Original Article

Does neurofibromatosis 1 status impact outcomes for pediatric/young adults undergoing spinal fusion?

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INTRODUCTION

Though rare, neurofibromatosis type 1 (NF1) is the most common autosomal dominant disorder found in humans. The patient presents with a heterogeneous range of clinical signs and symptoms. One of the most common and potentially debilitating factors in NF1 patients is the 38% incidence of spinal deformity (e.g., develop dystrophic or nondystrophic). [6]

Here, we evaluated whether, following spinal surgery, the short-term perioperative outcomes of pediatric/young adult patients with NF1 were inferior to those without NF1.
MATERIALS AND METHODS

Data source and patient population

Using the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, we retrospectively analyzed NF1 versus non-NF1 pediatric/young adult patients undergoing elective spinal fusions (2005–2014). We focused on the following major clinical variables: patient demographics, expected payer, diagnoses (e.g., pre- and post-operative diagnoses), procedures, length of stay (LOS), pre-, peri-, and post-operative risk factors associated with prolonged LOS, and nonroutine discharges with/without NF1.

Documentation of NF1

Documenting the diagnosis of NF1 was based on: International Classification of Disease (e.g. International Classification of Diseases-9, Ninth Revision [ICD-9] and ICD-9 clinical modification (ICD-9-CM) diagnosis and procedure codes), evaluation of all hospital discharges for pediatric and young adult patients ≤26 years of age with/without NF1, Type 1 (237.71), and patients undergoing elective Spinal Fusions (Procedures codes listed in Table 1).

Data collection

Patient demographics, comorbidities, perioperative variables postoperative events/complications, outcomes, LOS, and discharge dispositions, were excluding. In-hospital death and discharge against medical advice and complications were compared between NF1 and non-NF1 patients.

Statistical analysis

Counts and percentages were described for categorical variables for NF1 versus non-NF1 patients. Two-tailed Student’s t-tests were used to compare normally distributed continuous variables between NF1-status cohorts, while Mann–Whitney U-tests were used to compare nonnormally distributed continuous variables. Significance for all statistical tests was assessed with a threshold of \( P = 0.05 \). Due to the unbalanced disease status arms in our cohort, a propensity score (PS)-matched No NF1 cohort was generated.

RESULTS

Patient demographics

In our study, 238 (0.9%) had NF1 and 25,558 (99.1%) had no diagnosis of NF1 (No NF1) [Table 2], NF1 was more likely to receive an anterior surgical approach but less likely to undergo a 2–3 level vertebral fusion versus non-NF1 patients [Table 2].

Both patients groups had similar pre-, peri-, and postoperative clinical/other characteristics; age, sex, primary

| Procedure | ICD-9-CM |
|-----------|----------|
| Spinal fusion, not otherwise specified | 81.00 |
| Atlas-axis spinal fusion | 81.01 |
| Other cervical fusion, anterior technique | 81.02 |
| Posterior other cervical fusion, posterior technique | 81.03 |
| Dorsal and dorsolumber fusion, anterior technique | 81.04 |
| Dorsal and dorsolumber fusion, posterior technique | 81.05 |
| Lumbar and lumbosacral fusion, anterior technique | 81.06 |
| Lumbar and lumbosacral fusion, lateral transverse process technique | 81.07 |
| Lumbar and lumbosacral fusion, posterior technique | 81.08 |

ICD-9-CM: International classification of diseases-9 clinical modification

Table 2: Preoperative and perioperative variables.

