


Medical Students' Knowledge and Perception of Deep Brain Stimulation

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Journal of Medical Education and
Curricular Development
Volume 8: 1–7
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DOI: 10.1177/2382120521989977



ABSTRACT

BACKGROUND: Deep brain stimulation (DBS) is a well-established neurosurgical procedure commonly used in movement and psychiatric disorders. Its widespread clinical implementation, however, may not be commensurate with medical education. No current assessment of medical student's understanding of DBS as a treatment option for indicated conditions is available, potentially threatening the availability of DBS to future patients. The aim of the present study is to explore the current knowledge and attitudes of medical students toward DBS as a treatment modality.

METHODS: A total of 65 medical students at Virginia Tech Carilion School of Medicine were surveyed regarding their knowledge of DBS. The survey consisted of a 25-item questionnaire including a demographic section and 3 separate inventories designed to assess bias, knowledge, and self-assessment of knowledge specific to DBS therapy. Students in pre-clinical and clinical years were analyzed separately to describe changes in knowledge or attitude associated with clinical exposure to DBS. Comparisons were analyzed using *t* tests, ANOVA, and Pearson correlations.

RESULTS: Of surveyed students, 36% were unsure of the FDA approval status of DBS treatment; 65% of students believed they had not been adequately educated about DBS and its utility; and 10.6% of students believed that DBS is likely associated with severe adverse effects and/or brain damage. The overall baseline attitudes of students toward DBS were positive. There was no observed difference between surveyed pre-clinical and clinical students, highlighting a lack of exposure throughout the clinical years of medical school education.

CONCLUSION: Although DBS is an effective treatment modality for various conditions, current education is non-commensurate with its application, which can negatively impact awareness and understanding for its implications by medical professionals. In order to better serve patients who may benefit from DBS, medical curricula must change to educate future physicians on the benefit of this intervention.

KEYWORDS: Deep brain stimulation, medical education, student perception

RECEIVED: October 23, 2020. **ACCEPTED:** January 5, 2021.

TYPE: Original Research

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The Virginia Tech Open Access Subvention Fund provided funds supporting the publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Introduction

“Neurophobia” is a well-documented phenomenon observed among medical students internationally.¹ This discomfort associated with studying neuroscience subjects including psychiatry, neurology, and neurosurgery¹ has been associated with reduced levels of understanding and optimal treatment.^{2,3} Diseases of neurologic and psychiatric origins are frequently encountered in medical care and often associated with reduced overall well-being. Therefore, inadequate education or exposure of future doctors to treatment modalities may negatively impact timely and appropriate referrals and ultimate delivery of treatment to patients. A well-known example of this “neurophobia” is the enduring bias in the general population and medical students regarding electroconvulsive therapy (ECT).⁴

For example, in a study performed by Clothier et al⁴ 31% of medical students thought ECT was used to punish uncooperative patients. Perhaps even more surprising was that the group self-described as “highly knowledgeable” about psychiatric illness in this study had a greater bias against ECT.⁴ Although this study was performed over 10 years ago, it exemplifies the negative view held by the public and now practicing physicians in regards to this neuromodulatory technique.

Deep brain stimulation (DBS) is another type of neuromodulatory technique. DBS is a neurosurgical technique that involves implanting electrodes into specific neural targets to modulate abnormal brain activity. This technique has seen continuous advancements in both its effectiveness and clinical relevance as further understanding has allowed for new targets.



Initially used only in the treatment of movement disorders, research on DBS continues to expand its therapeutic applications including use in treatment-resistant cases of obsessive-compulsive disorder (OCD)⁵ and medically intractable epilepsy⁶ with 1 study documenting a total of 30 490 DBS procedures being performed between 2002 and 2011.⁷ As research in the field has pushed the efficacy and indication of this therapy, one can conclude that its prevalence will continue to increase significantly.

