Summary: Electrophysiology in the ICU

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Dr. Michael Aminoff, guest of the Canadian Society of Clinical Neurophysiologists, discussed the *Management of Status Epilepticus*. The EEG is essential for the recognition of status epilepticus where there are minor or no motor manifestations, and also in clarifying the nature of certain motor and behavioural disturbances that do not relate to seizures. It also is important in evaluating the adequacy of treatment, such as the response to barbiturate or midazolam induced anaesthesia.

Dr. Bryan Young discussed *Metabolic and Inflammatory Cerebral Diseases*. The EEG will show a wide range of abnormalities in patients who, on neurological examination, are found to simply be in coma, without other manifestations. It is sensitive to the depth and severity of brain dysfunction. If serial tracings or continuous EEG recordings are used, it gives some idea of the direction of the process, that is, whether improving or worsening. While the EEG rarely establishes the precise etiology of the coma, it will help to classify it into certain categories of disease process. It is especially valuable in prognosis, particularly in conditions causing neuronal death such as anoxia and ischemia. Thus, the EEG is an important diagnostic and prognostic tool in the intensive care unit (ICU).

Dr. Richard Moulton discussed *Monitoring Severe, Head Injury*. The EEG power spectrum and somatosensory evoked potentials (SEPs) were utilized at 12 hourly intervals in the ICU, in Toronto. The SEP showed the best correlation with outcome when outcome was assessed by a modified Glasgow coma scale. It was also valuable in making critical management decisions when utilized between 12 and 108 hours post injury.

Dr. John Kay discussed *Continuous EEG Monitoring*. Computerized digital EEG has made EEG practical in the ICU setting, and networking has allowed it to be monitored both at the bedside and at remote sites. The ICU nurse is the person who has the single greatest contact with the patient. Experience by Jordan and his group in San Bernardino, California, and most recently in the group in London, Ontario, has shown that the ICU nurse can learn to identify the important features on the EEG accurately, and thus, provide real time monitoring 24 hours per day. Digital data can be stored for later review and analysis. The EEG has the advantage of being non-invasive, relatively inexpensive, and available at the bedside without the need to transport the patient. In Jordan's retrospective review, the impact on care was considered decisive when at least one major clinical decision, such as the initiation or alternation of anti-epileptic drug therapy or transporting the patient out of the ICU, was made solely on the basis of the EEG. It was deemed contributory when at least one major decision was made on the basis of the EEG, plus the clinical examination. The EEG had a decisive or contributory impact on management in 82% of cases. However, before being widely accepted, it will have to be shown to not only influence medical decisions, but also patient outcomes, and such a prospective study is now underway in London, Ontario.

Dr. Bill Brown discussed *Quantitation in EMG*. A variety of methods are now being developed to assess the force of output of muscles, the number and functional capacities of motor neurons, motor conduction in motor nerve fibres between the spinal roots and the motor point, methods determining neuromuscular transmission and methods involved in studying primary disorders of muscle. Some of these methods are not applicable in the setting of an intensive care unit because they are too cumbersome, technically difficult or impractical. However, they may be used in certain special circumstances and may shed light on the pathogenesis of some of the complex neuromuscular disorders present in the intensive care unit.

Dr. Robert Chen discussed the *Investigating Polyneuropathies*. Polyneuropathies frequently contribute to ventilator dependency and prolonged stay in the intensive care unit. Electrophysiological studies are invaluable in establishing the diagnosis, determining the pathophysiology, the severity of the disturbance and in following the patient's progress. They assist in differentiating critical illness polyneuropathy, acute inflammatory demyelinating polyneuropathy and the axonal forms of acute inflammatory demyelinating polyneuropathy.

Dr. Udo Zifko discussed. *Electrophysiological Respiratory Studies*. A number of electrophysiological techniques have been developed in the last 10 years, which allow testing of both the central and the peripheral components of the nervous system function involved in respiration: transcortical magnetic stimulation of the brain and spinal cord and direct electrical stimulation of the phrenic nerve with recording from the diaphragm with surface electrodes; testing defects in neuromuscular transmission at the level of the diaphragm; needle electromyography of the diaphragm; and the technique of somatosensory evoked potential study of the phrenic nerve. All of these tests can be applied in the ICU to investigate any cause of respiratory insufficiency that is thought to be due to nervous system disease.

Dr. Francois Grand'Maison discussed *Methods of Testing Neuromuscular Transmission*. While neuromuscular transmission disorders are rare causes of ventilatory failure, they often arise in the differential diagnosis of more severe disturbances that require management in an intensive care unit. Electrophysiological studies may differentiate among myasthenia gravis, Lambert-Eaton myasthenic syndrome and other disorders of neuromuscular transmission acquired prior to admission to the ICU. Some patients after admission to the ICU may have prolonged respiratory muscle weakness due to the use of neuromuscular blocking agents. While electrophysiological studies are essential in investigating these conditions, at times, they are unhelpful and a final diagnosis can only be made after further testing: such as measurement of serum antibodies, muscle biopsy, and response to specific treatment, such as immunosuppression.

