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Article

Impact of Severe Obesity on Outcomes in Single-Level Anterior Cervical Discectomy and Fusion (ACDF): A Large-Scale Comparative Study

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Abstract: Background: Anterior cervical discectomy and fusion (ACDF) is a common procedure for cervical radiculopathy and myelopathy. Severe obesity (BMI ≥40 or BMI ≥35 with comorbidities) is associated with increased perioperative risks. This study examines the impact of severe obesity on outcomes in patients undergoing single-level ACDF. **Methods :**Data from the Nationwide Inpatient Sample (2016-2019) were analyzed, including 85,585 patients who underwent single-level ACDF. Patients were classified as severely obese (n = 4,935) or non-obese (n = 80,650). Outcomes such as length of stay, complications, and in-hospital mortality were compared using SPSS and MATLAB, with a significance level of $p < 0.05$. **Results:** Severely obese patients were younger (54 vs. 55.7 years, $p < 0.001$) and had more comorbidities like type 2 diabetes (38% vs. 17.8%, $p < 0.001$) and obstructive sleep apnea (31.1% vs. 9.5%, $p < 0.001$). They experienced longer hospital stays (1.92 vs. 1.65 days, $p < 0.001$) but similar in-hospital mortality (0.1%, $p = 0.506$). Severe obesity was linked to higher odds of complications, the risk of developing dehiscence was 8.2 times higher in severely obese patients. Respiratory failure had an odds ratio of 6.5, while myocardial infarction showed an odds ratio of 5.5. Horner syndrome was 4.7 times more likely to occur, and pulmonary edema had an odds ratio of 4.5. Dural tear risk was also significantly elevated, with an odds ratio of 4.1.The risk of developing acute kidney injury were 2.6 times higher, while the risk of pulmonary embolism was 2.5 times higher. Dysphonia was also more common in severely obese patients, with an odds ratio of 2.2. **Conclusion:** Severe obesity is associated with higher complication rates and longer hospital stays following ACDF. Tailored perioperative management is essential to mitigate risks and improve outcomes in this high-risk population.

Keywords: anterior cervical discectomy; severe obesity; BMI; postoperative complications; ACDF

1. Introduction

Anterior cervical discectomy and fusion (ACDF) remains the definitive treatment for cervical radiculopathy and myelopathy, particularly in patients with cervical spondylosis (1-3). With the global population aging rapidly, the incidence of spondylosis—and the corresponding need for ACDF—is expected to surge. ACDF is primarily indicated when conservative management fails to alleviate symptoms in degenerative cervical spine disorders, including spondylosis, disc herniations, fractures, and spinal tumors. Its high efficacy and favorable safety profile have cemented it as one of the most frequently performed procedures in addressing cervical spine degeneration.

Body mass index (BMI) is a well-established risk factor for increased complications and suboptimal outcomes after ACDF (4,5). Patients with elevated BMI, coupled with characteristics such as larger neck circumference and shorter neck length, are prone to longer operative times, greater blood loss, and a heightened likelihood of postoperative complications (6). These anatomical and physiological challenges further complicate the procedure, impacting both intraoperative management and postoperative recovery. In patients with severe obesity, however, ACDF poses

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specific challenges. The increased subcutaneous fat deposition and broader anatomical corridors introduce greater complexity in accessing the cervical spine. This often necessitates more forceful and prolonged retraction of adjacent structures such as the longus colli muscles, esophagus, and trachea, which can elevate the risk of complications. These include localized edema, tissue ischemia, longer operative durations, and increased intraoperative blood loss.

Obesity has been consistently associated with higher rates of perioperative complications and poorer outcomes in surgical procedures, including ACDF (7-10). According to WHO, obesity is categorized by BMI of ≥30.0, with further classifications as class I (30.0–34.9), class II (35.0–39.9), and class III (≥40.0). The prevalence of obesity in the United States continues to rise, placing this population at a significantly greater risk of developing degenerative spinal disorders across all levels of the spine, in comparison to individuals with a healthy BMI (11). Patients with a BMI over 30 have been identified as being at a heightened risk for developing complications such as dysphagia, neurological issues, respiratory complications, hematologic disorders, pulmonary embolism (PE), and durotomy.

