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Morbid Obesity and Diabetes Increase the Risk of Reoperation following Microvascular Decompression: A National Surgical Quality Improvement Program Analysis of 1,303 Patients

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Abstract

Background Microvascular decompression (MVD) is the preferred treatment for refractory trigeminal neuralgia (TN) and hemifacial spasm (HFS). MVD provides long-lasting results for these conditions with a relatively low risk of postoperative complications. However, reoperation rates are reported up to 11%, an unacceptably high rate for an elective procedure. We determined what factors may increase the risk of reoperation among patients undergoing MVD for TN or HFS.

Methods Patient data from 2015 to 2020 were obtained from the American College of Surgeons–National Surgical Quality Improvement Program database and were included in this study if they had a procedure corresponding to an MVD with the current procedural terminology code 61458. Patient demographics, comorbidities, and outcomes were analyzed. Patients were subsequently categorized based on body mass index (BMI) and a logistic regression analysis was used to model the association of comorbidities with reoperation and its indication.

Results The overall rate of reoperation in the cohort is 3.2 and 7.2% for patients with morbid obesity (BMI ≥ 40; $p = 0.006$). Patients with morbid obesity were more likely to present at a younger age (50.1 vs. 57.4; $p < 0.0001$), have comorbidities such as hypertension (60.9 vs. 33.5%; $p < 0.0001$) and diabetes (16.3 vs. 7.7%; $p = 0.0002$), and increased procedure duration (179 vs. 164 minutes; $p = 0.02$). Indications for reoperation include cerebrospinal fluid (CSF) leak (31%), wound complications (19%), refractory pain (11.9), intracranial hemorrhage (4.8%), and other/unknown (33.3%). Patients with either morbid obesity or diabetes have a 2-fold increase in risk of reoperation, while having both is associated with a 5-fold risk of reoperation.

Keywords
- obese
- pain
- trigeminal neuralgia
- microvascular decompression
- surgical complications
- reoperation

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Conclusion We demonstrate morbid obesity leads to increased procedure duration and increased risk of reoperation due to wound complications and CSF leak. In these patients, alternative treatment strategies or preoperative optimization may be reasonable to reduce the risk of surgical complications and reoperation.

Introduction

Microvascular decompression (MVD) is considered an excellent treatment for medically refractory trigeminal neuralgia (TN) and hemifacial spasm (HFS).[1,2] TN and HFS are thought to occur due to arterial or venous compression of associated cranial nerves at the nerve root entry zone on the brain stem.[3] The most common offending vessel in TN is either the superior cerebellar artery or the anterior inferior cerebellar artery (AICA), whereas in HFS the AICA or the posterior inferior cerebellar artery commonly compress the cranial nerve.[4,5]

MVD provides excellent long-lasting results for both TN and HFS.[5,6] Compared with percutaneous interventions for TN such as glycerol or radiofrequency rhizotomy, and balloon compression, MVD provides both a higher rate of long-term patient satisfaction and a lower rate of pain recurrence.[7] MVD has been reported with an initial success rate of 80 to 95%, and 70% of patients are pain-free and off medications at 10 years' postsurgery.[8–10] Radiosurgery is also a well-established and safe alternative for primary or refractory treatment of TN demonstrating high response rates for treatment.[11] Unlike other invasive interventions, however, patients treated with radiosurgery often have persistent or recurrent pain requiring additional procedures.

Among the available interventions to treat TN or HFS, MVD is undeniably the most invasive as it requires intracranial access via a burr hole or small craniotomy followed by surgical navigation around and manipulation of delicate neurovascular structures on the brainstem.[12] Postoperative complications following MVD are generally low, reported as less than 10% and can include cranial nerve palsy, cerebrospinal fluid (CSF) leak, infection, stroke, and in rare cases, hemorrhage, or death.[8,9,13–15] Risk factors associated with increased likelihood of postoperative complications include high body mass index (BMI), American Society of Anesthesiologists (ASA) class II to III, hypertension, tobacco use, chronic obstructive pulmonary disease (COPD), diabetes, and increased procedure duration.[13,16–18]

