Bilateral percutaneous cervical cordotomy: immediate and long-term results in 36 patients with neoplastic disease

STEFANO ISCHIA, ALDO LUZZANI, ALBERTO ISCHIA, GIANFRANCO MAFFEZZOLI
From the Anaesthesiology and Intensive Care Institute, Pain Relief Centre, University of Verona School of Medicine, Verona, Italy

SUMMARY Thirty-six patients with neoplastic disease suffering from chronic bilateral pain were subjected to bilateral percutaneous cervical cordotomy. The technique and precautions to be taken in bilateral percutaneous cervical cordotomy performed either in one or two stages are described using a traditional or Levin's thermocouple-monitored electrode. The sequelae, complications and immediate and long-term results are reported.

Bilateral percutaneous cervical cordotomy is rarely used, owing to its possible sequelae and complications. The main potential adverse consequences of the procedure are: a fairly high rate of operative mortality; sleep-induced apnoea; muscular weakness; urinary retention; a substantial reduction in sympathetic tone with resulting hypotension, especially orthostatic; a high degree of prostration and a deterioration in the patient's general sense of well-being. Two separate operations are usually performed at varying time intervals.

Bilateral percutaneous cervical cordotomy is indicated in patients with bilateral pain from neoplastic disease which cannot be controlled in any other way. Of a total of 540 cordotomies in our clinic the procedure was bilateral in 36 patients; the cordotomies were performed by one of the authors (SI). In 29 of the subjects the operation was performed in two separate stages at time intervals ranging from 1 to 2 weeks, using radiofrequency diathermocoagulation with a traditional electrode and fixed 3 mm exposure. In six patients the lesion was made bilaterally in a single operating session, using Levin's thermocouple-monitored cordotomy electrode. In one patient percutaneous cervical cordotomy was performed, using diathermocoagulation, followed 22 months later by percutaneous cervical cordotomy on the other side using Levin's thermocouple-monitored electrode. The indications, the immediate and long-term results, technique, sequelae and complications of bilateral percutaneous cervical cordotomy in this series are reported.

Method

The various steps involved in percutaneous cervical cordotomy are the following:

1. The patient is positioned so that the cervical spine is straight and the sagittal plane of the head perpendicular to the frontal plane.
2. The pilot needle is placed in the subarachnoid space immediately above the dentate ligament (subarachnoid target). With the aid of lateral fluoroscopy a short-bevel 18-gauge pilot needle is introduced immediately below the tip of the mastoid process in a direction perpendicular to the sagittal plane so as to reach the subarachnoid target. The latter is located a few millimetres immediately above the dentate ligament and as a rule can be imagined as lying at a distance of 1 cm from the posterior edge of the body of C2. We perform myelography, using 1 ml of iohendylate (Myodil Glaxo) contrast medium emulsified in 4 ml of CSF. This contrast medium provides an extremely accurate myelographic image with precise visualisation of the two dentate ligaments and the anterior edge of the spinal cord. This quality of image is essential for judging the degree of any possible rotation of the cord and thus affords a guarantee that the electrode is positioned perfectly at right angles to the spinal target. This is particularly important when performing bilateral percutaneous cervical cordotomy.
3. The pilot needle is next aligned with the sector of the spinohalamic tract where the lesion is to be made (spinal target). The spinal target is generally immediately alongside the dentate ligament in the lumbosacral segments,
1–2 mm anteriorly in the thoracolumbar segments, and 3 mm in the upper thoracic and cervical segments. During bilateral percutaneous cervical cordotomy it is imperative to make sure that the ventral portion of the antero-lateral quadrant is not involved in the lesion, to avoid the destruction of the reticulo-spinal respiratory fibres capping the anterior horn.\textsuperscript{4,}\textsuperscript{5} For this purpose it is essential to align the pilot needle immediately alongside the denteate ligament or at most 1 mm anterior to it, taking the maximum possible care to achieve this alignment without any separation of the images of the two denteate ligaments.

4 The normal or the thermocouple electrode is introduced with the hand free and unsupported so as to be able to feel the resistance afforded by contact with, and subsequent penetration of, the pia mater.\textsuperscript{14} Measurement of the impedance values and subsequent lateral fluoroscopy enable us to ascertain whether image shifting has occurred, especially rotation, following the introduction of the electrode.

5 The simple mechanical stimulation resulting from the introduction of the electrode into the spinothalamic tract is frequently enough to cause the disappearance or reduction of spontaneous pain and to evoke thermal sensations of varying degrees of intensity in all or part of the contralateral body of the half.

