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SURGICAL NEUROLOGY INTERNATIONAL

SNI: General Neurosurgery

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Editor: C. David Hunt, M.D. Marquette General Neurosurgery, Brooklyn, NY, USA

Original Article

Diabetes and morbid obesity are associated with higher reoperation rates following microvascular decompression surgery: An ACS-NSQIP analysis

Gregory D. Arnone, Darian R. Esfahani, Steven Papastefan, Neha Rao, Prateek Kumar, Konstantin V. Slavin, Ankit I. Mehta

Department of Neurosurgery, University of Illinois at Chicago, Chicago, Illinois, USA

E-mail: Gregory D. Arnone - garnone@uic.edu; Darian R. Esfahani - desfah2@uic.edu; Steven Papastefan - papaste2@uic.edu; Neha Rao - nrao5@uic.edu; Prateek Kumar - kumar33@uic.edu; Konstantin V. Slavin - kslavin@uic.edu; *Ankit I. Mehta - ankitm@uic.edu
*Corresponding author

Received: 29 August 17 Accepted: 01 September 17 Published: 01 November 17

Abstract

Background: Microvascular decompression (MVD) is the preferred treatment for refractory trigeminal neuralgia, hemifacial spasm, and glossopharyngeal neuralgia. Despite its high rate of success, MVD carries risk of complications. In this study, we examine outcomes following MVD and identify risk factors associated with adverse outcomes.

Methods: A review of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database was performed with CPT code 61458 queried between 2007 and 2014. Demographics, preoperative comorbidities, and 30-day outcomes were analyzed. Univariate and multivariate regression analyses were performed to identify predictors of reoperation and adverse events.

Results: Five hundred and six craniotomies were studied. Nineteen (5.5%) instances of 30-day readmission were reported, with 14 (2.8%) patients returning to the operating room. No instances of death or hemorrhage requiring operation were reported. Morbid obesity (body mass index >40) ($P = 0.030$) and diabetes ($P = 0.017$) were associated with risk of reoperation. Age, operative time, and indication for surgery were not associated with significant differences in adverse events.

Conclusions: MVD is a common and effective procedure with a relatively safe profile and low 30-day risk of reoperation. Advanced age is not associated with worse outcomes. Obesity and diabetes, however, are associated with increased risk of reoperation and may warrant additional precautions.

Key Words: Diabetes, microvascular decompression, NSQIP, obesity, readmission, reoperation

Access this article online

Website: www.surgicalneurologyint.com

DOI: 10.4103/sni.sni_325_17

Quick Response Code:

How to cite this article: Arnone GD, Esfahani DR, Papastefan S, Rao N, Kumar P, Slavin KV, *et al.* Diabetes and morbid obesity are associated with higher reoperation rates following microvascular decompression surgery: An ACS-NSQIP analysis. Surg Neurol Int 2017;8:268.
http://surgicalneurologyint.com/Diabetes-and-morbid-obesity-are-associated-with-higher-reoperation-rates-following-microvascular-decompression-surgery:-An-ACS-NSQIP-analysis/

INTRODUCTION

Microvascular decompression (MVD) is the preferred surgical treatment for refractory trigeminal neuralgia (TN), hemifacial spasm (HFS), and glossopharyngeal neuralgia (GN), debilitating conditions of the 5th, 7th, and 9th cranial nerves, respectively.[4,8,21,24,30] TN is characterized by paroxysmal, "lightning" pain in areas innervated by the trigeminal nerve,[18] HFS consists of recurrent, unilateral movements of muscles innervated by the facial nerve,[6] and GN includes sporadic ear, tongue, and throat pain triggered by chewing, swallowing, coughing, and speaking.[32] The most common cause of TN, HFS, and GN is compression of the trigeminal, facial, and glossopharyngeal nerves at the root entry zone from the brainstem.[11,15,32] MVD is a surgical treatment used to decompress exiting cranial nerves in medically refractory cases,[34] and has been associated with high rates of pain relief at small risk to cranial nerve dysfunction.[7,26,28]

The frequent use of MVD in TN, HFS, and GN is attributable to a high success rate and durability over time.[2,4,18,22,24,26,28-30,36] Despite its clinical utility, however, the retrosigmoid craniotomy required for MVD is invasive and carries risk of complications including cerebellar hemorrhage, stroke, cranial nerve injury, and death.[5,9,14,31,36] Due to the invasiveness of the procedure, not all patients are good candidates for MVD, and patients should be referred for an appropriate surgical strategy based on their operative risk, age, history of previous procedures, and associated conditions such as multiple sclerosis. Other procedures including stereotactic radiosurgery and percutaneous rhizotomy are appropriate alternatives for certain TN, HFS, and GN patients.[3,35]

The American College of Surgeons–National Surgical Quality Improvement Program (ACS-NSQIP) collects information from many types of surgeries in a standardized, risk-adjusted database with the aim of providing metrics for patient outcome improvement, and has been has shown to decrease morbidity and mortality in participating hospitals.[23] In this study, we utilize ACS-NSQIP to evaluate the risk of readmission, reoperation, and adverse outcomes in MVD for TN, HFS, and GN.