Surprisingly, reoperation rates have been reported as high as 11% and most commonly occur due to wound infection, wound dehiscence, CSF leak, or refractory/recurrent pain.[6,13,17,19] Risk factors for reoperation have been linked to obesity and diabetes but in series with small sample sizes.[17] Given the relatively high and unacceptable rate of reoperation for an elective procedure with reasonable treatment alternatives, we sought to further elucidate and characterize these risk factors for reoperation for MVD with the goal of potentially identifying a patient population that may benefit from further optimization prior to surgery and/or alternative initial treatment options. We hypothesized that morbidly obese (BMI $\geq$ 40) patients are at greater risk for reoperation following MVD.

Methods

Data Source

Patient data from 2015 to 2020 were obtained from the American College of Surgeons–National Surgical Quality Improvement Program (ACS-NSQIP) database. The NSQIP database contains validated, multi-institutional data collected by trained surgical reviewers across institutions using a uniform protocol.[20] Details on the sampling strategy, data abstraction procedure, variables, outcomes, and structure of the NSQIP have been previously published.[21–23] Trained reviewers at individual hospitals prospectively collect patient data on more than 200 variables including patient demographics, comorbid conditions, operative details, and 30-day postoperative outcomes. Data audits are regularly performed to ensure data reliability. This study was exempt from the institutional review board (IRB) approval as only deidentified data were received and analyzed.

Patient Population

Patients were included in this study if they had a diagnosis of TN or HFS for which they underwent a procedure with a current procedural terminology (CPT) code 61458, corresponding to a suboccipital craniotomy for exploration or decompression of cranial nerves. All procedures were performed under general anesthesia and patients were older than or equal to 18 years of age. Patient demographics and comorbidities were collected from the NSQIP database and include age, gender, BMI, hypertension, diabetes, smoking history, COPD, dyspnea, steroid use, bleeding disorder, recent weight loss, and ASA Classification System I, II, and $\geq$III. BMI was categorized into $<$30, 30–34.9, 35–39.9, and $\geq$40. Preoperative labs were collected and include platelets, partial thromboplastin time, and international normalized ratio. Procedure duration was defined as minutes from procedure start to finish (from skin incision to skin closure).

Reoperation was defined as any patient with an MVD that returned to the operating room within 30 days related to the original surgery. CPT codes were provided for the reasons of unplanned reoperation and grouped together based on similarity. Reasons for reoperation included CSF leak (CPT codes 62100, 61618, 63709, 63707), wound complications (CPT codes 13160, 10180, 10120, 11042), refractory pain (CPT codes 61458, 64610), and intracranial hemorrhage (CPT codes 61315). Several CPT codes were placed in an

other/unknown category (CPT 62142, 61304, 61345, 62146, 62160) because the CPT description was ambiguous or not provided. Frequency of 30-day postoperative complications were determined for the cohort and included superficial and deep wound infection, wound dehiscence, pneumonia, reintubation, deep vein thrombosis, pulmonary embolism, failure to wean, urinary tract infection, stroke, cardiac arrest, myocardial infarction, sepsis, readmission, and reoperation.

Statistical Analysis

Statistical analysis was performed using JMP Pro (Version 17.0.0, 2021 SAS Institute Inc.). Based on previous literature and our hypothesis, patient demographics, comorbidities, and outcomes were compared with the patient sample grouped into BMI < 40 and ≥ 40. Descriptive analyses were obtained, and the incidence of 30-day postoperative complications were determined for the entire sample size and patients based on BMI. Differences between normally and non-normally distributed continuous variables were compared using Welch's *t*-tests and Wilcoxon rank-sum tests, respectively. Fisher's exact tests were used to evaluate categorical variables. Logistic regression analysis was used to model the association of risk factors with reoperation. A univariate analysis was first performed and any factor with a $p \leq 0.15$ was included in the multivariate analysis for reoperation. A multivariate logistic regression analysis was also performed including diabetes and BMI variables on the indication for reoperation for the two most common indications for reoperation. Statistical significance was defined as $p < 0.05$; all statistical tests were two-sided.

