A MODIFIED TECHNIQUE FOR SPINOthalamic CORDOTOMY

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SURGICAL section of the spinothalamic tracts of the spinal cord, conceived by Spiller and developed by Frazier, has been useful in the control of lower-body pain. Many carefully conducted studies have been reported relative to the precise position in the anterolateral cord quadrant of pain and temperature fibers from specific body areas. These studies have shown a degree of spatial predilection for area representation, but in clinical cases of severe pain, the most satisfactory results have followed as near as possible complete transection of the anterolateral quadrant of the cord.

The technique of cordotomy has evolved since its origin, chiefly in perfection of a rather fixed surgical pattern. In general, this has consisted of resecting 2 or 3 spinal laminae, opening the dura mater and arachnoid in the midline, and severing at least 2, and often 3, pairs of attachments of the dentate ligament from the dura mater. By traction upon a dentation of the ligament, the cord is rolled as completely upon its side as possible. The degree of rotation is limited by the resistance of the nearby anterior and posterior nerve roots. A knife or a hook of some type then is introduced into the cord and a cut is made through the anterolateral quadrant as nearby as possible to a predetermined depth and extent. Several surgeons have emphasized that after the section, the patient should be awakened, if he is anesthetized, and the level of analgesia be tested to insure its adequacy.

The application of this technique has been followed by results and complications so variable from surgeon to surgeon, and from patient to patient, that the value of the procedure is by no means commonly accepted. Particularly dubious are physicians in other fields, who must care for the patients after operation.

Several years ago the writer began to doubt the validity of several of the standard assumptions basic for the existing operation. Progressive modifications in technique have gradually resulted in an operation considerably different from the usual one. Conversation with colleagues stimulated the report of this modified technique of cordotomy.

PHYSIOLOGIC BASIS FOR MODIFICATION

Anesthesia. In general, it appears to me desirable to operate upon anesthetized patients. Modern anesthetic agents and techniques make this safe.
Certainly in the case of patients whose need for surgery stems from long-continued pain, it is more merciful than is operation with local analgesia alone. The combination of mild pre-induction medication, anesthesia with intravenous pentothal sodium, with or without nitrous oxide and oxygen, and generous procaine infiltration of the surgical area has proved entirely satisfactory.

In more cases than not, I have been dissatisfied with the results obtained by testing patients immediately after tract section to determine the level of analgesia. The patient operated upon with local analgesia is often too exhausted and apprehensive, by the time that stage of the operation is reached, to give reliable responses. If he is awakened for this purpose from light anesthesia maintained through the earlier phases of the operation, his responses again may mislead the surgeon in the result to be anticipated. It seems preferable to depend instead upon a more nearly complete section of the anterolateral tracts.

Level of Section. For patients having pain in various parts of the body, individualization of the level of cord section requires variability of depth of section according to the diameter of the cord at the level of the attack. Practically all pain for which cordotomy is indicated requires the level of analgesia at or only slightly below the umbilicus. To the patient, it makes little practical difference whether his level of analgesia is at the umbilicus or at the clavicles. To make the operation as uniform as possible in performance, we have fixed upon the cervical level. In the average case, sections at C4–5 on one side and C5–6 on the other, have proved entirely satisfactory. This insures quite uniform, adequate levels of analgesia between the clavicles and the nipple level. In cases in which arm analgesia also is desired, cordotomy has proved safe at even C1 and C2 levels.

By adopting the C4–6 levels for section, it is possible to anticipate quite uniform results with a 6 mm. depth of incision in patients of average build. The incision is made 5 mm. deep in smaller patients.

Position. The sitting position has decided advantages in cervical spinal cord surgery. Bleeding is minimized, so the operating time and trauma are considerably lessened. The surgical field is more easily available to the surgeon and his assistants than in operations upon prone patients.

The patient is securely fastened in a chair with the trunk erect and the head supported in a moderately flexed position. This permits loss of cerebrospinal fluid without entirely draining the ventricular system. Acute flexion of the neck is avoided, thereby minimizing possible cord trauma against unrecognized midline disc protrusion.

Fear of surgical shock has kept several surgeons from using this position. Although it is a hazard in the case of conscious patients, anesthesia largely minimizes it. The blood pressure regularly falls a moderate amount initially, but quite regularly it regains its original level by the time draping is completed. The blood pressure usually falls temporarily to 80 mm. or even lower after the second cord section is made. In sluggish cases the administration of
vasopressor drugs is very effective. In refractory cases, blood pressure can be restored by elevation of the legs, or by placing an abdominal binder around the patient. An inflatable balloon between the binder and the patient's abdomen permits pressure to be controlled by the anesthetist. We have found that, when a competent anesthetist is in attendance, blood pressure has been entirely controllable in this position.

In the performance of cervical cord surgery in the sitting position, both surgeon and anesthetist must be aware of the possibility of air embolism. The mechanism, recognition and correction of this possible complication has been reported. Should the complication occur, it must be possible to flatten the chair immediately and turn the patient on his left side. No elaborate apparatus is needed; a hinged-back chair is the only essential. In the emergency, the operative wound is covered with two sterile towels held by the surgeon while the assistants release the restraining ties and turn the patient. Thereafter, the operation may be completed after redraping, or may be deferred until another time. Now that effective protection against a fatality is possible, this rare complication need not be a contraindication to the sitting position.

