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Steven R. Niedermeier, Sohrab S. Virk and Safdar N. Khan

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Clinical Outcomes of Single-Level Anterior Cervical Discectomy and Fusion

STEVEN R. NIEDERMEIER, MD, SOHRAB S. VIRK, MD, MBA, SAFDAR N. KHAN, MD
Department of Orthopaedics, Wexner Medical Center, The Ohio State University, Columbus, Ohio

Background: The purpose of the present study was to determine the differences in health outcomes between patients with cervical spondylosis who underwent single-level anterior cervical discectomy and fusion (ACDF) and patients with cervical spondylosis who did not undergo an ACDF fusion (non-ACDF). The hypothesis of the study was that patients undergoing single-level fusion have a lower risk of downstream cardiovascular disease and depression.

Methods: The Medicare 5% sample was used to identify patients who received a diagnosis of spondylosis during 2005–2012. All spondylosis patients were separated into nonoperative and operative groups. Differences in new disease diagnoses, age, sex, and Charlson Comorbidity Index (CCI) scores were recorded.

Results: The relative risk (RR) of heart failure was lower in the ACDF group after 3 years (RR = 0.6719; $P < .05$), 5 years (RR = 0.8477; $P = 1.17$), and 7 years (RR = 0.7709; $P = 1.625$). The RR of depression was higher in the ACDF group at 1 year (RR = 2.5008), 3 years (RR = 1.4473), 5 years (RR = 2.2625), and 7 years (RR = 2.2257; $P < .05$ for all). Mean CCI score of patients before undergoing ACDF was 10 (SD, 9.20), whereas the mean score after surgery was 8 (SD, 7.84; $P < .05$), and the score for non-ACDF patients remained unchanged at a CCI of 10 (SD, 9.00; $P < .05$).

Conclusions: The results demonstrate the patients in the ACDF cohort have an increased RR of depression but a decreased risk of cardiovascular disease. Further research may be needed to delineate why the ACDF procedure potentially benefits a patient for heart disease but may stress a patient's social/economic supports during the recovery process, thus leading to higher depression rates for patients undergoing ACDF.

Cervical Spine

Keywords: anterior cervical discectomy fusion, spondylosis, Medicare

INTRODUCTION

Degenerative disease of the cervical spine is the most common acquired cause of disability in patients older than 50 years.[1] Additionally, cervical spondylosis (CS) is the most common cause of spinal cord dysfunction in adults.[2] Matz et al.[3] pointed out in their systemic review that an anterior cervical decompression and fusion (ACDF) is an appropriate intervention that more rapidly alleviates symptoms of CS than conservative modalities and often improves clinical function. ACDF surgery is indicated for patients who have failed all nonoperative interventions, such as physical therapy, therapeutic steroid injections, and anti-inflammatory medicines.[4] It is believed that delaying surgical management of end-stage CS can lead to debilitating myelopathy and/or radiculopathy that, if left untreated long enough, often can cause permanent sequelae.[5]

The short-term benefits of surgery are well known, such as decreased pain, alleviation of radiculopathy, myelopathy, and return to activities of daily living. However, long-term effects that quantify the costs and disease burden after surgery or nonoperative management have not been well studied. It is generally accepted that alleviating a patient's pain and restoration of clinical function will positively affect his or her health downstream, but there has been limited research in terms of specific operations and the effect each procedure may have on a patient's overall health outcomes.[6]

ACDF has been shown in the literature to have a positive effect on patient outcomes. For instance, a long-term follow-up study done by Zigler et al.[7] demonstrated 60-month improvements and maintenance of Neck Disability Index, Visual Analog Scales (neck and arm), and SF-12 (quality of life measure) scores in single- and 2-level ACDF procedures. The hypothesis of the study was that patients undergoing ACDF have a lower incidence of downstream cardiovascular disease and depression.

Table 1. International Classification of Diseases (ICD-9) codes for heart failure (HF) and depression.