| Demographic feature | NF1 (n=238) | No NF1 (n=25558) | P |
|---------------------|-------------|------------------|---|
| Age (median, IQR)   | 13 (10–15)  | 15 (13–19)       | <0.001* |
| Female              | 48.3        | 38.8             | <0.001* |
| Race                |             |                  |     |
| White               | 49.6        | 54.4             | 0.274 |
| Black               | 13.0        | 8.9              |     |
| Hispanic            | 11.3        | 9.5              |     |
| Asian/Pacific Islander | 3.4 | 1.9             |     |
| Native American     | 1.0         | 1.0              |     |
| Other race          | 2.1         | 4.0              |     |
| Income quartile     |             |                  |     |
| Q1                  | 25.2        | 18.7             | 0.913 |
| Q2                  | 16.8        | 21.2             |     |
| Q3                  | 20.6        | 22.6             |     |
| Q4                  | 22.3        | 24.2             |     |
| Payer               |             |                  |     |
| Medicare            | 0.4         | 0.6              | <0.001* |
| Medicaid            | 42.9        | 24.9             |     |
| Private insurance   | 47.9        | 63.8             |     |
| Self-pay            | 2.1         | 1.7              |     |
| No charge           | 0.8         | 0.3              |     |
| Other payment       | 5.9         | 8.4              |     |
| Preoperative morbidity |         |                  |     |
| Alcohol use disorder | 0           | 0.1              | 0.557 |
| Hypertension        | 3.4         | 2.3              | 0.249 |
| DM                  | 0           | 0.5              | 0.257 |
| Obese               | 0           | 3.9              | 0.002* |
| Smoking             | 0.8         | 6.7              | <0.001* |
| Hypercoagulable     | 0           | 0.2              | 0.546 |
| HF                  | 0           | 0.1              | 0.699 |
| Atrial fibrillation | 0           | 0                | 0.760 |
| COPD                | 1.3         | 0.2              | 0.002 |
| CKD                 | 0           | 0.2              | 0.503 |
| PVD                 | 0           | 0                | 0.738 |
| Liver disease       | 0.4         | 0.2              | 0.349 |

(Contd...)
Table 2: (Continued)

| Demographic feature | NF1 (n=238) | No NF1 (n=25558) | P     |
|---------------------|-------------|------------------|-------|
| Surgical approach   |             |                  |       |
| Anterior            | 41.2        | 16.1             | <0.001*|
| Posterior           | 84.9        | 86.7             | 0.411 |
| Vertebrae fused     |             |                  |       |
| 2–3                 | 12.2        | 30.3             | <0.001|
| 4–8                 | 44.1        | 18.5             | <0.001|
| 9+                  | 45.0        | 45.8             | 0.789 |
| Perioperative transfusion | 31.9   | 24.3             | 0.006 |

DM: Diabetes mellitus, HF: Heart failure, CKD: Chronic kidney disease, COPD: Chronic obstructive pulmonary disease, PVD: Peripheral vascular disease.

NF1 patients were most commonly from the 0–25% income quartile (Q1) (25.2% vs. 18.7%), were more likely to be insured through Medicaid (42.9% vs. 24.9%), and had the most prevalent preoperative morbidities including; (1) hypertension, (2) chronic obstructive pulmonary disease, and (3) smoking; in the non-NF1 group they were (1) smoking, (2) obesity, and (3) hypertension [Table 2].

Perioperative outcomes after spinal fusion

The NF1 patients had more central nervous system complications, postoperative infections, longer length of stay, and more nonroutine discharges, but spinal fusion patients with or without NF1 had similar pre-, peri-, and postoperative characteristics [Tables 1-3]. Table 4 lists the variables for propensity score-matched set data. In multivariate logistic regression analysis, there was no significant difference between the odds of being discharged nonroutinely between spinal fusion patients with NF1 and those without (Odds Ratio [OR]: 0.91, CI: 0.53–1.56; P = 0.73), when controlling for other factors [Table 5]. When comparing PS-matched sets data in multivariate logistic regression analysis, this difference remained statistically insignificant (OR: 0.97, CI: 0.46–2.05; P = 0.93) [Table 5, Figure 1].

DISCUSSION

In this study, we determined that NF1 (238 [0.9%] pediatric/young patients undergoing spinal fusions had similar outcomes to non-NF1 patients 25,558 [99.1%]). We also found that those with NF1 were likely to have a greater number of vertebrae fused, and were more likely to receive perioperative transfusions. In our PS-matched analysis, the observed difference in length of stay between patients...
with and without NF1 did not reach significance. Similarly, we applied a multivariate logistic regression to explore the likelihood of nonroutine discharge in patients with and without NF1 and again found no difference between the two groups.

**CONCLUSION**

Comparing outcomes for NF1 versus non-NF1 pediatric/young patients (≤26 years old) undergoing spinal fusion, we found that NF1 patients were no more likely than their counterparts without NF1 to experience inferior surgical outcomes.

**Declaration of patient consent**

Patients consent not required as patients identity is not disclosed or compromised.

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**Conflicts of interest**

There are no conflicts of interest.

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