MATERIALS AND METHODS

A retrospective review of the prospectively-collected ACS-NSQIP database was performed. Data from 2007 to 2014 was investigated using primary Current Procedural Terminology (CPT) code 61458 (craniotomy, suboccipital; for exploration or decompression of cranial nerves). Only cases with ICD-9 (International Classification of Diseases) codes 350.1 (trigeminal neuralgia), 351.8 (other facial nerve disorders), 351.9 (facial nerve disorder), and 352.1 (glossopharyngeal neuralgia) were considered. Project approval was obtained through the university institutional review board. As data collection involved no risk to participants and all NSQIP data is anonymized, a waiver for consent was granted.

Demographics and medical comorbidities were reviewed. Body mass index (BMI) was calculated from height and weight data and morbid obesity was defined as BMI >40. The American Society of Anesthesiology (ASA) physical status classification was binned into groups 1–2 and >3 to classify patient fitness prior to surgery. Comorbidities were only analyzed if present in at least five patients, and data points must have been available in at least half of the patients to be considered for analysis. When complete data was not available, percentile values were calculated from the proportion of patients where the presence or absence of the comorbidity was recorded.

Outcome measures

Thirty-day readmission, return to the operating room, and death were the primary outcomes measured. Specific ICD-9 codes associated with each readmission as well as CPT codes for each reoperation were categorized and recorded. Medical complications and length of postoperative hospital stay were also noted.

Statistical analysis

Two-tailed Student's *t*-tests were performed for continuous variables, whereas Pearson's Chi-squared tests, analysis of variance, or Fisher's exact tests were used to compare proportions of categorical data or diagnoses with one another. Univariate analysis of risk factors for readmission or reoperation was performed for demographic variables, including age, sex, ASA class, and comorbidities. Statistically significant values were identified with a P value of less than 0.05, and confidence intervals were defined at 95%.

Multivariate logistic regression models were performed to evaluate predictors of readmission or reoperation. All demographic variables, indication for operation, and comorbidities with a P value less than 0.1 on univariate analysis were included in multivariate analysis. Statistics were calculated using SPSS (IBM Corporation, Armonk, NY).

RESULTS

Demographics

Five hundred and six craniotomies were reviewed. Demographic data is outlined in Table 1. In the cohort, surgery for TN was the most common (80.2%). The mean patient age differed significantly between the three surgery indications ($P = 0.009$), with an average age at surgery of 57.3 years and TN patients being the oldest (58.2 years). Over two-thirds (68.6%) of the cohort was female, with the largest proportion of females in the TN group (70.7%). Most patients were

ASA Class 2 (mild systemic disease) (62.2%). Patient preoperative comorbidities are illustrated in Table 2. Hypertension was the most common comorbidity present in 175 patients (34.6%), followed by smoking (15%) and diabetes (6.7%).

Clinical outcomes

Patient outcomes are outlined in Table 3. Thirty-day readmission data was available from 2011 and present in 345/506 (68.2%) of the patients, from which 19 readmissions (5.5%) were noted. Reoperation rate was measured in all 506 patients, with 14 reoperations (2.8%) observed. There were no instances of mortality. Medical complications were measured in all patients, and observed in 20 patients (4%). Urinary tract infection was the most common medical complication present in 6 patients (1.2%), and the mean postoperative length of stay was just under 3 days. No significant differences were noted between TN and HFS patients. No readmissions, reoperations, or medical complications were observed in the 9 GN cases.

Risk factors for readmission and reoperation

Analysis of risk factors for readmission and reoperation are illustrated in Table 4. Diabetes ($P = 0.012$) and morbid obesity (BMI >40) ($P = 0.049$) were found to be predictive of readmission; although these fell just short of significance on multivariate analysis. ASA class approached but was not found to be significantly associated with readmission ($P = 0.093$). Detailed data on cause of readmission, with ICD-9 code, was available in 10/19 patients in the cohort [Table 5]. Of this group, 3 were readmitted with pain symptoms, 2 with cerebrospinal fluid (CSF) leak, and 1 with aseptic meningitis. Three patients were readmitted with an unspecified neurologic complication and 1 with an unspecified facial nerve disorder.