Results

Patient Characteristics and Indications for Reoperation

A total of 1,303 patients met the criteria for this study. Demographics, comorbidities, and clinical characteristics are provided in ►**Table 1**. The average age of the cohort was 56.9 (standard deviation [SD] = 13.4) and predominantly female (68.6%). A little more than half of the patients were normal weight with a BMI < 30 (58.8%). The most common medical comorbidities included hypertension (37.8%) and diabetes (8.6%), and 14.6% of the cohort smoked tobacco. ASA class was grouped into class I (4.2%), II (57.5%), and $\geq$III (38.2%). Forty-two patients (3.2%) returned to the operating room within 30 days postoperatively (►**Table 1**). The most common indications for reoperation were CSF leak (31%), followed by wound complications including infections and wound breakdown (19%).

The cohort was grouped by BMI < 40 and ≥ 40 for comparison analysis based on our literature review. Among the groups, there were significant differences in patient age (57.4 vs. 50.1, respectively; $p < 0.0001$) and comorbidities including hypertension (33.6 vs. 60.9%; $p < 0.0001$), diabetes (7.7 vs. 16.3%; $p = 0.0002$), bleeding disorders (0.58 vs. 4.3%; $p = 0.0001$), and ASA Class $\geq$ III (35.8 vs. 69.6%;

Table 1 Patient characteristics, comorbidities, and postoperative outcomes

Patient characteristics	All	BMI < 40	BMI ≥ 40	*p*-Value
N	1,303	1,211	92	
Age	56.9 (13.4)	57.4 (13.4)	50.1 (12.1)	<0.0001[a]
Gender				
Male	409 (31.4)	383 (31.7)	26 (28.3)	
Female	894 (68.6)	827 (68.3)	66 (71.7)	0.56
BMI				
< 30	766 (58.8)	–	–	–
30–34.9	285 (21.9)	–	–	–
35–39.9	159 (12.2)	–	–	–
≥ 40	92 (7.1)	–	–	–
Comorbidities				
HTN	493 (37.8)	437 (33.6)	56 (60.9)	<0.0001[a]
Diabetes	112 (8.6)	94 (7.7)	15 (16.3)	0.0002[a]
Smoking history	190 (14.6)	181 (15.0)	9 (9.8)	0.22
COPD	11 (0.84)	10 (0.83)	1 (1.1)	0.55
CHF	0 (0.0)	0 (0.0)	0 (0.0)	–
Dyspnea	32 (2.5)	31 (2.6)	1 (1.1)	0.76
Steroid use	30 (2.3)	27 (2.2)	3 (3.3)	0.46
Bleeding disorder	11 (0.84)	7 (0.58)	4 (4.3)	0.0001[a]
Recent weight loss	7 (0.54)	7 (0.58)	0 (0.0)	1.0

Table 1 (*Continued*)

