Technical, Physiological and Anatomic Considerations in Nerve Conduction Studies

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Summary

Nerve conduction studies and their interpretation are subject to a variety of factors. First, technical factors including submaximal stimulation, environmental electrical noise, inaccurate placement of the recording electrodes, and stimulus artifact can substantially interfere with accurate recording of nerve and muscle responses. Second, physiological factors, such as the effects of body height and age, can cause profound variation in all nerve conduction parameters, and studies require interpretation keeping these individual variations in mind. Another physiological factor is temperature, in which cooling can produce a variety of changes, including slowing of conduction velocity and increase of response amplitude. Anatomic factors are also important, the most common being the Martin–Gruber anastomosis, usually presenting with a reduction in response amplitude with proximal stimulation of the ulnar nerve, and the second most common being the presence of an accessory peroneal nerve. Paying constant attention to all of these details is a critical element to the accurate performance and interpretation of nerve conduction studies.

Key Words: Conduction velocity; distal latency; Martin–Gruber anastomosis; nerve conduction study; stimulation; temperature.

1. INTRODUCTION

Nerve conduction studies (NCS) are considerably more technically demanding than EMG. Correct interpretation of NCS data is dependent on re-creating the conditions that prevailed when the normal data tables were generated. This means that close attention to temperature and electrode placement are crucial. Physiological potentials are tiny in comparison with ambient electrical noise and must be amplified many times for evaluation. Artifacts may be similarly amplified and need to be recognized and minimized.

2. SKIN PREPARATION

Good skin preparation is vital to performing NCS. The skin acts as a barrier to the measurement of electrical signals of interest and the effect of this barrier can be minimized by application of conductive gel that provides a low-resistance pathway to the electrode. Thick or edematous skin adds additional distance between the recording electrodes and the signal generator (i.e., the nerve or muscle), resulting in lower amplitudes. When the skin is callused, there may be different amounts of resistance to measuring the charge over the skin between the active and reference recording electrodes. Impedance is the term used to describe resistance
to current flow in NCS. The impedance of recording electrodes must be similar, or ambient electrical noise will appear different at the electrodes. When this occurs, 60-Hz artifact or a broad stimulus artifact may obscure the waveforms. Skin lotions or perspiration can provide a conductive medium from the stimulator to the recording electrodes and can also result in a broad stimulus artifact. Soap and water cleansing is usually effective, but alcohol and acetone may be used to obtain a clean surface.

3. STIMULUS ARTIFACT

Spread of excess current along the skin and deeper tissues results in a stimulus artifact. Modern instruments use a variety of technical mechanisms to minimize this, but, even so, stimulus artifact can obscure potentials with very short latencies, especially palm-to-fingers or palm-to-wrist recordings. Reducing stimulus duration and intensity can reduce stimulus artifact, but it is imperative to obtain supramaximal responses. Placing the ground electrode between the stimulating and recording electrodes can reduce stimulus artifact by providing a low-impedance pathway for excess current to flow through. Rotating the anode of the stimulator while leaving the cathode in place can minimize the stimulus artifact. Increasing the distance between stimulating and recording electrodes or decreasing the distance between the active and reference recording electrodes will reduce stimulus artifact at the cost of lengthening the latency and, possibly, reducing the amplitude of the waveforms.

4. RECORDING ELECTRODES

Recording electrodes used in routine NCS include disc electrodes, ring electrodes, and bar electrodes that connect two discs at a fixed distance. Disc electrodes are commonly used to record motor potentials and nondigital sensory potentials. The discs are connected to separate wires that allow the distance between the active and reference electrode to be altered. Standard interelectrode distance is 3 to 4 cm, but there are occasions when adjustments must be made because of anatomic or physiological conditions. Any variation from standard positioning can change the characteristics of the recorded potentials, therefore, understanding the underlying electrophysiology is helpful in interpreting the data when alterations are necessary.

NCS and EMG electrodes record all potentials using a differential amplifier system that magnifies differences between the active and reference electrodes at each point in time. Identical signals appearing simultaneously at both electrodes undergo common mode rejection and are not displayed in the waveform. This is an ideal situation to minimize noise, but can also reduce physiological potentials.

In sensory NCS, the active and reference recording electrodes are placed linearly along the course of the nerve, approx 3 cm apart. It is optimal for the traveling depolarized zone to pass completely under the active electrode before beginning to pass under the reference electrode, because this maximizes the displayed amplitude. Interelectrode differences of less than 3 cm may result in reduction of the amplitude. Increasing interelectrode difference beyond 3 to 4 cm does not increase the amplitude further and improves the chance of introducing electrical noise that may appear different at the two points. When the interelectrode distance is necessarily altered (as occurs with an amputation of a distal phalanx or to avoid bandages or similar obstacles), these concepts need to be kept in mind because normal values depend on specific interelectrode distances. Amplitudes vary inversely with the recording electrode’s distance from the nerve, thus, it is advisable to take steps to minimize edema, particularly