ORIGINAL ARTICLE *Van Medical Journal*

Van Med J 33 (1): 25-30, 2026
DOI: 10.5505/vmj.2026.49469

Anesthesia Strategies and Patient Outcomes in Deep Brain Stimulation Surgery

Esra Turunc, Bahriye Binnur Sarıhasan

Ondokuz Mayis University, Faculty of Medicine, Department of Anaesthesiology and Reanimation, Samsun, Türkiye

Abstract

Introduction: This study aims to evaluate the anesthesia management strategies employed in deep brain stimulation (DBS) surgery for movement disorders, focusing on patient comfort, surgical conditions, and the effect on electrophysiological monitoring.

Materials and Methods: A retrospective analysis was conducted on the data of 166 patients who underwent DBS surgery for movement disorders at xxx between January 2011 and December 2021. The patients were categorized based on the anesthesia approach used: local anesthesia throughout the procedure, local anesthesia during electrode placement followed by general anesthesia during battery insertion, and general anesthesia for the entire procedure. Data were collected on demographics, comorbidities, anesthesia types, drug usage, surgical procedures, and 30-day postoperative mortality.

Results: The study included 166 patients, with 97 males (58.5%) and 69 females (41.5%). The majority of patients were classified as ASA II (86%). The mean surgical duration was 235 minutes. Comorbidities included Parkinson's disease (57.8%), hypertension (18%), and diabetes mellitus (11.4%). DBS was primarily performed for tremor (78.9%). Anesthesia management included sedation with dexmedetomidine, remifentanil, and propofol in patients receiving local anesthesia. General anesthesia involved remifentanil, propofol, and muscle relaxants. No respiratory complications occurred, and all patients were transferred to the service without incident.

Conclusion: Anesthesia management in DBS surgery is critical for optimizing patient comfort and maintaining intraoperative electrophysiological integrity. While both local anesthesia and general anesthesia are used, careful monitoring and the choice of appropriate anesthetic agents are essential to minimize complications and ensure the success of the procedure. Further studies are needed to explore long-term outcomes and refine anesthesia protocols for DBS surgeries.

Key words: Anesthesia management; deep brain stimulation; general anesthesia; movement disorders; parkinson's disease; sedation; tremor.

Introduction

Deep brain stimulation (DBS) is an advanced neurosurgical intervention that has gained significant attention in recent years for its efficacy in treating a variety of neurological and psychiatric conditions. It involves the implantation of electrodes in specific brain regions through a stereotactic method, aiming to modulate abnormal neural activity by delivering electrical impulses (1). DBS has demonstrated proven effectiveness in managing movement disorders such as Parkinson's disease, dystonia, and essential tremor, as well as in the treatment of chronic pain and certain psychiatric disorders, such as obsessive-compulsive disorder and depression, when pharmacological treatments have failed (2). As a sophisticated procedure, DBS requires careful anesthetic management to ensure both the success of the surgery and patient safety. Anesthesia for DBS surgery is particularly challenging due to the need for precise intraoperative monitoring and target localization, which directly influences the placement of the electrodes (3). An optimal anesthetic strategy must balance patient comfort, hemodynamic stability, and surgical conditions, while allowing for critical intraoperative assessments such as microelectrode recording (MER) and macrostimulation testing. Given the complex nature of the procedure, the choice of anesthesia—whether local anesthesia combined with sedation or general anesthesia—remains a subject of ongoing debate among anesthesiologists and neurosurgeons. While local anesthesia with sedation is often favored due to its facilitation of real-time MER and stimulation testing, general anesthesia may be necessary in cases involving severe tremor, patient anxiety, or challenging movement disorders like dystonia (4). This study aims to analyze the anesthesia management protocols utilized at our clinic for DBS surgeries conducted. By reviewing these cases, we seek to

*Corresponding Author: Esra Turunc Ondokuz Mayis University Faculty of Medicine Department of Anaesthesiology and Reanimation, Samsun, Türkiye E-mail: esra.kiymaz.ek@gmail.com
Orcid: Esra Turunc 0000-0003-0159-7403, Bahriye Binnur Sarıhasan 0000-0002-8012-8981

Received: 11.07.2025, Accepted: 10.11.2025

provide insights into the evolving strategies of anesthesia in DBS, evaluate the factors influencing anesthetic decisions, and assess the outcomes associated with different anesthetic techniques in this complex surgical context.

