Motor potentials of bulbocavernosus muscle after transcranial and lumbar magnetic stimulation: comparative study with bulbocavernosus reflex and pudendal evoked potentials

A Ghezzi, L Callea, M Zaffaroni, R Montanini, G Tessera

Abstract

Motor potentials of the bulbocavernosus muscle were recorded in 17 healthy subjects after transcranial and lumbar magnetic stimulation. The latencies (SD) were respectively: 22.9 (1.8) and 5.9 (0.4) ms. The central conduction time was 17.0 (2.5) ms. The bulbocavernosus reflex presented an onset at 34.5 (3.3) ms and a negative peak at 43.1 (3.9) ms. The cortical pudendal evoked potential was W shaped: the first peak had a latency of 35.4 (2.8) ms. The concurrent recording of motor potentials, bulbocavernosus reflex, pudendal evoked potentials gives a measure of peripheral and central, afferent and efferent neurological pathways related to pudendal nerve function.

From studies carried out by Merton and Morton¹ and Barker *et al.*,² it became possible to record motor potentials (MPs) of upper and lower limb muscles after cortical electrical or magnetic stimulation. An interesting development of these techniques seems to be the possibility of recording MPs of pelvic floor muscles when evaluating motor conduction from the cortex along the spinal cord:¹⁻³ it should be particularly helpful in neurophysiological diagnosis of sphincter and sexual disturbances in addition to tests for evaluation of pudendal nerve function such as pudendal evoked potentials (PEPs) and bulbocavernosus reflex (BCR).⁴⁻⁷ Pudendal nerve is strictly involved with bladder, sexual and bowel function: it supplies the external urethral and external sphincters, pelvic floor and bulbocavernosus muscles. We attempted to record MPs of bulbocavernosus muscle to transcranial and lumbar magnetic stimulation, comparing results with PEPs and BCR.

Material and methods

Seventeen healthy male volunteers took part in the study. The mean age was 47.8 years (range 22-80), the mean height was 169.2 cm (range 161-188). All subjects were neurologically normal and had normal sphincter and sexual functions.

The bulbocavernosus muscle potential to magnetic stimulation was recorded using a surface Ag/AgCl electrode referenced to S1, bandpass 2-2000 Hz. Cortical stimulation was performed by a Novamatrix Magstim mag-

netic stimulator, placing the coil over the vertex, or slightly anterior to it: in preliminary recordings this site was found optimal to obtain good responses. The intensity of stimulation was increased starting from 70% of the maximal output of the device. Lumbar stimulation was performed placing the coil over the L1 spinous process. Subjects were asked to relax and then to contract perineal muscles slightly: at least eight responses were recorded in the two conditions.

BCR-square wave stimuli of 0.1 ms duration were applied to the penis through ring electrodes. The intensity was increased gradually, above the sensory threshold but below the painful threshold. The frequency was 4 Hz, 10-100 responses were averaged with a bandpass of 1-2000 Hz. (Recording electrodes as above).

PEPs-responses were recorded from the scalp (active electrode 2 cm behind Cz, reference Fpz) and lumbar spine (L1-L5 electrodes). At least 250 responses were averaged, two recordings were obtained and superimposed. Filters: 1-2000 Hz. Stimuli characteristics were similar to those used for BCR recording.

Figure 1 Examples of motor potentials from bulbocavernosus muscle following transcranial magnetic stimulation in five healthy subjects.

Gallarate Hospital,
Gallarate, Italy
Multiple Sclerosis
Study Centre

A Ghezzi
L Callea
M Zaffaroni

Neurological
Department
R Montanini

Surgical Department
G Tessera

Correspondence to:
Dr Ghezzi, Centro Studi
Sclerosi Multipla, Gallarate
Hospital, Via Pastori 4,
20013 Gallarate, Italy

Received 14 May 1990.
Accepted 20 September 1990

Figure 2 Motor responses after transcranial (a) and lumbar (b) stimulation. Calibration: 600 μ V, time 20 ms (a) and 5 ms (b).