(a) Motor stimulation is used to make sure that the electrode is properly positioned in the spinal quadrant concerned. The strength of stimulus which is used (2–5 Hz; 0.5–1 V) is such that the motoneurons of the anterior horn are only stimulated when the electrode is properly positioned. If the electrode is excessively ventral or in a very deep position, the motoneurons of the contralateral anterior horn will also be stimulated. Rhythmic contraction affecting the more cranial or more caudal portions of the trapezius and sternocleidomastoid muscles is evidence of a more ventral or more dorsal positioning of the electrode. When performing bilateral percutaneous cervical cordotomy it is necessary to avoid positioning the electrode in such a way as to cause contraction of the medium or high portions of these muscles, as this means it has been inserted in an excessively ventral position.\textsuperscript{7}

(b) Sensory stimulation is carried out with frequencies of 75–100 Hz and 0.05–0.1 V. The stimulation sequences thus imparted provide a number of basic pointers: tetanic contractions of the ipsilateral muscles (hand and foot) indicate involvement of pyramidal fibres (electrode situated in an excessively dorsal position and thus necessitating repositioning); intense thermal sensations affecting a contralateral area of the body are evidence of perfect positioning of the electrode in the spinothalamic fibres.

6 The lesion is made in successive steps with progressive increments in current intensity for predetermined time periods (5–10 s), when using the traditional electrode, and in temperature when using the thermocouple electrode. It is essential to keep a constant check, before and during each lesion, on conservation of strength in the ipsilateral half or the body (upper and lower limbs) and stop immediately at the first hint of muscle weakness. The lesion is made only after making quite sure that all the variables examined match up to the above-mentioned requirements and is then continued until deep analgesia is achieved.

\section*{Bilateral percutaneous cervical cordotomy in one stage only, using Levin's thermocouple-monitored electrode}

This procedure is performed using an 18-gauge pilot needle instead of a 20-gauge needle; this needle offers better correction of alignment with the spinal target.

On completion of unilateral percutaneous cervical cordotomy, we slowly advance the same electrode with continuous application of the stimulation parameters used for motor stimulation (2 Hz; 0.5–1 V). We thus observe disappearance of stimulation of the motoneurons of the ipsilateral anterior horn and appearance of contralateral motoneuron stimulation. When the rhythmic contraction of the caudal portions of the trapezius and sternocleidomastoid muscles is only contralateral and in all respects similar to that obtained ipsilaterally for identical stimulation parameters, we perform sensory stimulation. On obtaining the latter, we then proceed to make the lesion.

It proved possible to perform a histological examination in three patients who died in hospital. In all three patients, bilateral percutaneous cervical cordotomy had been performed in two stages, and the result was similar to that shown in the figure, though not at the same levels.

\section*{Results}

We treated 36 patients suffering from neoplastic disease, in whom the pain often involved numerous segments and was felt often in parts of the body far removed from one another. In one group of patients the pain was originally bilateral and the stage of the disease so far advanced as to indicate an immediate bilateral operation. Among these were the six cases of bilateral percutaneous cervical cordotomy performed in a single stage using Levin's thermocouple-monitored electrode technique. In other patients unilateral percutaneous cervical cordotomy was followed shortly afterwards by the onset of contralateral pain. In mediastinal, pulmonary, abdominal and bladder neoplasms and in neoplastic vertebrospinal pathology, pain localised in one half of the body may be minimised or completely masked by the predominance of pain present in the other half of the body. Once these symptoms have been eliminated, free rein is given to the contralateral pain. In such patients a second percutaneous cervical cordotomy was indicated shortly after the first operation. Finally, in a further group of patients who had already undergone percutaneous cervical cordotomy, the evolution of the neoplasms led to events due course to the onset and aggravation of contralateral pain of such a nature as to require a second percutaneous cervical cordotomy. In our series the time elapsing between the first and second operation ranged from 2 days to 2 weeks. Only in one patient was the second percutaneous cervical cordotomy performed much later (22 months) than the first.

In the 36 patients subjected to bilateral percutaneous cervical cordotomy deep pin-prick
analgesia was obtained from T10, T4 or T1 to S5 in 35 patients (97.2%), while hypoalgesia resulted in one case (2.8%). The Claude Bernard-Horner syndrome occurred in all patients (table 1).

The mortality during the 7 days after operation was four patients (11.1%) (table 2).

