The human lumbar cord circuitry disconnected from the brain can generate a variety of motor outputs in response to non-pattemed spinal cord stimulation at different frequencies

Introduction

Spinal reflex studies with stretch and cutaneous-muscular reflexes have been performed at low stimulation rate, if at all repetitive, in order to understand their physiological properties. Recent developments in epidural lumbar spinal cord stimulation (SCS) offer the possibility to elicit reflexes similar to the H-reflex in multiple segments, posterior (M1) and anterior (M2) M2 reflexes, and at various frequencies. When trains of stimuli are applied, each stimulation pulse and measured reflex response, respectively, acts both as a conditioning and test stimulus with observable dynamics in the motor out put. In motor complete tetraplegia (SCI), in which the lumbar cord is completely deprived from brain input we hypothesize that lumbar SCS at various frequencies can be used to initiate and assess functional organizations of intrinsic lumbar cord spinal circuitry.

Examples of dynamic response amplitudes

- Example 1: The dynamic response of the reflex arc is characterized by a peak amplitude of the response at a specific latency. The response amplitude decreases over time, and the latency increases with increasing frequency.
- Example 2: The dynamic response of the reflex arc is characterized by a peak amplitude of the response at a specific latency. The response amplitude decreases over time, and the latency increases with increasing frequency.
- Example 3: The dynamic response of the reflex arc is characterized by a peak amplitude of the response at a specific latency. The response amplitude decreases over time, and the latency increases with increasing frequency.

Stimulation and recording

- The data was collected during the clinical protocol for evaluating the optimal site and parameters of the epidural electrode for spinal cord treatment. For the present study’s subjects, electrodes were stereotaxically placed at the level of the upper thoracic or lumbar region, depending on the clinical diagnosis and the need for pain relief. The results of the clinical trials are consistent with the protocol. All subjects gave informed consent.
- The recorded data were analyzed post hoc, and the stimulation parameters were optimized prior to implantation.

Model of alternating responses (C)

- A model explaining the pattern of alternating response amplitudes (B). A physiological description of the pathway. The stimulated site controls the reflex arc, which in turn can activate flexor muscles that inhibit the contralateral M2. The M2 response is mediated by a chain of reflex arc components. A chain of reflex arc components control the chain of reflex arc components.

Results

- Figure 1: Example of the three dynamic changes of the shape of the reflex arc in response to SCS. The response amplitude shows a gradual increase over time, and the latency decreases with increasing frequency.

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References


Discussion

When SCS is used repeatedly it can result with specific configurations, in rhythmic and even stepping-like EMG activity [1]. Furthermore, at low frequencies (0.5 Hz), with a constant and steady stimulation, the elbow flexors maintain a steady and strong response. In contrast, at high frequencies (5-10 Hz), the reflex amplitudes were more variable, but with increasing frequencies the standard deviation of the response amplitudes increased. A plateau of the dynamic response amplitudes was observed, but less frequently. Rhythmic, low frequency (0.5-0.5 Hz) alternating between phases of increased and decreased excitability of M1EMG reflexes, resembling bimanual EMG activity was observed in few cases as SCS frequencies above 25 Hz, but with and without multigenetic coupling. In these cases the rhythmic activity consisted of relatively high response amplitudes, which were consistent with the general observation that with higher frequencies the response amplitudes decrease.

Basic research on interneurons and intersegmental networks of several hierarchically brain and spinal cord regions, structures in under continuous progress. Electrophysiological extracellular and intracellular recordings, histochemistry, biostatistics may be used to determine functional processing paths, configuration and their role between input and output of "black boxes". IMOG reflexes are further methodology for such studies. The frequency of occurrence of different patterns of IMOG reflex dynamics are related to the rate of SCS. These findings illustrate that multigranular, non-patterned externally controlled input through the lumbar posterior roots can be processed and converged into a pattern of functional and (or) non-functional outputs to the intrinsic circuitry of the lumbar cord. We propose that these features are processed output of the spinal cord lumbar intersegmental system. SCS enable systematic studies of the spinal motor and polysegmental inputs to and outputs of human spinal nervous cord. This allows the assessment of the efficacy range of the input and in an important factor in modification of output if we speculate that excitatory and inhibitory interneurons are responding to different sets of descending inputs. Thus, further studies in humans with intact and impaired nervous system are warranted.