Results

Motor potentials of the bulbocavernosus muscle to transcranial magnetic stimulation were recorded in all subjects of our series: some examples of MPs are given in fig 1. An intensity of 90–100% and a slight contraction of pelvic floor muscles were necessary to obtain well defined responses. In these conditions the motor potentials (SD) presented an onset at 22.9 (1.8) ms and a peak at 27.7 (3.6) ms, the amplitude peak to peak was 353 (205) μ V.

After lumbar stimulation, responses presented an onset at 5.9 (0.4) ms. Muscle contraction was not necessary and an intensity at 70–80% of the maximal output was sufficient to obtain reliable responses. An example of MPs after transcranial and lumbar stimulation is shown in fig 2.

The difference between the latency of lumbar and transcranial responses represents the central conduction time (CCT) of the motor pathway: this measure was 17.0 (2.5) ms in our series. Normal values of BCR and cortical PEPs are reported in figs 3 and 4 respectively.

Lumbar responses were barely perceptible in most subjects. Only in two cases a potential with onset at 11–12 ms could be recorded.

Figure 3 Example of bulbocavernosus reflex. Mean (SD) normal values of the corresponding waves are reported (ms).

Figure 4 Example of cortical pudendal evoked potential. Mean (SD) normal values of the corresponding waves are reported (ms).

Discussion

Our observations show that MPs of the bulbocavernosus muscle can be easily recorded with surface electrodes during mild pelvic muscle contraction. The latency of the response was 22.9 (1.8) ms in our series: a similar value was found by Merton and Morton in response to electric stimulation in some individual cases.¹³ We are not aware of studies carried out with magnetic stimulation.

Placing the coil over the L1 spinous process an MP could be recorded with onset at 5.9 (0.4) ms, a value similar to that obtained using electrical stimulation at the same spinal level.⁸ The motor CCT was 17.0 (2.5) ms. In our laboratory the motor CCT is 11.5 (1.7) ms recording from the tibialis anterior muscle (unpublished data), in agreement with other reports.^{9–11} It means that conduction of motor fibres supplying pudendal motor neurons is slower than fibres supplying the spinal motor neurons in the legs.

The afferent and efferent conduction of pudendal nerve is evaluated by the BCR: the latencies of its onset and peak were respectively 34.5 (3.3) ms and 43.1 (3.9) ms. The whole afferent pathway activated by electrical stimulation of the penis is measured by cortical PEPs: the response is characterised by an onset at 35.4 (2.8) ms, followed by a positive peak at 41.5 (2.9) ms. BCR and PEP latencies in our series are similar to the values of other studies.^{4–7}

Lumbar PEPs were hardly recognisable in most cases of our series, making it hard to calculate the CCT of the afferent pathway. An indirect measure of peripheral sensory conduction can be given by the difference in lumbar MP latency from BCR: however, this value does not correspond to the afferent peripheral conduction (see below).

Haldeman *et al*⁴ found that the CCT after pudendal stimulation was 30.0 (3.2) ms. As the CCT of the afferent pathway in response to tibialis posterior nerve stimulation was 16.5 (1.6) ms, they concluded that the central afferent pathway activated by pudendal nerve stimulation conducts more slowly than the one activated by the tibialis posterior nerve. This is similar to our finding with motor CCT.

The latency of BCR is surprisingly higher than expected on the basis of latency of lumbar PEPs and MPs. As the lumbar PEP latency was approximately 12–13 ms, Hadelman *et al*¹ stated that the reflex should appear after 24–26 ms, assuming that the afferent and efferent limbs of the BCR conduct at the same velocities. This hypothesis is probably right: the latency of lumbar MPs (5.9 ms) was effectively lower than that proposed by Hadelman *et al*¹ but spinal magnetic stimulation may activate the motor roots near to their exit from the spinal column.¹² These findings are consistent with the fact that the BCR is a polysynaptic reflex.

The recording of RBC, PEPs and MPs to transcranial and lumbar magnetic stimulation permits evaluation of the peripheral and central afferent and efferent pathways concerned with sphincteric and genital functions: in clinical diagnosis they should help to evaluate the site of lesion in patients with bowel, urinary and sexual disorders of neurogenic aetiology.

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