Chapter 6.4

H reflexes from the tibial and median nerves

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Introduction

The H reflex is the simplest of spinal reflexes. It depends on electrical stimulation of group Ia afferents from primary muscle spindle endings, transmission of the evoked afferent volley to the spinal cord, the production of a synchronised excitatory post-synaptic potential (EPSP) sufficient to discharge motoneurones of the relevant pool, and transmission of the reflex discharge along α motor axons to muscle. However, the reflex is not quite as simple as it at first appears. The afferent volley involves group Ib afferents and it is impossible to restrict the stimulus to only afferents from the muscle being tested, e.g. only to muscle afferents from soleus when testing the soleus H reflex (Burke et al. 1983). The size of the compound EPSP and its duration are limited by postsynaptic inhibition from the Ib component of the volley (see Pierrot-Deseilligny et al. 1981). This is one reason why the size of the reflex discharge often involves a small percentage of the motoneurone pool and why the duration of the EPSP is so short (~1–2 ms in soleus of human subjects; Burke et al. 1984).

H reflexes can be recorded from virtually all limb muscles, though special techniques, such as post-stimulus time histograms on single motor units, may be required to demonstrate that the discharge is of reflex origin when the reflex arc is very short. Performance of a weak voluntary contraction potentiates the H reflex by raising the motoneurone pool to firing threshold but alters reflex latency little if at all. This allows reflexes to be demonstrated reliably for some muscles for which they cannot be recorded at rest (e.g. tibialis anterior, extensor carpi radialis and abductor pollicis brevis) and often allows reflex onset to be clearly delineated from the M wave because a lower stimulus intensity can be used (Burke et al. 1989).

Under normal circumstances, the H reflex can be recorded from soleus on stimulation of the tibial nerve and from flexor carpi radialis (FCR) on stimulation of the median nerve in all healthy subjects at rest, provided that a low stimulus repetition rate (<0.3 Hz) is used. Failure to demonstrate a reflex response can then be attributed to an afferent disturbance or low central excitability. With the former, the EPSP is too small or too desynchronised to reach threshold for motoneurone discharge, and this can be due to either loss of afferent axons or increased dispersion of the afferent volley. The latter may occur with the conduction slowing asso-
associated with a demyelinated or compressive lesion. Low central excitability may not indicate specific pathology but there should be similar hyporeflexia for other muscle groups. In both instances, testing during a weak voluntary contraction may then reveal an intact reflex pathway with a normal reflex latency.

**Patient’s posture**

For the soleus H reflex, the knee should be slightly bent, by ~30°, to avoid stretch of the gastrocnemius muscles which, unlike soleus, have a weak knee flexor action. The soleus H reflex attenuates with ankle dorsiflexion (Delwaide 1973), and the ankle should therefore be plantar flexed ~20° from the right angle. For the FCR H reflex, the patient should be seated or supine, again avoiding stretch on the test muscle.

**Stimulation**

The strength-duration curves for motor axons and group Ia afferents differ, such that the optimal stimulus duration for eliciting the H reflex is long, 0.5 ms or 1.0 ms (Panizza et al. 1989). There is also a significant increase in latency the longer the stimulus duration (Mogyoros et al. 1997), and this means that normal values are dependent on technique. The best method for ensuring that group Ia afferents are excited at lower threshold than motor axons involves placing the cathode over the nerve and the anode on the opposite side of the limb (Hugon et al. 1973), so that current passes transversely through the nerve. Bipolar electrodes are more convenient clinically and are usually quite satisfactory for routine purposes, but the arc of current flow is then between the electrodes and the penetration of current into the nerve may not be as satisfactory. With bipolar electrodes, the cathode should be placed over the nerve in the popliteal fossa (for soleus) or at the elbow (for FCR), with anode distal (or lateral) to avoid the largely theoretical possibility of anodal block.

There is reflex attenuation as stimulus rate is increased above once every 10 s (‘low frequency depression’ or ‘homosynaptic depression,’ perhaps due to depletion of transmitter in afferent terminals). For clinical purposes it is advised that stimulus rate be less than once every 3–5 s, unless using a conditioning-test paradigm to examine the changes in excitability of the motoneurone pool produced by a conditioning stimulus. This reflex depression is not apparent when the reflex pathway is tested during a voluntary contraction (Burke et al. 1989), and rates of 2–3 Hz can be used without reflex attenuation or discomfort. It is often convenient to optimise the reflex using a rate of 1 Hz and then to decrease the rate so that latency and amplitude can be measured.

**Recording**

For routine diagnostic purposes, surface electrodes are preferred for recording H reflexes, unless it is important to ensure that the discharge involves a specific muscle. Intramuscular electrodes are necessarily selective and cannot be guaranteed to detect the EMG potentials of shortest latency.

To record more selectively from soleus, an electrode should be placed over soleus in the apex of the hollow formed by the heads of the gastrocnemius muscles, with the second electrode 3–5 cm distally. However, all calf muscles can contribute to the H reflex (though, when the subject is at rest, the recorded response is dominated by activity in soleus) and it is convenient to place the distal electrode in the apex between the gastrocnemii and the proximal electrode some 5 cm proximal. The H reflex invariably has a triphasic waveform when the calf muscles are relaxed (because it is difficult to place the electrodes over the motor point). The response recorded during a contraction of the calf muscles may begin with a dominant negativity, probably because the gastrocnemius muscles contribute more to the reflex response.