Materials and Methods

Study design: This retrospective, observational, single-center study was approved by the Ondokuz Mayıs University Faculty of Medicine Clinical Research Ethics Committee (Decision No: 2025/85, dated April 1, 2025). The study data of patients who underwent DBS surgery for movement disorders at Ondokuz Mayıs University between January 2011 and December 2024 were obtained from the hospital's medical information system (Monad Software and Consulting Company, Istanbul, Turkey) and anesthesia record forms.

Study population: The data of patients who underwent DBS surgery for any movement disorder between 01.01.2011 and 31.12.2024 in the neurosurgery operating room of Ondokuz Mayıs University Faculty of Medicine were retrospectively analyzed. Data were obtained from the hospital Nucleus Medical Information System. Patients over the age of 18 who had undergone DBS surgery for any movement disorder were included in the study. Patients whose data could not be reached were excluded from the study.

Data collecting: The following data were collected for each patient included in the study: demographic data (age, gender, etc.), medical comorbidities (diabetes mellitus, hypertension, coronary artery disease, etc.), anesthesia type and drugs used in anesthesia management, duration of anesthesia, data on the surgical procedure (available movement disorder, underlying disease, which side was treated) and postoperative 30-day mortality.

Anesthesia management: In our clinical practice, anesthesia management is applied in three different approaches: patients who receive local anesthesia throughout the entire procedure, patients who receive local anesthesia during the DBS electrode placement and general anesthesia during battery insertion, and patients who are given general anesthesia from the start of the case. General anesthesia was performed either during the second stage of surgery for IPG battery placement or when local anesthesia with sedation proved insufficient for patient comfort.

Preoperative management: All patients are fasted for up to two hours for clear liquids and up to six hours for solids before anesthesia induction in the preoperative period. As premedication, 300 mg of oral ranitidine is administered one hour before the operation. Upon arrival in the operating room, standard American Society of Anesthesiologists (ASA) monitoring (electrocardiography, peripheral oxygen saturation) and invasive blood pressure monitoring via the left radial artery are performed.

Intraoperative management: For patients receiving local anesthesia or sedation, 4-6 L/min O_2 with a face mask is provided, and intraoperative peripheral oxygen saturation is targeted to remain between 95-100%. Sedation is managed with dexmedetomidine (0.2-0.7 mcg/kg/hour), remifentanil (0.005-0.05 mcg/kg/min), and/or propofol (25-50 mcg/kg/hour) as needed. For general anesthesia, remifentanil infusion (0.02-1 mcg/kg/min) and propofol (1-2 mg/kg) are administered to all patients during induction. Rocuronium (1 mg/kg) is given for muscle relaxation. Halogenated inhalation anesthetics, such as desflurane and sevoflurane (1 minimum alveolar concentration, O_2/air [0.40 fraction of inspired oxygen], inspiratory fresh gas flow 2 L/min), are preferred for anesthesia maintenance. At the end of surgery, neuromuscular block effects are reversed with either neostigmine or sugammadex.

Intraoperative hypertension management: In cases of intraoperative hypertension, esmolol (25-100 mcg/kg/min) infusion is initiated in patients with a mean arterial pressure greater than 100 mmHg despite sedoanalgesia. If hypertension persists, nitroglycerin infusion (0.1-0.2 mcg/kg/min) is added. For some patients, nicardipine infusion (starting at 5 mg/hour with dose adjustments based on blood pressure) is used.

Surgical technique: The stereotactic frame was applied under local anesthesia in the neurosurgery ward prior to the preoperative computed tomography (CT) scan, and all imaging data were merged for target localization before transferring the patient to the neurosurgery operating room. In all patients, a non-contrast CT scan is performed after placing the preoperative stereotactic frame. After merging the axial magnetic resonance imaging (MRI) scans with the acquired CT images, the target points are identified and marked. Following this step, the patient is transferred to the operating room for the procedure. The surgical procedure consists of two stages: In the first stage, electrodes are placed in the target areas of the brain, and in the second stage, the electrodes and extension cables are connected via a tunnel to the programmable battery unit, which

is placed in the infraclavicular area (typically on the right side).