Patient characteristics	All	BMI < 40	BMI ≥ 40	*p*-Value
ASA class				
I	55 (4.2)	53 (4.4)	2 (2.2)	
II	749 (57.5)	723 (59.8)	26 (28.3)	
≥III	498 (38.2)	434 (35.8)	64 (69.6)	<0.0001[a]
Preoperative labs				
Platelets		242 (72.4)	243 (10.8)	0.95
PTT		29.1 (4.2)	31 (8.9)	0.12
INR		0.99	1.03	0.15
Procedure duration (min)	164.8 (58.0)	163.8 (57.5)	178.7 (60.2)	0.02[a]
Hospital LOS (d)	2.8 (3.5)	2.7 (3.6)	3.0 (2.54)	0.31
30-day postoperative complications	72 (5.5)	65 (5.4)	7 (7.6)	0.37
Superficial wound infection	14 (1.1)	12 (0.99)	2 (2.2)	0.45
Deep wound infection	4 (0.31)	3 (0.25)	1 (1.1)	0.45
Wound dehiscence	1 (0.08)	1 (0.08)	0 (0.0)	0.78
Pneumonia	5 (0.38)	5 (0.41)	0 (0.0)	0.54
Reintubation	4 (0.31)	2 (0.17)	2 (2.2)	0.19
Deep vein thrombosis	4 (0.31)	4 (0.33)	0 (0.0)	0.58
Pulmonary embolism	2 (0.15)	2 (0.17)	0 (0.0)	0.69
Failure to wean	2 (0.15)	2 (0.17)	0 (0.0)	0.69
Urinary tract infection	17 (1.3)	17 (1.4)	0 (0.0)	0.25
Stroke	8 (0.61)	8 (0.66)	0 (0.0)	0.43
Cardiac arrest	2 (0.15)	2 (0.17)	0 (0.0)	0.69
Myocardial infarction	2 (0.15)	2 (0.17)	0 (0.0)	0.69
Sepsis	10 (0.77)	9 (0.74)	1 (1.1)	0.72
Mortality	1 (0.08)	1 (0.08)	0 (0.0)	0.78
Readmission	76 (5.8)	68 (5.6)	8 (8.7)	0.10
Time to readmission (d)	13.8 (7.1)	13.5 (7.2)	16 (6.2)	0.32
Reoperation	42 (3.22)	34 (2.6)	7 (7.6)	0.006[a]
Time to reoperation (d)	13.8 (8.2)	13.9 (8.2)	14.3 (9.1)	0.99

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HTN, hypertension; INR, international normalized ratio; LOS, length of stay; PTT, partial thromboplastin time.
Notes: Patient sample grouped by BMI < 40 and BMI ≥ 40. Statistical comparison of means and frequency for patient characteristics and 30-day postoperative outcome provided by the *p*-value.
[a]Statistical significance.

$p < 0.0001$). There were no significant differences between gender, smoking history, COPD, dyspnea, steroid use, and recent weight loss.

Postoperative Outcomes

Postoperative outcomes are provided in ►**Table 1**. For the entire patient cohort, the mean procedure duration was 164.8 minutes (SD = 58.0). There was a statistically significant difference between patients with a BMI < 40 and ≥40 in the mean procedure duration (163.8 vs. 178.7 minutes, respectively; $p = 0.02$). For the entire cohort, the most frequent 30-day postoperative complications included superficial wound infection (1.1%), urinary tract infection (1.3%), readmission (5.8%), and reoperation (3.2%). Mean time to return to the operating room was 13.8 days (SD = 8.2). When grouped by BMI < 40 and ≥40, there was a significant difference between the frequency of reoperation (2.6 vs. 7.6%, respectively; $p = 0.006$; ►**Table 1**).

A univariate and multivariate logistic regression analysis was performed to evaluate the relationship between comorbidities and reoperation (►**Table 2**). Variables that met statistical significance on univariate analysis included diabetes (odds ratio [OR] = 3.7, 95% confidence interval [CI] = [1.7–7.7]; $p = 0.0006$), BMI ≥ 40 (OR = 2.79 [1.2–6.7]; $p = 0.022$), and procedure duration (OR = 1.01 [1.0–1.01]; $p = 0.021$). On multivariate analysis, diabetes (OR = 2.7

Table 2 Univariate and multivariate logistic regression analysis of patient characteristics and comorbidities on likelihood of reoperation

