Surgical interruption of a midline dorsal column visceral pain pathway

Case report and review of the literature

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A punctate midline myelotomy performed in a patient effectively eliminated residual, intractable pelvic pain, which remained after resolution of uterine cervical cancer. The authors describe the case history of the patient, in whom pain assessments were made, and a surgical procedure performed. Despite large doses of opiate analgesic medications, the patient experienced constant pressure pain in the right lower pelvis, with excruciating pain on bowel movement. Severe weight loss necessitated better pain control. A minimally invasive surgical procedure, a 5-mm deep puncture using a 16-gauge needle on either side of the median septum in the dorsal column of the spinal cord (T-8), resulted in no new neurological deficits. Narcotic medication was tapered, no pain was reported, and the patient resumed daily household activity. Midline myelotomy has typically been performed with the intention of eliminating the crossing fibers of the spinothalamic tract in the anterior white matter commissure. The punctate midline myelotomy described here was performed with the specific intention of interrupting a newly described visceral pain pathway that ascends to higher brain centers through the midline of the dorsal column. The effectiveness of the pain relief seen in this patient suggests that visceral pain of the pelvis in humans may be transmitted in the midline of the dorsal column, as has been recently reported in studies using rats. The effectiveness of the punctate midline myelotomy performed in this one case of pelvic visceral pain suggests that the surgery may eventually be effective in greatly reducing or replacing opiate narcotic medication for visceral pain management.

KEY WORDS • myelotomy • pain

Classic anatomical teaching holds that the somatic pain pathways ascend crossed in the anterolateral quadrant of the spinal cord, whereas the pathway for “epicritic” sensory modalities ascends uncrossed in the posterior columns. It comes as a surprise, therefore, to learn that recent evidence obtained in experimental animal studies shows there is a major visceral pain pathway that ascends in the midline of the posterior column (Fig. 1). The cell bodies of origin of this “new” pathway lie in the spinal gray matter dorsal to the central canal near the base of the dorsal horn where they are directly or indirectly in receipt of segmental primary afferents. As their axons ascend ipsilaterally in the posterior columns, they congregate near the posterior midline before terminating in the nuclei gracilis. Internal arcuate fibers then transmit nociceptive input to viscerosensitive neurons of the ventral posterolateral thalamus.

New knowledge of this pathway, combined with previous clinical reports of successful pain relief following midline myelotomy, led us recently to recommend a modified midline myelotomy to a young woman who was literally dying of lower abdominal pain. In earlier reported successful cases of midline myelotomy in humans, the intent of the operation had been to interrupt the midline commissure over some rostrocaudal length and thereby sever the bilateral crossing fibers of the anterolateral quadrant ascending pain fiber system. A retrospective evaluation of the basis for the pain relief, however, suggests that the benefit was probably derived not from the interruption of the crossing spinothalamic fibers but from the coincidental damage to the midline region of the dorsal columns. Hirshberg and colleagues reached this conclusion in part based on their own autopsy material and on the clinical material of others, which showed that some successful myelotomies had either not been deep enough or had been performed at the wrong rostrocaudal level to reach the appropriate region of the commissure. Gubels and Sweet, in particular, had raised the suggestion that a revision in thinking about pain pathways was necessary based on such observations. To our knowledge, the present case is the first report of an operation performed specifically with the intent of interrupting only the midline posterior column visceral pain pathway in a human. The successful short- and intermediate-term pain relief with the punctate midline myelotomy in the case reported here supports the idea that there is an ascending midline dorsal column visceral pain pathway in humans and that its interruption may provide a way to relieve midline visceral pain.

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syndromes that have not had a satisfactory solution in the past.

**Case Report**

This 39-year-old woman with insulin-dependent diabetes mellitus noted the onset of lower abdominal pain beginning in 1993.

