Stereotactic extralemniscal myelotomy

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SYNOPSIS A procedure is reported in which radiofrequency lesions were stereotactically placed in the central cord region at the cervicomedullary junction to interrupt selectively the extralemniscal system. Physiological recognition of the target site was based upon the homuncular organization of the dorsal funiculi, which is analysed. Only subjective (segmentally unrelated) analgesia was achieved, usually without demonstrable sensory loss. Stimuli were not painful, while ability to localize it and the discrimination between sharp and blunt components were preserved. A rational approach is offered to certain central pain phenomena which resulted in abolition of hyperpathia and disappearance of, or marked reduction in, deep background pain. Both upper and lower body pain were easily dealt with. Pathways for automatic respiration or for micturition were not encroached upon. Therefore it was electively used for cases with diminished respiratory reserve and for cases with midline and/or bilateral pain.

Severing the decussating fibres to the spinothalamic tracts in the spinal cord was first conceived of by Armour (1927). Leriche (1936) and Putnam (1934) independently reported a similar technique, which finally became an accepted procedure for relieving pain.

Hitchcock in 1968, reappraising the advantages and risks of splitting the spinal cord, was the first to perform a commissural myelotomy with a stereotactic approach, reporting in 1970 his first five cases, with both upper and lower body pain (Hitchcock, 1970, 1972a, b). I have used a similar technique since 1971 (Schvarcz, 1973, 1974) and now report 45 cases.

This procedure, however, was not aimed at severing segmental decussating fibres, but at interrupting selectively the extralemniscal system—that is, an ascending nonspecific polysynaptic pathway, as, for example, with the lesions of the centromedianum-parafascicularis complex at thalamic level.

Although it has not been fully proved, we consider that this is a suitable *model*, in which the fact that only subjective analgesia occurs is accounted for, and as it is consistent with the im-

plications of the gate control theory (Melzack and Wall, 1965) it provides a rational therapeutic approach to certain central pain phenomena.

Noordenbos (1959) has emphasized the importance of a short fibre, slowly conducting system, forming a multisynaptic bilateral net. This received strong support from Shealy *et al.* (1966), who have found in the central cord region bilateral activity elicited by C fibres, in the same area where extensive cross-connections within the propriospinal system have been reported (Gernandt and Shimamura, 1961), and where this is more densely grouped, at the base of the dorsal funiculi (Tower *et al.*, 1941).

METHODS

All patients were operated on under local anaesthesia, using a modified Hitchcock apparatus. The midline of the odontoid process was assumed to superimpose on the midline of the spinal cord, provided that there was no rotation. The cord was outlined with positive contrast (emulsified iophendylate (Pantopaque) in CSF) injected by cisternal puncture. The dorsal border of the cord was then used as baseline for target construction (Fig. 1).

With the head in full flexion within the stereotactic frame and holder, the spinal cord was approached through the atlantooccipital interspace, by

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FIG. 1 *Lateral radiograph, showing a cisternal myelogram, with the coordinates outlined.*

FIG. 2 *Lateral radiograph, showing the straight posterior atlantooccipital approach, with the electrode in place.*

a straight posterior tract (Fig. 2), with an external cannula which was advanced until CSF was aspirated.

Physiological corroboration of electrode placement is considered mandatory, so the electrodes should allow recording, stimulation, and destruc-

tion, since they should not be interchanged. Tungsten wires of 0.5 mm diameter were used, with a 2 mm bare end and the tip electrolytically sharpened to 50 μ m.

The target is the central cord region, 5 mm in front of the dorsal border of the spinal cord at the midsagittal plane. However, its exact site was always determined by the results of stimulation.

The dorsal column has a definite homuncular arrangement, which allowed accurate recognition of electrode position. This implies the existence of a dorsoventral topical organization, combined with the commonly recognized mediolateral lamination of the funiculus.

Provided that a midsagittal tract was used, sensory responses from both lower limbs were consistently elicited, with representation of the distal parts located deeper, towards the central canal, and with the fibres from the dorsal segments of the limb lying on the central septum (Fig. 3).