	Odds ratio of reoperation	
	Univariate OR [95% CI] (*p*-value)	**Multivariate OR [95% CI] (*p*-value)**
Age	0.99 [0.97–1.0] (0.49)	–
Sex		
Male	Ref	–
Female	1.11 [0.56–2.19] (0.77)	–
Diabetes	**3.66 [1.7–7.7] (0.0006)**	**2.7 [1.3–5.8] (0.011)**
BMI		
≤30	Ref	Ref
31–34.9	0.97 [0.43–2.2] (0.96)	1.7 [0.55–2.5] (0.68)
35–39.9	0.87 [0.29–2.6] (0.79)	0.89 [0.33–2.4] (0.82)
≥ 40	**2.79 [1.2–6.7] (0.022)**	**2.5 [1.06–6.0] (0.036)**
Diabetes and BMI ≥ 40	–	**4.9 [1.07–22.6] (0.04)**
Smoking history	1.4 [0.65–3.2] (0.37)	–
Dyspnea	1.1 [0.14–7.9] (0.95)	–
COPD	3.1 [0.39–25.0] (0.28)	–
Hypertension	0.94 [0.49–1.8] (0.87)	–
Steroid use	2.2 [0.52–9.8] (0.28)	–
Bleeding disorder	3.13 [0.39–25.0] (0.28)	–
ASA classification		
1	Ref	–
2	0.54 [0.16–1.9] (0.34)	–
3+	0.50 [0.14–1.8] (0.29)	–
Procedure duration	**1.01 [1.00–1.01] (0.021)**	**1.01 [1.00–1.01] (0.028)**

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disorder; OR, odds ratio; Ref, reference.
Bolded values have *p*-value significance of <0.05.

[1.3–5.8]; $p = 0.011$), BMI ≥ 40 (OR = 2.5 [1.1–6.0]; $p = 0.04$), and procedure duration (OR = 1.01 [1.0–1.01]; $p = 0.028$) maintained statistical significance for reoperation. For patients who had both diabetes and a BMI ≥ 40, there was a statistically significant cumulative increase in the odds of reoperation (OR = 4.9 [1.07–22.6]; $p = 0.04$).

In patients with a BMI ≥ 40 and diabetes, there is a near-linear increase in the probability of reoperation with increasing operation time (►**Fig. 1**). At the mean procedure length for the cohort with a BMI ≥ 40, the probability of reoperation is 18%. The projected probability of reoperation increases to 30% for a procedure duration of 411 minutes in this model.

The indications for reoperation included CSF leak ($n = 31$, 31% of reoperations), wound complications ($n = 8$, 19% of reoperations), refractory pain ($n = 5$, 11.9% of reoperations), intracranial hemorrhage ($n = 2$, 4.8% of reoperations), and other ($n = 14$, 33.3% of reoperations; ►**Table 3**). A multivariate logistic regression analysis was performed to determine the association of diabetes and BMI by specific indication for reoperation (►**Table 4**). The sample sizes allowed for analysis for CSF leak and wound breakdown only. For wound complications, we found significance with diabetes (OR = 8.3 [1.9–35.5]; $p = 0.005$) and BMI ≥ 40 (OR = 8.2 [1.4–57.8]; $p = 0.0226$). Additionally, there was an increased risk of CSF leak with increasing procedure duration (OR = 1.01 [1.00–1.02]; $p = 0.0089$). Diabetes and BMI were not associated with CSF leak.

Discussion

Reoperation after an MVD has been reported as high as 11%[10] and typically occurs due to CSF leak, surgical site infection, or recurrent/persistent pain or spasm.[17] The reoperation rate is unacceptably high for a surgery with reasonable alternative treatment options. Moreover, postoperative complications following repeat surgery has been reported at 37% and includes facial numbness, hearing loss, infection, and CSF leak.[15] The high rates of reoperation surgery and associated complications emphasize the importance of identifying these high-risk patient populations for preoperative optimization or alternative treatment strategies.

We demonstrate that 30-day postoperative reoperation rate is associated with morbid obesity (BMI ≥ 40), diabetes, and