**History.** Physical and imaging examinations revealed cancer of the uterine cervix in February 1994. The patient was treated with internal radium implants as well as radiation therapy to her pelvis; this treatment was completed in April 1994. Her pain continued to worsen despite apparent resolution of the cancer following her treatment and large doses of opiate analgesic medications. As best could be determined by her gynecologist and oncologist, the pain was caused by radiation changes in the bowel, bladder, and ureter. Later in 1994 the patient underwent abdominal surgery to repair a ureteral stricture. By December 1995 she described her pain as a constant pressure in the right lower pelvis with exacerbating "ripping" pain following a bowel movement. These exacerbations lasted for 2 hours and were intolerable even with maximum analgesic doses. She described the overall pain as worsening, with nausea and vomiting associated with the morphine contributing to her weight loss. The patient was receiving a three times daily oral dose of 45 mg morphine sulfate, 20 to 40 mg morphine elixir taken orally three times daily, and 20 mg compazine every 4 hours. This medication regimen was ineffective in reducing her pain significantly, and the side effects at this dosage were severe. Her weight dropped from 96 lbs to 75 lbs. An evaluation by a general surgeon revealed no evidence of bowel obstruction. It seemed clear to the patient that she would continue to lose weight and vigor unless some solution were found.

**Preoperative Examination and Pain Assessment.** The patient was cachectic, but with full strength considering her decreased muscle mass. She had decreased light touch, vibratory sense, and proprioception in the toes bilaterally. She had absent reflexes bilaterally in the lower extremities, consistent with her known diabetes mellitus, and a mildly abnormal Romberg’s sign. The remaining neurological examination was normal. The following pain assessment measures were used in the evaluation of this patient: 1) the Karnofsky Performance Scale, which describes the level of activity the patient can engage in: she was able to feed and dress herself, but was wheelchair bound. Her preoperative score was 50%; 2) the Brief Pain Inventory, which indicates the location of pain (pelvic and rectal), average daily pain (8/10), and most severe pain (10/10 following bowel movements), quality of pain in words, and mood (10/10 worst). Her pain (10/10) completely interfered with activity, normal work, enjoyment of life, and walking ability; 3) the Memorial Symptom Assessment Scale, which describes multiple symptoms, their severity, frequency, and distress level. Her total score on this measure was 198/352; and 4) a visual analog scale, the Memorial Pain Assessment Card, which describes average pain severity (6/10), description (strong), relief with medications (3/10), and mood (5/10).

**Operation.** In January 1996, after induction of general endotracheal anesthesia, the patient was placed prone on a Wilson frame so as to avoid abdominal compression. A wide laminectomy was performed at T-8 with additional partial removal of T-7 and T-9. The dura was opened longitudinally in the midline to allow the dorsal root entry zones to be identified without question on each side. The arachnoid was opened longitudinally just lateral to the septum posticum. The exact midline of the spinal cord was then determined under the operating microscope by interrupting this pelvic visceral pain pathway by making a punctate lesion in the midline of the dorsal column. The punctate lesion was made by lowering a 16-gauge needle into the midline of the dorsal column to a depth of 5 mm on either side of the medial septum, avoiding the dorsal vein (as shown in the upper left).

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**Fig. 1.** Artist’s drawing showing how nociceptive input from the pelvic viscera arrives in the dorsal horn of the spinal cord where it is relayed to higher centers by cells near the central canal. These postsynaptic dorsal horn cells send their axons in the midline of the dorsal column to synapse in the nucleus gracilis. The pathway then crosses the midline in the lower brainstem to ascend to the ventral posterolateral nucleus of the thalamus. Alleviation of pelvic visceral pain in the present case was accomplished by interrupting this pelvic visceral pain pathway by making a punctate lesion in the midline of the dorsal column. The punctate lesion was made by lowering a 16-gauge needle into the midline of the dorsal column to a depth of 5 mm on either side of the medial septum, avoiding the dorsal vein (as shown in the upper left).
Observations on her pain in the course of these various conditions and procedures are as follows. First, no pain of the severity prompting the myelotomy procedure was ever reported again. She did complain of postoperative pain on the abdominal wall at the colostomy site but it was managed with modest increases in narcotic analgesic agents. This pain later settled in a time course compatible with postsurgical somatic pain. With her peritonitis, she reported pain in the upper abdomen but nothing below the umbilicus (approximate T-10 level). Pain following each nephrostomy procedure was reported to be severe but could be controlled with modest increases in opiate analgesic agents. She became aware of pain at the sacral decubitus ulcer, pain around the nephrostomies, and some upper abdominal pain when the analgesic agents were tapered. The residual upper abdominal pains were attributed to the kidneys, radiation enteritis, and only very slowly resolving peritonitis. The pain was easily controlled with 30 to 45 mg of morphine sulfate twice daily. The patient suspected that even this was excessive and it was tapered slowly; however, neither she nor her physicians want her to go through overt withdrawal just as she is recovering from this most recent series of problems and procedures. At the time of this writing (10 months after the punctate myelotomy procedure), she has no complaints of any pain in the lower abdomen, and she continues to believe that the myelotomy eliminated her original pain without recurrence or new dysesthesias.