Need for reoperation was associated with diabetes ($P = 0.011$) and approached significance with morbid obesity ($P = 0.052$). On multivariate analysis, both diabetes ($P = 0.017$; OR 6.32; CI 1.39–28.70) and morbid obesity ($P = 0.030$; OR 5.26; CI 1.17–23.59) were significant risk factors for reoperation. Data on reoperations with CPT code were available in 9/14 patients in the cohort [Table 6]. Among patients with eligible data, listed reoperations included 5 treatments for CSF leak, 3 wound revisions, and 1 CSF diversion procedure. Neither age, sex, nor indication for surgery were found to be related to readmission or reoperation risk.

Table 1: Demographics

	n (%)			
	TN	HFS	GN	All
Total Cases	406 (80.2%)	91 (18%)	9 (1.8%)	506
Age (mean years)	58.2	54.2	50.2	57.3
Gender				
Male	119 (29.3%)	35 (38.5%)	5 (55.6%)	159 (31.4%)
Female	287 (70.7%)	56 (61.5%)	4 (44.4%)	347 (68.6%)
ASA Class				
1	17 (4.2%)	10 (11%)	1 (11.1%)	28 (5.5%)
2	254 (62.7%)	54 (59.3%)	6 (66.7%)	314 (62.2%)
3	132 (32.6%)	27 (29.7%)	2 (22.2%)	161 (31.9%)
4	2 (0.5%)	0	0	2 (0.4%)

ASA: American Society of Anesthesiologists, GN: Glossopharyngeal Neuralgia, HFS: Hemifacial Spasm, TN: Trigeminal Neuralgia

Table 2: Comorbidities

	n (%*)
Hypertension	175 (34.6%)
Smoking	76 (15%)
Diabetes	34 (6.7%)
Morbid Obesity	32 (6.3%)
Dyspnea	17 (3.4%)
Percutaneous coronary intervention	10 (3.5%)
Alcohol Abuse	8 (2.8%)
Steroid Use	7 (1.4%)
Recent Weight Loss	6 (1.2%)
Cardiac Surgery	5 (1.8%)

*Of patients where data was available

Table 3: Clinical outcomes

Clinical outcomes	*n* (%)		*P*
	TN	HFS	
Readmission (30 days)	14 (5.0%*)	5 (7.6%*)	0.379
Reoperation	10 (2.5%)	4 (4.4%)	0.300
Death	0	0	
Medical Complication	14 (3.4%)	6 (6.6%)	0.231
Urinary Tract Infection	5 (1.2%)	1 (1.1%)	1.000
Organ Space Infection	3 (0.7%)	0	1.000
Superficial Infection	1 (0.2%)	2 (2.2%)	0.088
Pneumonia	2 (0.5%)	0	1.000
Sepsis	2 (0.5%)	0	1.000
Transfusion	1 (0.2%)	0	1.000
DVT	0	1 (1.1%)	0.183
Stroke	0	1 (1.1%)	0.183
Wound Infection	0	1 (1.1%)	0.183
Mean postoperative length of stay (days)	2.82	2.86	0.851

DVT, Deep Venous Thrombosis. *Of 345 patients where data was available

DISCUSSION

TN, HFS, and GN are episodic, debilitating craniofacial syndromes. MVD is a nondestructive surgical procedure that is both common and highly effective in refractory cases, with complete pain relief rates of 76–98% reported.[22,25,26,34] Although generally considered safe, MVD has been associated with complications including CSF leak, hydrocephalus, and cranial nerve dysfunction.[7,26,28,31] Previous studies have described

Table 4: Readmission and reoperation risk factors

	Readmit (%)	Univariate		Multivariate			Reoperation (%)	Univariate		Multivariate		
		Odds ratio	*P*	Odds ratio	*P*	CI		Odds ratio	*P*	Odds ratio	*P*	CI
Demographics												
Age			0.837		0.791				0.766		0.796	
Sex			0.848		0.923				1		0.859	
F	5.3						2.9					
M	5.8						2.5					
ASA Class			0.093		0.343				1		0.384	
1-2	3.8						2.6					
3+	8						2.5					
Indication												
TN	14		0.379		0.288		10		0.300		0.169	
HFS	5						4					
Comorbidity												
Hypertension	6.1		0.677				3.4		0.572			
Smoking	5		1				2.6		1			
Diabetes	17.9	4.80	0.012		0.059		11.8	6.16	0.011	6.32	0.017	1.39-28.70
Morbid Obesity	14.8	3.57	0.049		0.084		9.4		0.052	5.26	0.030	1.17-23.59
Dyspnea	12.5		0.362				5.9		1			
PCI	0		1				0		1			
Alcohol Abuse	0		1				0		1			
Steroid Use	25		0.2				14.3		0.179			
Recent Weight Loss	0		1				0		0			
Cardiac Surgery	0		1				0		0			

