Chapter 1

Introduction

The Expanding Role of Deep Brain Stimulation

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Overview

Since the publication of the first edition of this book more than two decades ago, the field of neuromodulation has undergone remarkable transformation. Deep brain stimulation (DBS) is now a firmly established treatment for movement disorders, and an increasing body of evidence supports DBS in the treatment of other neurological and psychiatric disorders. When DBS first arrived on the scene, the prospect of using a fully implantable neurostimulation system to deliver targeted, adjustable, nondestructive, and reversible brain modulation was paradigm shifting. Since then, remarkable advances in our understanding of numerous clinical aspects related to DBS have occurred. Furthermore, more sophisticated device platforms to deliver DBS are now available.

The enduring attractiveness of DBS is that stimulation parameters can be programmed noninvasively to deliver the appropriate level of stimulation to the optimal anatomical nodes and networks to maximize therapeutic benefits and minimize adverse effects. The benefits of DBS compared to ablative surgery include its nondestructive nature, reversibility, and adjustability. In addition, when used bilaterally the technique does not typically produce the permanent speech, swallowing, or cognitive complications sometimes seen with ablative procedures; DBS is thus safer for bilateral use. Serious surgical complications are relatively uncommon and adverse effects related to unintended stimulation of adjacent structures are readily reversible by altering stimulation parameters.

The Deep Brain Stimulation Device and Implant Surgery

Deep brain stimulation uses a device with three implantable components: brain lead(s), neurostimulator(s), and extension wire(s).

The DBS lead, containing an array of electrodes or electrode segments on its distal end, is implanted into the deep brain target using stereotactic neurosurgical techniques. Such procedures typically use image-based targeting and intraoperative physiological confirmation to accurately implant the DBS lead into the appropriate target. Deep brain stimulation lead implantation is often performed using local anesthesia in the awake patient to optimize the recording of physiological data during the mapping procedure, as well as to elicit the patient's report of stimulation-induced adverse effects during intraoperative test stimulation of the lead. Newer techniques harness the power of real-time interventional magnetic resonance imaging (iMRI) and even robots to guide and confirm DBS lead placement while the patient is under general anesthesia.

Following implantation of DBS leads, the neurostimulator is implanted under general anesthesia. The neurostimulator is typically placed in the subclavicular region, although it can be located elsewhere. Bilateral stimulation necessitates the implantation of two single-channel neurostimulators or one dual-channel neurostimulator. Extension wires (extensions), tunneled under the skin, connect the brain leads to the neurostimulator(s). Days to weeks after device implantation, stimulation is activated. Using the DBS programmer, the clinician can select which electrodes (sometimes colloquially referred to as "contacts") on the DBS lead to use to deliver stimulation, as well as the stimulation parameters themselves (including amplitude, pulse width, and rate of stimulation).

Indications for Deep Brain Stimulation

Figure 1.1 shows the evolution of DBS over the past several decades. There are currently three major movement disorders in which DBS is commonly used: essential tremor, Parkinson's disease,

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and dystonia. Deep brain stimulations at three different brain targets are used to treat these disorders.

For the treatment of epilepsy, two approaches have emerged: noncontingent stimulation that delivers continuous or cyclical stimulation on a regular basis with the intent of suppressing seizure occurrence, and closed loop, "responsive" stimulation that delivers stimulation upon detection of electrographic seizure activity with the goal of aborting or minimizing the impact of the seizure.

Obsessive-compulsive disorder is presently the sole psychiatric condition for which regulatory approval of DBS has been granted in the United States, although considerable investigation is underway to treat refractory depression with DBS.

Factors for Success in Deep Brain Stimulation

In the opinion of many clinicians involved in the use of DBS, many patients who are good candidates for treatment with DBS fail to be referred to a DBS center for an evaluation to determine their suitability for this treatment option – or when patients finally are referred, they have unnecessarily endured prolonged disability, impaired function, and compromised quality of life. Conversely, patients who are poor candidates for treatment with DBS may be referred in a last-ditch attempt to do something when all else fails.

As experience with the clinical application of DBS has grown, several factors have emerged as vital to achieving successful outcomes for patients treated with DBS. These include the following.

- Appropriate patient selection, based on an interdisciplinary evaluation.
- Reasonable expectations on the part of the patient and their family regarding the outcome from DBS treatment.
- Accurate and uncomplicated implantation of the DBS leads into the appropriate anatomical target(s).
- Optimal programming of the DBS device, including selection and configuration of the appropriate electrode(s) on the DBS lead and choice of stimulation parameters (amplitude, pulse width, rate), in conjunction with pharmacological management.
- Adept long-term management, including management of disease progression and troubleshooting of device issues.

Note that most of these issues are nonsurgical in nature. Indeed, DBS is a chronic neuromodulation therapy and not a surgical treatment.

