Stereotactic cervical myelotomy

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The first spinal commissurotomy was performed by Armour and reported in 1927. The patient, suffering from tabetic gastric pain, died post-operatively. Putnam (1934) devised a similar procedure independently and advocated it for intractable pain in the arms and shoulders. The operation aimed at interrupting the decussating fibres passing to the spinothalamic tracts and, since the decussation was believed to take place over two to three segments for each dermatome, an attempt was made to split the commissure over several segments. Putnam's first patient was completely relieved of pain, and analgesia was produced from C5 to approximately T9 by splitting the commissure from C4 to T3, subsequently confirmed at necropsy. His second patient had only incomplete relief and a third patient died post-operatively. The method soon fell into disrepute because of cases of paralysis caused by injury to the anterior spinal artery. Leriche performed commissurotomy at lower levels in 1928 and reported it in 1936. It is now an established pain-relieving procedure, notably by French workers.

Theoretically, cervical commissurotomy would be ideal for bilateral shoulder, arm, or upper chest pain which is uncommon. Unilateral arm or chest pain due to bronchial carcinoma, however, is relatively common and, although such pain can be relieved by high cervical cordotomy, pre-operative respiratory inadequacy may make the procedure hazardous due to injury to descending respiratory pathways (Belmusto, Brown, and Owens, 1963; Hitchcock and Leece, 1967). The advantages of a procedure which would not interfere with these pathways encouraged a reappraisal of the operation of cervical commissurotomy.

The extensive laminectomy and myelotomy required, with the risk of injury to the anterior spinal artery, seemed to demand the use of a more precise method. Percutaneous stereotactic spinal tractotomy had been described, using a special stereotactic instrument (Hitchcock, 1969), and a similar technique has been used to interrupt the spinal commissure at the first cervical segment or cervico-medullary junction.

MATERIAL AND METHOD

Patients with intractable pain due to advanced malignant disease were offered this procedure after conservative methods had failed.

The patient was seated in the upright posture with the head moderately flexed on the neck and the stereotactic frame applied. The midline of the cord was assumed to lie in the midline of the odontoid process and spinal canal. A posterior-anterior radiograph was taken to determine the offset of the frame in respect of the midline and to enable necessary corrections of the electrode carrier.

A lateral view was then taken, again using the odontoid as a bony landmark and assuming that, with the head in the mildly flexed position, the anterior surface of the cord was approximately 2 to 3 mm behind the odontoid line and the thickness of the cord was 10 mm. The cord equator was marked on the film and a suitable point chosen along it to permit the entry of an electrode by direct percutaneous track through the atlanto-occipital membrane. After the theca was penetrated and cerebrospinal fluid obtained, a 50% mixture of Conray was instilled to determine the cord outline which in all cases corresponded extremely closely to the approximate coordinates based on the bony landmark. The electrode was then inserted and the position and depth checked by recording and stimulating procedures.

For the first three cases the electrodes were stainless steel tubes of 22 gauge containing a diamel-coated gold wire 0.009 in. in diameter, protruding approximately 1 mm beyond the tip of the tube. The upper end of the gold wire extended beyond the tube and was connected to a pre-amplifier for use in recording and stimulation studies. The electrode itself was insulated apart from 1 mm at the tip. A lesion was made in small steps, using a spark-gap diathermy machine. Subsequently, tungsten electrodes, varnished apart from 1 mm at the tip, were used.

Immediately after making the lesion, assessments were made of the extent and depth of analgesia. Sensory function was tested regularly post-operatively up until discharge from hospital, and then intermittently at follow-up clinics.

CASE HISTORIES

CASE 1 (RS 090711) This 56-year-old man suffered intractable pain in the neck and both arms from secondary deposits from an adenocarcinoma of the oesophago-