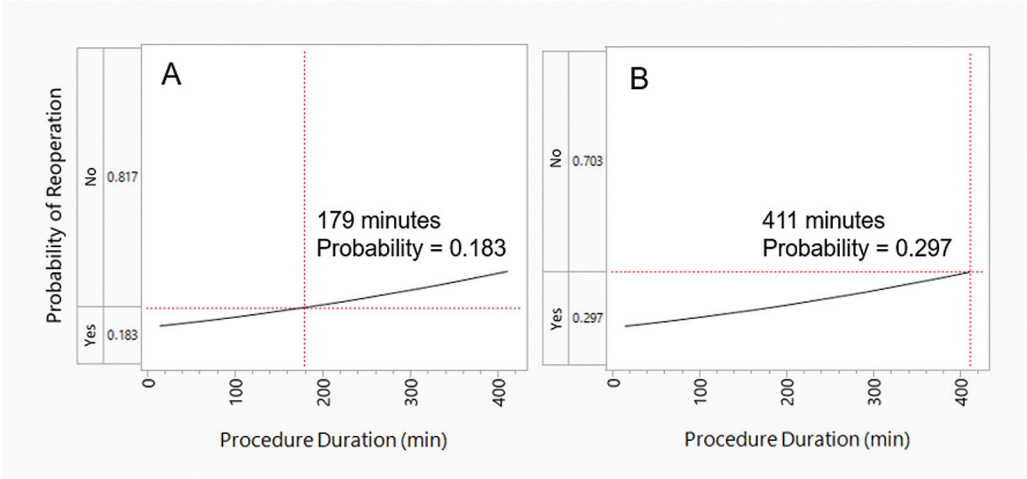

Fig. 1 Probability of reoperation based on procedure duration. Probability is based on patients with a BMI $\geq$ 40 and diabetes. There is a near-linear relationship between procedure duration and probability of reoperation. (A) At the mean procedure duration for the with a BMI $\geq$ 40 (179 minutes), the probability of reoperation is 18%. (B) At the longest procedure duration that is calculated by the model (411 minutes), the risk of reoperation increases to 30%.

Table 3 Indication for reoperation with corresponding CPT code, procedure detail, and total number of patients with percent frequency in the entire sample and within the reoperations group

Indication	CPT	Procedure	*N*, %	% of reoperations
CSF leak			**13 (1.0)**	**31.0**
	62100	Craniotomy for repair of dural/cerebrospinal fluid leak	7 (0.54)	16.7
	61618	Secondary repair of dura for cerebrospinal fluid leak, anterior, middle or posterior cranial fossa following surgery of the skull base; by free tissue graft	3 (0.23)	7.1
	63709	Repair of dural/cerebrospinal fluid leak or pseudomeningocele, with laminectomy	1 (0.08)	2.4
	63707	Repair of dural/cerebrospinal fluid leak, not requiring laminectomy	2 (0.15)	4.8
Wound complications			8 (0.61)	19.0
	13160	Secondary closure of surgical wound or dehiscence, extensive or complicated	4 (0.31)	9.5
	10180	Incision and drainage, complex, postoperative wound infection	2 (0.15)	4.7
	10120	Incision and removal of foreign body, subcutaneous tissues; simple	1 (0.08)	2.4
	11042	Debridement, subcutaneous tissue	1 (0.08)	2.4
Refractory pain			5 (0.38)	11.9
	61458	Craniectomy, suboccipital; for exploration or decompression of cranial nerves	3 (0.23)	7.1
	64610	Destruction by neurolytic agent, trigeminal nerve; supraorbital, infraorbital, mental, or inferior alveolar branch; second and third division branches at foramen ovale under radiologic monitoring	2 (0.15)	4.8
Intracranial hemorrhage			2 (0.15)	4.8
	61315	Craniectomy or craniotomy for evacuation of hematoma, infratentorial; extradural or subdural; intracerebral	2 (0.15)	4.8
Other/ unknown			14	33.3
	62142	Removal of bone flap or prosthetic plate of skull	2 (0.15)	4.78
	61304	Craniectomy or craniotomy, exploratory; supratentorial	1 (0.08)	2.4

(*Continued*)

Table 3 (*Continued*)

Indication	CPT	Procedure	*N*, %	% of reoperations
CSF leak			**13 (1.0)**	**31.0**
	61345	Other cranial decompression, posterior fossa	1 (0.08)	2.4
	62146	Cranioplasty with autograft	1 (0.08)	2.4
	62160	Neuroendoscopy, intracranial, for placement or replacement of ventricular catheter and attachment to shunt system or external drainage	1 (0.08)	2.4
	61321	Incision and subcutaneous placement of cranial bone graft; infratentorial	1 (0.08)	2.4
	NA	Not reported	7 (0.54)	16.7
Total			42	

Abbreviations: CPT, current procedural terminology; CSF, cerebrospinal fluid; NA, not applicable.