ASA: American Society of Anesthiologists, CI: Confidence Interval, HFS: Hemifacial Spasm, PCI: Percutaenous Coronary Intervention, TN: Trigeminal Neuralgia

Table 5: Readmissions

Reason for readmission	ICD9	Code	*n*	% of readmissions	% of patients*
Postoperative pain	338.18	Other acute postoperative pain	1		
	350.1	Trigeminal neuralgia	1		
	784.0	Headache	1		
			3	30	1.65
CSF Leak	349.31	Accidental puncture or laceration of dura during a procedure	1		
	349.81	Cerebrospinal fluid rhinorrhea	1		
			2	20	1.10
Meningitis	322.0	Nonpyogenic meningitis	1	10	0.55
Other	351.9	Facial nerve disorder, unspecified	1		
	997.09	Other nervous system complication	3		
			4	40	2.20
Total			10	100	5.50

CSF: Cerebrospinal Fluid, ICD: International Classification of Diseases. *As a proportion of available data

complication rates between 3% and 19%,[26,29,34] and a recent paper described an overall 30-day complication rate of MVD at 20%, with 6.1% of patients requiring repeat surgery.[1] In the NSQIP cohort, a 30-day readmission rate of 5.5% and reoperation rate of 2.8% was observed, a finding slightly less than that of previous reports.

A challenge of investigating surgeries with low risk profiles is that often very large samples are necessary to capture complications. Given the relatively safe nature of MVD procedures, risk factors predisposing to complications have been poorly identified. ACS-NSQIP is a national database gaining acceptance as a tool in quality improvement and reducing complications.[19] This paper is the first to utilize the large sample size of the NSQIP to review a sample of 506 patients and identify the risk of readmission, reoperation, and medical complications in patients undergoing MVD.

Readmissions and reoperations

The findings of the NSQIP cohort reaffirm MVD as a relatively safe procedure. With an overall readmission rate of 5.5%, reoperation rate of 2.8%, and no deaths,

Table 6: Reoperations

Reason for reoperation	CPT	Procedure	*n*	% of reoperations	% of patients*
CSF Leak	62100	Craniotomy for repair of dural/cerebrospinal fluid leak, including surgery for rhinorrhea/otorrhea	3		
	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	2		
			5	55.5	1.54
Wound management	10180	Incision and drainage, complex, postoperative wound infection	1		
	11042	Debridement, subcutaneous tissue (includes epidermis and dermis, if performed)	1		
	13160	Secondary closure of surgical wound or dehiscence, extensive or complicated	1		
			3	33.3	0.92
Hydrocephalus	62160	Neuroendoscopy, intracranial, for placement or replacement of ventricular catheter and attachment to shunt system or external drainage	1	11.1	0.31
Total			9	100	2.77

CPT: Current Procedural Terminology, CSF: Cerebrospinal Fluid. *As a proportion of available data

these findings are similar to slightly better than elsewhere reported in the literature.[1,26,29] However, complications are poorly described in the literature, and are generally reported in a very heterogeneous manner.[1] In the NSQIP cohort, the most common reported reasons for readmission included postoperative pain and unspecified neurologic or facial nerve problems, which together prompted readmission in approximately 4% of patients. It is unclear how prevalent this is in the general population, however, as readmissions for pain are usually not considered to be surgical complications, and may be underreported. In this regard, the NSQIP cohort is unique in that it quantifies readmission rate for all causes. These results are potentially valuable as they provide a good overview of the realities of daily practice.

Need for repeat surgery is uncommon following MVD. A recent literature review of MVD complications by Bartek *et al*,[1] for example, noted rates of postoperative complications requiring repeat surgery, organ failure, or death ranging 0–4.3% of patients across a large number of studies, with the author's own cohort having a rate of 6.1%. In the NSQIP cohort, the most common reason for reoperation was CSF leak, with 1.54% of the patients returning to the operating room for this purpose. In the literature review by Bartek *et al*.,[1] reported rates of postoperative CSF leak ranged 0–5.2% of patients, although the frequency of patients needing repeat surgery was not reported.

