Journal of Clinical Neuroscience xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Case report

Multivariable analysis of factors affecting length of stay and hospital charges after single-level corpectomy

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ARTICLE INFO

Article history:
Received 21 March 2017
Accepted 19 June 2017
Available online xxxx

Keywords:
Cervical vertebrae
Comorbidity
Hospital charges
Length of stay
Multivariate analysis

ABSTRACT

Anterior cervical corpectomy and fusion (ACCF) is commonly employed for treating myelopathy, deformity, and a variety of other cervical pathologies. Limited data are available on factors associated with longer hospitalization and higher hospital charges following ACCF. The purpose of this study was to evaluate the pre-, intra-, and postoperative variables that are associated with length of hospital stay and hospital charges for patients undergoing single-level anterior cervical corpectomy and fusion in a retrospective case series. We retrospectively identified from a clinical database 69 patients who underwent single-level ACCF at a single institution from 2010 through 2014. Demographic variables, clinical information, and intraoperative data were analyzed with respect to length of hospitalization and hospital charges. T-test and Chi-squared testing as well as univariate and multivariable analysis were performed with $p < 0.05$ considered significant. On multivariable analysis, polytrauma, postoperative complications, lower postoperative hematocrit, and two-staged procedures were significantly associated with longer lengths of stay. Length of stay, postoperative complications, and two-staged procedures were significantly associated with higher hospital charges. Patients undergoing a two-staged procedure and those having postoperative complications experience a longer postoperative length of stay and incur higher hospital charges. Avoidance of postoperative anemia may help to reduce length of stay following ACCF.

1. Introduction

Anterior cervical corpectomy and fusion (ACCF) has become a mainstay of treatment for a wide array of cervical pathologies ranging from cervical spondylotic myelopathy (CSM) to deformity correction [1]. While offering the benefit of maximal decompression and minimizing graft interfaces [2], the procedure is not without drawbacks [3]. In addition to the risks associated with the surgery itself, the costs associated with cervical surgery are substantial [4]. Although extensive work has been done establishing the safety profile [5,6] and arthrodesis rates of ACCF [7,8], significantly less information is available regarding factors driving the economics of the procedure. With attention increasingly focused on the "value" of surgical procedures [9], information about what factors influence drivers of cost such as length of stay (LoS) [10] and hospital charges becomes critical.

In this study, we examined various pre-, intra- and postoperative factors that may be associated with LoS and hospital charges after single-level ACCF through multivariable analysis.

2. Methods

2.1. Study population

After obtaining approval from the institutional review board, we queried a clinical database to obtain information about patients 18 years and older who underwent single-level ACCF between January 1, 2010, and December 31, 2014. This information was then confirmed and supplemented through individual chart review. All procedures were performed by experienced spine surgeons.

2.2. Data collection

Demographic, intraoperative, and postoperative information was collected on all patients. Demographic data included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) Physical Status Classification System Grade, active tobacco use, active alcohol use, preoperative opioid use, employment

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http://dx.doi.org/10.1016/j.jocn.2017.06.052
0967-5868/

status, marriage status, and insurance type. Relevant medical history including the presence of type 2 diabetes, hypertension, pulmonary comorbidities (i.e., asthma, chronic obstructive pulmonary disease, pulmonary embolism, bronchitis), cardiac comorbidities (i.e., atrial fibrillation, heart murmur, arrhythmia, myocardial infarction, coronary artery disease, congestive heart failure, mitral valve prolapse), previous cervical spine surgeries, preoperative hematocrit, and the presence of nonspinal malignancy. The preoperative diagnosis prompting surgical intervention was also recorded and used to classify patients into one of six categories (deformity, myelopathy, trauma, pathologic fracture, degenerative, or infection). The presence of polytrauma at the time of admission in trauma patients was also recorded.

Intraoperative variables included estimated blood loss, intraoperative crystalloid and colloid infusion volumes, and intraoperative complications. Each procedure was also assessed to determine whether an anterior cervical discectomy and fusion (ACDF) at a separate level was performed concurrently to the ACCF and whether a posterior fusion was performed concurrently or during the same hospitalization. Postoperative variables consisted of need for readmission within 30 days, postoperative complications, discharge destination, and postoperative hematocrit when available. Finally, hospital charge data were collected on all patients.

2.3. Statistical analysis

Continuous variables in all cases were analyzed using Student's *t*-test, while categorical variables were analyzed utilizing Chi-square analysis. We performed both univariate and multivariable analysis for LoS. For univariate analysis, LoS was dichotomized into "extended" (≥5 days) and "normal" (<5 days) based on mean LoS for the cohort. For multivariable analysis, LoS was examined as a continuous variable. Variables that demonstrated a $p < 0.05$ in univariate analysis were included in our multivariable model, with $p < 0.05$ being defined as statistically significant. For missing variables in our multivariable analysis (seven patients missing postoperative hematocrit data), we utilized multiple imputation with a Mersenne Twister active generator, a Monotone imputation scheme, and five imputed data sets for pooled analysis.