Similar to ECT, the delivery of deep brain stimulation (DBS) is largely dependent on clinicians' knowledge of and exposure to the modality, familiarity with mechanisms of action, as well as treatment indications. A study by Kimmerle et al⁸ found that it is uncommon for laypeople to have knowledge of DBS. Interestingly many physicians, despite being high-ranking members in the medical fields, are also unaware of the current applications as well as immense research underway to further expand its clinical role in treating depression, bipolar disorder, schizophrenia, Alzheimer's disease, and various other disabling neuropsychiatric conditions.⁹⁻¹¹ This lack of knowledge could, like ECT, be due to "neurophobia," lack of education about the procedure, or a combination of the 2.

Given the current clinical applications and continued advances in DBS technology, its use is expected to increase in future patients. It is therefore imperative to investigate physician education to try to rectify the lack of knowledge about DBS. Although various studies have assessed the public's knowledge and perception toward DBS,¹²⁻¹⁴ no study to date has assessed U.S. medical student perceptions of DBS. Only 1 study assessing medical student perception of DBS has been performed worldwide, taking place in Germany.¹⁵ In this study, it was found that students gain a greater understanding of DBS as they progress throughout their 6-year curriculum at Hannover.¹⁵ It remains unclear however, whether medical students within the United States at 4-year programs have adequate knowledge, possess underlying negative biases, or are appropriately educated regarding the use of DBS. To better understand the current knowledge and attitudes of medical students toward DBS, a survey-based study among a cohort of first, second, third-, and fourth-year medical students assessed their knowledge, bias, and self-assessment of knowledge of DBS.

Methods

Study design

This study was approved by the Institutional Review Board of Carilion Clinic. It incorporated the use of a standardized electronic survey and targeted all current medical students at Virginia Tech Carilion School of Medicine (VTC SOM). Medical students receive 8 weeks of neurophysiology first year, 5 weeks of neuropathology second year, and 1 week of psychiatry second year. There are no dedicated lectures to DBS during this pre-clinical time. Third year medical students rotate for 6 weeks on psychiatry, with 1 mandated session of ECT observation, and

2 weeks of neurology. Additionally, third- and fourth-year students have the opportunity to take 2 to 4 weeks electives in neurosurgery, neurology, and psychiatry. Following the design of a comprehensive questionnaire, electronic distribution to all subjects was achieved through REDCap technology (Research Electronic Data Capture). Subjects were solicited via email to complete the survey and consent was obtained using a RedCap-based electronic consent form upon opening the survey link. Invitations were first issued in February 2019 and the survey was open for 2 weeks with 2 reminder emails sent to participants prior to closure. Responses were entered through the online portal in REDCap and all survey responses were anonymous.

A 25-item questionnaire was administered. It contained a 7-item demographic data section, a 9-item knowledge inventory, a 7-item bias inventory to assess attitudes toward DBS, and a self-assessment of knowledge question (Table 1). Additionally, 1 independent item, self-perceived education on DBS, assessed whether the subject felt he/she had been trained appropriately about DBS and its therapeutic applications. All items were derived from questionnaires used in prior studies to assess medical student knowledge and attitude toward ECT whereas instead of querying for knowledge and bias toward ECT, the questions were directed toward DBS.¹⁶ Demographic information collected included age, gender, year in medical school, previously obtained advanced degrees (MPH, MS, etc), intended specialty, and any history of family member(s) treated with DBS.

The knowledge inventory included responses limited to yes (+1), no (-1), and I don't know (0). The bias inventory was rated on a 5-point Likert-type scale ranging from strongly agree to strongly disagree. These were re-coded such that an indication of 5 (higher responses indicated more bias) was recoded as 1 and a score of 1 was recoded as -1. Answers in between were scored as 0.5 or -0.5 and 0 if neutrality was indicated. The scores for each inventory were independently summed resulting in a knowledge inventory score and a bias inventory score for each participant. Questions addressed specific indications, procedure, adverse effects, benefits on movement and psychiatric symptoms, as well as personal attitudes toward being treated or advising a relative to be treated with DBS. Self-assessment of knowledge was measured by asking students to judge their understanding of DBS on a 7-point scale ranging from 1=vague understanding to 7=thorough understanding. Instructions and the single-item rating scale were adapted from prior ECT and DBS studies.^{4,15,16} All instruments were piloted with test subjects prior to distribution to assess for clarity and to address any items that may be deemed inappropriate for the specific aims of this project.