Discussion

Midline and visceral pain syndromes have traditionally been frustrating to treat by either medical or surgical means. The severity of the patient’s pain often requires such high doses of opiate analgesic medications that side effects commonly accompany incomplete relief. Even intrathecal morphine pumps have limitations in that they require refills and maintenance, and tachyphylaxis can again lead to incomplete relief or side effects. Bilateral anterolateral cordotomies performed to lesion the spinothalamic tracts have been used with some success in the past for the relief of such pain, but the complications, especially incontinence and respiratory disorders, can be significant. Midline myelotomy was developed on the theory that bilateral spinothalamic tract lesions could thereby be produced segmentally without damage to other functional fiber tract systems in the anterolateral quadrant. However, complications have been reported with commissural myelotomy for the relief of visceral pain, including a decrease in proprioception, dysesthesia, bowel and bladder dysfunction, and even death. Limited midline myelotomies introduced by Hitchcock were originally designed to sever only the crossing spinothalamic tract fibers at a specific spinal level. Despite the restricted extent of the lesion, the limited midline lesions at C-1 and at T-10 were reported to provide surprisingly widespread visceral pain relief while sparing proprioceptive and other sensory perception. Schwarcz postulated that the pain relief was due to interruption of a polysynaptic ascending system in the central region of the cord. Although his idea that he was interrupting an ascending system now seems correct, his intended target was a central

was mobilized to allow access to the precise midline. After a short rostrocaudal segment of the precise midline was exposed, a punctate incision was then made with a 16-gauge needle attached to a tuberculin syringe as a handle. The needle was kept perpendicular to the pial surface precisely at the midline. It was inserted twice, first with the bevel to the right, then to the left, each time to a depth of 5 mm. This depth could be judged accurately by first measuring the bevel length (approximately 6 mm from tip to intact needle shaft). The intention was to interrupt only the most medial fibers ascending in the fasciculus gracilis. No attempt was made to “feel the ependyma” or to make a cut in the sagittal plane as described by Hirshberg and colleagues. Just before the needle was inserted, great care was taken to maintain the surgeon’s sense of the exact vertical midline of the cord because a lateral angulation might both miss some of the intended fibers and result in unnecessary damage to the fasciculus gracilis. The patient’s position was rechecked to make certain it was as level as possible and the microscope angle was kept perfectly vertical as the lesion was made.

Postoperative Examination and Pain Assessment. At examination on postoperative Day 1 there were no new neurological deficits. The patient’s vibratory, light touch, and proprioceptive sensation remained unchanged with only the mild changes already noted preoperatively and attributed to her preexisting diabetic neuropathy. Pain assessment with the Memorial Pain Assessment Scale on postoperative Day 1 indicated complete pain relief, severity (0/10), description (no pain), relief (10/10; 100%) and mood (5/10). This has not changed up to publication time (10 months postoperatively) concerning the previous disabling abdominal pain below the umbilicus (T-10 spinal level). The Memorial Symptom Assessment Scale improved from 198 to 96 by postoperative Day 2 and to 82 by postoperative Day 10. The patient’s morphine sulfate dosage was slowly reduced and after 2 weeks, at a level of 30 mg twice daily, she began to demonstrate tachycardia, sweating, and a mild temperature increase. A tentative diagnosis of narcotic withdrawal was made, and her symptoms resolved after her morphine dosage was increased to 45 mg twice a day. Narcotic medications were tapered more slowly thereafter. Seventy-two days after her surgical procedure she was receiving a dose of 15 mg morphine sulfate per day and 500 mg Anaprox twice daily with no pain at baseline or after bowel movements. She was able to travel out of town, attend her daughter’s school functions, and perform her daily household chores. Her weight increased to 80 lbs and she had a normal appetite without nausea.