Ethical Approval: The protocol of this retrospective, single-center study was approved by Ondokuz Mayıs University Faculty of Medicine Clinical Research Ethics Committee (Approval number: 2022/85) prior to the conduct of the study. The research adhered to the principles outlined in the "Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013)".

Statistical Analysis: Descriptive statistics were presented as means ± standard deviations for normally distributed continuous variables, medians (minimum–maximum) for non-normally distributed data, and frequencies (percentages) for categorical variables. The Kolmogorov–Smirnov test was applied to assess the normality of distribution. Comparisons between groups were performed using the Student's t-test or Mann–Whitney U test for continuous variables, depending on data distribution. The Chi-square test or Fisher's exact test was used for categorical variables. A p-value of <0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA).

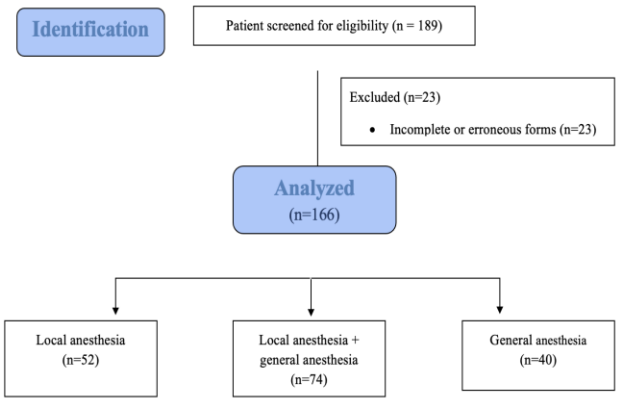

Figure I: Flow diagram of participants

Results

189 patients who underwent DBS surgery at our clinic between the specified dates were screened. However, 166 patients were included in the study. Data for 23 patients were unavailable, and they were excluded from the analysis (Figure I). Of the included patients, 97 (58.5%) were male and 69 (41.5%) were female. Regarding the ASA classification, 143 patients were ASA II (86%), and 23 patients were ASA III (14%). The mean surgical time was 235 minutes. When examining the comorbidities, 96 patients (57.8%) had Parkinson's disease, 30 patients (18%) had hypertension, and 19 patients (11.4%) were diabetic. Huntington's chorea was diagnosed in 5 patients (3.1%), Tourette's syndrome in 3 patients (1.8%), and essential tremor in 15 patients (9.1%). DBS surgery was performed for tremor in 131 patients (78.9%) and for dystonia in 35 patients (21.1%) (Table I). Except for 5 patients, all patients were fitted with a frame (headgear) under local anesthesia.

Table I: Demographic and clinical characteristics of patients

Age (years)	51.0 (20-70)
Sex ⁋ *(n, %)*	
Male	97 (58.5)
Female	69 (41.5)
Weight (kg) ‡	75.3 [60.0 – 97.0]
Height (cm) ‡	175.0 [160.0 – 187.0]
ASA grade ⁋ *(n, %)*	
II	143 (86)
III	23 (14)
Comorbidities ⁋ *(n, %)*	
Parkinson's disease	96 (57.8)
Hypertension	30 (18.0)
Diabetes Mellitus	19 (11.4)
Huntington's Chorea	5 (3.1)
Tourette Syndrome	3 (1.8)
Essential Tremor	15 (9.1)
Operation time (min) ‡	235.0 [100.0 – 400.0]
30-day mortality, n	1

‡: median [min-max], ⁋: n (%). ASA: American Society of Anesthesiologists

Table II: Data on anesthesia management and surgical management of patients

DBS etiology *(n, %)*	
Tremor	131 (78.9)
Dystonia	35 (21.1)
DBS side *(n, %)*	
Unilateral	10 (6.1)
Bilateral	156 (93.9)
Anesthesia Management *(n, %)*	
Local anesthesia	52 (31.3)
Local anesthesia+General anesthesia	74 (44.5)
General anesthesia	40 (24.0)
Preferred Sedative Agents *(n, %)*	
Dexmedetomidine	12 (7.2)
Remifentanil	10 (6.1)
Propofol	6 (3.1)
Combination of remifentanil and dexmedetomidine	72 (43.3)