HF		Depression	
ICD-9 Code	**Definition**	**ICD-9 Code**	**Definition**
428.0	Congestive HF, unspecified	309	Adjustment reaction
428.1	Left HF	309.0	Adjustment disorder with depressed mood
428.2	Systolic HF	309.1	Prolonged depressive reaction
428.20	Systolic HF, unspecified	309.2	Adjustment reaction with predominant disturbance of other emotions
428.21	Acute systolic HF	309.21	Separation anxiety disorder of adolescence
428.22	Chronic systolic HF	309.22	Emancipation disorder of adolescence
428.23	Acute on chronic systolic HF	309.23	Specific work or academic inhibition
428.3	Diastolic HF	309.24	Adjustment disorder with anxiety
428.30	Diastolic HF, unspecified	309.28	Adjustment disorder with mixed anxiety and depressed mood
428.31	Acute diastolic HF	309.29	Other adjustment reactions with predominant disturbance of other emotions
428.32	Chronic diastolic HF	309.3	Adjustment disorder with disturbance of conduct
428.33	Acute on chronic diastolic HF	309.4	Adjustment disorder with mixed disturbance of emotions and conduct
428.4	Combined systolic and diastolic HF	309.8	Other specified adjustment reactions
428.40	Combined systolic and diastolic HF, unspecified	309.81	Posttraumatic stress disorder
428.41	Acute combined systolic and diastolic HF	309.82	Adjustment reaction with physical symptoms
428.42	Chronic combined systolic and diastolic HF	309.83	Adjustment reaction with withdrawal
428.43	Acute on chronic combined systolic and diastolic HF	309.89	Other specified adjustment reactions
428.9	HF, unspecified	309.9	Unspecified adjustment reaction
		311	Depressive disorder, not elsewhere classified

MATERIALS AND METHODS

The Medicare 5% data set sample was used to identify patients with a diagnosis of CS from 2005 to 2012; this includes patients who had a diagnosis prior to 2005 or received a diagnosis in 2005. We queried the Medicare 5% national sample administrative database using software from PearlDiver (PearlDiver Technologies, Fort Wayne, Indiana). The 5% sample consists of people who were Medicare beneficiaries during the given time period. In this sample all of the patient's deidentified data are available as a representative of all Medicare beneficiaries. This database is compliant with all regulations associated with the Health Insurance Portability and Accountability Act (HIPAA) because all patient identifiers were removed from the clinical/financial data. The study was exempt from approval by our local Institutional Review Board.

CS patients were identified using the following International Classification of Diseases-9 (ICD-9) diagnosis codes: ICD-9-D-7210 and ICD-9-D-7211 (CS without and with myelopathy, respectively). The CS code was required to be the principal diagnosis. Patients were followed until the end of the study period (December 31, 2012), until their benefits were terminated, or until death. CS patients were separated into ACDF and non-ACDF groups using the presence of ICD-9-D-8102 (ie, cervical fusion of the anterior column, anterior technique) for the ACDF group. The ACDF procedure was confirmed by current procedural terminology (CPT) code 22551 (ie, anterior interbody fusion, with discectomy and decompression; cervical below C2). We excluded patients with codes for additional levels of fusion by CPT code 22552.

Outcomes of interest included diagnoses of heart failure (ICD-9-D-428XX) and depression (ICD-9-D-309XX and 311XX). "XX" indicates that we included all ICD-9 codes that began with 428, 309, and 311 in order to include the entire spectrum of diagnoses (Table 1). Heart failure was chosen because of the gravity of the disease and because it is potentially modifiable by ACDF, which may lead to decreases in patients' inactivity and decreased risk of new-onset cardiovascular disease(s). The same could be said for choosing depression as a marker for mental health because it is also potentially modifiable by ACDF, which can improve a patient's preoperative symptoms, leading to improvements in his or her quality of life. Differences in incidence between ACDF and non-ACDF groups for each outcome were analyzed. The Charlson comorbidity index (CCI) quantifies the presence of comorbid conditions into a single score, and it has been determined to be a valid method for estimating the risk of death from comorbid disease.[8,9] The CCI can predict the risk of mortality, with each subsequent level in the index demonstrating increases in the sum total mortality attributable to comorbid disease.[10] CCI was used to assess the effect of comorbidities on patients' mortality in

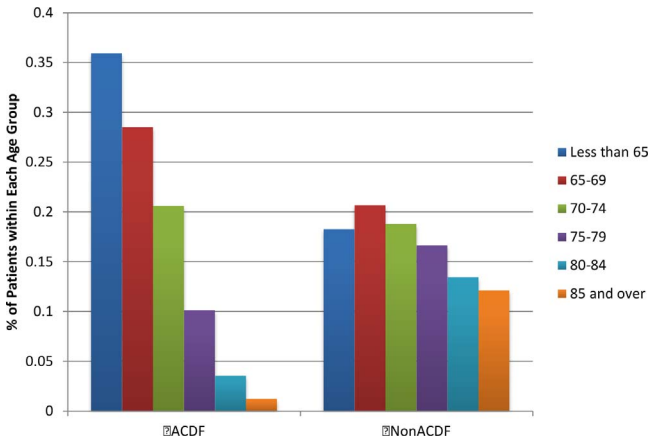

Figure 1. Age groups for anterior cervical decompression and fusion (ACDF) and non-ACDF.