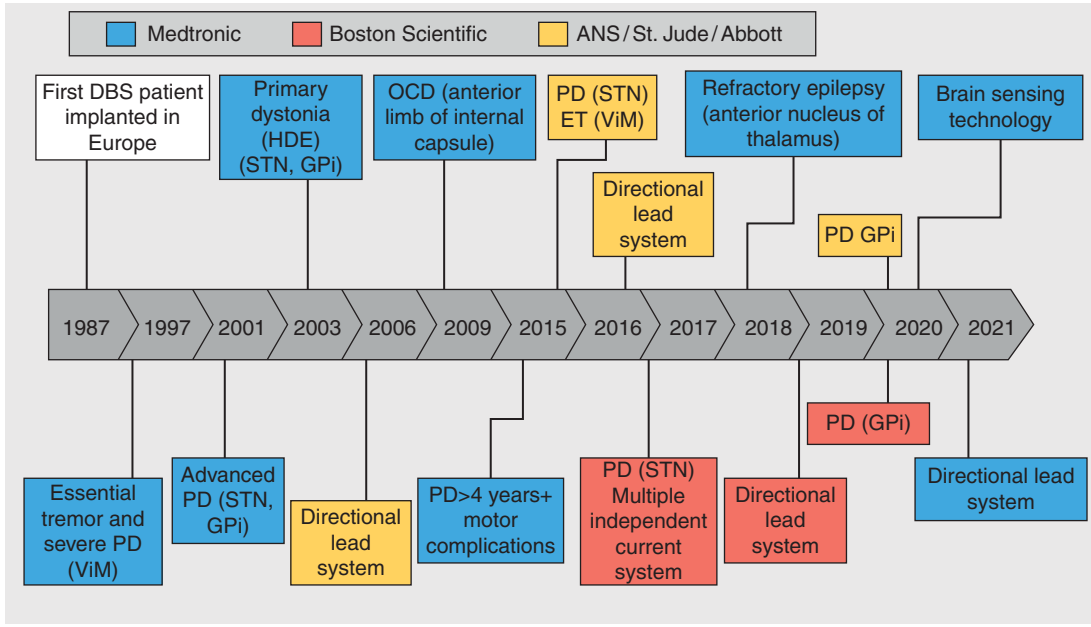

Figure 1.1 A timeline of the evolution of deep brain stimulation: indications, device manufacturers, and technology

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Although it is true that expert surgical implantation of the DBS device components (especially the DBS brain leads) is necessary to achieve a successful outcome and that the surgical team is commonly involved over the long term in the care of the patient, most of the issues to be dealt with are nonsurgical in nature. Typically these issues fall under the purview of neurologists, psychiatrists, nurse practitioners, nurses, physician assistants, and other non-surgeon clinicians.

Deep Brain Stimulation: A Different Way to Think about Neurological and Psychiatric Treatment

Neurologists, psychiatrists, and other clinicians who treat neurological or psychiatric disorders are quite familiar with pharmacological approaches to treating these conditions. The concept of using a device-based therapy to modulate brain function using electrical current may still seem very foreign. New knowledge and skills are required to become proficient in the use of DBS. These include:

- understanding when in the course of each patient's disease process it is appropriate to consider the use of DBS;
- developing the processes for conducting and coordinating a multidisciplinary evaluation for DBS or aligning with an expert center to assist in this process;
- understanding the basic neurophysiological principles underlying the use of DBS;
- becoming familiar with the DBS device and how to optimally program it; and
- attaining comfort with the assessment of patient outcomes and determining whether patients have derived the expected benefit from DBS, and how to approach troubleshooting in those who fail to achieve the expected outcomes or lose the benefit later.

How This Book Can Help

In teaching clinicians around the world about the various facets of DBS for many years, we have found a need for a concise but comprehensive practical guide for clinicians interested in becoming involved with – or who are already involved in – using DBS for their patients.

This book was therefore created to serve as a practical reference – a go-to guide to be kept in the clinic and consulted in the course of managing patients being considered for or treated with DBS. We designed this book to address in a clear, comprehensive, and yet concise manner all of the key topics pertaining to use of DBS for clinicians.

The first edition of this book focused on the use of DBS to treat movement disorders and was extremely well received in the United States and internationally. The second edition provided updates and added dedicated chapters on the treatment of epilepsy and psychiatric disorders with DBS, as well as a new chapter focused on interventional MRI approaches to DBS lead implantation.

In this new, third edition, we've updated the content, included the latest information on new DBS devices, and expanded information on a broader scope of conditions that may benefit from treatment with DBS. We begin with a practical discussion of how to implement a DBS program. We then turn to surgical aspects, including new approaches to DBS lead implantation. Following this, we outline the neurophysiological principles of DBS, discuss the clinical aspects of DBS generally and for specific movement disorders, and then turn to the emerging indications of epilepsy, psychiatric conditions, and other disorders. Finally, we end with a comprehensive discussion of troubleshooting.

We hope this book will be a valuable resource for a wide spectrum of clinicians who encounter patients with DBS, including general neurologists, movement disorder neurologists, epileptologists, movement disorder fellows, neurology residents, neurosurgeons, psychiatrists, nurses, advanced practice nurses, clinical nurse specialists, nurse practitioners, physician assistants, physical therapists, and any other healthcare providers who work with patients treated with DBS.

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