Radiofrequency lesions (averaging 2.5×3 mm) were placed just in front and where distal lower limb-threshold responses were obtained. These usually started at the soles of both feet and were propagated to the dorsal aspect of the legs with increasing voltage of stimulation. However, additional responses superimposed on the described basic pattern were occasionally elicited, such as trigeminal and/or crossed limb involvement. They were regarded as due to the stimulation of decussating fibres. These four possible stimulation patterns were all considered as

FIG. 3 *Somatotopic organization of the dorsal funiculus, in the light of stimulation data.*

being equally significant for physiological determination of the target site.

These threshold, low intensity stimuli (50–75 Hz, 0.5–1.0 V) did not usually modify the patient's spontaneous pain. However, higher voltages frequently produced a transient pain relief which outlasted the stimulation, probably because of dorsal column stimulation.

No modality difference was detected at different depths within the dorsal funiculi, at least by subjective sensations, nor was it possible to determine any obvious difference from spinothalamic stimulation, both being usually described as tingling or a feeling of electricity.

RESULTS

Forty-six myelotomies were performed on 45 patients. The underlying pathology was neurological in 10 cases and neoplastic in the remaining 35.

In the central pain group, the clinical diagnoses were: causalgia (four), postherpetic neuralgia (three), central dysaesthesia (two: one after a Brown Séquard syndrome, another with disseminated sclerosis), and brachial plexus avulsion (one), with pain histories ranging from six to 24 months. Both the hyperpathia and the deep pain were satisfactorily relieved in all but two cases. One was a patient with postherpetic neuralgia, who had an immediate, complete recurrence of pain, but did not accept reoperation. The other was the patient with dysaesthesia following a Brown-Séquard syndrome, whose deep pain recurred six months later. Follow-up time was nine and 11 months in two cases and between 12 and 24 months in the remaining six. Longer time, however, is still required for evaluating late failures.

In the neoplastic group, 22 patients had lower body, midline and/or bilateral pain (12 rectal carcinoma, six cervix carcinoma, one prostate carcinoma with multiple bone metastases, two bladder carcinoma, and one Hodgkin's disease) and 13 patients had unilateral upper body pain (12 lung carcinoma, all with diminished respiratory reserve, and one breast carcinoma). Satisfactory pain relief was obtained in 30 cases, but early, partial recurrence occurred in the remaining five. There was another, relatively late recurrence, five months after surgery. The case of Hodgkin's disease was additionally relieved of her severe

pruritus, up to C₂ dermatome. The follow-up period was up to the time of death in all but one case, who still survived without pain 18 months after myelotomy. It ranged between one and three months in 11 cases, between three and six months in 12 cases, between six and nine months in four cases, between nine and 12 months in one case, and between 12 and 18 months in one case.

There were no lasting side-effects whatsoever. Transient gait unsteadiness was not infrequent, but it never lasted for more than 48 hours. There were no detectable proprioceptive alterations, nor was any motor weakness found. There was no postoperative dysaesthesia.

In most cases no objective sensory loss could be demonstrated. Although the stimulus itself was not painful, both sharp and blunt discrimination and the ability to localize stimuli were preserved. However, a few patients developed analgesia to pinprick of a rather unconventional distribution, in one or both arms or in the trigeminal territory, or more rarely in the lower half of the body, but this was not regarded as a side effect. Usually these deficits could be correlated with the stimulation patterns with superimposed responses which were already described. No relationship could be demonstrated between the results on pain and the presence or absence of objective sensory changes.

CASE REPORT

This 68 year old patient developed pain immediately after a right L₁ dermatome herpes zoster, in July 1973. He had severe hyperpathia and deep burning pain which were unresponsive to medical treatment. No neurological deficit was demonstrated apart from hypalgesia and hypothermaesthesia over the scarred L₁ distribution. In December 1973 an open dorsal cordotomy was carried out elsewhere. Hyperpathia disappeared for a few days, but the deep pain remained unchanged despite production of a good sensory level up to T₉ dermatome. On admission one month after cordotomy, both symptoms were as bad as ever, confining him to bed, with his leg protected from draughts or touch.