For FCR, the electrodes are placed 4-5 cm apart over the belly of the muscle in some laboratories, though others use a less selective montage with the ‘active’ over the mid-belly and the ‘remote’ over the tendon or the ulnar styloid (Jabre 1981). A selective voluntary contraction can be used to focus on the desired muscle: the contraction allows
such a low stimulus intensity that the reflex discharge occurs predominantly or only in the contracting muscle.

**Procedure**

It is convenient to begin testing with a stimulus rate of 1 Hz to define the relative ease of obtaining the M and H waves, and then to reduce stimulus rate to 0.2–0.3 Hz. Repeated single trials should be recorded of the maximal H reflex: averaging is unnecessary. If no H reflex can be defined, the position of the stimulating electrodes should be adjusted, and posture checked to ensure that the test muscle is not under stretch. It is then convenient to test during a voluntary contraction, but averaging is required to define onset latency accurately. However, the stimulus rate can then be increased to 2–3 Hz without significantly altering the latency.

Having recorded the maximal H reflex at rest, the maximal M wave may be recorded if the H:M ratio is to be calculated. This may be somewhat painful, and a single maximal M wave is sufficient, provided that the stimulus is supramaximal. The H:M ratio is increased in patients with spasticity as a group, but there is a broad range of variability of the ratio in healthy subjects and, in practice, measuring the ratio is of little diagnostic value in the individual patient, except when there is asymmetrical pathology due, e.g., to a nerve root lesion. However, in some patients with increased muscle tone but uncertain clinical findings, a high H:M ratio will suggest spasticity rather than rigidity.

If a manoeuvre is performed to alter the size of the H reflex (e.g., muscle contraction, tendon vibration, muscle stretch, conditioning stimuli to different nerves), the changes are well documented by plotting the recruitment curve, using multiple stimulus intensities. The recruitment curve demonstrates the growth of the H reflex and then its attenuation as the M wave grows with increasingly strong stimuli (e.g., Delwaide 1973). Superimposition of the curves for the M wave provides reassurance that any changes in the H reflex are not due to electrode displacement. Whether or not the full recruitment curve is used, it is necessary to confirm that the test manoeuvre does not change the size of the M wave. Alternatively, it can be useful to define the threshold for the H reflex, using a liminal H reflex (~50 μV), and to keep stimulus intensity as a fixed multiple of threshold. This avoids the consequences of an antidromic volley in motor axons.

When comparing evoked changes in reflex amplitude, it is important to keep in mind that changes in the H reflex may depend on the size of the test reflex. For example, Crone et al. (1990) suggest that, in general, small reflexes may be less susceptible to change than large reflexes, and that it is best to keep reflex amplitude within the range (usually 10–20% of the maximal M wave) over which the reflex change is not dependent on the size of the test reflex, a view supported for the FCR H reflex by Malmgren and Pierrot-Deseilligny (1988). However, under some circumstances, it may not be possible to establish a linear range for the H reflex, such that changes in it remain dependent on the size of the test reflex (Fuhr and Hallett 1993).

**Measurement**

Reflex latency is measured to the first deflection of the H wave from baseline. For soleus, the recording electrodes are not over the motor point, so that measurement should be to the onset of the initial positivity, not its peak. With FCR it should be possible to place electrodes over the motor point, in which case measurement should be to the onset of the initial, dominant negativity. If not, measurement should be as for soleus.

In practice it makes little difference whether the amplitude of the H reflex is measured from baseline (or for soleus, initial positivity) to negative peak or from negative peak to following positive trough. With FCR it may be difficult to define the baseline between the end of the M wave and the onset of the H reflex (unless the response is recorded during a contraction), such that baseline-to-peak measurements may be difficult. Whichever way the H reflex is measured, the same method should be used for the M wave when calculating H:M ratios.
Normal values

Reflex amplitude varies widely in normal subjects and its measurement should be expressed as a percentage of the maximal M wave (roughly corresponding to the percentage of responding motoneurones in the available pool). However, amplitude measurements are of little value except when pathology is asymmetrical.

Reflex latencies depend on the duration of the stimulus current (Mogyoros et al. 1997), and have a strong correlation with height and a weak but significant correlation with age (Schimshheimer et al. 1987). The following values are from the study of Schimshheimer et al. (1987) in which the stimulus duration was 1.0 ms:

Soleus H reflex: 94 control subjects

mean latency: 30.0 ± 2.1 ms (mean ± SD)
right/left difference (i.e. symmetry): 0.09 ± 0.70 ms (mean ± SD)

Soleus H reflex = 3.00 + 0.1419 × height (in cm) + 0.0643 × age (in years) ± 1.47(±SD)

FCR H reflex: 80 control subjects

mean latency: 16.84 ± 1.33 ms (mean ± SD)
right/left difference: 0.002 ± 0.42 ms (mean ± SD)

FCR H reflex = 0.44 + 0.0925 × height (in cm) + 0.0316 × age (in years) ± 0.83(±SD)

References


