

“F” WAVE: Clinical Importance

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Citation

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Abstract

F-wave is one of the late responses produced by antidromic activation of Motoneurons by supramaximal stimulation. They are variable in latency, amplitude, and configuration. Whenever we talk of nerve conduction studies, the importance of F wave are considered less. One should understand the characteristics and the physiology of F wave. This is important since F-waves are one of the most frequently used studies in clinical neurophysiology and much of the controversies surrounding the use of F-waves relates to a failure to adequately consider the requirements of F-wave analysis. These requirements include the number of F-waves that need to be recorded, the parameters that should be evaluated, and the muscle from which the F-waves are recorded. They are recorded over a muscle innervated by the stimulated nerve. F-waves are the only parameter in nerve conduction studies particularly useful for the diagnosis of proximal nerve lesions

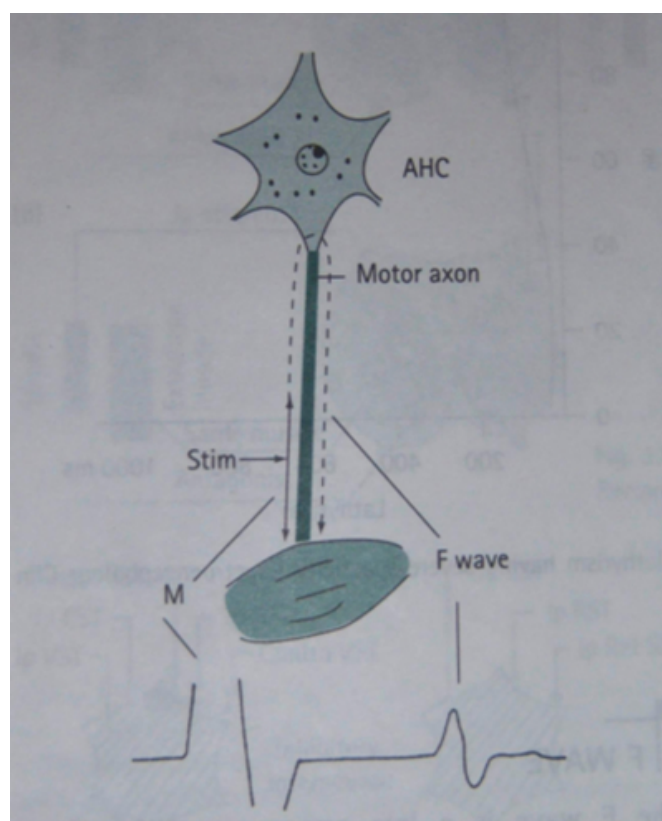
INTRODUCTION

Nerve conduction studies are basically performed to study the distal segment involvement. The late responses are performed to study the proximal segment involvement. There are 3 different late response: H reflex, F wave and the axon reflex. Out of this H reflex and F wave are performed to study the proximal regions of nerves (i.e., portions of nerves near the spinal cord). F wave occurs after the CMAP (Compound Muscle Action Potential). It results from antidromic stimulation of motor neurons involving conduction to and from spinal cord and occurs at the interface between peripheral and central nervous system.

In a typical F wave study, a strong electrical stimulus (supramaximal stimulation) is applied to the skin surface above the distal portion of a nerve so that the impulse travels both distally (towards the muscle fiber) and proximally (back to the motor neurons of the spinal cord) as shown in figure 1.

Figure 1

Figure 1: Mechanism of F response

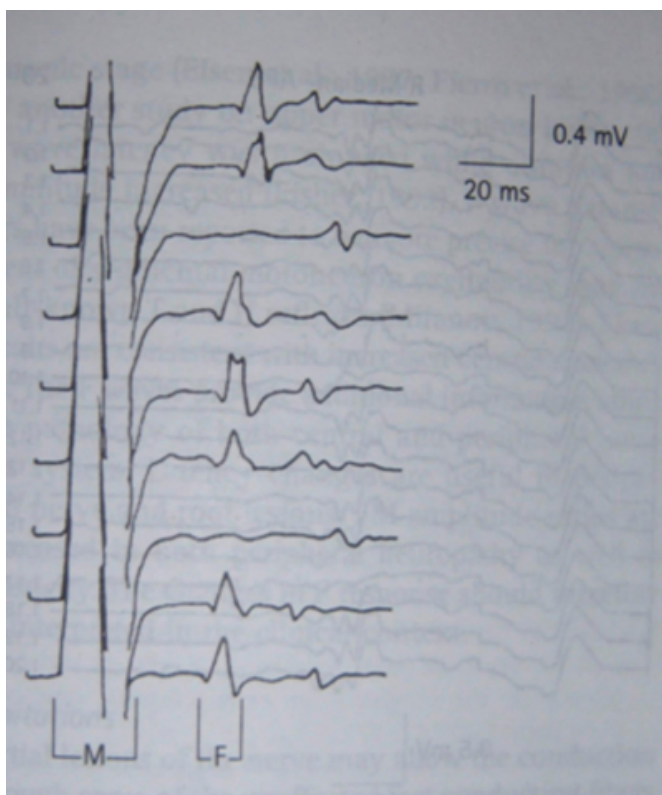


(These directions are also known as orthodromic and antidromic, respectively.) When the orthodromic stimulus reaches the muscle fiber, it elicits a strong M wave indicative of muscle contraction. When the antidromic stimulus reaches the motor neuron cell bodies, a small