gastric region. Neck movements were extremely painful. There was radiological and clinical evidence of a metastasis to the lower cervical vertebrae on the right side, with marked wasting and weakness of the interossei in the right hand, and hypoaesthesia of the ulnar side of the right forearm and hand. On 20 December 1968 stereotactic cervical commissurotomy was attempted. After application of the frame and radiographic delineation of the cord, an attempt was made to insert an electrode to the target taken as the centre of the cord. Because of difficulties in penetrating the atlanto-occipital membrane and electrode distortion, depth measurements were only approximate and, as a result, electrode penetration was deeper than desired so that complete cord penetration occurred. Placement of the electrode, however, resulted in a deep analgesia in both arms with some sparing of hand sensation. The analgesia extended from C3 to D11 on both sides (Fig. 1). Simultaneously, he reported complete relief of pain. A small electrolytic lesion was made. Subsequent testing confirmed the sensory deficit which entirely relieved his pain until his death on 15 January 1969. Repeated testing, however, also revealed analgesia in both legs below the knee (Fig. 2). Necropsy (Dr. A. F. J. Maloney) showed a moderate degree of cervical spondylosis and tumour deposit in the C4

vertebral body extending posteriorly to present as a smooth flattened nodule 1 cm in diameter on the right anterolateral aspect of the spinal canal. No lesion could be seen on naked-eye examination of the cervical cord, but sections (Fig. 3) revealed an electrode tract limited to one of the 10 μ thick sections at the C1 segment.

The lower body analgesia produced in this patient by cervical commissurotomy—or perhaps, more correctly, myelotomy—suggested that the procedure could be applied to patients suffering intractable pain in the lower half of the body. The theoretical advantage again would be avoidance of autonomic pathways, such as those for respiration and micturition, which lie in the lateral columns and are often affected by spinothalamic tractotomy.

CASE 2 (MG 060899) This 69-year-old woman had severe dysuria and intractable perineal pain and discomfort from extensive invasion of the bladder from cervical carcinoma. Intrathecal saline relieved her pain for only a few days and, in view of the experience with case 1, a cervical stereotactic commissurotomy was attempted on 13 January 1969. A small electrolytic lesion was made at the target point which produced complete loss of pain to pinprick over the whole body

FIG. 1 (Left). Case 1. Analgesia to pinprick in shaded area with 'sparing' of left hand and a portion of the right hand. Discrimination between sharp and blunt retained on the right side but lost in the analgesic area on the left.

FIG. 2 (Right). Case 1. Analgesia to pinprick in shaded area with 'sparing' of both hands. Analgesia to pinprick both legs below knees.

FIG. 3. Case 1. Cervical cord section at C1 segment showing electrode track. There is some distortion due to fixation but the track can be seen passing parallel to the posterior midline septum and anterior sulcus.

except the muzzle area (Fig. 4). Post-operatively, she became somnolent for a few days and sensory testing was unreliable. On 19 January 1969, however, complete spinothalamic loss was demonstrated over the whole

head (with the exception of the muzzle area) extending to D12 dermatome. Below this level, while sharp and blunt stimuli could be discriminated, pinprick was not painful. She no longer required analgesics. On 25 February 1969, sensory testing revealed sacral sparing with normal sensation, and sensory sparing of the right hand to the wrist and the left thumb. Over the rest of the body pain sensation was absent (Fig. 5). On 21 May 1969, sacral sparing could no longer be demonstrated but both hands and face appeared to have normal sensation. She was pain free.

CASE 3 (CR 170102) This 67-year-old woman complained of intractable pain due to invasion of the right lower abdominal wall by a fungating malignant ulcer arising from a carcinoma of the caecum. The pain was constant and aggravated by movement. Massive doses of analgesics and strong hypnotics failed to control her pain adequately. On 22 January 1969, stereotactic cervical commissurotomy was attempted, the electrode track passing to the right of the midline. The first electrolytic lesion produced dense analgesia from C2 to L3 on the left, and with further increase in current, a similar analgesia on the right. She required no further analgesics, but testing revealed a well-marked spinothalamic sensory loss on the left, from C2 to L3, and loss of pain sensation

FIG. 4 (Left). Case 2. Analgesia to pinprick in shaded area with 'sparing' of muzzle area; sharp and blunt discrimination preserved.

FIG. 5 (Right). Case 2. Analgesia to pinprick in shaded area with 'sparing' of right hand and sacral segments and left thumb. Sharp or blunt discrimination preserved.

on the right with, however, the ability to discriminate between sharp and blunt. When examined on 4 March 1969, although she no longer had pain in the ulcer, it was still tender to touch. Examination revealed analgesia in the right leg from L1, including coccygeal segments, and loss of discrimination between sharp and blunt. On the left side the sensory loss remained at C3 to L3 (Fig. 6). A few weeks later pain returned in the ulcer but of a different quality, requiring mild analgesics in moderate doses, which controlled the pain.