Statistical analysis

Statistical analysis was completed with the assistance of the Statistical Applications and Innovations Group (SAIG) at Virginia Tech. For each demographic group, the bias score,

Table 1. Participant demographics.

N	65							
Age (years)	Range: 22 to 30							
	Mean=25.77 ± 2.04							
Gender	Female	Male						
	45%	55%						
Year	Preclinical	Clinical						
	49%	51%						
Intended specialty	Emergency medicine	General surgery	Med Sub-specialty	Medicine	OB-GYN	Psychiatry/ neurology	Surg sub-specialty	Undecided
	15.5%	6.0%	12.0%	15.5%	3.0%	5.0%	23.0%	20.0%
Have a family member that has been treated with DBS?	Yes	No						
	2%	98%						

knowledge score, self-perception of education, and self-perception of current DBS knowledge were all compared. The 2 primary groups of interest were preclinical (first- and second-year students) and clinical (third- and fourth-year students). They were contrasted using *t* tests and regression. Between-group demographic differences were analyzed using regression and ANOVA. Pearson's *r* was used to test correlation. The significance level was chosen as $p < 0.05$. Statistical analysis was conducted using R studio (V) (Boston, MA).

Results

Demographics

The survey was e-mailed to 165 medical students at VTCSOM and a total of 65 students completed the questionnaire (40% response rate). Of the 65 respondents, 49% of students were in pre-clinical training (years 1 and 2) and 51% were in clinical training (years 3 and 4). Of those who completed the survey, 55% identified as male ($n=35$) and 45% as female ($n=30$). The average participant age was 25.77 ± 2.04 years (range 22–30 years). The most common intended specialty choice listed was surgical subspecialty (23%, $n=15$) with 20% of students listing “undecided” for intended specialty and 16% of students listing internal medicine as their future specialty. Only 2% of respondents had any experience with DBS in terms of a family member or themselves having undergone treatment with DBS (Table 1).

Self-perceived education about DBS

Of the student respondents, 68% ($n=45$) indicated that they did not believe they had been appropriately educated about DBS while only 6% ($n=4$) of students reported feeling adequately educated about the technique and 26% of students ($n=16$) reported feeling somewhat educated (Table 2).

A non-significant trend toward increase in self-perception of knowledge was found between preclinical and clinical medical students (preclinical [mean ± SD] 2.3 ± 1.3 vs clinical 2.9 ± 1.7 ; $P=.08$). No significant difference in objective knowledge or attitude toward DBS was demonstrated between these 2 groups of students ($P=.58$; $P=.52$). Furthermore, there is inconclusive evidence to support a significant association between increasing bias and self-assessment of knowledge ($r^2=0.02$, $P=.12$).

Objective knowledge of DBS

Participants scored 4.54 ± 2.6 upon answering the 9-item knowledge inventory (range 0–9), indicating incomplete objective knowledge. None of the participants had full knowledge about DBS to achieve a full score of 9. There were no significant differences in scores when analyzing data by year in medical school, age, sex, or presence of advanced degrees. When preclinical and clinical students were compared, there was no significant difference in objective knowledge scores between the 2 groups (preclinical mean ± SD 4.4 ± 2.8 vs clinical 4.7 ± 2.4 ; $P=.58$) as seen in Table 3.