A deeper insight into the impact of obesity on inpatient complications after ACDF could enhance patient selection, preoperative risk stratification, and patient counseling, potentially mitigating avoidable perioperative complications. This study seeks to evaluate the prevalence of obesity among ACDF patients and to assess its influence on postoperative inpatient outcomes, with the goal of improving clinical management strategies for this high-risk population.

Research Questions

Our goal is to investigate the correlation between severe obesity (BMI ≥40 or BMI ≥35 with obesity-related comorbidities) and the outcomes of patients undergoing single-level ACDF

2. Methods

Research Questions

This study utilized a comprehensive dataset extracted from the Nationwide Inpatient Sample (NIS), the largest publicly available all-payer inpatient care database in the United States. The dataset included a total of 85,585 patients who underwent single-level Anterior Cervical Discectomy and Fusion (ACDF) between 2016 and 2019.

Study Period and Data Source

The study period spanned from January 1st, 2016, to December 31st, 2019. The NIS, a core component of the Healthcare Cost and Utilization Project (HCUP), captures 20% of inpatient stays from HCUP-associated hospitals, amounting to approximately seven million unweighted enrollments annually.

Patient Identification and Obesity Definition

Patients undergoing single-level ACDF were identified using specific ICD-10 codes. Severe obesity was defined by the ICD-10 code E66.01, indicating patients with a body mass index (BMI) of 40 or higher, or a BMI of 35 or higher with obesity-related health conditions (e.g., diabetes, hypertension). In total, 4,935 patients were identified as having severe obesity, while 80,650 patients were classified as non-severe or non-obese.

Statistical Analyses

Statistical analyses were performed using SPSS 26 and MATLAB 2024. Crosstabs and independent sample t-tests were conducted to compare outcomes between severely obese and non-obese patients undergoing single-level ACDF. A significance level of $p < 0.05$ was applied..

Comorbidity and Outcome Identification

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Comorbidities were identified using ICD-10 codes and included conditions such as diabetes, hypertension, and chronic respiratory disease. Clinical outcomes were also extracted using ICD-10 codes and included in-hospital mortality, length of stay, complications, and overall hospitalization costs. Complications analyzed included dysphagia, blood loss anemia, cervical spinal cord injury, urinary tract infection (UTI), acute renal failure, pneumonia, blood transfusion requirement, venous thromboembolism, pulmonary edema, ileus, sepsis, and pulmonary embolism.

Ethical Considerations

The study was conducted under exempt status granted by the institutional review board due to the de-identified nature of the data. No informed consent was required.

3. Results

Comparison of Key Demographic and Hospital Characteristics

Table 1 presents the demographic and hospital characteristics of patients undergoing single-level ACDF surgery, comparing those with and without severe obesity.

Severely obese patients were younger (54 vs. 55.7 years, p<0.001) and had a higher percentage of females (57.1% vs. 51.3%, p<0.001). Medicare coverage was more common among severely obese patients (35% vs. 33.8%, p<0.001). A greater proportion of surgeries for severely obese patients occurred in rural hospitals (75.6% vs. 72.9%, p<0.001).

Table 1. Demographic and Hospital Characteristics of Patients Undergoing Single-Level ACDF Surgery Stratified by Severe Obesity Status.

Parameter	Without Severe Obesity (%)	Severe Obesity (%)	Significance
Total Surgeries	80650	4935	-
Average Age (y)	55.7	54	P<0.001
Female (%)	51.3	57.1	P<0.001
Primary expected payer - Medicare (%)	33.8	35	P<0.001
Primary expected payer - Medicaid (%)	10.6	12.2	
Primary expected payer - private including HMO (%)	44.5	44.8	
Primary expected payer - self-pay (%)	1.2	1.1	
Primary expected payer - no charge (%)	0.1	0.1	
Primary expected payer - other (%)	9.8	6.9	
Status of hospital (STRATA) - Rural (%)	72.9	75.6	P<0.001
Status of hospital (STRATA) - Urban nonteaching (%)	23.3	20.7	
Status of hospital (STRATA) - Urban teaching (%)	3.8	3.7	

Comparison of Comorbidities Between Severely Obese and Non-Obese Patients

Table 2 shows the comorbidities associated with patients undergoing single-level ACDF surgery, comparing those with and without severe obesity.Severely obese patients were significantly more likely to have type 2 diabetes mellitus (38% vs. 17.8%, p<0.001), obstructive sleep apnea (31.1% vs. 9.5%, p<0.001), and chronic kidney disease (6.4% vs. 3.6%, p<0.001). They also had a higher prevalence of mental disorders (45.7% vs. 40.4%, p<0.001) and thyroid disorders (15.4% vs. 11.7%, p<0.001). However, they were less likely to have hypertension (43.7% vs. 56.3%, p<0.001) and dyslipidemia (30% vs. 70%, p<0.001). Other notable differences include higher rates of chronic lung disease (11.4% vs. 7.8%, p<0.001) and chronic anemia (3.5% vs. 2.3%, p<0.001) in severely obese patients.