As in the case of unilateral percutaneous cervical cordotomy, the sequelae were partly the result of the operations and partly related to nerve structures directly or indirectly involved in the lesion. The greater incidence of sequelae in bilateral percutaneous cervical cordotomy is attributable to the loss of the functions performed by the contralateral spinal fibres spared in the previous percutaneous cervical cordotomy. The immediate reversible sequelae resulting from the operations were usually of only minor significance and were identical in degree and frequency to those observed during unilateral percutaneous cervical cordotomy (headache, neck pain, high temperature).7

Much more important were the immediate sequelae resulting from the spinal lesion (table 3): (a) In 13 patients in our series (36.1%), weakness of varying degree and duration occurred in the ipsilateral lower limb; it generally improved with time. Paresis occurred in one patient (2.8%); there was no case of hemiplegia. Evaluation of the patient's ability to walk provided a further indication as to the extent of the motor involvement as well as to the patient's general condition following bilateral percutaneous cervical cordotomy. The degree of damage to the pyramidal tract could be assessed from the patient's ability to walk. In the 29 percutaneous cervical cordotomies performed in two stages, 21 patients (72.4%) could not be evaluated as they were bedridden; six of the other eight patients (20.7%) were still able to walk, while the remaining two patients (6.9%) could no longer do so. In the six patients undergoing bilateral percutaneous cervical cordotomy in a single operation, walking could not be evaluated in one case; the other five retained their ability to walk. The ability to walk could not be assessed in the patient who underwent a contralateral percutaneous cervical cordotomy 22 months after the first operation.

Within the context of motor problems secondary to percutaneous cervical cordotomy we should also
include paralysis or paresis of the ipsilateral respiratory muscles. This becomes more important when ventilation is already compromised by pathology involving the lungs or rib cage. In our series, however, impaired ventilatory efficiency did not prove to be of any great clinical significance.

(b) The motor fibres of the striate sphincters of the bladder and anus have partly crossed and partly uncrossed spinal innervation. For this reason urinary retention, generally of a transient nature, was observed in a modest percentage (6%) of patients undergoing unilateral percutaneous cervical cordotomy, but in a higher percentage in patients with existing subclinical sphincter problems. At the time bilateral percutaneous cervical cordotomy was performed, 10 patients (28%) had a permanent indwelling catheter and two (5-6%) had ureterostomies. Of the remaining 24 patients (15 males and nine females) nine males and three females already had permanent urinary retention, and one male and one female had urinary incontinence. Overall, 14 out of 24 patients with no serious sphincter problems at the time of the bilateral operation subsequently acquired permanent sphincter disorders. In our series the incidence may be summarised as follows: 12 patients (33-3%) could not be evaluated because they already possessed no micturition ability, 14 patients (38-9%) exhibited postoperative sphincter disorders, and 10 patients (27-7%) had no such disorders. Incontinence of the anal sphincter was observed in one patient, while another exhibited chronic constipation.

(c) Thirteen patients (36-1%) had varying degrees of arterial hypotension, accentuated in the orthostatic posture. The pathogenesis of this condition may be ascribed to the interruption of reticulo-spinal fibres partly distributed among and mingling with the tracts of the antero-lateral funiculus and partly grouped together in the lateral and ventral reticulospinal tracts.

(d) Destruction or disturbance of the antero-lateral reticulo-spinal fibres capping the anterior horn of the spinal cord may give rise to loss of automatic control of respiration (Ondine’s syndrome). The phenomenon manifests itself during sleep when the voluntary respiration mediated by the pyramidal tract ceases. None of our patients exhibited this phenomenon. In view of the danger of this complication, we started performing bilateral percutaneous cervical cordotomy only when we had completely mastered the technique, that is to the extent that we were at all times in a position to know the site of the lesion within the spinal quadrant with a sufficient degree of precision. From the technical point of view, we should stress the particular attention paid to reaching the spinal target: it is essential, both in patients undergoing bilateral percutaneous cervical cordotomy in two separate operations and, even more so, in those undergoing a single-stage bilateral operation, for the two dentate ligaments to appear in line with one another on the lateral myelographic image. This enables us to achieve penetration of the electrode in very close proximity to the dentate ligament and perpendicular to the spinal cord. In this way there is no risk of the lesion involving the ventral portion of the antero-lateral quadrant of the spinal cord, which means that the reticulo-spinal fibres will remain intact. In our experience a lesion in this site will always succeed in producing equally deep analgesia in the segments below T10, sometimes extending even up to T4–T1, and very rarely as far as C5, suggesting that the spinothalamic fibres were grouped together in a small, clearly delimited tract. In those cases in which the analgesia obtained is confined to T10 and S5, that is a level inadequate to deal with pain at higher levels, one only needs to keep the electrode inserted in the spinal cord in a position just above the dentate ligament and perform the lesion by slightly depressing the outer end of the pilot needle. This will yield an extension of deep analgesia as far as T4–T1.