CASE 4 (AC 281208) This 61-year-old man had intractable pain in the left shoulder from direct invasion of the brachial plexus by bronchial carcinoma. The examination revealed mild hypoaesthesia over C8 in the left arm and hand, and muscle wasting in the left hand. On 7 February 1969, cervical commissurotomy was attempted, the electrode track passing slightly to the left of the midline. A small electrolytic lesion produced analgesia in both arms and shoulders, a patchy hypoaesthesia in the left face, and hypoaesthesia in the lower half of the body. For the first 24 hours after operation his pain remained as bad as ever but he became pain free over the next day and was discharged. Sensory examination at that time indicated a band of hypoaesthesia in the left arm at approximately D1 dermatome within the

larger area of analgesia. He returned to Out-patients in March complaining that, although his shoulder and neck pain had not returned, he was now troubled with severe pain on the inner aspect of his left arm within the area of hypoaesthesia. An open right-sided fractional spinothalamic tractotomy was performed on 7 March 1969, producing complete analgesia and failure to recognize sharp and blunt stimuli on the left side from C3 to S1 dermatomes. Reviewed on 18 June 1969, the left-sided sensory loss was unchanged. The right side was generally hypoaesthetic, deepening over D10 to L2 and over the upper part of the chest, with deep analgesia over D1 to 2 dermatomes (Fig. 7).

CASE 5 (DT 080901) This 67-year-old man had multiple metastases in many parts of his body, most prominently in the perineum and over his chest wall. His major pain was in the interscapular region, and he had failed to respond to drugs and cytotoxic agents. An intrathecal saline injection had failed to procure relief for longer than two days, and, on 21 March 1969, cervical commissurotomy was attempted. He was rendered pain free and had an extensive area of sensory loss involving both sides of the body (Fig. 8). Subsequently, on 29 April 1969, he complained of pain in one hip and in the right shoulder, and in these areas

FIG. 6 (Left). Case 3. Analgesia to pinprick in shaded area with loss of sharp or blunt discrimination.

FIG. 7 (Right). Case 4. Analgesia to pinprick in shaded areas with loss of sharp or blunt discrimination. Hypoaesthesia in stippled area deepening over lower abdomen and upper chest on the right with complete analgesia ulnar aspect right arm where sharp or blunt discrimination lost.

sparing of analgesia was found (Fig. 9). He died suddenly on 4 March 1969. A necropsy was not performed.

In four other patients the procedure was abandoned—in one, because of loss of electrical insulation. In one patient, despite a good initial sensory loss, pain continued, and, in another, pain relief was immediate without sensory loss but recurred within a few days. In the fourth patient, analgesia was achieved on the left side up to D10 dermatome, on the right up to the knee and hypoalgesia up to D10 dermatome. Although pain in the right hip continued it was less severe and no longer required strong analgesics.

DISCUSSION

These results, although not entirely satisfactory, indicate that percutaneous stereotactic cervical commissurotomy is a safe and relatively simple procedure. High analgesic levels can be achieved, a point of special importance in dealing with patients with upper limb pain. An important advantage is that injury to important pathways, such as those of micturition and respiration, is avoided. The close relationship between cervical sensory segments and

respiratory fibres implies that in the conventional cervical cordotomy, with a section more than 3 mm deep, injury to the respiratory pathway cannot be avoided, with the result that there is severe impairment of respiratory function.

The use of this procedure to deal with lower body pain is more controversial. In spinothalamic tractotomy for lower body pain injury to the vesicomotor fibres of the bladder is almost inevitable if satisfactory analgesia is to be obtained in sacral dermatomes. A procedure which would not damage these fibres would obviously be helpful and accounts for the popularity in some parts of the world of lumbosacral and thoracic myelotomy. Conventional anatomical teaching, however, would not support the view that pain fibres from the lower parts of the body are still decussating or lying near the central canal of the cervical spinal cord, while the sensory distribution of the loss of pain sensation without loss of discrimination between sharp and blunt components raises many problems. The posterior root fibres may ascend the cord in the tract of Lissauer by some five segments before synapsing with posterior horn

FIG. 8 (Left). Case 5. Analgesia to pinprick in shaded area with 'sparing' of both hands and feet and loss of sharp or blunt discrimination.