Risk factors

In the NSQIP cohort, neither age and sex nor indication for surgery were associated with risk of readmission or reoperation. The relatively low overall complication overall and lack of significance of age support MVD as a relatively safe procedure suitable for most patients, including the elderly. These findings are reinforced by a recent comparison of elderly and nonelderly patients which identified equally effective outcomes following surgery and no significant differences in hospital stay or complications.[31]

Both diabetes and morbid obesity in the NSQIP cohort were found to be significantly associated with risk of readmission and reoperation, with risk of reoperation remaining significant on multivariate analysis. A higher complication rate in diabetic patients has been observed in other surgical specialties as well, including breast reconstruction and head and neck surgery.[12,27] A probable cause of these complications is the association between diabetes and poor surgical wound healing,[12,16] a finding supported by the high rate of wound reoperations in the NSQIP cohort. A high rate of complications in obese patients has been observed in other neurosurgical procedures as well. A recent NSQIP review of patients undergoing craniotomy for tumor, for example, revealed a significantly higher readmission rate in patients with morbid obesity.[10] The relationship between obesity and adverse outcomes has also been observed in spinal procedures, with morbidly obese patients reported to have a 10-times higher rate of wound complications versus nonobese patients.[13] The high complication rate in obese patients may be secondary to longer length of surgery, operating at greater depth, and decreased mobility postoperatively. Obesity is also associated with elevated intracranial pressure, which may make patients more prone to CSF leak, which is the most common cause for reoperation in the NSQIP cohort.

Avoiding readmission and reoperations

Although uncommon, readmissions and reoperations after MVD occur. How can they be prevented? Postoperatively, expedient discharge is preferable to avoid medical complications seen in any hospital admission, including urinary tract infections, pneumonia, and deep venous thrombosis (DVT). While neurologic monitoring in the immediate postoperative setting is necessary, a recent study revealed that patients without postoperative ICU

stay after MVD had the same number of complications as patients sent to the ICU but had a significantly shorter length of stay and hospital cost.[20] These findings suggest postoperative care in the recovery room followed by step-down unit may be appropriate for some patients.

While diabetes and morbid obesity are preoperative characteristics that cannot be controlled on admission, additional care in patients with these risk factors may help avoid adverse outcomes. Meticulous dural closure and complete cranial defect reconstruction,[33] for example, may help mitigate the risk of CSF leak in these high-risk patients. Intensive postoperative wound management, including more frequent surveillance, local topical agents and dressings to take home, as well as additional education about wound care after discharge may also make a difference for diabetic or obese patients. If feasible, in high-risk patients with only mild symptoms, delay of surgery until weight loss and better glucose control can be achieved may be an acceptable option.

Limitations

Studies of the NSQIP cohort include several limitations. The NSQIP, by design, collects data relevant to most surgical patients, including rates of readmission, reoperation, and death, but does not include several variables of interest for neurosurgery patients, including Karnofsky performance status on discharge or improvement of symptoms. The success rate for MVD in the short term, however, is very high, with reoperations for recurrent symptoms extremely uncommon, a finding observed in the NSQIP cohort. Data for the NSQIP MVD cohort is also partially incomplete, with most data on patient readmissions absent before 2011. Hospital MVD volume, which is associated with complication rate,[17] as well as affiliation (academic, private, etc.) are also not reported, making it challenging to draw conclusions about the level of surgeon experience or hospital type. A sample size of 506 patients is also relatively low for a 7-year period, with some large centers independently performing a similar number of cases in the same time frame.

Despite these limitations, however, the NSQIP avoids the inherent biases of single institution or single surgeon series. The NSQIP, by design, is a composite of data from hundreds of hospitals throughout the world, including academic and community centers, making it fairly representative of the neurosurgical community as a whole. The NSQIP further affords a sufficient sample size of patients for detailed statistical analysis in populations even with a low complication rate such as MVD. This cohort of patients collected over a relatively short time frame, therefore, provides an adequate "snapshot" of current management for MVD.

CONCLUSIONS

MVD is an effective and commonly performed procedure in neurosurgery and forms an essential part of treatment for refractory TN, HFS, and GN. In this NSQIP cohort, a 30-day readmission rate of 5.5% and reoperation rate of 2.8% were identified, reaffirming the relative safety of contemporary surgery for TN, HFS, and GN.

Although safe, risk of complications after MVD persist despite optimal surgical management. Diabetes and morbid obesity were significantly associated with risk of reoperation, and approached significance for readmission. Age, sex, ASA class, and indication for surgery were not associated with poor outcomes. While further research is needed to identify the optimal strategy to reduce readmissions and repeat surgery, additional care in patients with these risk factors may help avoid adverse outcomes.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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