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Letters to the Editor

The problem of conduction velocity of the human spinothalamic tract

A few years ago Kakigi and Shibasaki (1991), and again very recently Rossi et al. (2000), reported in *Clinical Neurophysiology* the conduction velocity of the human spinothalamic tract, as assessed by laser evoked potentials (LEPs).

Brief laser impulses selectively activate nociceptive afferents and readily evoke wide-amplitude brain potentials that provide neurophysiological assessment of the central and peripheral pathways for temperature and pain (Kakigi et al., 1991; Treede et al., 1991; Bromm and Lorenz, 1998; Agostino et al., 2000b). The LEP technique is an effective tool for obtaining physiological information on the human nociceptive system.

The first investigators to estimate conduction velocity in the human spinothalamic tract were Kakigi and Shibasaki (1991). In a study recording LEPs after stimulation of the hand and foot they calculated the time difference between the two responses, eliminating from the two latencies the peripheral conduction time assumed from theoretical values of conduction velocity of peripheral A-delta fibers. These calculations yielded a central conduction velocity of 9.9 m/s. In their article Rossi et al. (2000) refined this technique. In each subject, besides the total conduction time yielded by LEP latencies, they also estimated intraindividual peripheral conduction velocities by recording the electrical cutaneous silent period, corrected for F- and M-wave latency values. The reported mean conduction velocity for the spinothalamic tract was 9.9 m/s.

In a paper published in 2000 (Cruccu et al., 2000) we estimated the conduction velocity in the human spinothalamic tract. We did so by recording LEPs after stimulation of the dorsal skin overlying the vertebral spinous processes at various levels between C5 and T10. Dorsal stimulation provides the shortest peripheral conduction and a relatively constant receptor density (Agostino et al., 2000a). In this way we tried to eliminate errors caused by miscalculating the peripheral component in the LEP latency. This method yielded a central conduction velocity of 21 m/s, which is substantially higher than the value reported by others (Fig. 1).

All methods share common drawbacks, due partly to the use of laser stimulation. One is the inconstant afferent input in the various areas stimulated, owing to topographical variations in skin receptor density. The other is the difficulty in reliably estimating conduction distances and velocities in peripheral afferents. Our method can only minimize these

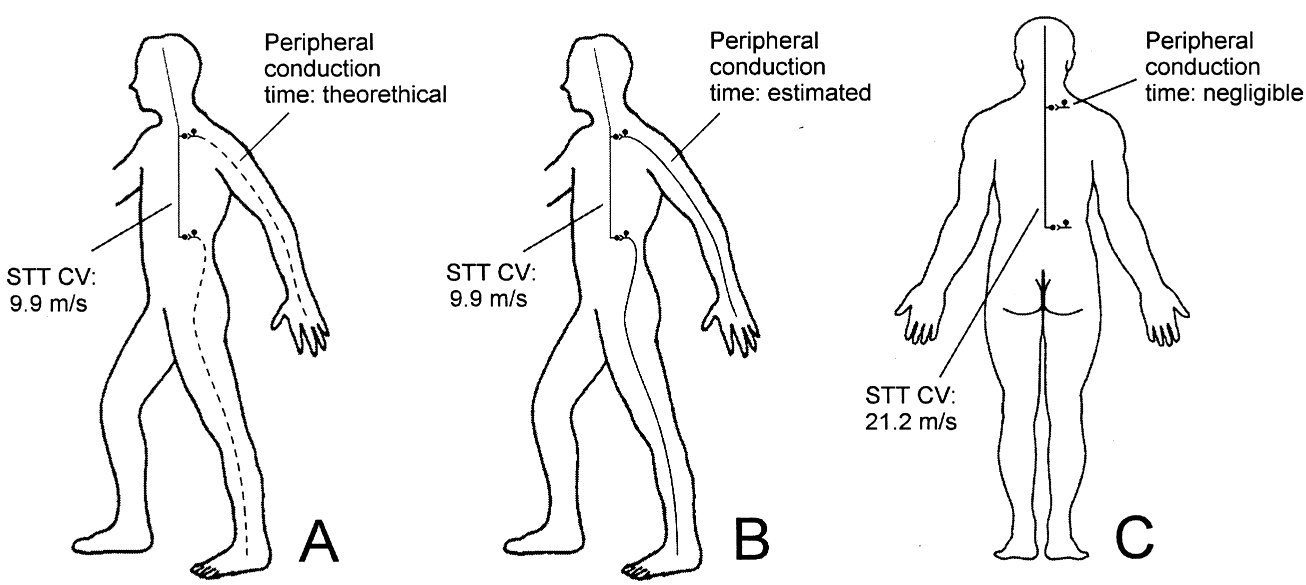

Fig. 1. Different techniques for assessing the conduction velocity (CV) of the human spinothalamic tract (STT). The LEPs were evoked by stimulating the hand and foot in (A) (Kakigi and Shibasaki, 1991) and (B) (Rossi et al., 2000), and the skin overlying the vertebral spinous processes in (C) (Cruccu et al., 2000). The peripheral conduction times were assumed by theoretical values of conduction velocity in (A), estimated in each subject by measuring the latency of the cutaneous silent period in (B), and considered negligible in (C).

weaknesses, which make the task of obtaining definitive results arduous.