In January 1974 a stereotactic myelotomy was performed. A target at 5 mm in front of the dorsal aspect of the cord and at the midline was selected. When the electrode was placed in position he complained of a shock-like sensation. At target, electrical stimulation with monopolar 0.5 V, 1 ms pulses at 50/s produced a feeling of electricity in both soles,

propagated to the dorsal aspect of the legs at 1.0 V intensity. At target +0.5 mm the response was similar, but there was also tingling on the right side of the face, with 0.75 V stimuli. The sequence was foot-face-leg. A lesion was made at target and at target +0.5 mm. It produced immediate relief of both the hyperpathia and the deep pain. No additional sensory loss was produced except hypalgesia on the whole of the right trigeminal territory, with preservation of light touch and corneal reflex. Beyond the pre-existent area of analgesia, both sharp and blunt discrimination and localization of stimuli were preserved. Light touch, vibratory sensation, and joint position sense were not altered.

In July, 1974 he was pain free, although the level of sensory loss from his previous open cordotomy had dropped to T₁₂ dermatome. This good result was maintained until his death, in March 1975, from myocardial infarction.

DISCUSSION

The somatotopic organization of the dorsal funiculi of the spinal cord has facilitated accurate placement of the lesion. The arrangement proposed for the medial region fits in with Hitchcock's (1972a) findings. This is not so, however, for the lateral region—which was explored during trigeminal nucleotomy (Schwarcz, 1975)—mainly with respect to the position of the hand representation. Curiously enough, the whole disposition except for the hand representation is different from that reported by Hosobuchi *et al.* (1971).

Only subjective (segmentally unrelated) analgesia was achieved, without any demonstrable sensory loss. Ability to localize stimuli and to discriminate between sharp and blunt components were preserved, and yet the stimuli were not painful. Similar, though unexpected, findings have been reported with open myelotomy (Wertheimer and Lecuire, 1953; Sourek, 1969; Lippert, Hosobuchi, and Nielsen, 1974). Rarely, however, bizarre sensory losses did occur with an unusual, unpredictable distribution. Their low incidence, as compared with Hitchcock's (1970) results, was probably due to the fact that the lesions were more dorsally placed, as the decussating fibres were not aimed for.

Extralemniscal myelotomy has proved to be useful in the management of certain central pain states, resulting in complete relief of the hyperpathia and abolition of, or marked reduc-

tion in, the deep background pain. Furthermore, troublesome anaesthesia was avoided.

Fast and slow conducting fibres influence each other (Wall, 1964; Melzack and Wall, 1965), and in the words of Noordenbos (1972) '... danger arises if the damage is not evenly distributed'. This 'fibre dissociation syndrome' (Noordenbos, 1972) is due to the undamped, released action of the relatively less altered C fibres, a situation that has been proved for postherpetic neuralgia and causalgia, existing evidence suggesting the same mechanism centrally (Noordenbos, 1959, 1972; Melzack, 1971). Therefore a selective attack on the extralemniscal system is a rational approach to pain of central origin. Indeed, in such cases, surgical lesions of the spinothalamic tract tend to enhance rather than to decrease the pain.

High levels of analgesia were consistently achieved without encroachment on the automatic respiratory pathways, which are located far away, thereby avoiding the hazards associated with high cervical cordotomy. It is, therefore, a specially suitable procedure for patients with diminished respiratory reserve.

Lower body pain was easily dealt with, yet the autonomic pathways for micturition were conveniently spared. Consequently, it is a procedure of choice for bilateral pain. This is also true for pain from midline structures which, being represented in both spinothalamic tracts, were hitherto difficult to manage by current techniques.

Henceforth, an attractive possibility also arises, by the combination of specific and unspecific spinal destructions in one stage, which in the long run might secure better results by preventing the take-over of pain conduction by the remaining system, at least in selected cases with long life expectancy. Only four such lesions (not included in this series) have been carried out so far.

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