The majority of students (65%, $n=42$) accurately identified DBS as an FDA-approved treatment modality, while 35% of students ($n=23$) reported not knowing whether DBS was FDA-approved, and no students reported DBS as unapproved. The majority of students (74%, $n=49$) were aware of the utility of DBS in treating movement disorders, however, less than half of the respondents (48%, $n=33$) were aware of its use in psychiatric disorders. Less than half of students knew that DBS resulted in long-term improvement in symptoms (43%, $n=29$) while 42% ($n=28$) of students indicated not knowing whether effects lasted short or long term. A majority of students indicated that DBS does not worsen underlying psychiatric illness (58%, $n=38$) and does not lead to permanent cure of the illness

Table 2. Knowledge and bias inventory answer data.

INVENTORY	QUESTIONS	YES (%)	NO (%)	I DON'T KNOW (%)
Knowledge	Is DBS an FDA-approved treatment?	42 (65)	0 (0)	23 (35)
	Is DBS useful in treating psychiatric disorders?	32 (49)	5 (8)	28 (43)
	Is DBS useful in treating movement disorders?	49 (75)	1 (2)	15 (23)
	Do the effects of DBS last only a short while?	9 (14)	28 (43)	28 (43)
	Does DBS result in a permanent cure?	3 (5)	35 (54)	27 (42)
	Are psychiatrists involved in administering DBS?	19 (29)	11 (17)	35 (54)
	Are neurologists involved in administering DBS?	40 (62)	1 (2)	24 (37)
Self-perception of education	Are neurosurgeons involved in administering DBS?	47 (72)	2 (3)	16 (25)
	Does DBS often worsen or improve the psychiatric illness?	Improve (%) 38 (58)	Worsen (%) 3 (5)	I don't know (%) 24 (37)
	Do you feel you have been trained about DBS appropriately and its applications to medicine?	Yes (%) 4 (6)	No (%) 45 (69)	Somewhat (%) 16 (25)
Bias	The procedure is associated with severe adverse effects	Strongly agree (%) 1 (2)	Agree (%) 7 (11)	Disagree (%) 25 (38)
	The procedure is associated with brain damage	Strongly agree (%) 0 (0)	Agree (%) 7 (11)	Disagree (%) 29 (45)
	DBS is a painful procedure	Strongly agree (%) 0 (0)	Agree (%) 4 (6)	Disagree (%) 38 (58)
	DBS is dangerous and should not be used	Strongly agree (%) 0 (0)	Agree (%) 1 (2)	Disagree (%) 25 (38)
	I would advise a close relative to receive DBS if recommended	Strongly agree (%) 8 (12)	Agree (%) 34 (52)	Disagree (%) 0 (0)
	If required, I would undergo DBS	Strongly agree (%) 11 (17)	Agree (%) 37 (57)	Disagree (%) 14 (22)
Self-perception of knowledge	DBS is often given to people who do not need it	Strongly agree (%) 0 (0)	Agree (%) 3 (5)	Disagree (%) 25 (38)
	How would you rate your understanding of DBS?	Strongly agree (%) 19 (29)	Agree (%) 18 (28)	Disagree (%) 9 (14)
		Neither agree nor disagree (%) 10 (15)	Disagree (%) 9 (14)	Strongly disagree (%) 2 (3)
		Neither agree nor disagree (%) 3 (3)	Disagree (%) 4 (4)	Strongly disagree (%) 6 (6)
		Neither agree nor disagree (%) 3 (3)	Disagree (%) 5 (5)	Strongly disagree (%) 7 (7)
		Neither agree nor disagree (%) 10 (15)	Disagree (%) 6 (9)	Strongly disagree (%) 1 (2)

Table 3. Differences found between preclinical and clinical students.

