cost-effective healthcare environment From a health policy perspective, pre-operative optimization of modifiable factors (such as obesity and/or diabetes) is particularly important. According to a recent national database study, modifiable co-morbidities, such as diabetes mellitus and obesity can increase the cost of a 90-day episode of care by $1000-$3000 [24]. Launching appropriate pre-operative optimization protocols and/or delaying surgery till patients are in a better health status will ultimately result in cost-savings for providers and hospital systems in a bundled-payment care environment.

Limitations to our study are primarily related to the database, and

the lack of granular spine-specific clinical information contained therein. First, the NSQIP dataset records complications and readmissions up to 30 days only. Given that certain complications, such as surgical site infections, are known to occur well beyond the 30-day period [25], future research revisiting the same idea with a dataset having the capability of a longer follow-up is warranted. It would also be useful to assess costs associated with complications, readmissions and emergency department (ED) visits following a home discharge; however that information is not available through the NSQIP, which solely relies on capturing surgical outcomes related data only, and lacks relevant cost and/or ED visit data. Even though the NSQIP database records a comprehensive list of co-morbidities, it does not specify whether pre-operative optimization for certain co-morbidities was performed. For instance, HbA1C values are not provided in the database that may be an indicator of glycemic control in individuals. Another limitation is that NSQIP database does not contain information with regard to provision of home health services in individuals, which would have been useful for including as part of the analysis. The NSQIP database relies on primary billing codes to identify causes of readmissions/reoperations, and therefore the exact indications of undergoing a revision fusion or decompression (such as fracture etc.) could not be determined.

Based off our findings, patients with a history of chronic steroid use, bleeding disorder, higher BMI grades, hypertension, insulin-dependent diabetes mellitus (IDDM), undergoing a complex surgery (e.g. 2-level fusion, longer operative times) and those experiencing a complication prior to discharge were likely to experience adverse events following discharge to a home environment. As the healthcare system moves toward increasing the proportion of home discharges, in an attempt to maximize cost-optimization in the post-acute care phase following elective lumbar spine surgery, understanding the risk profile of patients going home will be an effective tool to identify individuals who may experience adverse events in a home setting, and may benefit from continued inpatient care in a post-acute care facility.

Disclosures

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.clineuro.2019.105501.

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