Dr. Douglas Zochodne discussed *Diagnosis of Myopathies*. Patients may present with a pre-existing myopathy, such as muscular dystrophy, which involves the respiratory muscles severely enough to require mechanical ventilation and management in an intensive care unit. Electrophysiological studies, as well as, measurement of muscle enzymes, muscle biopsy and other tests are usually essential in diagnosis. After admission to the intensive care unit for some other cause, myopathies, at times severe, may then develop. These may be precipitated by the use of neuromuscular

blocking agents or steroids, and may be accompanied by severe weakness and myoglobinuria. Complete recovery usually occurs, although it may not if the myopathy is unusually severe. Zochodne and colleagues have applied the term "acute necrotizing myopathy of intensive care" to these severe myopathies.

The Table summarizes the various electrophysiological tests and their application depending upon the nature and presumed site of the nervous system dysfunction. The Figure is a guide to the investigation of patients in the CCU who have weakness of limb and respiratory muscles.

Table: The Application of Electrophysiological Tests in the Critical Care Unit.

Conditions	Site of Nervous System Dysfunction	Electrophysiological Test
Seizures	Cerebral Cortex	Standard EEG, Continuous EEG monitoring (CEM)
Diffuse encephalopathies	Cerebral hemispheres and brainstem	Standard EEG, CEM, Somatosensory evoked responses (SEPs)
Severe closed head injuries	Cerebral hemispheres and brainstem	SEPs, EEG power spectrum, CEM
Neurological respiratory insufficiency	Brain, spinal cord, phrenic nerves, n-m junction, diaphragm	Transcranial and cervical magnetic stimulation, phrenic nerve SEPs, phrenic nerve conduction, repetitive phrenic nerve conduction, needle EMG of the diaphragm
Polyneuropathies	Peripheral nerves	Motor and sensory nerve conduction, needle EMG
Neuromuscular Transmission defects	Neuromuscular function	Repetitive limb nerve stimulation. Stimulation single fibre studies
Myopathies	Skeletal muscle	Motor and sensory nerve conduction, needle EMG
Neuromuscular Quantitative Methods		Motor unit estimates, measurements of muscle force, quantitative computer analysis

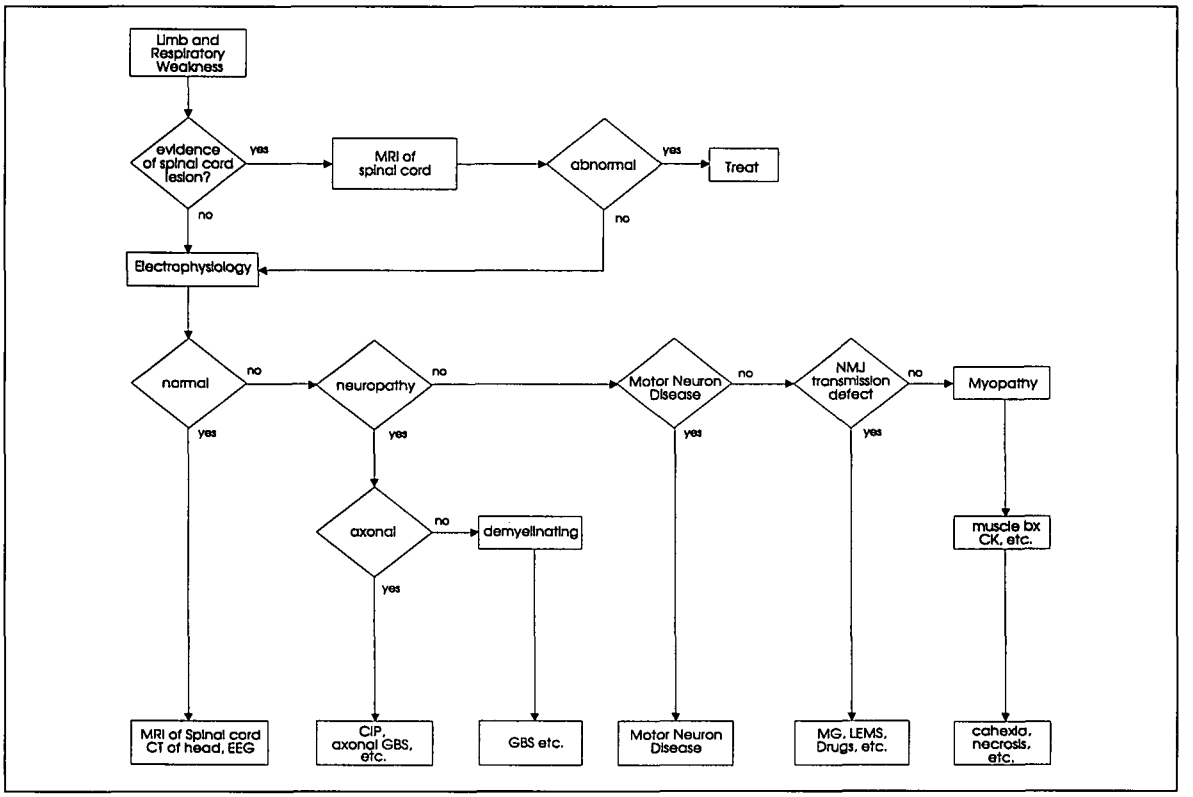

Figure: An algorithm for investigation of limb and respiratory weakness in the critical care unit. (With permission, Bolton CF. Neuromuscular conditions in the intensive care unit. Intensive Care Med (1996) 22: 841-843.

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