Spinal Locomotion: An Approach to Human Neurophysiology and Treatment in Spinal Cord Lesion. New results obtained with basic methods

Preface

The cure of spinal cord lesion, hemiplegia and cerebral palsy are unsolved clinical problems. The papers presented herein offer a scientific approach to possible treatment in spinal cord lesion, and show similarities to the treatments of hemiplegia and cerebral palsy. The basic principle behind these new treatments is that the same rhythm coupling of neuronal subnetworks is used for the treatment of central nervous system (CNS) lesions as is at least partly used by the human CNS to self-organize movements and homeostatic regulations. By long-term training of rhythmic stereotyped dynamic movements, the neuronal networks of the lesioned human CNS are forced to re-preformate in such a way that self-organizations of the networks emerge to achieve physiologic movements. The essential fact in this treatment is that rhythmic stereotyped dynamic movements are mainly generated by the neuronal networks located in the lumboscral spinal cord (spinal locomotion). The most obvious demonstration of spinal locomotion is the primary automatic stepping in newborn infants. These lumboscral spinal cord networks are not directly damaged in cervical CNS lesions (but their functioning becomes deteriorated), need little supraspinal drive and can be used via the movement-induced afferent input and the remaining little volitional control to force the cephalic CNS parts to re-preformate their networks to allow improved self-organization.

The new understanding of the functioning of the human CNS, namely the rhythmic coupling of oscillatory firing neuronal subnetworks and the organization to integrative functions comes from human measurements with basic methods. Similar developments take place in animal physiology, pediatry (system theory of infant motor development) and robotics. The neuronal network organization and reorganization by changing oscillator coupling shows similarities to nuclear physics where it was tried to explain nuclear forces by models of paired or quadrupled coupling of nucleons. Anyhow, biological oscillators organized in the human CNS, and oscillator recouplings can easily be measured electromyographically with surface electrodes and provide precise information concerning the neuronal network states and their reorganizations. In this new concept, natural afferent input patterns will affect the whole neuronal network of the CNS rather than certain pathways only as claimed by the reflex theory.

Since there generally is a gap between animal research, clinical research and treatment, and comparable measurements in animals and man are missing to transpose animal data to man, the current research starts from the scratch with human measurements. Animal data are

only used to better understand and widen the human data. Besides phylogenetic considerations there also are ontogenic comparisons. Because this original new human neurophysiologic research leads to a new treatment (oscillator formation training) with a result not expected to be possible so far (a patient with spinal cord lesion re-learning running), this new understanding of the functioning of the CNS has to be compared to the existing reflex theory to see whether it can explain more human data, and has to be compared with existing treatments to find its field of application. Since the discussion of the last paper became too large, we decided to offer all five papers together in a supplement. Most of the data in this volume on human neurophysiology refer to man, and reference to animal data are clearly indicated. Standard textbooks of neurophysiology for medical students on the other hand contain mostly less than 10% human data. Approximations of the animal data to man are mostly missing. A transmission frequency of 5,000 Hz has, e.g. been measured in man for secondary muscle spindle afferents ([95] of paper 5); in animal physiology it is believed that 1,000 Hz is the border transmission frequency. The papers in this volume could therefore be of interest to readers interested in human neurophysiology and corresponding clinical treatment.

This approach to the functioning of the human nervous system under physiologic and pathophysiologic conditions is mainly based on a new recording technique applicable to man: the recording of natural impulse patterns of single afferent and efferent nerve fibres from undissected nerve roots. The method is generally applicable, since electrical anterior root stimulators are implanted world-wide for urinary bladder control in spinal cord lesioned patients. An improved identification of the representation of the nervous system functions in the sacral nerve roots may further improve the operational techniques.

The principles of the human neurophysiologic research are similar to those of animal research: study lesion-induced changes of the nervous system. In animal research the nervous system is lesioned artificially. In human research nervous system lesions often occur in traffic accidents and sports.

With respect to ethical issues, it not only is a question what is allowed in relation to man, but also what is allowed to be left out. Spinal cord lesioned patients generally suffer from incontinence, pain and inability to move. Five percent of the society including young women after the birth of their first child suffer from incontinence. The reorganization of the neuronal networks of incomplete spinal cord lesioned patients shows similarities to those in infants with cerebral palsy and adults with hemiplegia, and its knowledge can also be used for the treatment of other diseases. If incomplete spinal cord lesion can be treated generally on a scientific basis one can expect that also the treatment of a complete lesion can be improved in the future.

The problem for the time being is not that little can be done for patients with a lesioned CNS; rather, the problem is to organize the necessary clinical research and to motivate clinicians and therapists for new treatments and for updating of their knowledge of human neurophysiology. The authors are aware that more human measurements are needed, but it should be realized that such human measurements are extremely difficult to perform due to organizational reasons. The current research follows the line of two earlier statements:

1. Treatments initiated by therapists should be based on theory; clinicians should be able to provide a theoretical justification for their clinical decision making and the application of a certain therapeutic intervention (page 2 of [73] of paper 5).
2. ... It is true that my tactic is to make sweeping categorical statements. Whether or not this is a fault ... is debatable. My own feeling is that it leads more quickly to the solution of scientific problems than a cautious sitting on the fence (E. Mayr in 1982 ([60] of paper 5)).

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