Intractable pain of spinal cord origin: clinical features and implications for surgery

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The clinical features and types of pain affecting 127 patients with central pain caused by lesions in the spinal cord were studied and correlated with the results of surgical procedures performed on 103 of them. The surgical procedures consisted of percutaneous cordotomy in 39 cases, cordectomy in 12, dorsal root entry zone (DREZ) surgery in four, dorsal cord stimulation in 35, and brain stimulation in 13. The three most common types of pain in the 127 patients were characterized as: steady in 95% of cases, intermittent (usually shooting) in 31%, and evoked (allodynia, hyperpathia, or hyperesthesia) in 45%. Steady pain was usually causalgic (74.8%) or dysesthetic (27.6%). The only obvious clinical correlation with pain type was the association of intermittent pain with lesions at the T10-L2 vertebral level. Destructive surgery (cordotomy, DREZ surgery, or cordectomy) affected the three chief types of pain differently from treatment with cord or brain stimulation. Destructive surgery resulted in reduction of steady pain in 26% of affected cases, of intermittent pain in 89%, and of evoked pain in 84%, while stimulation resulted in pain reductions in 36%, 0%, and 16% of cases, respectively. The differential effect of destructive surgery on steady and intermittent pain is consistent with published experience. These observations suggest differing mechanisms for the three types of pain.

KEY WORDS • central pain • spinal cord lesion • cordotomy • cordectomy • spinal cord stimulation • brain stimulation

The management of central pain of spinal origin, which affects up to 30% of patients with lesions of the cord, remains difficult. One problem is the uncertainty of choice of surgical procedure and the unpredictability of results, given the wide variety of operations advocated for those patients in whom simpler therapy fails. We have reviewed the clinical features of the pain in 127 consecutive patients and examined the results of different surgical procedures performed on 103 of them in an attempt to establish guidelines for the choice of surgery.

Clinical Material and Methods

Case Material

Between 1961 and 1989, 127 patients with central pain caused by spinal cord lesions were referred to one of us (R.R.T.) for consideration of neurosurgical treatment. Clinical features, including the descriptors used by the patients to characterize their pain, were documented using a constant data base, as was information obtained at postoperative follow-up examination.

Treatment was as follows: percutaneous cordotomy was performed in 39 cases, “cordectomy” in 12, dorsal root entry zone (DREZ) surgery in four, chronic stimulation of the sciatic nerve in one (not further considered in our analysis), chronic epidural dorsal cord stimulation in 35, and chronic brain stimulation in the medial lemniscus, somatosensory relay nucleus, internal capsule, or the periaqueductal gray area in 13. These techniques have been described previously.6–8,11,12,20 Some patients underwent multiple operations. The decision to operate and the choice of procedure were based upon pain severity as assessed by multiple criteria and balanced against the anticipated success and the risks of available procedures, a process that varied over time according to published data and accumulating personal experience. The degree of pain relief accomplished by surgery was assessed using a visual analog scale and by noting changes in analgesic drug intake, level of vocational and avocational activity, and quality of sleep; a good result constituted a reduction in pain of 50% or more, and a fair result a 25% to 50% reduction in pain for at least 1 year.
The lesions responsible for the pain were traumatic in 65% of cases, iatrogenic in 12%, inflammatory in 9%, neoplastic in 6%, skeletal in 2%, vascular in 2%, and congenital or uncertain in 4%. Of the 127 patients, 76% were male; 42% suffered from lesions at the cervical level, 21% at the T1–9 level, and 37% at the T10–L2 level; 32% had clinically complete sensory loss, 43% had incomplete interruption of all sensory function, 21% had dissociated sensory loss, and 4% displayed no clinically detectable sensory abnormality.

**Clinical Features of Pain**

In patients for whom the precise timing of the cord lesion responsible for the pain was known, the onset of pain was delayed in 79%, occurring up to 1 month following the lesion in 36%, up to 1 year after in 62%, and more than 1 year after in 26%. A total of 37% of patients with a delay of up to 1 year and 56% with a delay of more than 1 year were known to harbor a syrinx.

The three most common types of pain reported by the 127 patients were characterized as steady and spontaneous in 96%, intermittent and spontaneous in 29.8%, and evoked (allodynia, hyperpathia, and hyperesthesia) in 47%. The relationship of the three types of pain with respect to lesion level and clinical completeness is shown in Table 1.