**Long-term pain relief (Table 4).**

The pain relief was assessed during the rest of the patient’s life and with the aid of information received from relatives after the patient’s death. In the four patients who died during the first week, there was complete relief in three cases; in the fourth it could not be assessed as this patient fell into coma.
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In 15 cases (47%) pain relief was complete: these patients died pain-free. Three of them died during the second week after operation, two within one month, four within a month and a half, three within 2 months, one within 4 months, one within 5 months and one within 9 months. In four patients (12.5%), pain relief was partial, the residual pain being controlled with minor analgesics and mild narcotics. Two died in the second week, one within 20 days, and one within 1 month. In eight patients (25%) undergoing bilateral percutaneous cervical cordotomy in two separate operations, pain persisted in the site treated by the second cordotomy despite deep pin-prick analgesia. One patient (3.1%) who had contralateral percutaneous cervical cordotomy 22 months after the previous operation experienced pain in the site treated by the first percutaneous cervical cordotomy 24 hours after the second operation, which, however, had been performed in a technically correct manner. The pain was well controlled by means of narcotics.

In one case (3.1%) the pain was experienced in other segments not affected by the analgesia (above T4). Diffuse pain was experienced by three patients (9.4%).

Discussion

Bilateral cervical cordotomy has a fairly high mortality rate. This mortality is mainly associated with sleep-induced apnoea and cardiovascular collapse.8-10,13,20 Mortality rates have been reported by various authors according to criteria which are not always sufficiently precise or homogeneous.4,9,10,13,20,23,24 In the case of surgical cordotomy, French4 reported a 41.6% mortality rate in 12 patients subjected to a bilateral high cervical cordotomy performed in a single stage; Rosomoff20 reported a mortality rate ranging from 20 to 36% for the same operation; White and Sweet23 reported that out of 84 patients undergoing the bilateral operation, 65 of whom were operated on in one stage and 19 in two stages, the operative deaths amounted to six cases (7.1%), five of them among patients operated on in one stage. These latter authors did not state at which level the bilateral incisions were performed, but merely stated that the incidence of mortality in the unilateral operation was greater when it was performed at high cervical level than when performed at high thoracic level. White and Sweet,24 comparing the results of percutaneous cervical cordotomy with those of open cordotomy, concluded that mortality was higher for the open operation; the latter is still recommended at the second stage at high thoracic level in case of bilateral pain of the abdomen, pelvis or lower limbs. The mortality rate in bilateral percutaneous cervical cordotomy ranged from 12%, as reported by Rosomoff,20 with 2% due to sleep-induced apnoea, to 10%, as reported by Kuhner,9,10 due to respiratory and blood pressure complications, and 4%, as reported by Lipton,13 due entirely to sleep-induced apnoea. The mortality figure in the 36 patients we subjected to bilateral percutaneous cervical cordotomy was four patients (11.1%) (table 2).

The incidence of sleep-induced apnoea in bilateral percutaneous cervical cordotomy was 4% as reported by Rosomoff,20 8% as reported by Lipton,13 and 18-1% as reported by Kuhner.9 To prevent sleep-induced apnoea from occurring, alternative routes have been proposed such as the anterior route between C5 and C6,12 or high thoracic open surgery as the second stage of a unilateral percutaneous cervical cordotomy.24 None of the 36 patients treated by us exhibited sleep-induced apnoea (table 3). This result confirms that the ventral portion of the antero-lateral quadrant of the spinal cord may be spared by the lesion, if care is taken to perform the operation according to the techniques described above. The site and extent of the lesion just above the dentate ligament are compatible with the achievement of deep pin-prick analgesia in the regions from T10, T4 or T1 to S5. Impairment of sympathetic tone is the rule following bilateral cordotomy. Belmusto1 asserted that hypotension may be used as a measure of the adequacy of a surgical cordotomy in a bilateral procedure when performed in the lower cervical region. In his experience a permanent analgesic level was not produced unless hypotension was observed after cutting the second side.

The incidence of hypotension in the course of bilateral percutaneous cervical cordotomy ranged from 40% as reported by Kuhner,10 to 4% as reported by Rosomoff.20 In particularly debilitated patients or those with hypovolaemic coronary heart disease, such alterations may be the cause of operative mortality. Arterial hypotension, especially orthostatic, occurred in 13 (36-1%) of our 36 patients (table 3), and in one case this event was the cause of death (table 2).