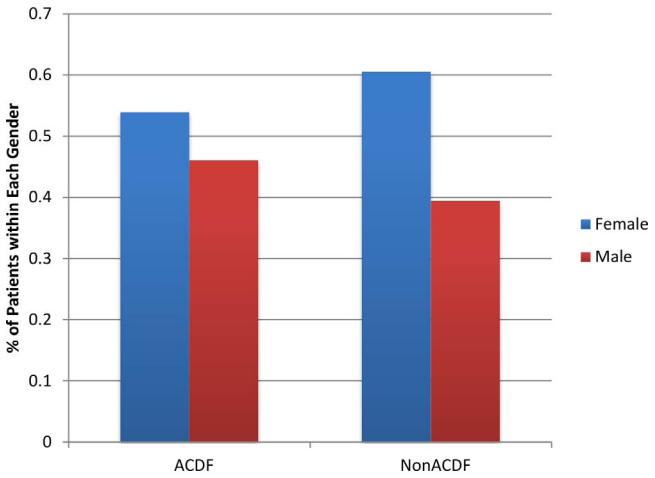

Figure 2. Sex for anterior cervical decompression and fusion (ACDF) and non-ACDF.

those patients who underwent ACDF versus those who did not.

Preoperative and postoperative CCI scores were obtained for those patients who underwent ACDF, and disease diagnoses were obtained at 1, 3, 5, and 7 years after CS diagnosis and were compared for the both groups.

RESULTS

Results are presented for patients who had data available for 1, 3, 5, and 7 years of follow-up. The study included 271 073 patients. Of these, 3110 underwent ACDF, and the remaining 267 963 patients did not undergo ACDF. The demographic characteristics for both groups are shown in Figures 1 and 2. Table 2 demonstrates that the mean CCI scores of patients before undergoing ACDF was 10, whereas the mean CCI after surgery was 8 ($P < .0001$). Additionally, there was no statistically significant difference in preoperative CCI when compared to the non-ACDF group; however, there was a statistically significant difference in postoperative CCI when compared to the non-ACDF groups ($P < .0001$).

Table 3 shows the incidences for heart failure and depression. The incidence of heart failure was higher in the non-ACDF group at all follow-up time points. The incidence of depression was higher for the ACDF group at 1, 5, and 7 years.

Table 4 shows the relative risk (RR) of heart failure and depression. The RR of heart failure was lower in the ACDF group after 3 years (95% confidence interval [95% CI], 0.554–0.815; $P = .0001$), 5 years, and 7 years, with only 3 years being statistically significant. The RR of depression was higher in the ACDF group at 1 year (95% CI, 1.920–3.258; $P < .0001$), 3 years (95% CI, 1.186–1.766; $P = 0.0003$), 5 years (95% CI, 1.762–2.906; $P < .0001$), and 7 years (95% CI, 1.646–3.010; $P < .0001$). A Bonferroni correction factor was calculated to counteract the potential problem posed by multiple comparisons and making a type 1 error.[11] When calculated, the adjustment lowered the 0.05 to 0.0125; however, this did not alter the statistical significance of our results.

DISCUSSION

This investigation is the first of its kind, to our knowledge, to analyze the disease burden in patients with CS. The analysis of the 5% Medicare sample

Table 2. Preoperative, postoperative, and nonoperative Charlson comorbidity index (CCI) scores.

CCI	Preoperative	Postoperative	Non-ACDF
Mean	10	8	10
SD	9.20375	7.84043	9.004816
No.	1996	2407	246 529
P value		<.0001	<.0001

Abbreviation: ACDF, anterior cervical decompression and fusion.

Table 3. Incidence of heart failure (HF) and depression (as a percentage).

	After 1 y	After 3 y	After 5 y	After 7 y
CHF				
ACDF	1.3	2.25	4.5	5.4
Non-ACDF	1.8	5.6	9.2	12.2
Depression				
ACDF	1.5	2.1	4.7	5.8
Non-ACDF	1	2.5	3.6	4.6

Abbreviation: CHF, congestive heart failure; ACDF, anterior cervical decompression and fusion.

Table 4. Relative risk of heart failure (HF) and depression.