Table 4 Multivariate logistic regression analysis of risk factors for cerebrospinal fluid leak and wound complications leading to reoperation

	Multivariate odds ratio of complications	
	CSF leak ($n = 13$)	**Wound complications ($n = 8$)**
Diabetes	2.16 [0.45–10.3] (0.33)	**8.3 [1.9–35.5] (0.005)**
BMI		
≤30	Ref	Ref
31–34.9	0.94 [0.24–3.62] (0.93)	1.97 [0.11–16.7] (0.51)
35–39.9	NA	1.42 [0.12–16.7] (0.78)
≥40	1.8 [0.36–8.99] (0.47)	**8.2 [1.4–57.8] (0.0226)**
Procedure time	**1.01 [1.00–1.02] (0.0089)**	0.99 [0.98–1.01] (0.36)

Abbreviations: BMI, body mass index; CPT, current procedural terminology; CSF, cerebrospinal fluid; NA, not applicable; Ref, reference.
Bolded values have *p*-value significance of <0.05.

increasing procedure duration. Most common indications for reoperation included CSF leak, wound-related issues (dehiscence and/or infection), and refractory symptoms. Using this larger sample size, we found that a patient with either diabetes or BMI $\geq$ 40 is associated with a 2-fold increase in risk of reoperation, while having both diabetes and BMI $\geq$ 40 has an almost 5 times the risk of reoperation. In addition, we show a linear-type relationship in the probability of reoperation and procedure duration for patients with a BMI $\geq$ 40 and diabetes such that the risk of reoperation for the mean procedure duration is 18% and, with increasing procedure duration, increases to as high as 30%. Given that patients with a BMI $\geq$ 40 consist of 7% of the population receiving an MVD, these are important findings that can impact a significant portion a neurosurgeon's patient population and potential management.

Patients with diabetes and/or morbid obesity are in a chronic state of inflammation and dysmetabolism, impeding wound healing and increasing the risk of infection.[24–29] Obesity also increases tension on the fascial edges of the wound closure, directly contributing to wound dehiscence.[29] Indeed, patients with BMI $\geq$ 40 had rates of reoperation of 8% compared with 3% in patients with BMI $<$ 40 in this study. Our findings are consistent with and support a prior NSQIP study from 2017 by Arnone et al that investigated risk factors associated with readmission and reoperation. This study demonstrated that patients with morbid obesity (9.5%; OR = 5.3; $p = 0.030$) and diabetes (11.8%; OR = 6.32; $p = 0.017$) have increased risk of reoperation after an MVD.[17] Although this study was the first to demonstrate this relationship, its findings were limited and restrictive because there were only 14 cases of reoperation. With a larger sample size and 42 cases of reoperation, we were able to conduct univariate and multivariate logistic regression analysis on the risk factors and indications for reoperation, which have not been previously published.

Patients with morbid obesity had a statistically significant longer surgical time. It is possible an increase in procedure duration reflects the increased challenges with exposing the relatively small corridor used for MVD associated with a larger body habitus. The difficulties leading to an increase in procedure duration, such as difficult exposure and/or closure with a more limited access. Whereas morbid obesity and diabetes were not correlated with CSF leak, longer procedure time was independently associated with increased risk of CSF leak (►**Table 4**). We hypothesize that, unlike wound complications, where patients with morbid obesity may have wound healing issues due to poor skin integrity related to

medical and nutritional confounders, CSF leaks may be more likely due to incomplete closure of dura or opening of the mastoid air cells that cannot be adequately repaired due to body habitus and exposure. These factors do not appear to be influenced by BMI, but rather procedure length may reflect possible challenges due to morbid obesity encountered intraoperatively that may increase the risk of CSF leak.