Categorical variables are presented as counts (%). DBS: Deep brain stimulation

After CT images were taken, the patients were transferred to the operating room, where appropriate anesthesia management was applied. DBS was performed unilaterally in 10 patients (6.1%) and bilaterally in 156 patients (93.9%). Sedation was administered to 94 patients (56%) during electrode placement in the groups receiving local anesthesia. As sedative agents, dexmedetomidine was administered to 12 patients (7.2%), remifentanil and dexmedetomidine to 72 patients (43.3%), remifentanil to 10 patients (6.1%), and propofol infusion to 6 patients (3.1%) (Table II). No major intraoperative complications apart from transient, manageable blood pressure elevations were recorded, and no sedation-related adverse events were observed. All patients were transferred to the service without any issues.

Discussion

DBS is used in the treatment of patients with neurological disorders with functional changes, such as Parkinson's disease, movement disorders such as essential tremors, dystonia, and certain psychiatric conditions, pain, and epilepsy, which are usually not accompanied by major structural or anatomical changes (5). This procedure, which is used in cases where pharmacological treatments are insufficient, aims to increase the patient's quality of life and comfort. DBS insertion is a minimally invasive procedure that involves the insertion of electrodes into deep brain structures for MERs and macrostimulation and connection of DBS to an implanted pacemaker for clinical testing of the patient (6). Anesthesia management of patients is very important in DBS surgery. Although anesthesia applications vary according to the preference of each clinic and anesthesiologist; It includes monitored care under local anesthesia, conscious sedation and general anesthesia. Some complications may develop in anesthesia management. These conditions should be recognized and treated quickly by the anesthesiologist. In general, it has been reported that complications occur in 12% to 22% of patients (7,8). Intraoperative respiratory complications, occurring in 1.6% to 2.2% of patients, are of great concern (9). They may be caused by intracranial events such as excessive sedation, seizure, or bleeding that lead to a decline in consciousness in the awake patient. Airway management may be difficult in patients with respiratory distress, since the frame restricts neck movement and is located in front of the mouth and nose. Ideally, one should try to secure the airway without removing the patient's frame, if possible, so that surgery can be continued if necessary. It may take time to get the frame off the table. Larengeal mask airway may be the most appropriate option to secure the airway in an emergency (9,10). Cardiovascular complications can lead to undesirable results intraoperatively and postoperatively. Hypertension has been associated with an increased risk of intracerebral hemorrhage, and this may be even more distressing in the awake patient with agitated anxiety (11). Arterial blood pressure should be closely monitored before and after electrode placement to prevent intracranial hemorrhages. The most commonly used antihypertensives are labetalol, hydralazine, nitroglycerin, sodium nitroprusside, esmolol, and calcium channel blockers. The optimal blood pressure level is not well defined; A systolic blood pressure of >140 mmHg or a 20% increase in the patient's usual range may be used. Orthostatic hypotension may result from antiparkinsonian drugs or be exacerbated by the vasodilatory effects of anesthetics, perioperative hypovolemia, and autonomic dysfunction. Since the surgical procedure is mostly performed in a sitting position, it is necessary to be careful in this respect. For this reason, intra-arterial blood pressure monitoring is performed in all patients for close hemodynamic monitoring in our clinic, and in case of intraoperative hypertension, esmolol infusion, nitroglycerin or calcium channel blockers are preferred first. Less common complications include venous air embolism. The risk increases in hypovolemic patients in the sitting position (12). Sudden severe cough, unexplained hypoxia, and hypotension may be signs of venous air embolism in awake patients. Early diagnosis may be possible with precordial Doppler monitoring. Neurological complications may develop during or after the procedure. Focal deficits such as limb weakness or confusion may not require any acute treatment. In the literature, it has been reported that 0.8% to 4.5% of the seizures occur during the procedure and are frequently seen during the stimulation test, but most of the seizures are focal and do not require treatment. In case of seizure, small doses of midazolam and/or propofol can be used initially and the procedure is continued after the seizure is controlled. Sudden loss of consciousness due to intracranial hemorrhage or neurologic injury will require prompt and more aggressive treatment (13, 14). Anesthetic agents have a wide variety of effects on electrophysiological recordings; both surgeons and anesthetists need to be aware of how each agent can affect the electrophysiology of the target localization. Dexmedetomidine is gaining