	After 1 y	After 3 y	After 5 y	After 7 y
CHF				
RR	1.213	0.6719	0.8477	0.7709
95% CI	0.918–1.604	0.554–0.815	0.643–1.119	0.563–1.055
P value	1.356	.0001	1.17	1.625
Depression				
RR	2.5008	1.4473	2.2625	2.2257
95% CI	1.920–3.258	1.186–1.766	1.762–2.906	1.646–3.010
P value	<.0001	.0003	<.0001	<.0001

Abbreviation: CHF, congestive heart failure; RR, relative risk.

demonstrated that patients who underwent ACDF had an RR reduction of new diagnoses of heart failure at 3, 5, and 7 years after surgery, but they had a short- and long-term increased RR of depression. Additionally, CCI scores decreased for patients postoperatively in the ACDF group and when compared to the non-ACDF group as well. This could signify a general increase in overall health in patients with spondylosis after surgery.

Cardiovascular disease has seldom been investigated in relation to spine surgery in general, let alone ACDF. In a paper by Worley et al.,[12] the authors reported an increased inpatient morbidity/mortality risk in patients with a previous diagnosis of heart failure in spinal deformity procedures. The present study is the first to demonstrate that the incidence and RR of heart failure in patients who underwent ACDF decreased relative to patients treated conservatively starting 3 years postoperatively. These findings demonstrate the benefits of alleviating symptoms related to cervical radiculopathy and/or myelopathy on diverse medical conditions, such as heart disease.

Data in previous literature concerning depression in patients undergoing cervical spine surgery have predominantly evaluated a posterior approach to the spine. This emphasizes the novel aspect of the present study's investigation of the relationship between anterior cervical spine surgery and depression. Additionally, this study appears to be the first to assess new diagnoses of depression in patients undergoing operative fixation for CS, anterior or otherwise. The literature has demonstrated for lumbar stenosis that depression was a negative predictor of postoperative patient reported outcomes, and preoperative depression was an independent predictor of lower functional improvement postoperatively.[13,14] Zong et al.[15] used retrospective analysis to conclude a poorer postoperative outcome in patients who underwent posterior cervical spinal fusion with preoperative depression than those patients who were depression-free throughout. Li et al.[16] stated that despite improvements in pain and quality-of-life scores, postoperative depression assessments were not statistically different from preoperative scores and had negative effects of prognosis after cervical total disc replacement. Ghori et al.[17] investigated long-term societal costs of ACDF and showed that the long-term societal costs for an average 45-year-old patient undergoing ACDF are $31 178. This can be a potentially large source of stress on a patient and his or her family, showing that medical intervention may lead to more social/economic stressors for a patient. This in turn could relay a potential cause of a persistence or exacerbation of depressive symptoms seen in this study.

Limitations of this study are similar to those of other retrospective database reviews. A disadvantage of using a Medicare database is that the data lack certain particulars, including but not limited to indices for patient pain and function. Although a generalized comparison of ACDF and non-ACDF groups is an appropriate investigation for this database, it is difficult to discern why some patients elected to decline decompression and fusion. We realize that the diagnosis of cardiac disease or depression may or may not be strongly associated with myelopathy, and this is a limitation of this study. Also confounding the data is the fact that comorbid conditions are assumed to be underreported; therefore, the approach may miss identifying all comorbidities in patients who were not designated for surgery. In addition, because of the nonspecificity in the coding system, we employed new disease diagnoses as a substitution for a patient's general health state. As with other large database studies that rely on physician/hospital billing of CPT and ICD-9 codes, there are weaknesses associated with this study related to discrepancies between claims databases and patient chart reviews.[18] We also recognize that diagnoses like depression and cardiac disease are often underdiagnosed.[19,20] Additionally, hospitals and providers have a vested interest in accurately portraying charges for third-party payers in order to avoid fraud allegations and to be appropriately compensated for their work.

The results demonstrate the patients in the ACDF cohort have an increased RR of depression but a decreased risk of cardiovascular disease. Further research may be needed to delineate why

the ACDF procedure potentially benefits a patient for heart disease but may stress a patient's social/economic supports during the recovery process, thus leading to higher depression rates for patients undergoing ACDF.

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Corresponding Author: Safdar N. Khan, MD, Division of Spine Surgery, Department of Orthopaedics, Spine Research Institute,725 Prior Hall, The Ohio State University, Columbus, OH 43210. Phone: (614) 293-2165; Fax: (614) 293-4755; Email: safdar.khan@osumc.edu.

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