FIG. 9 (Right). Case 5. Analgesia to pinprick in shaded area with loss of sharp or blunt discrimination. Analgesia to pinprick in stippled areas with preservation of sharp or blunt discrimination. 'Sparing' of right sacral region, foot and right upper thoracic dermatomes. On the left side the thumb and leg are also spared.

cells and decussating fibres to the spinothalamic tract may not cross for six segments. At most then, a small lesion of the cord should not produce a greater analgesia than eleven segments—thus, a lesion at C1 segment should only cause analgesia extending to D3 dermatome. Since satisfactory analgesia can be achieved by spinothalamic tractotomy for lower limb pain by sections at levels as high as the C1 segment, which do not encroach upon the medial portions of the cord, it would seem from these findings that two modalities of sensation may be involved in the procedure of cervical commissurotomy. Spinothalamic fibres decussating from the upper part of the body would appear to lie much closer to the commissure than is generally realized, and for greater distances. This may explain the difficulty in obtaining high levels of analgesia with thoracic cordotomy and provides a partial explanation of the sensory loss in the upper part of the body by commissurotomy. The loss in the lower part of the body, however, often appeared to be of a different nature in that the ability to discriminate between sharp and blunt was retained and yet the stimulus was not painful.

Mansuy, Lecuire, and Acassat (1944) reporting on 30 cases of commissural myelotomy did not, in fact, extend the incision to the anterior commissure but noted that objective changes of temperature and pain sensation were present in only 30%, and then only slight and transient. Wertheimer and Sautot (1949) reporting the results in 59 cases of thoracic commissurotomies, produced anaesthetic areas in only 23 patients, although they produced total pain relief in 29, and a failure in only 13 cases. In their opinion the results could not be correlated with the presence or absence of changes in temperature or pain sensation. Wertheimer and Lecuire (1953), reviewing 107 commissurotomy patients some of whom had already been reported by Mansuy *et al.* (1944) and Wertheimer and Sautot (1949), noted only 30% with disturbances of temperature or pain sensation.

Davis, Hart, and Crain (1929) demonstrated the existence of both direct and crossed pain pathways ascending close to the grey matter of the cord and crossing in the higher cervical cord and lower medulla. Although perhaps 50% of pain fibres cross within three or four segments, these views have received recent support from Richards, Tyner, and Shealy (1966) who brought forward evidence for uncrossed ascending small fibres. Morin (1955) describes a tract, the spinocervical tract, arising from cells in the posterior grey column and passing in the region of the posterior spinocerebellar tract to the lateral cervical nucleus. From the lateral cervical nucleus third order neurones decussate to ascend to

the opposite thalamus. Such a pathway has been demonstrated in cats (Taub, 1964) and in primates (Oswaldo-Cruz and Kidd, 1964) but has not yet been demonstrated in man. In the high cervical procedure described, it is possible that these decussating fibres are interrupted, thus interrupting pain sensation from the whole of the body below it.

Sourek (1967), however, felt that myelotomy severed a slow-conducting anterolateral system and a fast-conducting mediodorsal system, and that the results of commissural myelotomy were not due to a lesion in a single specific pain system. He attributed the changes in pain sensation to a distortion of pattern in time and space of peripheral impulses travelling in these two different systems, basing his views on his experience with commissural myelotomy at thoracic level in 25 patients. In these patients it was noted that pain disappeared, not only from the girdle distribution corresponding to the level of the incision, but also from lower dermatomes although normal sensation of pain was preserved.

The bizarre sensory losses obtained in the stereotactic operation could be explained by interruptions of decussations at different levels. Further work may demonstrate a somatotopic arrangement in the decussation similar to that already shown for the internal arcuate fibres forming the medial lemniscus.

Although future investigations may provide a simple explanation of the effects of this procedure, for practical purposes it seems that this technique can provide good pain relief without the hazards attendant upon spinothalamic tractotomy and seems especially suitable for certain cases where a bilateral procedure is necessary.

I am grateful to Dr. A. F. J. Maloney for the pathology report and careful sectioning in case 1 described. Some of this material was presented at the Meeting of the Society of British Neurological Surgeons, London, 30 May 1969.

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