Chapter 3.14
Transcranial Magnetic Stimulation (TMS) as a Tool for Neurorehabilitation in Parkinson's Disease

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ABSTRACT

Transcranial Magnetic Stimulation (TMS) is a stimulation technique introduced to clinical practise by Anthony Baker in 1985. TMS has become very valuable either for neurophysiological examination as for research. When use in a repetitive way it has shown to have a therapeutic role for treatment of neurological and psychiatric disorders. This chapter summarizes the basic principles of the technique focusing on its interaction with the neural tissue along with the analysis of different stimulation protocols, potential risks, and its effectiveness on Parkinson's disease.

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INTRODUCTION

TMS is based on the generation of magnetic fields to induce currents in the cortical tissue (or any excitable tissue) interfering, therefore, with the electrical activity of neurons. TMS was introduced by Anthony Barker in 1985 as a painless and non-invasive technique that, based on the principles of electromagnetic induction, is able to generate currents in the brain and modulate the function of the cortex. The prototype presented by Barker was capable of generating current pulses of 110μsec at a frequency of 0.3Hz and an intensity of 4kA. This device (developed by Magstim and under an exclusive license to the University of Sheffield) was the first magnetic stimulator built for commercial purposes. Today there are new versions of magnetic stimulators manufactured by different companies specially designed for clinical and research applications and able to work with higher current and frequency ranges. The following is a review of the technique that includes the general aspects of the device, the physics behind TMS and its main applications in both, clinical and experimental protocols, focused on Parkinson's disease.

Basic Setup of TMS:

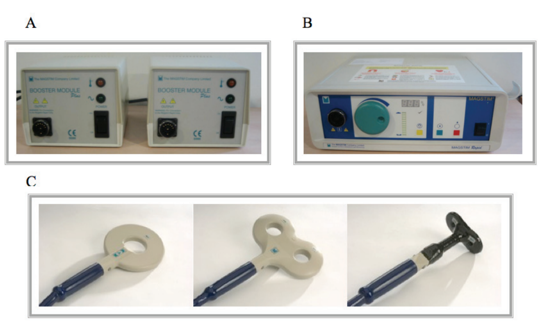
A TMS apparatus is composed by (see Figure 1):

A: A capacitive systems of charge-discharge current designed to store an electric charge at high potential (in the kV range) and to supply a high current (in the kA range).

B: A control system which allows to determine the current level, according to the user needs, and generates a magnetic stimulus either manually or by an external trigger circuit. In addition, it governs all electric and thermal protections for a safe operation.

C: A stimulating coil whose design is crucial because it determines the profile of the induced magnetic field and because it is the only component in direct contact with the subject to study.

Figure 1. Transcranial magnetic stimulator Magstim model Rapid. A: two capacitive systems to accumulate electric charge above 2.8 kV. B: control system to adjust stimulation parameters and safeguards. C: circular coil and two figure-eight coils with different diameters, each of them induces a magnetic field with different characteristics



Operating Principles

Whenever the capacitor bank is discharged by the action of the control system, a pulse of current I flows through the stimulating coil and, according to Ampère's Law (eq. [1]), induces a magnetic field $\vec{H}$ surrounding the coil. Figure 2A shows a simplified circuit equivalent to a *figure of eight* (or *butterfly*) coil (Figure 1C, center & right). Note that the induced magnetic field is greater (*2H*) where the more current flows.

Because I varies with time (pulse) so does $\vec{H}$ and, by virtue of the Faraday's law (eq. [2] in Figure 3), an electric field is induced in the air

Figure 2 A. a circulating current I induces a magnetic field H. The magnetic field is greater (2H) at points with greater current flow and is zero where the net current is zero. B: The right-hand rule is a mnemonic rule to determine the spatial relationship between current and magnetic field. The Ampère's law (eq. [1]) expresses the relation between the current and the magnetic field