popularity in this regard, it generally works well during awake neurosurgical procedures such as DBS and has little effect on MER (15, 16). When the data in our study were examined, it was seen that dexmedetomidine was mostly preferred for sedation. Anesthetic agents, both intravenous and inhalation agents, affect the MER and are a major concern during intraoperative target localization. Bos et al. In their study published on the effects of anesthesia on MER, it was shown that gamma aminobutyric acid (GABA)ergic anesthetic agents affect both background activity and neuronal spike activity (17). Non-GABAergic drugs (dexmedetomidine, ketamine) and short-acting opioids (fentanyl, remifentanil) have minimal effects on MER (15). Localization of subthalamic nucleus (STN) using interoperative MER may still be possible with low doses of various inhalational (sevoflurane, desflurane) and intravenous (propofol, ketamine, and dexmedetomidine) anesthetic agents (18). Although desflurane and sevoflurane produce different neurophysiological profiles, there is no difference in STN mapping accuracy or clinical outcome of the DBS electrode (19). Placement of DBS electrodes is usually performed under local anesthesia with or without sedation to facilitate intraoperative neurophysiological testing. A better understanding of the neuronal activity of the STN allowed patients to undergo STN-DBS under general anesthesia with intraoperative MER guidance. Placement of DBS under general anesthesia allows patients to continue their antiparkinsonian medication before surgery and offers greater patient comfort and acceptance during surgery. Many studies have shown that localization of STN using intraoperative electrophysiological recordings is possible with various inhalation and intravenous anesthetic agents (6, 20). In addition, many centers now routinely perform all DBS insertions under general anesthesia with intraoperative image-guided technology. Therefore, general anesthesia may be an alternative option for patients who can not tolerate awake surgery (21).

Study Limitations: Our study has several limitations. First, its retrospective nature introduces the possibility of selection bias and reliance on historical data, which can limit the ability to draw definitive causal conclusions. Second, there was insufficient access to intraoperative hemodynamic data, which hindered a more comprehensive analysis of the physiological changes during the procedure. Additionally, the study's sample size may limit the generalizability of the findings, as a larger cohort might have provided more robust results. Another limitation is the lack of long-term follow-up data, which prevents us from assessing the sustained effects or potential complications over time. Furthermore, there may be confounding factors that were not accounted for, such as variations in anesthesia techniques or patient comorbidities, which could have influenced the outcomes. Another limitation of our study was the lack of data on hospital discharge duration, which precluded further analysis of postoperative recovery metrics. Lastly, the study relied on a single institution, which may reduce the external validity of the results, as practices and patient populations can vary across different settings.

Conclusion

Anesthesia management for DBS surgery is important in terms of both the patient profile and the surgical procedure. Optimal anesthesia management, continuous monitoring and extreme alertness, early diagnosis of complications and prompt treatment are very important to ensure patient comfort without interfering with electrophysiology.

Funding: None.
Disclosure and conflict of interest: None.
Author Contrubutions: *Esra Turunc:* Study conception and design, data interpretation, drafting and critical revision of the manuscript. *Bahriye Binnur Sarihasan:* Supervision, critical revision of the manuscript for important intellectual content, and final approval of the version to be published.
Acknowledgements: None.

References

1. Kundu B, Brock AA, Englot DJ, Butson CR, Rolston JD. Deep brain stimulation for the treatment of disorders of consciousness and cognition in traumatic brain injury patients: a review. Neurosurgical focus 2018;45(2):E14.
2. Larson PS. Deep brain stimulation for movement disorders. Neurotherapeutics 2014;11(3):465-74.
3. Sánchez-Gómez A, Valldeoriola F, García-Orellana M, de Riva N, Valero R. Subthalamic Deep Brain Stimulation under General Anaesthesia for Parkinson's Disease: Institutional Experience and Outcomes. Stereotact Funct Neurosurg 2024;27:1-9.
4. Bos MJ, Buhre W, Temel Y, Joosten EAJ, Absalom AR, Janssen MLF. Effect of