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Table 2. Comorbidities in Patients Undergoing Single-Level ACDF Surgery by Severe Obesity Status.

Prameter	Without Severe Obesity (%)	Severe Obesity (%)	Significance
Type 2 Diabetes Mellitus	17.8	**38**	P<0.001
Diabetes Mellitus	19.5	**38.5**	P<0.001
Mental Disorders	40.4	**45.7**	P<0.001
Hypertension	**56.3**	43.7	P<0.001
Dyslipidemia	**70**	30	P<0.001
Obstructive Sleep Apnea	9.5	**31.1**	P<0.001
Chronic Kidney Disease	3.6	**6.4**	P<0.001
Chronic Lung Disease	7.8	**11.4**	P<0.001
Thyroid Disorder	11.7	**15.4**	P<0.001
Chronic Anemia	2.3	**3.5**	P<0.001
Heart Failure	0.1	**0.3**	P<0.001
Connective Tissue Disorder	0.1	0.1	P=0.621
History of Myocardial Infarction	2.9	3.1	P=0.372
Peripheral Vascular Disease	1.3	1.4	P=0.559
Dementia	**0.2**	0.2	P=0.002
Peptic Ulcer Disease	0.3	0.3	P=0.623
IBD (Inflammatory Bowel Disease)	**0.5**	0.3	P=0.038
Hemiplegia	0.2	0.1	P=0.085
Neoplasms	0.8	0.9	P=0.576
Neoplasms of Lymphoid/Hematopoietic	0.3	0.3	P=0.664
Fibromyalgia	3.8	**4.4**	P=0.041
Smoking	**1.2**	0.7	P=0.001
Alcohol Abuse	1.2	1	P=0.279
Osteoporosis	2.3	2	P=0.137
Parkinson Disease	0.5	0.3	P=0.103
Alzheimer Disease	0.1	0.1	P=0.097

Comparison of Hospitalization Outcomes Between Severely Obese and Non-Obese Patients

Table 3 shows the hospitalization outcomes for patients undergoing single-level ACDF surgery. There was no significant difference in in-hospital mortality between severely obese and non-obese patients (both 0.1%, p=0.506). However, the length of stay was significantly longer for severely obese patients (1.92 days vs. 1.65 days, p<0.001). Total hospital charges were similar between the two groups, with no significant difference ($66,655 vs. $66,913, p=0.702).

Table 3. Hospitalization Outcomes for Single-Level ACDF Surgery by Severe Obesity Status.

Parameter	Without Severe Obesity (%)	Severe Obesity (%)	Significance
Died During Hospitalization (%)	0.1	0.1	P=0.506
Length of stay (Days)	1.65	1.92	P<0.001
Total charges ($)	66913	66655	P=0.702

Postoperative Complications in Severely Obese vs. Non-Obese Patients

Table 4 highlights the postoperative complications that did not differ significantly between severely obese and non-obese patients undergoing single-level ACDF surgery. The rates of venous thromboembolism (0.1% vs. 0.1%, p=0.452), pneumonia (0.3% vs. 0.2%, p=0.446), and dysphagia (4.9%

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vs. 5.1%, p=0.383) were similar between the two groups. Other complications such as cardiac arrhythmias, urinary tract infections, and cerebrospinal fluid leaks also showed no statistically significant differences.

Table 4. Postoperative Complications with No Significant Difference Between Severe and Non-Severe Obesity Groups Following Single-Level ACDF Surgery.

