Constant Current Versus Constant Voltage DBS Stimulators—Changing Trend

Bilateral subthalamic nuclei deep brain stimulation (DBS) has become the established mode of therapy for advanced Parkinson's disease over the last 30 years.[1,2] There has been progressive improvement in all aspects of the surgery, including more sophisticated imaging modalities for localization, better frames, the leads implanted, the hardware as well as technologies for post-op programming.[3]

Implantable pulse generators (IPG) are the only source of power for the DBS systems and are the programable component. The IPG has a battery, a CPU built in with program memory, and a microprocessor which communicates with external devices and manages the entire stimulation system. There have been tremendous changes in the IPGs also in the past few years, with recharging and sensing capacities being included in the latest pulse generators.[4]

The delivery of current can be by two modes—the older constant voltage and the more recent constant current pulse generator. Some of the recent models have the capacity to deliver in either the constant current or constant voltage mode.[4]

Constant voltage generators provide a constant voltage over time to the brain. The amount of current delivered depends on the resistance offered in the path of the current. This can be determined by Ohm's law ($I = V/R$), where I is the current delivered, V is the voltage provided, and R is the resistance. The resistance provided is the combination of various factors—external pertaining to the IPG, the lead connections and their extensions, and the total surface area of the electrode and internal factors—the conductivity and electrolyte ion concentration of the tissue being stimulated and the impact of encapsulation.[5] The factors associated with the IPG, its connections, and the total surface area of the lead are more stable compared to the other factors involved.

On the other hand, a constant current generator keeps the current constant irrespective of the resistance.

The only possible disadvantage is that the dynamic voltage changes may cause more battery consumption.[4] In a resource-poor country, where we use primary cell, it would mean an additional burden on the finances of the patients with more frequent IPG replacement. The increased production of rechargeable batteries and the shift toward its use worldwide have made constant current stimulators better suited for patients.

The changes in the resistance initially after surgery have been well described. But the tissue resistance continues to change through time and this has been demonstrated in a recent study.[6] In our center too, in a cross-sectional study with patients who were operated more than 2 years before, it was noted that changes in the rate of firing as well as changes in the amplitude of voltage changed the resistance to the current acutely which persisted. Although there was significant variation of resistances among different patients, intra-individually the variations caused only around 1–2% change in the current and this did not translate into clinical effects.[7]

In the current study, the authors look into a change from constant voltage to a constant current with hybrid devices and found no significant differences in their outcomes. The change actually led to an improvement in three patients, thus emphasizing that constant current devices can be better steered to achieve optimal stimulation. The change from one device to hybrid devices also was safe and had a good outcome.[8]

There do not seem to be significant differences between constant voltage and constant current IPGs in terms of the outcome in most studies, but the rationale and the benefit of finer tuning of the current with constant current IPGs suggest that they should be the preferred mode of stimulation in the future.

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Conflicts of interest

There are no conflicts of interest.

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