She continued well until May of 1996 when, more than 4 months postoperatively, she developed a fistula between the rectum and bladder, a presumed complication of her radiation in the setting of diabetes mellitus. The bladder then developed a second fistula within the peritoneal cavity, and peritonitis proved difficult to eradicate even with prolonged antibiotic therapy. A colostomy of the descending colon was made in the left lower quadrant of the abdomen and total parenteral nutrition was initiated. Bilateral nephrostomy tubes were placed and later replaced. The patient lost more weight and developed a sacral decubitus ulcer.
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region in the cord (5 mm deep to the posterior surface) rather than the midline of the posterior columns his lesioning probe must have traversed. The present report describes a midline myelotomy in a patient with chronic visceral pain of the pelvis with the intent of interrupting only the recently characterized visceral nociceptive pathway ascending in the midline of the dorsal columns. This pathway has been defined in animals using retrograde and anterograde tracer labeling as well as with electrophysiological monitoring to distinguish the spinothalamic tract from the visceral pain pathway. In the present case, the details of the operative procedure were guided by this new anatomical knowledge. The limited, punctate extent of the midline lesion was designed to sever only the ascending visceral pain pathway and the successful result cannot reasonably be attributed to any interruption of the crossing spinothalamic fibers. Furthermore, the lesion at T-8 is at a site remote from the spinal segments innervated by afferents of the lower abdomen.

Accurate access to the ascending visceral pathway is possible because of its location on the exact midline of the posterior aspect of the spinal cord. An open laminectomy allows the best visualization of the midline of the spinal cord so that a punctate midline myelotomy can be positioned as accurately as possible; therefore, the effective transverse component of the cut can be kept small (1 mm to each side of the midline) to minimize damage to the fasciculus gracilis. We have no experience with a percutaneous method to interrupt this pain pathway but advise caution because a percutaneous needle could damage the midline dorsal vein, and the thickened arachnoid and pia related to the septum posticum may divert the needle off midline into an adjacent part of the posterior columns.

In most previous myelotomy surgeries, the emphasis had been on the sagittal dimension of the cut. In this case, we show that an essentially punctate transverse cut with no appreciable rostral caudal dimension is effective (Fig. 2). Although we report here only a single case, the successful result is clearly consistent with the broader context of earlier unexplained clinical observations that midline myelotomy remained effective even when the sagittal cut was too short, at the wrong level, or not deep enough to cut the commissural fibers of the spinothalamic tract at their anticipated rostrocaudal level of crossing. These observations are now well explained by the recent evidence in experimental animal models.

The scope of effectiveness of this punctate midline myelotomy procedure remains unclear. Whether it will be helpful in the long term, whether it will relieve visceral pain generally or only in particular organ systems, whether it will also be helpful in some types of somatic pain, whether it can be refined to a safe and effective percutaneous procedure—all remain to be explored.

References


Fig. 2. Artist’s drawing showing how commissural myelotomies have been performed at various rostrocaudal levels. In the past, commissural myelotomies were performed with the intent of eliminating crossing fibers of the spinothalamic tract segmentally for relief of pain (left). In addition to lesioning the portion of the spinothalamic tract crossing at the site of the lesion, the commissural myelotomy would also interrupt the pelvic pain pathway traveling in the midline. Punctate midline myelotomy (right) eliminates only the ascending pelvic visceral pain pathway, leaving the spinothalamic tract and most of the dorsal column intact.

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