Rotation of the Spinal Cord. To make an incision of precise size and extent into the anterolateral aspect of the cord from the dorsal position, the cord must be rolled toward the opposite side. The cord is "gyued" in place by the two dentate ligaments placed roughly at the centers of the sides of the cord, and by the anterior and posterior nerve roots on each side. The ligaments are short and relatively inelastic; the nerve roots are less rigid restraints to rotation, dependent upon their lengths at various levels along the cord. In the standard cordotomy, mobility of the cord is increased by severing two or three dentations of the ligament on each side.

Were the spinal cord a more rigid cylinder, sufficient traction upon a dentate ligament to displace it 45° (A, Fig. 1) would result in 45° of rotation of the cord along its axis. The approach to 45° of rotation would be limited only by the limits of length and elasticity of the nerve roots. Physically, however, the cord is not even a semirigid cylinder, but is quite soft and approaches a semiliquid, contained within a flexible sheath. The result of 45° of traction upon a surface point of such a structure does not result in a true, but rather in a distorted rotation (B, Fig. 1). The vertical diameter (a-b) curves with its convexity to the right. Tension then is exerted upon the surface by guys 2 and 3 while guys 1 and 4 are relaxed. The play of these forces distorts the cylindrical cross-section, flattening it between "y" and 3 ventrally and expanding it between "y" and 3 dorsally.

To complicate the matter still further, the restraint of the guys is not applied uniformly along the cord, but variably at the points of attachments of the nerve roots. For technical convenience, the point chosen for traction on the dentate ligament usually is about midway between the points of attachment of two posterior nerve roots. This results in an irregular distortion upward of the surface of the cord at the point of incision.
The variability of the described forces acting upon the displaced soft spinal cord results in great variation in the depth of incision into the anterolateral surface of the cord, even when using a standard depth of section. These factors seem adequate to explain the variable results obtained in even apparently similarly treated cases. It seems possible that some of the variable morbidity following standard cordotomy may result from the application to the cord of the described physical forces as well as from the effects of the incision. Data from our cordotomy series are too variable to allow conclusions to be drawn concerning this possibility.

A technique was sought that would permit sections of the anterolateral surface of the cord with minimal or no amount of rotation. To attain this end, a knife* was developed that could be introduced 6 mm. into the cord through the approximately 5 mm.-wide space between the dura mater and cord. The knife (Fig. 2) consists of a fragment of a thin double-edged razor blade, held in a gripping shaft. Although the end of a spear-tipped surgical knife can be broken to the proper length and held in a fine-tipped hemostat for this purpose, such a tool is not entirely adequate. The blade is too thick and not sharp enough, and only rarely can a hemostat be found that is fine enough at its tip and yet strong enough to grip the hard and minute surface of the blade securely.

The blades for this special knife are prepared by grasping the edge of a razor blade obliquely with a smooth-jawed pliers and breaking the fragment

* This knife is obtainable from Codman & Shurtleff, Inc., Boston, Mass.
away from the blade. A desirable fragment is approximately the shape of a right triangle, 8 mm. along its base and 2 mm. on its side. To permit the grasping instrument to hold securely upon the slick, hard, 2 mm.-square surface, each blade must be coated with a thin layer of solder applied with heat insufficient to draw the temper of the steel. These tips are prepared in quantity and are cold-sterilized as needed. Such a blade can be advanced through cord substance against the resistance of simple fixation of a dentate ligament. Blades are discarded after use.

Approach to the Cord. The type of cord incision described was applied earlier through a standard laminectomy. It soon was realized that if the cord need not be mobilized, an extensive bony removal is not necessary. Even-

![Image](image_url)

**Fig. 2.** Photograph of a knife handle devised to hold tips made from thin razor-blades.

tually the cord section was made through an interlaminal approach similar to that of an intervertebral disc exploration, removing portions of adjacent hemilaminae to produce a small dural exposure placed as far laterally as possible.

The dura mater is incised vertically. Closure of the dural incision is quite easy, through even so small a bony defect, with a continuous suture placed with a \( \frac{3}{8}\)", half-curved Lane cleft-palate needle, using a long, curved tonsil hemostat for a needle-holder.

When a bilateral cordotomy is done, muscles are separated from the spinous processes and laminae without disrupting the interspinous ligament. Dura mater is exposed at different levels on the two sides (Fig. 3). When the wound is closed, a few sutures are placed in the deep muscles through the interspinous ligaments. The other tissues are closed with separate layers of interrupted cotton sutures. This technique results in a great deal less post-operative pain in the shoulders and neck than usually follows cervical laminectomy. The patients can be mobilized as early as their general condition permits, making convalescence shorter and less complicated.

**SURGICAL TECHNIQUE**

The patient is anesthetized with intravenous pentothal sodium solution and the trachea is intubated. He is postured upright as described earlier. The skin of the
neck is prepared and draped. The skin and subjacent tissues are infiltrated to the bone with 1 per cent procaine solution. A vertical skin incision is made from the spinous process of C5 to C6 and muscles are reflected on the side of the cordotomy, from the spinous processes and laminae of C5 and C6. The ligamentous attachments may be removed from additional spinous processes to make retraction easier if required, but no more muscle than necessary is removed from the bone.

