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Challenges for the Use of Evoked Potentials and Electrophysiology for Monitoring Patients in the Operating Theater

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INTRODUCTION

THE APPLICATION OF ELECTROPHYSIOLOGIC METHODS, such as the electroencephalogram and sensory evoked potentials, for measuring neural activity in patients undergoing surgery will alter current operating room practices. Surgeons working on sensitive neural structures within the spinal cord, peripheral nerve, or the brain would be assured that sensory and motor pathways traversing through the field of operation maintain their function throughout the operative procedure. A deterioration of evoked potentials could signal a possible damaging situation that might be reversed by changes in operative technique, and an enhancement of the potentials might signal that the operation is successful. These electrophysiologic techniques are relatively simple, using surface electrodes to record the events, computers to process the derived electrical events, and video monitors to display the information for the surgeon and anesthetist.

CRITERIA

There are certain criteria that must be fulfilled if we are to achieve the promise that electrophysiologic measures offer for monitoring neural functions in the operating room. First, it is not acceptable to incorrectly signal the occurrence of damage to the nervous system. Second, it is unacceptable if the measures were insufficiently sensitive to detect damage to the nervous system. It is necessary to balance requisite sensitivity without an unduly high false alarm rate.

This goal can be accomplished by, first, defining the effects of the many variables encountered in the operating room, such as the preoperative medication, the various anesthetic agents, the depth of anesthesia, systemic effects such as blood chemistries, cardiovascular factors of pressure and output, pulmonary function, and changes in liver and renal processes. We know that certain of the evoked potentials, particularly those reflecting activity in subcortical sensory pathways, i.e., auditory brainstem and spinal cord dorsal column components, are quite resistant to extremes of many of the variables listed above. Thus, auditory brainstem potentials provide an excellent monitor of brainstem function in operations on the posterior fossa, whereas recordings of spinal cord activity above and below a laminectomy site provide reliable information of the integrity of dorsal column pathways in that area.

In contrast, both the EEG and certain components of sensory evoked potentials reflecting activity in diencephalic structures (thalamus and cerebral cortex) are particularly sensitive to the variables

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encountered during an operation. The latency of evoked potentials will lengthen, and amplitude will be reduced. Since these latter changes are exactly the same as those accompanying damage to sensory pathways, the distinction between the two alternatives—surgical injury vs physiologic change—is difficult. There are shifts in the frequency distribution and amplitude of the EEG that accompany the administration of various doses of anesthetic agents, changes in blood flow, or damage to the cerebral cortex. We need to develop methods to distinguish among the various etiologies causing these EEG changes.

It is important to recognize that current methods of testing evoked potentials assess only a limited portion of the structures being investigated. For instance, auditory brainstem potentials measure the brainstem auditory pathway and do not reflect the integrity of other portions of the brainstem, such as the reticular formation. Somatosensory potentials evoked by stimulation of mixed or sensory nerves traverse the dorsal column and do not provide information as to the functional integrity of the ventral or lateral portions of the spinal cord. It is essential that we develop a variety of techniques to more thoroughly assess the nervous system. The measurement of activity of motor systems, for example, would provide valuable additions to our current methods of assessing neural function in the operating room. It has been shown recently that it is possible to electrically stimulate the motor pathways through scalp electrodes to cause contraction of selected muscles in the limbs. Such a technique might allow the monitoring of motor pathways in the spinal cord during surgery to complement somatosensory evoked potentials. Furthermore, the ability to monitor the EMG of muscles innervated by those nerves exposed to the possibility of injury in the course of an operation can provide valuable information. Thus, the measurement of facial muscle activity has proven to be of value in limiting damage to the facial nerve during surgical removal of acoustic neuromas. Finally, the measurement of the EEG can provide useful quantification of hemispheric asymmetry during operations on the carotid artery to alert the surgeon to impending damage from ischemia.

DISCUSSION

Thus, it is the use of the many methods of electrophysiology in the operating room that offers the best hope for providing quantitative information of neural function to assist the surgeon in minimizing inadvertent damage and maximizing therapeutic benefits. These techniques include sensory evoked potentials, electrical stimulation of motor pathways, EMG, and EEG. It is within our grasp to be able to document the normal variability of these methods to provide secure guidelines for the surgeon of the functional integrity of the neural systems under consideration.

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