Both univariate and multivariable analysis were also performed for hospital charges. For univariate analysis, hospital charges were dichotomized into "high" (≥$92,000) and "normal" (<$92,000) based on mean charges for the cohort. For multivariable analysis, hospital charges were examined as a continuous variable. Variables that demonstrated a $p < 0.05$ in univariate analysis were included in our multivariable model, with $p < 0.05$ being defined as statistically significant. For missing variables in our multivariable analysis (three patients missing transfusion data, two patients missing operative time data, two patients missing preoperative hematocrit data, and seven patients missing postoperative hematocrit data), we utilized multiple imputation with a Mersenne Twister active generator, a Monotone imputation scheme, and five imputed data sets for pooled analysis.

All statistical analysis was performed using SPSS V20.0 (IBM Corporation, Armonk NY). The STROBE guidelines were used during the preparation of this work [11].

3. Results

3.1. Length of stay

Sixty-nine patients were identified who met our inclusion and exclusion criteria. Mean LoS for these patients was 4.9 days (95% confidence interval ±1.2 days). For our univariate analysis, 25 patients met the criterion for "extended" LoS and 44 met the criterion for "normal" LoS. Preoperatively, demographic factors were largely similar between the normal and extended-stay groups (Table 1), including age, BMI, sex, marital status, insurance type, and employment status. Patients in the extended-stay group were more likely to have higher preoperative ASA grades (64% vs. 36%, $p = 0.027$, Table 1) and to have had a previous cervical spine surgery (40% vs. 11%, $p = 0.006$). Extended-stay patients were also more likely to have surgery for a traumatic cause (24% vs. 7%, $p = 0.038$) and to suffer from polytrauma (31% vs. 0%, $p = 0.009$).

Intraoperatively, extended-stay patients were more likely to have surgery as part of a two-staged procedure (32% vs. 0%, $p < 0.001$). Other intraoperative variables including blood loss, surgical time, and rates of concurrent ACDF at other levels were similar between the two groups. Postoperatively, patients in the extended-stay group were more likely to suffer from postoperative complications (48% vs. 0%, $p < 0.001$). Complications occurred in 12 patients for a postoperative complication rate of 17%, the most common being dysphagia and urinary tract infection. Patients in the extended-stay group were also more likely to have lower postoperative hematocrit compared with those in the normal group (35.3 ± 5.8 vs. 38.6 ± 4.7, $p = 0.016$) and to discharge to a location other than home (76% vs. 16%, $p < 0.001$).

Variables that had a $p < 0.05$ in our univariate analysis were included in our multivariable logistic regression. Discharge destination, ASA category, polytrauma, postoperative complications, postoperative hematocrit, need for two-staged procedure, preoperative diagnostic category, and previous cervical spine surgery were incorporated into our model. Within this model, postoperative hematocrit, polytrauma, postoperative complications, and a two-staged surgery remained significantly associated with LoS (Table 2).

Average charges for the extended LoS group were significantly higher than that for the normal LoS group ($149,900.01, 95% CI ± $34,948.43 vs. $58,396.46, 95% CI ± $7,804.47, $p < 0.001$) but were not included in our multivariable analysis as we thought it was unlikely that charges had any causal affect on LoS.

3.2. Hospital charges

Mean hospital charge for our patient cohort was $91,549.92 (95% confidence interval ±$17,030.37). For our univariate analysis, 22 patients met the criteria for "high" hospital charges and 47 met the criterion for "normal" hospital charges. Preoperatively, patients in the high-charge group were more likely than the normal-charge group to have a preoperative traumatic diagnosis (27% vs. 6%, $p < 0.001$, Table 3), to suffer from polytrauma (23% vs. 0%, $p = 0.001$), and to have had a previous cervical spine procedure (41% vs. 13%, $p = 0.001$). Patients in the normal-charge group also had higher preoperative hematocrit values (43.6 ± 3.0 vs. 39.3 ± 7.3, $p = 0.001$).

Intraoperatively, high-charge patients were more likely to have a longer operative time (174.1 ± 114.9 min vs. 171.9 ± 107.3 min, $p = 0.034$) and to require blood transfusion (10% vs. 0%, $p = 0.036$). They were also less likely to have had a corpectomy without a concurrent ACDF (45% vs. 70%, $p = 0.048$) and more likely to have had their surgery as part of a two-staged procedure (36% vs. 0%, $p < 0.001$). Postoperatively, high-charge patients were significantly more likely to have postoperative complications (50% vs. 2%, $p < 0.001$), to have a longer LoS (10.0 ± 5.9 days vs. 2.5 ± 1.4 days, $p < 0.001$), and to discharge to a location other than home (77% vs. 19%, $p < 0.001$). Patients in the high-charge group also had significantly lower postoperative hematocrit values than those in the normal-charge group (33.7 ± 6.1 vs. 39.1 ± 4.0, $p < 0.001$).

Variables that had a $p < 0.05$ in our univariate analysis were included in our multivariable logistic regression. Length of stay, operative time, preoperative and postoperative hematocrit, lack of concurrent ACDF, two-staged procedure, diagnostic category,

Please cite this article in press as: Guan J et al. Multivariable analysis of factors affecting length of stay and hospital charges after single-level corpectomy. J Clin Neurosci (2017), http://dx.doi.org/10.1016/j.jocn.2017.06.052