Parameter	Without Severe Obesity (%)	Severe Obesity (%)	Significance
Venous Thromboembolism	0.1	0.1	P=0.452
Cardiac Arrhythmias	2	2.3	P=0.092
Pneumonia	0.2	0.3	P=0.446
Urinary Tract Infection (UTI)	0.6	0.8	P=0.059
Blood Transfusion	0.2	0.1	P=0.347
Blood Loss Anemia	1.6	1.6	P=0.907
Dysphagia	5.1	4.9	P=0.383
Brachial Plexus Injury	0	0	P=0.338
Cerebrospinal Fluid Leak	0.3	0.2	P=0.483

Postoperative Complications with Significantly Higher Odds in Severely Obese Patients

Figure 1 presents the odds ratios (OR) and confidence intervals (CI) for various postoperative complications in severely obese patients after single-level ACDF surgery. The OR provides a measure of the likelihood that a complication occurs in severely obese patients compared to non-obese patients. An OR greater than 1 indicates a higher risk of complication in the severely obese group.

- Dehiscence had the highest OR at 8.2 (95% CI: 2.8–23.9, p<0.001.
- Respiratory failure had an OR of 6.5 (95% CI: 3.1–13.6, p<0.001), showing a significantly increased risk for severely obese patients.
- Myocardial infarction had an OR of 5.5 (95% CI: 2.0–15.0, p<0.001), indicating a markedly higher risk in the severely obese group.
- Horner syndrome had an OR of 4.7 (95% CI: 2.3–9.5, p<0.001).
- Pulmonary edema had an OR of 4.5 (95% CI: 2.5–7.9, p<0.001).
- Dural tear had an OR of 4.1 (95% CI: 2.0–8.2, p<0.001).
- Acute kidney injury had an OR of 2.6 (95% CI: 2.0–3.3, p<0.001).
- Pulmonary embolism had an OR of 2.5 (95% CI: 1.3–4.9, p=0.005).
- Dysphonia had an OR of 2.2 (95% CI: 1.6–3.1, p<0.001).

These findings indicate that severely obese patients are at significantly higher risk for multiple complications following single-level ACDF surgery compared to non-obese patients.

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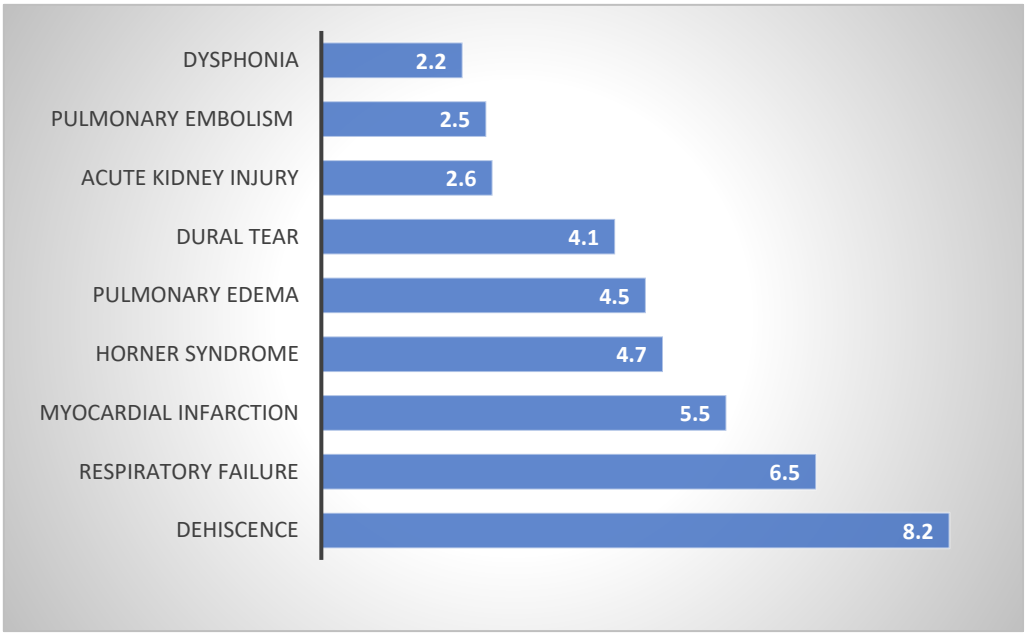

Figure 1. Odds Ratios (OR) of Postoperative Complications in Severely Obese Patients Undergoing Single-Level ACDF Surgery compared to patients without severe obesity.