	PRECLINICAL MEAN (SD)	CLINICAL MEAN (SD)	F	P<	ADJUSTED R ²
Knowledge score	4.36 (2.8)	4.7 (2.4)	0.3	.58	0
Perception of education/training	1.2 (0.5)	1.5 (0.67)	3.08	.08	0.03
Bias score	0.92 (1.24)	1.156 (1.6)	0.42	.52	0.006

(53%, $n=35$). A significant number of students, however, reported not knowing whether DBS worsens or improves the condition (36%, $n=24$) or if DBS provides a lasting reduction in symptoms (41%, $n=27$).

Most students correctly identified neurologist (61%, $n=41$) and neurosurgeon (72%, $n=48$) involvement in administering DBS. Conversely, most students (52%, $n=35$) did not recognize the role of psychiatrists in DBS with 18% of students ($n=12$) disagreeing that psychiatrists were involved in the treatment. Most students (64%, $n=42$) were aware that DBS is infrequently associated with being a painful procedure while 30% ($n=20$) of students reported a lack of knowledge to provide a definitive response to this question.

Bias toward DBS

Approximately half (48%) of students reported neither agreeing nor disagreeing that DBS is associated with severe adverse effects while 38% disagreed that DBS is associated with adverse outcomes. Most participants (80%, $n=53$) disagreed that DBS is dangerous and should be withheld as a treatment option while 18% of students neither agree nor disagree on this statement. While the majority (60%, $n=39$) of students were either unsure of or believed that DBS is associated with severe adverse effects, the minority of students (40%, $n=26$) disagreed with that statement. Most students, however, would advise a close relative to receive DBS if recommended (65%, $n=43$) and would undergo DBS themselves if recommended (74%, $n=49$). A significant portion of students could not agree or disagree with advising a close relative to receive DBS (33%, $n=22$) or to undergo DBS themselves (21%, $n=14$). More than half of students (52%, $n=34$) disagreed with the statement that DBS is often given to patients who do not need it.

Discussion

The present study examined the knowledge and attitudes of medical students toward DBS. Our findings indicate that, amongst surveyed students, there is a generally poor understanding of the clinical use of DBS regardless of a pre-clinical versus a clinical student. It is expected that the increase in clinical exposure should be reciprocated with an increase fund of knowledge and clinical confidence, yet this result contradicts that expectation. This may highlight both a lack of formal education in the classroom in addition to insufficient exposure to DBS in the clinical setting. Importantly, while it is not expected

that physicians outside of psychiatry, neurology, and neurosurgery should understand the nuances, intricacies, and complex physiology of DBS, the increasing prevalence of this therapy certainly raises the probability of these physicians caring for a patient that either has an indication for DBS or that has a stimulator already placed. Therefore, it is imperative that all physicians are at the very least educated on the basic principles and indications for this therapy so that they may better treat the patients that they encounter.

More than half of students surveyed (68%) were able to identify the inadequacy of their training on this therapeutic modality. This is both troubling and enlightening in elucidating a medical knowledge gap. Psychiatry and neurology are core topics covered in medical school; yet it appears DBS is not sufficiently understood within the current standard medical curriculum, a similar finding seen in prior studies elucidating a lack of knowledge of ECT by medical students leading to biases toward the treatment modality.⁴ Interestingly, although 68% of students felt that they didn't receive enough education about DBS, 65% of students felt comfortable enough to advise a relative to receive this therapy. Perhaps this represents the faith medical students' have in their chosen field, regardless of their procedural knowledge.

Yet another concerning finding was the fact that 35% of students were unsure if DBS is an FDA-approved treatment modality. With DBS's effectiveness for epilepsy, movement disorders, and psychiatric disorders, it is concerning that a large number of students are unaware that DBS is an FDA-approved treatment. Furthermore, while it was found that 48% of students were aware that DBS was a useful treatment for psychiatric disorders, a staggering 70% of students were unsure or did not believe psychiatrists were involved in the administration of DBS. Given its current indication for OCD and potential use in other psychiatric conditions, it is vital to overcome this knowledge gap so that future physicians are equipped to refer optimally to available treatment modalities including DBS.