portion of the motor neurons backfire and orthodromic wave travels back down the nerve towards the muscle. This reflected stimulus evokes small proportion of the muscle fibers causing a small, second CMAP called the F wave. The name F wave is derived for the first time in the intrinsic muscles of foot by Magladery and McDougal in 1950. The afferent and efferent for F waves are alpha motor neurons. They are produced at the supramaximal stimulus unlike H reflex. The morphology is variable whereas in H reflex it is consistent throughout as shown in figure 2.^{2,3}

Figure 2

Figure 2: Normal F response by stimulating median nerve and recording from abductor pollicis brevis.



PROCEDURE

Stimulation: Supramaximal stimulus (25% above maximal at a rate of not more than 0.5 Hz) is required for the elicitation of F wave. Cathode is placed proximal to anode. The gain is set to 200 microvolt and the sweep speed to 5 or 10 ms. At least 10-20 F responses are elicited. If no response occurs at the supramaximal stimulus, the Jendrassik maneuver helps in priming the anterior horn cells.^{4,5}

The properties of F waves are as follows:

1. Latency
2. Chronodispersion

3. Amplitude
4. Persistence

LATENCY

The minimal latency is the most reliable and useful measurement. Errors in placing the markers are common which may alter the latency. The markers are best placed at a point where the wave departs from the baseline. In addition, superimposing the traces once all the responses are obtained is helpful in determining the minimal latency. F latencies vary with the height of the patient. F responses are longer in tall patients. The upper limit of minimal F latency is 31 ms for females and 34.4 ms in normal males (Nelson et al 1990). The right to left asymmetry of minimal F latency exceeding 2 ms in hand and 4 ms in foot is considered abnormal.

CHRONODISPERSION

F-waves are required for estimation of chronodispersion (50-60%). It basically refers to the difference of maximal and minimal latencies in a series of F waves. It is highly sensitive for diagnosing demyelinating neuropathy.

AMPLITUDE

The ratio of F wave amplitude to the associated M wave (FM ratio) is a measure of the proportion of motoneuron pool activated by antidromic stimulation. It helps in the diagnosis of axonal neuropathy, though not highly sensitive.

PERSISTENCE

It is a measure of antidromic excitability of a particular motor neuron pool. It is decreased in axonal neuropathy. It is calculated by dividing the number of F responses to the number of stimuli.

THE "F" ESTIMATE

Whether the prolonged F response is truly due to a lesion of the proximal nerve segment or merely reflects an abnormal distal motor latency or conduction velocity or an unusually tall patient, could be estimated by the help of F Estimate. The distal motor latency, conduction velocity, and the patient's limb length are the parameters required for calculating F estimate. It is calculated by the theoretical time it should take for the F response to occur, taking into account these variables. First, to calculate the time it takes for F response to go from stimulation site to the anterior horn cell, one divides the distance between those sites by the motor nerve conduction velocity. Second, there is a brief

turnaround time at the anterior horn cell, which has been estimated to be approximately 1ms. Third, the time it takes the F response to travel back down from the anterior horn cell to the stimulation site. Finally, the time it takes from the stimulation site to the muscle is the distant motor latency.

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$$F \text{ Estimate} = (2D/CV) \times 10 + 1 \text{ ms DL}$$

Where D is the distance from stimulation site to the spinal cord, Cv is conduction velocity, DL is Distal motor latency and 10 is the conversion factor to milliseconds. The actual measured F response is shorter than F estimate. Therefore, if F response is prolonged as compared to the F estimate it is suggestive of proximal nerve segment injury.

CLINICAL APPLICATION

It is a sensitive measure of polyneuropathy and radiculopathy. In Guillain Barré syndrome (GBS) even if the nerve conduction study in terms of distal motor latency and conduction velocity is normal, the F response could be the only parameter which would help in diagnosis. F wave latencies are prolonged in GBS affecting the proximal nerve segment. In amyotrophic lateral sclerosis, reduced persistence of F wave is attributed to the loss of anterior horn cell. ^{5,8}

LIMITATION

1. It checks only the nerve or nerve segments which innervates the muscle being recorded.
2. Could not check for radiculopathy affecting the sensory nerve root fibers, as F response measures the motor fibres.
3. Could measure only severe radiculopathy or plexopathy.

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