Several studies have provided information on the conduction velocity in the primate spinothalamic tract by recording directly from the thalamus and spinal cord (mean values ranging from 17 to 22.6 m/s) (Willis et al., 1974; Ferrington et al., 1987). However, in a study delivering stimuli to the contralateral thalamus and recording the antidromic activity from single nerve fibers of the spinothalamic tract, Zhang et al. (2000) measured a conduction velocity of about 50 m/s.

The discrepant findings, both in humans and primates, prompt efforts to develop the highly sensitive techniques needed for more reliable measurement of central conduction velocities in the temperature and pain pathways in humans. We believe that meaningful information can be ensured only by recording spinothalamic neural cell activity directly from at least two levels of the exposed spinal cord in patients undergoing spinal surgery.

References

Agostino R, Cruccu G, Iannetti G, Romaniello A, Truini A, Manfredi M. Topographical distribution of pinprick and warmth thresholds to CO_2 laser stimulation on the human skin. Neurosci Lett 2000a;285:115–118.

Agostino R, Cruccu G, Romaniello A, Innocenti P, Inghilleri M, Manfredi M. Dysfunction of small myelinated afferents in diabetic polyneuropathy, as assessed by laser evoked potentials. Clin Neurophysiol 2000b;111:270–276.

Bromm B, Lorenz J. Neurophysiological evaluation of pain. Electroenceph clin Neurophysiol 1998;107:227–253.

Cruccu G, Iannetti GD, Agostino R, Romaniello A, Truini A, Manfredi M. Conduction velocity of the human spinothalamic tract as assessed by laser evoked potentials. NeuroReport 2000;11(13):3029–3032.

Ferrington DG, Sorkin LS, Willis WD. Responses of spinothalamic tract cells in the superficial dorsal horn of the primate lumbar spinal cord. J Physiol (Lond) 1987;388:681–703.

Kakigi R, Shibasaki H. Estimation of conduction velocity of the spinothalamic tract in man. Electroenceph clin Neurophysiol 1991;80:39–45.

Kakigi R, Shibasaki H, Kuroda Y, Neshige R, Endo C, Tabuchi K, Kishikawa T. Pain-related somatosensory evoked potentials in syringomyelia. Brain 1991;114:1871–1889.

Rossi P, Serrao M, Amabile G, Parisi L, Pierelli F, Pozzessere G. A simple method for estimating conduction velocity of the spinothalamic tract in healthy humans. Clin Neurophysiol 2000;111:1907–1915.

Treede RD, Lankers J, Frieling A, Zangemeister WH, Kunze K, Bromm B. Cerebral potentials evoked by painful laser stimuli in patients with syringomyelia. Brain 1991;114:1595–1607.

Willis WD, Trevino DL, Coulter JD, Maunz RA. Responses of primate spinothalamic tract neurons to natural stimulation of hindlimb. J Neurophysiol 1974;37:358–372.

Zhang X, Honda CN, Giesler GJ. Position of spinothalamic tract axons in upper cervical spinal cord of monkeys. J Neurophysiol 2000;84:1180–1185.

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Reply to Dr Cruccu

We thank Dr Cruccu for his comment and the opportunity to reply.

In his letter Dr Cruccu exhaustively summarizes the difficulties encountered in the calculation of conduction velocity of the human spinothalamic tract (STT). We agree with him that current electrophysiological methods based on laser evoked potentials (LEPs) are technically limited. After a laser stimulation, unlike the conventional methods using electric shocks, it is impossible to record the peripheral and spinal components of the evoked response (Kakigi et al., 1989; Bromm and Treede, 1991) and the cortical response is generally used to obtain information about the peripheral and central tracts. As a consequence the methods proposed for the measurement of the STT are necessarily indirect.

In 1991 Kakigi and Shibasaki firstly analyze the conduction velocity of the STT by applying a method whose reliability was proven on posterior columns (Dorfman, 1977), with the crucial difference that peripheral afferent times were not measured but assumed from theoretical expected values. In our recent paper (Rossi et al., 2000) we tried to improve the method of Kakigi and Shibasaki (1991) by using an indirect approach to calculate the peripheral conduction times. In fact, in addition to laser evoked potentials from hand and foot stimulation, we evaluated the latency of the electrical cutaneous silent period corrected for F- and M- wave to estimate the conduction time of the peripheral tract. Our results were very similar to those obtained by Kakigi and Shibasaki (1991) when the conduction velocity of peripheral afferents was assumed to be 10–15 m/s, that is the most appropriate estimate of A-delta fibers velocity.

Few months before the publication of our article on Clinical Neurophysiology, Cruccu et al. (2000) published an alternative approach to the measurement of the conduction velocity in the human spinothalamic tracts. The peculiarity of this method and its theoretical advantages have been synthetized by Dr Cruccu in his comment. These authors report a mean value of central conduction velocity (21 m/s) substantially higher than those previously published. Thus, it seems that different methods yield to different results raising the problem of which method is more appropriate. We retain that these discrepancies are not only to ascribe to the different methodology in terms of sites of stimulation and relative contribute of the peripheral afferent tract, as