In terms of attitude and bias, positive attitudes toward DBS were found to be highly prevalent. The majority of students (65%) indicated that they would advise a relative to undergo DBS if recommended and an even larger majority of students (74%) indicated that they would undergo DBS themselves if needed. While 80% of students believed DBS is not dangerous and should not be withheld as a treatment option, many students (53%) were still unaware as to whether DBS is associated with severe adverse effects or brain damage. Ultimately, the bias

inventory showed promising results, as the low fund of knowledge and perceived lack of education on DBS in medical students did not appear to stem from a negative bias toward DBS, but rather from an intrinsic lack of objective understanding. This finding enforces the sentiment that incorporating DBS into the current medical education curriculum would be accepted with a positive attitude for the opportunity to optimize patient outcomes.

Physician knowledge, attitude, and misconceptions are of crucial influence on patients' decision-making regarding medical-surgical intervention. Thus, the gaps of knowledge demonstrated in this study reflect the need for improvement in medical education and future residency training to improve physician understanding of DBS-related care and patient outcomes.

Limitations

The present study has several limitations. First, the sample size used is small ($n=65$, 40% response rate) and representative of a single, academic medical center, and its curriculum. While medical school accreditation is dependent on the Liaison Committee on Medical Education (LCME) assuring that the medical curriculum provides content of sufficient breadth and depth to prepare medical students for entry into any residency program and for the subsequent contemporary practice of medicine, it is unclear how widely the results of our survey can be generalized. Second, currently no validated metric has been developed for the questionnaire we administered for this study. No prior studies have evaluated the knowledge and attitudes of medical students in the United States toward DBS. To our knowledge, only 1 other study was undertaken to date in German medical students assessing knowledge of DBS.¹⁵ Therefore, it is difficult to directly compare our findings with any previous study.

Conclusion

For many medically refractory patients with Parkinson's disease, essential tremor, dystonia, and obsessive-compulsive disorder, DBS is often an effective treatment option. Other conditions, such as Major Depressive Disorder and Tourette syndrome, show potentially promising results in the preclinical phase.^{17,18} At its current state, DBS is a therapy administered by a small percentage of neurologists, psychiatrists, and neurosurgeons; however, the research advancements and broadened clinical applicability has led to an increase in both patients treated by this therapy as well as physicians exposed to these patients treated. Given its ever increasing usage, medical education must adapt to include introduction of this treatment modality so that future practitioners of all medical specialties are aware of its potential role as a treatment option for future patients as well as its function in the treated patients that they will likely eventually care for. And for these research advancements to continue, the phenomenon of neurophobia must be

combated in the classrooms with increased exposure as to assure that medical students are given the opportunity to learn about this therapy and develop further research interests.

The role of increasing medical education on DBS through didactics and practical demonstrations remains unclear and given the pre-existing difficulties associated with didactic load on medical students, may prove to be difficult. Prior studies focused on medical student perceptions of electroconvulsive therapy (ECT) have clearly demonstrated a positive impact on attitude of students who both observed an ECT session and watched an educational video.¹⁶ Future studies may explore the role of such interventions pertaining to DBS. Also, clinical DBS research by future physicians may advance knowledge of the underlying mechanisms in DBS, allowing future improvement.

Future studies may consider implementing a longitudinal design to assess student knowledge in the same individuals at later stages in medical training. They should also target residents across a variety of specialties to assess limitations of DBS knowledge and how this might be improved. Finally, it is notable that this study was limited to 1 medical school; it may be beneficial to include participants enrolled at multiple medical schools.

Author Contributions

All authors were involved with conception and design, acquisition of data, analysis and interpretation of data as well as drafting the article and revising it critically for important intellectual content, and final approval of the version to be published.

Ethics Approval and Consent to Participate

All students who participated in filling out this survey were willing participants.

Consent for Publication

No individual person's data such as images and videos, is included in this project.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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