As regards motor disorders, White and Sweet23

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Table 4 Long-term pain relief (32 patients)*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Patients (Percentage)</th>
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<tr>
<td>Complete</td>
<td>15 pts. (47%)</td>
</tr>
<tr>
<td>Partial</td>
<td>4 pts. (12.5%)</td>
</tr>
<tr>
<td>Persistent pain in the site treated by the 2nd cordotomy</td>
<td>8 pts. (25%)</td>
</tr>
<tr>
<td>Recurrence of pain in the site treated by the 1st cordotomy</td>
<td>1 pt. (3.1%)</td>
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<tr>
<td>Occurrence of pain in another site</td>
<td>1 pt. (3-1%)</td>
</tr>
<tr>
<td>Diffuse pain</td>
<td>3 pts. (9-4%)</td>
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*Mortality (1st week): 4 pts. (12-5%)
observed a motor weakness in 8% of patients subjected to cervical or high thoracic surgical bilateral cordotomy performed in a single operating session, and in 10% when the patients are treated in two stages. Rosomoff reported an incidence of paresis ranging from 2% to 12% after surgical cervical cordotomy and a 10% incidence (3% permanent) after bilateral percutaneous cervical cordotomy. According to Kuhner, bilateral cordotomy is characterised by the same incidence of motor deficit as unilateral cordotomy (hemiplegia in 5% of patients treated via the percutaneous route and in 8% of those treated surgically). The motor sequelae occurring in our 36 patients are given in Table 3. Permanent paresis occurred in only one case (2.8%), while on no occasion did we observe recurrence of paresis on the same side as the first cordotomy after performing a second cordotomy. After bilateral surgical cervical cordotomy, Rosomoff reported an incidence of permanent bladder sphincter disorders ranging from 11% to 92%; White reported a 29% incidence after cordotomies performed in a single stage and a 16% incidence after a two-stage procedure; Brihaye reported a 33% incidence. Bilateral percutaneous cervical cordotomy presented a varying percentage of permanent bladder function impairment: 2% according to Rosomoff, 12% according to Kuhner, 21% according to Tasker and 60% according to Lipton (40% manifested prior to the second operation). In 33.3% of our 36 patients bladder function impairment could not be assessed because the patients were already catheterised or had ureterostomies, while 38.9% were obliged to use indwelling catheters after the second cordotomy.

In our series of 36 patients suffering from chronic pain of neoplastic origin and undergoing bilateral percutaneous cervical cordotomy, 15 patients (47%) had complete pain relief for the entire period of remaining life and died pain-free. Four patients (12.5%) obtained sufficient benefit to be able to eliminate their pain with the aid of non-narcotic analgesic drugs or mild narcotics. Eight patients (25%) complained of persistence of the original pain in the site treated by the second cordotomy despite deep pin-prick analgesia. This phenomenon may be related to a preoperative unsuspected or undiagnosed deafferentation pain, or may be interpreted as a phenomenon originating at spinal level. The reason for such a high incidence of persistence of pain in the site treated by the second percutaneous cervical cordotomy remains, however, difficult to explain. In the case of unilateral or bilateral pain, it is essential to obtain as complete a picture as possible of the case history and objective data ("numb, tingling, pins and needles, the freezing coming out and pricking") to assist in the diagnosis of deafferentation pain. In the presence of these evident or highly suspect symptoms a percutaneous cervical cordotomy is useless. The reason for the reappearance of pain in the site treated by the first cordotomy on performance of a second cordotomy 22 months later might be explained as a reference of sensation from the analgesic side to the analogous place on the opposite side on which hypoalgesia subsequently set in.

Bilateral percutaneous cervical cordotomy carries a fairly high mortality (approximately 10%) even in the absence of respiratory complications. The operation should be performed only by those who can guarantee that the ventral portion of antero-lateral quadrant of the spinal cord will be spared.

The effects on sympathetic tone, sphincter control and, albeit to a lesser extent, muscular strength affect the quality of life of patients who are already sorely tried as a result of the progressive, inexorable decline in their general condition associated with the neoplasm. It is thus difficult to assess whether a certain measure of the deterioration observed in the general sense of well-being of our patients is related to the procedure itself or is due to other causes. Enhanced quality of life following bilateral percutaneous cervical cordotomy was observed by us in patients in good general condition with no cardiocirculatory problems. In such patients with bilateral neoplastic pain without unmistakeable or highly suspect signs of deafferentation pain, we now usually perform bilateral percutaneous cervical cordotomy. It is our opinion that there is now no justification for proposing and performing open cordotomy, even when carried out at high thoracic level as the second stage of a bilateral procedure.

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