



## INTRODUCTION

As the number of deep brain stimulation (DBS) procedures performed under general anesthesia ("asleep" DBS) increases, it is important to assess the rate of adverse events, inpatient length of stay, and 30-day readmission rates for these patients compared with those undergoing traditional "awake" DBS without general anesthesia. There have been no previous studies evaluating these specific metrics for "asleep" DBS surgery.

## METHODS

All patients undergoing asleep or awake DBS by a single surgeon between August 2011 and August 2014 were reviewed from a prospectively collected database. Adverse events, inpatient length of stay, and 30-day readmission rates were analyzed for 490 electrodes placed in 284 patients. All procedures were performed utilizing uniform methods in each cohort (awake vs. asleep).

Direct targeting was utilized for subthalamic nucleus (STN) and globus pallidus interna (GPi) placement, and indirect targeting was utilized for ventral intermediate nucleus (VIM) placement. The asleep cohort had a stereotactic Leksell frame or NexFrame bone fiducials placed in the operating room after induction of general anesthesia. Intraoperative CT (iCT) images were obtained and co-registered with preoperative MRI sequences utilizing Framelink software. After leads were implanted, iCT was obtained prior to skin closure to determine accuracy and necessity for lead repositioning. For awake patients, all leads were implanted with the Leksell stereotactic frame utilizing microelectrode recordings to guide STN and GPi placement. Intraoperative test stimulation was performed for all patients to assess for clinical benefit and side effects.

## RESULTS

126 patients (63.7%) underwent asleep surgery, and 158 patients (56.6%) underwent awake placement. The most frequent complication was postoperative mental status change (13 patients, 4.6%), followed by hemorrhage (4 patients, 1.4%), seizure (4 patients, 1.4%), and hardware-related infection (3 patients, 1.1%).

Mean length of stay for all 284 patients was  $1.18 \pm 1.22$  days (awake:  $1.05 \pm 0.46$  days; asleep:  $1.28 \pm 1.59$  days;  $p=0.12$ ). Overall 30-day readmission rate was 1.4% (1 awake patient, 3 asleep patients). There were no significant differences in complications, length of stay, and 30-day readmissions between awake vs. asleep cohorts. Within the asleep cohort, a significantly higher proportion of patients with mental status change were greater than or equal to age 65 compared to those without mental status change ( $p=0.003$ ).

## Logistic Regression Models Predicting Complications and Mental Status Change

Variable	Complications			Mental Status Change		
	P value	OR	95% CI	P value	OR	95% CI
Sex	0.17	0.48	0.17-1.35	0.21	0.36	0.07-1.75
Asleep (vs. awake)	0.55	1.35	0.51-3.55	0.33	2.08	0.48-9.08
Unilateral (vs. bilateral)	0.52	0.72	0.26-1.98	0.61	1.54	0.30-7.89
PD (vs. ET)	0.33	0.56	0.18-1.79	0.59	1.50	0.35-6.44
Age $\geq 65$ (vs. $< 65$ )	0.16	1.90	0.78-4.65	0.05	4.71	0.99-22.32
All-in-one (vs. staged)	0.17	0.48	0.17-1.35	0.10	2.88	0.81-10.25

Abbreviations: CI = confidence Interval; ET = essential tremor; OR = odds ratio; PD = Parkinson's disease.

There was no significant association between complications, and specifically mental status change, with sex, age, primary diagnosis, and DBS technique. There was a trend toward a significant association between mental status change and age 65 years or greater.

## Inpatient Length of Stay and 30-day Readmissions by DBS Technique, Leads, Procedure, and Target

Variable	DBS Technique		P value	Lead Type		P value	Procedure Type		P value	DBS Target				P value	Diagnosis			
	All Patients (N=284)	Awake (n=126)		Asleep (n=158)	Unilateral (n=78)		Bilateral (n=206)	Staged (n=209)		All-in-one (n=84)	GPi (n=137)	STN (n=67)	VIM (n=80)			PD (n=202)	ET (n=74)	Dystonia (n=8)
Hospital stay $\geq 2$ nights	16 (5.6)	3 (2.4)	13 (8.2)	0.04	2 (2.6)	14 (6.8)	0.25	6 (3.0)	10 (11.9)	0.003	7 (5.1)	4 (6.0)	5 (6.3)	0.93	13 (6.4)	3 (4.1)	0	0.59
Hospital stay $\geq 3$ nights	9 (3.2)	1 (0.8)	8 (5.1)	0.047	1 (1.3)	8 (3.9)	0.45	2 (1.0)	7 (8.3)	0.001	5 (3.6)	3 (4.5)	1 (1.3)	0.49	9 (4.5)	0	0	0.15
Readmit within 30 days	4 (1.4)	2 (1.6)	2 (1.3)	>0.99	1 (1.3)	3 (1.5)	>0.99	2 (1.0)	2 (2.4)	0.37	3 (2.2)	1 (1.5)	0 (0)	0.42	4 (2.0)	0	0	0.44

Abbreviations: DBS = deep brain stimulation; GPi = globus pallidus interna; STN = subthalamic nucleus; VIM = ventral intermediate nucleus.  
 \*Values are number (percentage) unless indicated otherwise. P value determined by chi-square test. Statistical significance set at  $p < 0.01$ .

In the cohort of patients with prolonged hospital stays (2 or more nights and 3 or more nights) and 30-day readmissions, there were no significant differences between awake vs. asleep cohorts, unilateral vs. bilateral leads, staged vs. all-in-one procedures, and among DBS targets or indications

## CONCLUSIONS

Asleep DBS likely confers no difference in incidence of complications, length of stay, or 30-day readmission rates when compared with traditional awake DBS. Asleep patients who are age 65 years or older may have an increased likelihood of postoperative mental status change due to the effects of general anesthesia.