Anesthesia on Microelectrode Recordings During Deep Brain Stimulation Surgery: A Narrative Review. J Neurosurg Anesthesiol. 2021 Oct 1;33(4):300-307.
5. Dinsmore M, Venkatraghavan L. Anesthesia for deep brain stimulation: an update. Curr Opin Anaesthesiol 2021;34(5):563-8.
6. Kocabicak E, Temel Y, Höllig A, Falkenburger B, Tan SK. Current perspectives on deep brain stimulation for severe neurological and psychiatric disorders. Neuropsychiatr. dis. treat 2015;11:1051.
7. Khatib R, Ebrahim Z, Rezai A, Cata JP, Boulis NM, John Doyle D, et al. Perioperative events during deep brain stimulation: the experience at cleveland clinic. J Neurosurg Anesthesiol. 2008 Jan;20(1):36-40.
8. Venkatraghavan L, Manninen P, Mak P, Lukitto K, Hodaie M, Lozano A. Anesthesia for functional neurosurgery: review of complications. J Neurosur 2006;18(1):64-7.
9. Santos P, Valero R, Arguis MJ, Carrero E, Salvador L, Rumià J, et al. Incidencias peroperatorias durante la cirugía estereotáctica con utilización de microelectrodos intracerebrales profundos en la enfermedad de Parkinson [Preoperative adverse events during stereotactic microelectrode-guided deep brain surgery in Parkinson's disease]. Rev Esp Anestesiol Reanim. 2004 Nov;51(9):523-30.
10. Pereira EA, Green AL, Nandi D, Aziz TZ. Deep brain stimulation: indications and evidence. Expert Rev Med Devices 2007;4(5):591-603.
11. Binder DK, Rau GM, Starr PA. Risk factors for hemorrhage during microelectrode-guided deep brain stimulator implantation for movement disorders. Neurosurg 2005;56(4):722-32.
12. Suarez S, Ornaque I, Fabregas N, Valero R, Carrero E. Venous air embolism during Parkinson surgery in patients with spontaneous ventilation. Anesth Analg 1999;88(4):793-4.
13. Beric A, Kelly PJ, Rezai A, Sterio D, Mogilner A, Zonenshayn M, et al. Complications of deep brain stimulation surgery. Stereotact Funct Neurosurg 2001;77(1-4):73-8.
14. Higuchi Y, Iacono RP. Surgical complications in patients with Parkinson's disease after posteroventral pallidotomy. Neurosurg 2003;52(3):558-71.
15. Rozet I. Anesthesia for functional neurosurgery: the role of dexmedetomidine. Curr Opin Anaesthesiol 2008;21(5):537-43.
16. Rozet I, Muangman S, Vavilala MS, Lee LA, Souter MJ, Domino KJ, Slimp JC, et al.. Clinical experience with dexmedetomidine for implantation of deep brain stimulators in Parkinson's disease. Anesth Analg 2006;103(5):1224-8.
17. Bos MJ, Buhre W, Temel Y, Joosten EA, Absalom AR, Janssen ML. Effect of anesthesia on microelectrode recordings during deep brain stimulation surgery: a narrative review. J Neurosurg 2021;33(4):300-7.
18. Martinez-Simon A, Alegre M, Honorato-Cia C, Nuñez-Cordoba JM, Cacho-Asenjo E, et al. Effect of dexmedetomidine and propofol on basal ganglia activity in Parkinson disease: a controlled clinical trial. Anesthesiology 2017;126(6):1033-42.
19. Chen Y-C, Chen S-Y, Chen T-Y, Pan J-I, Tsai S-T. Desflurane and sevoflurane differentially affect activity of the subthalamic nucleus in Parkinson's disease. Br J Anaesth 2021;126(2):477-85.
20. Hippard HK, Watcha M, Stocco AJ, Curry D. Preservation of microelectrode recordings with non-GABAergic drugs during deep brain stimulator placement in children. J Neurosurg Pediatr 2014;14(3):279-86.
21. Liu Z, He S, Li L. General anesthesia versus local anesthesia for deep brain stimulation in Parkinson's disease: a meta-analysis. Stereotact Funct Neurosurg 2019;97(5-6):381-90.