**Steady Pain.** Steady pain tended to fluctuate in severity with time, following one of two patterns: aggravation by activity and relief by rest, or aggravation by inactivity (particularly attempts to sleep) and relief by distraction. It was causalgic in nature in 74.8% of all patients with steady pain, dyesthetic in 27.6% (tingling 19.7%, numbness 5.5%, crawling 1.6%, pricking 0.8%), aching in 12.6%, compressive or destructive in 17.9% (crushing 3.1%, tightening 2.4%, squeezing 2.4%, pulling 2.4%, pinching 1.6%), rhythmic in 9.4% (throbbing 4.7%, cramming 3.1%, pounding 0.8%, pumping 0.8%), cold in 3.7%, and cutting in 2.4%.

Steady pain occurred in 98% of patients with complete and 94% with incomplete lesions, its incidence being similar regardless of lesion sites in the cord. Pain occurred as a band at the upper level of cord damage in 6.8% of patients with complete lesions and 2.6% with incomplete lesions; diffusely below that level in 18.6% with complete lesions and in 18.1% with incomplete lesions; patchily below the level in 59.3% with complete lesions and 65.5% with incomplete lesions; and in the perineum in 15.3% with complete lesions and in 9.5% with incomplete lesions. The 4.3% of patients with facial pain all had incomplete lesions and a syrinx.

**Intermittent Pain.** Of the 127 patients, 30% suffered from spontaneous, intermittent pain (1% in isolation). The pain was described as shooting in 11.8%, shocks in 7.8%, stabbing and jabbing in 3.1% each, sharp in 2.4%, and knotting and stinging in 0.8% each. Intermittent pain afflicted 27% of patients with complete lesions and 33% with incomplete lesions, and ran either up or down the body and/or legs or around the body at the level of the cord damage. Intermittent pain was most prevalent in the 37% of patients with lesions from the T10–L2 level, and was present in 81.8% of patients with complete lesions and 64.3% with incomplete lesions at this level. It occurred much less often with cervical or T1–9 lesions. Looked at another way, 81.8% of all patients with complete lesions with intermittent pain and 64.2% of all patients with incomplete lesions with this type of pain suffered from lesions in the T10–L2 area. Intermittent pain was somewhat more prevalent with incomplete lesions (21.4% of cervical and 14.3% of T1–9 level lesions) than with complete lesions (9.1% each of cervical and T1–9 level lesions), while with T10–L2 level lesions it was more prevalent with complete lesions. Intermittent pain running around the body at the level of neural damage was the pattern most frequently seen with complete lesions, while that shooting up and down the legs was most common with incomplete lesions.
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**Table 2**

Results of surgery in 103 patients correlated with particular types of cord central pain

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Steady Pain</th>
<th>Intersectant Pain</th>
<th>Evoked Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Destructive surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percutaneous cordotomy (39 cases)</td>
<td>34</td>
<td>6%</td>
<td>21%</td>
</tr>
<tr>
<td>Cordectomy (12 cases)</td>
<td>10</td>
<td>6%</td>
<td>30%</td>
</tr>
<tr>
<td>DREZ (4 cases)</td>
<td>3</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total destructive</td>
<td>47</td>
<td>4%</td>
<td>22%</td>
</tr>
<tr>
<td>Modulatory treatment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCS for incomplete lesions (24 cases)†</td>
<td>22</td>
<td>27%</td>
<td>14%</td>
</tr>
<tr>
<td>DCS for complete lesions (11 cases)‡</td>
<td>11</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>DBS (13 cases)</td>
<td>12</td>
<td>25%</td>
<td>17%</td>
</tr>
<tr>
<td>Total modulatory</td>
<td>45</td>
<td>20%</td>
<td>16%</td>
</tr>
</tbody>
</table>

*Values represent the percentage of total patients in each category. DREZ = dorsal root entry zone surgery; DCS = dorsal cord stimulation; DBS = direct brain stimulation.
† Of the cases relieved, 67% had T10-L2 lesions.
‡ Of the cases relieved, 100% had T10-L2 lesions.

**Evoked Pain.** In total, 47% of the 127 patients exhibited evoked pain (alldynia, hyperpathia, or hyperesthesia), 3% in isolation. This type of pain affected 39% of patients with complete lesions in a band at the level of sensory loss and 51% of patients with incomplete lesions. In this latter group, the pain occurred diffusely below the level of cord dysfunction in 66.8%, patchily in 75%, and in a band at the upper level in 18.2%.

**Additional Types of Pain.** Twenty-four patients described two additional types of pain. Of these, 20 complained of deep aching, cramping, or other sensations referred to the vertebral column and surrounding musculature. This was sometimes aggravated by particular movements, yet was experienced below clinically complete levels of interruption of cord function. This pain resembled musculoskeletal pain and sometimes merged with similar pain perceived at the level of the traumatic injury. Four additional patients described pain below a complete level of functional interruption located in the abdomen or pelvis resembling that of visceral disease, which had frequently led to extensive fruitless investigation. Although these two types of pain appeared more commonly with complete lesions than incomplete (29% vs. 13%), the numbers are too small for further analysis.