4. Discussion

ACDF is the most commonly performed procedure on the cervical spine, with its incidence tripling over the past two decades. Despite its reputation as a safe and effective intervention, ACDF is not without risks, and significant complications can still arise (1,2,12,14-16). Advances in surgical techniques and innovations in interbody fusion devices and plating systems have contributed to reducing postoperative morbidity. However, surgeons must remain vigilant, recognizing potential complications, fully informing patients of the associated risks, and implementing appropriate management strategies. ACDF remains the gold standard for addressing cervical radiculopathy and myelopathy, particularly when dealing with focal anterior compression of the nerve roots and/or spinal cord, often caused by cervical spondylosis.

Impact of BMI on ACDF Outcomes

BMI is a recognized risk factor for increased complications and poorer clinical outcomes following ACDF. Elevated BMI, often associated with anatomical challenges such as increased neck circumference and reduced neck length, predisposes patients to longer operative times, greater intraoperative blood loss, and a significantly higher rate of postoperative complications. (1,4,12)

Study Findings: Demographics

Severely obese patients were generally younger and more likely to be female compared to non-obese patients. Interestingly, a larger proportion of surgeries for severely obese patients were performed in rural hospitals. This finding could reflect a geographic disparity in the distribution of obesity or surgical access in certain populations. Other studies, such as those by Roberto et al. (2), have similarly observed a higher prevalence of female patients among obese individuals, particularly those from lower socioeconomic backgrounds. These demographic differences suggest that gender, socioeconomic status, and geographic location may influence surgical outcomes differently across populations.

Study Findings: Comorbidities:

Severely obese patients in our study exhibited higher rates of significant comorbidities, including type 2 diabetes, obstructive sleep apnea, chronic kidney disease, and mental health

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disorders. However, we found surprisingly lower rates of hypertension and dyslipidemia in this population. The increased prevalence of conditions like diabetes and sleep apnea in severely obese patients aligns with findings from previous studies, which have linked higher BMI with a greater burden of metabolic and respiratory disorders (1,2). The presence of these comorbidities can complicate both the surgical procedure and the postoperative recovery process, underscoring the importance of thorough preoperative assessment and planning.

Study Findings: Postoperative Complications:

Severely obese patients were found to have significantly longer hospital stays compared to non-obese patients (1.92 days vs. 1.65 days), reflecting more complex postoperative courses. However, no significant differences were observed in in-hospital mortality rates or total hospital costs between the two groups. Interestingly, while conditions like venous thromboembolism, pneumonia, and dysphagia showed similar rates across BMI categories, severely obese patients had a markedly higher risk of certain serious complications, including wound dehiscence, respiratory failure, myocardial infarction, Horner syndrome, and pulmonary edema. In some cases, the odds ratios (ORs) indicated up to an 8-fold increased risk for these complications.

These findings emphasize the need for increased vigilance and tailored preoperative strategies for severely obese patients. It is essential to implement a multidisciplinary approach, involving anesthesiologists, nutritionists, and physical therapists, to optimize patient outcomes and mitigate the risks associated with obesity.

Limitations

While our study provides valuable insights, several limitations should be acknowledged due to the nature of database-driven research.

The NIS relies on administrative billing codes, which lack detailed clinical information such as comorbidity severity, preoperative status, or disc displacement. These missing variables are important for surgical decision-making and may affect the accuracy of the findings. Additionally, the retrospective nature of the NIS introduces potential inaccuracies and underreporting of complications (22-25).The study does not include detailed information on operative techniques or surgeon expertise, both of which can significantly impact outcomes. Without this data, it is difficult to fully assess the differences between patient groups based on surgical approach or skill. The lack of Patient-Reported Outcomes limits our understanding of long-term recovery and quality of life, as they provide essential information about postoperative satisfaction and functional outcomes. Future studies should incorporate PROs for a more complete evaluation of patient recovery.

5. Conclusions:

Severely obese patients were younger, predominantly female, and had higher rates of comorbidities, such as type 2 diabetes and sleep apnea. They also faced increased risks of complications like respiratory failure and myocardial infarction, though hospital costs remained similar to non-obese patients. The study's limitations include reliance on retrospective coding and lack of patient-reported outcomes. Despite this, it offers important insights into managing high-risk ACDF patients.

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Acknowledgments: Irrelevant.

Conflicts of Interest: None.

Ethical approval: The study was conducted under exempt status granted by the institutional review board, and the requirement for informed consent was waived due to the de-identified nature of the NIS dataset.

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