Interestingly, we found that for every increasing minute of procedure duration, there is a 1% increased risk of reoperation (►**Table 2**). This is particularly applicable for patients with higher BMIs who have an on average longer procedure duration. Indeed, we demonstrate the near-linear relationship of procedure duration and the predicted risk of reoperation in patients with diabetes and a BMI ≥ 40. At the mean procedure duration (164 minutes), the predicted probability of reoperation is 18%. The highest predicted probability for a procedure duration of approximately 400 minutes is as high as 30%. Importantly, the procedure duration, recorded as time from skin opening to closure in the NSQIP database, underestimates the overall time the patient is in the operating room and at risk for perioperative complications. The critical periods between anesthesia induction and waking are especially tenuous for patients with obesity who are at increased risk of perioperative respiratory failure, aspiration, myocardial infarction, infection, and anesthetic failure.[28,30]

Alternative treatment strategies may be considered for patients with morbid obesity and/or diabetes. Stereotactic radiosurgery (SRS) is a recognized alternative and effective means for providing relief for patients with TN.[31,32] Interestingly, in a retrospective study, Khattab et al found that patients with a BMI > 25 had a poorer response and lesser improvement to pain post-SRS, perhaps due to a blunted response to SRS therapy.[16] Although Botox injections are routinely used for HFS, the mean duration of effect is typically 12 weeks, requiring repeat injections for continued relief. Medical therapy may be possible with anticonvulsants such as carbamazepine, clonazepam, and gabapentin; however, these are less effective and have significant side effects that may decrease quality of life. These treatments may be used transiently while optimizing the patient prior to surgical decompression.

Using the important findings in this study, providers may have informed discussions with patients about the risks and benefits of an MVD. When consenting patients with diabetes or higher BMI, it may be prudent to discuss potential increased risk of reoperation and the risks that may follow. It may even warrant preventative measures prior to surgery to decrease this risk such as optimizing blood sugar levels, reducing HgA1c levels $< 6\%$, and encouraging weight loss.[33–35] Weight loss may even improve postoperative refractory/recurrent pain outcomes.[16] Alternative intervention strategies may also be worthy of discussion given the risks of reoperation and should be discussed with the patient.

Limitations

The ACS-NSQIP is a national database, but there still is potential for selection bias related to nonrandomized participation of institutions. The ACS-NSQIP only reports 30-day postoperative outcomes, which narrows the interpretation of our results to a short postoperative period. The reoperation rate in the NSQIP cohort was 3.2%, which is lower than other reported reoperation rates. This limitation is particularly important when considering persistent/recurrent pain after a failed MVD.

Additionally, postoperative complications were not comprehensively reported in the NSQIP database. In the context of this study, postoperative pain scores are important determine the effectiveness of the procedure. The NSQIP database does not report radiosurgery procedures, preventing a comparison analysis between MVD and SRS. Comparing postoperative pain outcomes and complications in patients with BMI > 40 receiving either an MVD or SRS would be an important follow-up study.

The indication for reoperation was also limited based on the provided CPT codes. The largest category indication for reoperation was the "other/unknown" group, which included 14 different CPT codes. The CPT codes in this group corresponded to indication such as removal of bone flap, exploratory craniotomy, and cranioplasty. There were also seven reoperations that were reported as "NA" or not reported. Better characterization of the indications for reoperation may have increased the sample size in the groups and may have affected the statistical analysis.

Conclusion

This study demonstrates in a large cohort that the incidence of reoperation in patients with morbid obesity almost 8%. Patients with morbid obesity are at risk for lengthier surgery times and wound complications leading to reoperation. Diabetes is also associated with increased risk of reoperation and wound complications. Patients with morbid obesity and diabetes have almost a 5 times increased risk of reoperation with a near-linear relationship of reoperation and procedure duration. Given that patients with morbid obesity consist of 7% of the population receiving an MVD, these are crucial findings that may impact a neurosurgeon's practice and potential management. Additional studies are needed to determine if treatment outcomes in other treatment modalities are equally efficacious and minimize postoperative complications for patients with morbid obesity.

Conflict of Interest
None declared.

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