**Results**

Table 2 presents the effects of different surgical procedures in 103 patients with the three main types of pain described above. Destructive surgery (cordotomy, cordectomy, or DREZ surgery) was more effective for relief of intermittent pain (56% good, 33% fair) and of evoked pain (58% good, 26% fair) than of steady pain (4% good, 22% fair). Chronic stimulation was more effective for relief of steady pain (20% good, 16% fair) than of intermittent pain (0%) or evoked pain (16% fair). These differences were significant at the p < 0.001 level using the chi-squared test. Dorsal cord stimulation was notably ineffective even for steady pain in patients with complete lesions (20% fair relief).

**Discussion**

**Pain Patterns and Sensory Loss**

The pain patterns described in our 127 patients with cord lesions were similar to those described by others.2-4,8,13-15,17-19,24,27 Of our series, 4% showed no clinically detectable sensory loss, recalling Livingston's suggestion10 that even “subclinical” lesions of the nervous system could result in pain. The sensory findings in our patients, most of whom displayed complete or incomplete interruption of all sensory modalities or else dissociated sensory loss, support the view advanced by others1 that central pain depends upon damage to the spinothalamic tract. However, in addition to patients with no clinically detectable sensory loss, we have also seen one patient with a traumatic cord lesion who suffered from constant burning and tingling pain in both hands and the lower extremities, squeezing, pressure-like pain along the lower costal margin, and aching in the right first and left fourth and fifth fingers. This patient's sensory abnormality consisted of questionable reduction of appreciation of pinprick in the left third to fifth fingers, loss of position sense below the ankles, absent vibration appreciation below the mid-calf of both legs, reduced vibration sense in both hands, and touch allodynia over most of the body. The patient's appreciation of temperature, pinprick, and touch were otherwise normal.
Onset of Pain

The onset of cord central pain was delayed in 82% of those patients in whom timing could be determined, a feature common to other types of neural injury pain.19,21-23 This implies that the responsible pathophysiological process might take time to develop. Delayed onset was most extreme in patients known to have a syrinx, suggesting that in these particular patients the development of the syrinx rather than the original cord injury was responsible for the pain and that late onset of pain should raise suspicions of a syrinx. Facial pain was always associated with a known syrinx. Successful syringosubarachnoid shunting in seven patients relieved radicular stress-aggravated pain (not to be confused with spontaneous intermittent pain as described above) but never spontaneous or evoked pain.

Level and Completeness of Lesion

Neither vertebral level nor completeness of lesion affected the incidence of steady or evoked pain, except that steady (usually burning) perineal pain occurred more often with complete lesions, and evoked pain by definition can occur only in areas of incomplete or clinically undetectable sensory loss or as a band at the upper margin of complete sensory loss. Intermittent pain occurred equally in complete and incomplete lesions overall, although it was particularly characteristic of T10-L2 level lesions, with which it tended to run around the trunk at the level of the cord lesion in complete cases, and up and down the legs in incomplete lesions.

Two rarer patterns of pain resembling that of musculoskeletal or visceral disease tended to occur in patients with complete lesions. Beric's suggestion1 that such pain is dependent upon surviving somatosensory fibers that are clinically undetectable (because local anesthetic spinal blockade temporarily relieved it) is not convincing since such blockade usually relieves all types of cord central pain independent of the degree of completeness of the responsible lesion.21

Modulatory Surgery

Dorsal cord stimulation usually failed in patients with complete lesions, with 20% reporting fair relief of steady pain. This was usually associated with an inability to induce paresthesiae in the area of pain, and is in turn attributable to atrophy of the dorsal columns after severe cord lesions. Although this was more successful in patients with incomplete lesions (27% achieved good and 14% fair relief of steady pain), the overall yield is still low, and the procedure is acceptable only because of its low risk, reversibility, and the fact that there is no good alternative for treating steady pain. It is not known why chronic stimulation techniques are effective in only about half of apparently appropriate patients.21 Cord stimulation was most successful in our patients with T10-L2 level lesions. All of those with complete and 67% of those with incomplete lesions in whom this treatment modality succeeded had T10-L2 level lesions. It is possible that the pain with T10-L2 lesions is dependent upon root rather than cord damage and, therefore, that it constitutes an example of deafferentation pain caused by injury to the peripheral nervous system rather than central pain, a pain type that has been generally found more amenable to control by chronic stimulation.