With a sharp curette, the lower edge of C5 lamina is cleared of its attached ligamentum flavum. If the upper edge of C6 lamina is easily approachable at this time, it is treated similarly. If not, this is deferred until after the laminotomy of C5. With a straight or angled rongeur, the lower edge of C5 lamina is removed through about one-half of the vertical width of the lamina, laterally as far as possible, and medially almost to the base of the spinous process. Then the upper edge of C6 lamina is removed similarly, until a bone defect about 2.5 cm. × 15 mm. is produced. When the patient is in the sitting position, the wound is irrigated freely during the bone removal, until the raw edges can be waxed, to minimize the likelihood of air entering opened marrow-veins.

The epidural vessels are lifted with forceps and coagulated gradually until they and the exposed ligamentum flavum are removed. The dura mater is incised vertically. The incision will lie above the attachments of the dorsal rootlets to the cord. Guy sutures separate the dural edges. The lateral suture should be tied into the muscle mass to increase the exposure laterally as much as possible (A, Fig. 4). The arachnoid is opened and fluid drains. The anesthetist is notified, so he can be alert to blood pressure changes. The dentate ligament is grasped with a straight mosquito hemostat and is severed from its dural attachment with a long-handled, small scalpel (B, Fig. 4). As the mosquito forceps is carried medially, the attachment of the dentate ligament to the cord can be seen. Usually a few small blood vessels run vertically along the cord at this site. This is the point for incision into the cord. If it is not easily and accurately demonstrable, a small septal elevator, or some such thin-tipped instrument can be introduced into the dorsal angle between cord and ligament to reveal it.

The knife then is prepared, the blade edge at a right angle to the shaft and directed distally. The tip of the blade is set 6 mm. from the shaft. The handle of the knife is held vertical to the cord. There usually is not enough room between the side of the cord and the dura mater to permit the whole blade length to approach the cord at a right angle, so the blade tip is put on the cord at the dentate angle, with the blade making an acute angle with the cord (B, Fig. 4). The point of the blade is inserted and the shaft is rotated until the blade is directed transversely and is advanced inward to its full 6 mm. length (C, Fig. 4). Using the dentate ligament only...
Fig. 4. Stages in the modified left-sided cordotomy operation. (A) Dura mater opened through laminotomy, exposing posterior roots and dentate ligament. (B) Knife point applied at point of penetration. It is advanced to the transverse position by rotation of the shaft. (C) Knife introduced to depth of 6 mm.

for counter- traction to the knife, and with no attempt at rotation of the cord, the knife is passed anteriorly as far as it will go. This is limited by the curvature of the spinal canal (A, Fig. 5). The knife is removed with the same type of rotary motion with which it was introduced. The blade is loosened in the handle and angled 45° downward (B, Fig. 5). It is reinserted into the cord incision and the remainder of the anterolateral quadrant is cut through. To insure denervation of the sacral

Fig. 5. (A) Anterior thrust of right-angled knife arrested by curvature of spinal canal. (B) Angulated blade position for completing cord incision.
areas, it is important that the incision extend up to or even a little dorsal to the attachment of the dentate ligament. The tip of the blade is thrust through the dentate ligament and into the cord 1–2 mm. dorsal to the point of attachment to the ligament, and is advanced into the previously made cordotomy incision. Some cord bleeding may ensue. In my experience this has always been controllable with Gelfoam®. A split-thickness fragment of wet Gelfoam®, measuring about 4×6 mm., is placed on the concave surface of a septal elevator and is thus applied to the site of the incision. A small strip of cottonoid is placed outside the instrument, which then can be slipped out without displacing the Gelfoam®. Intermittent drying and wetting of the cotton for a few minutes usually results in adhesion of the foam so the cotton can be removed. Any other incidental details of wound toilet are concluded, and the Gelfoam® may then be removed from the cord. Should bleeding follow, a small piece of foam may be left permanently adherent to the cord.

The dura mater then is closed with a continuous locked cotton suture, using a small half-circle needle held in a tonsil hemostat. The exposure is too small for comfortable work with regular dural needles and needle holders. A piece of wet, full thickness Gelfoam® is placed to cover the entire dural exposure. Retractors are removed and the wound is closed in layers with interrupted cotton sutures.

If a bilateral cordotomy is indicated, the second side is done in the same way as the first, but at a higher or lower level.

Because of our experiences with air emboli following operation in the sitting position, these patients are placed on the cart and transported to their rooms in the left lateral decubitus.

**SUMMARY**

A modification is described for the technique of spinothalamic cordotomy. The technique was devised to permit cordotomy without rotation of the spinal cord.

The operation is done through minimal laminotomy openings in a shorter time and, it is believed, with less shock and with more precision than attend the standard operation.

The sequelae of the incision are sufficiently predictable that the operation can be done under general anesthesia without the necessity of sensory testing in the operating room.

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**REFERENCES**