Brain stimulation, usually bilateral, yielded overall results (25% achieved good and 17% fair relief of steady pain) similar to those reported by cord stimulation in incomplete lesions. This treatment was usually reserved for patients with complete lesions and those with incomplete lesions in whom dorsal cord stimulation had failed. Both chronic cord and brain stimulation were ineffective in the treatment of intermittent pain (0% success in complete and incomplete lesions) and evoked pain (25% fair relief in incomplete lesions).

Destructive Surgery

Destructive surgery was very effective for treating intermittent pain (56% good, 33% fair relief) and evoked pain (58% good, 26% fair relief) but not steady pain (4% good, 22% fair relief). Although the DREZ procedure has become associated with the treatment of central and deafferentation pain, it consists of making a lesion in the vicinity of Lissauer's tract where inflowing nociceptive fibers from the dorsal roots congregate before penetrating the cord. Thus, it constitutes an alternative strategy for interrupting nociceptive transmission and is therefore considered here alongside cordotomy and cordectomy.

Pain Pathophysiology

The differential response of the three main types of pain to modulatory and destructive surgery was statistically significant, suggesting pathophysiological differences between them. Without embarking upon a discussion of theories proposed to explain central pain,3,19 it is reasonable to conclude that intermittent and evoked pain are dependent upon transmission in somatosensory (probably spinothalamic) pathways, while steady pain is not. Intermittent shooting pain may be the result of ectopic impulses instituted at, or proximal to, injury sites, possibly through ephapses,3,16 and then transmitted centrally in these pathways to be perceived as pain; destructive surgery presumably interrupts their transmission. Evoked pain depends upon stimulation of somatosensory receptors, probably with perverted central processing resulting from the centripetal effects of the original injury;6 interruption of the propagated impulses should therefore eliminate evoked pain.

On the other hand, steady pain appears not to be dependent upon transmission in somatosensory pathways but rather to be the result of central, possibly thalamocortical, perversion of function induced by the "cascade" of centripetal changes that follow cord damage.8 This perverted function somehow impinges upon the "final common path" to be interpreted as pain and
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appears capable of modulation in some patients by chronic stimulation.

Relevance to Published Experience

The dichotomy of response referred to above is not a new observation. In 1954, discussing the results of open cordotomy for cord central pain, Botterell et al. stated; “Burning pain has proved a problem difficult of solution. ... By contrast, jabbing, shooting, crampy, gripping, colicky and vice-like pains, have been regularly relieved by bilateral tractotomy.” Porter, et al., wrote, “The effectiveness of cordotomy in relieving the symptoms of sharp, lancinating pains in the lower extremities in patients with cauda equina lesions is summarized. ... The operation had no effect, however, on the frequently encountered burning pain in the lower extremities.” White and Sweet seemed to infer that intermittent pain is radicular in origin while steady pain arises in the cord. They reported, “Cordotomy is very useful in paraplegia for relief of pain of radicular origin. ... Provided the injury involves the cauda equina and does not extend rostrally beyond the conus medullaris to involve the cord, we believe that relief can be obtained in a high proportion of cases by anterolateral cordotomy.” Jefferson, in reviewing his experience with cordectomy in similar patients, noted that the procedure was differentially effective for discrete pain radiating into the thighs, knees, or legs, especially if shooting and episodic, and especially if caused by lower cord lesions. Pain associated with high lesions, particularly if diffuse, steady, and in a “shooting trunk” distribution, was relieved poorly. He stated, “One of the very interesting, and perhaps characteristic features of the pain which is likely to respond ... is that it is episodic.” Friedman and Bullitt, in evaluating the DREZ operation in similar patients, remarked that “one component is aching or burning, and the second component is paroxysmal. ... The DREZ lesions had a different effect on each of the two classes of pain [being more effective for the latter].”

Conclusions

The data presented show that steady pain, the most common type suffered by patients with cord central pain, responds poorly to destructive surgery such as cordotomy, cordectomy, and DREZ, and better to chronic stimulation of the cord or brain which induces paresthesiae in the area of pain. Despite their limited efficacy, the low risk and reversibility associated with stimulation procedures, even in the brain, and the lack of alternatives make them the treatment of choice for patients with cord central pain, 96% of whom suffer from steady pain. Both the present and previously published data show that destructive surgery is selectively successful in relieving the spontaneous intermittent, often shooting radicular pain that tends to project down the legs; this type of pain was present in 30% of our patients with cord central pain and was particularly associated with thoracolumbar lesions. The present data also show that evoked pain, present in 47% of our patients, responds similarly to destructive surgery. Thus, in a patient in whom intermittent and evoked pain predominate or continue to be problems after institution of a stimulation technique, the appropriate destructive procedure should be considered.

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