A new approach to the surgical treatment of lesions of the cervical spine was developed in 1956. The spine was attacked by an anterior approach and pathological lesions including cervical discs, osteophytes, fracture-dislocations, and tumors and infections involving the vertebrae have been operated upon successfully by this method with excellent results. The writer’s series of anterior operations on the spine has now exceeded 450 cases, most of which were performed for lesions of the intervertebral disc. Through a small transverse incision in the skin the spine is exposed by blunt dissection in the line of cleavage between the carotid sheath and the larynx or trachea. Ruptured or protruded fragments of disc and vertebral osteophytes encroaching upon the spinal canal are removed through a large hole drilled completely through the vertebral bodies at the interspace. The trephine hole is then filled with a cylindrical dowel of bone to effect a vertebral-body fusion. A generous area of dura mater covering the anterior surface of the spinal cord and nerve roots frequently is exposed during removal of fragments of intraspinal disc. In 1960 it occurred to the writer that if the dura mater was opened, exposing the anterior surface of the spinal cord, this could possibly be an easier surgical approach for section of the anterolateral spinothalamic tract for relief of pain.

Since chordotomy operations in the average neurosurgeon’s practice occur infrequently, some 6 months or more passed after the idea was conceived before a suitable patient appeared. In the meantime the procedure was carried out on several cadavers.

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Cervical Chordotomy by the Anterior Approach

Technique and Advantages

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The chordotomy operation, which by laminectomy often is difficult, was found to be accomplished easily by the anterior approach. In the development of a new surgical technique, however, some problems cannot be perfected on autopsy material as situations are not comparable to those found in the living. In this operation, surgical problems such as hemorrhage, the pulsating cord, and the flow of spinal fluid into the wound awaited solution on the living subject. This report will describe the operative technique of cervical chordotomy by the anterior approach which has been used in the past 18 months in a series of 10 cases. The complications encountered and their solution, and the advantages of this operation will be described. A case report of this operation was published recently by Collis from Tripler Army Hospital, Honolulu.

The C4-5 level was chosen as the most desirable location for the chordotomy incision in the cervical cord for problems of pain involving the trunk, pelvis and lower extremities. If anterior horn cells are damaged or destroyed at this level, function of the forearm, hand or fingers would not be impaired. Also this level is more accessible surgically by the anterior approach. Hamby previously had advocated the C4-5 segment as the optimum area for cervical chordotomy. Experience has proven this to be correct, as no motor deficit has occurred in our patients operated upon at this level. For patients whose pain involved the upper extremities, the anterior approach was made between C2-3. Two patients in our series were operated upon at C2-3 and a high sensory level was obtained. A differential, unilateral section of the spinothalamic tract, as reported by Jenkner, was accomplished in 1 patient, and an analgesic level sufficiently
high to include the neck, arm and chest was obtained with sparing of sensation in the trunk and lower extremity.

**Operative Technique**

*Anesthesia.* As many of our anterior operations for cervical disc are done under local anesthesia, it was hoped that this could be used in the chondotomy operation so that sensation could be tested. Local anesthesia was used in the first case, but the patient became uncooperative and a general anesthetic was required. For the second case, local anesthesia was used throughout the operation with good cooperation from the patient. A high sensory level, almost to the clavicle, was obtained with the first incision into the cord. It was decided after this case, that since the incision in the cord is made under direct vision, it would be unnecessary to have the patient’s cooperation to determine if the chondotomy incision was adequate to produce the desired analgesia. Endotracheal general anesthesia has been used in all subsequent cases and good sensory level was obtained without the patient’s cooperation. The operation can be done under local anesthesia in cooperative patients and stimulatory experiments on the anterior half of the spinal cord are planned in future cases.

*Preparation.* Prior to positioning and preparation of the patient a malleable lumbar-puncture needle is inserted into the lumbar sac with a short tube and stopcock attached for removal of spinal fluid by aspiration when the dura mater is opened. Also prior to operation a needle is inserted into the anterior surface of the C4-5 disc by the technique of cervical discography,\(^1\) and a portable roentgenogram is taken in the operating room to identify the interspace to be operated upon. When the roentgen ray demonstrates the needle in the correct interspace, a drop of methylene blue dye is injected through the needle to mark the disc for identification when the wound is opened.

The patient is placed in a supine position and secured to the operating table with a strap about the pelvis. The table is tilted or rotated slightly to the right, and the foot is elevated. This will place the head down slightly and the neck in a diagonal rather than horizontal position, which facilitates visualization of the right side of the spinal cord when the dura mater is opened. A sandbag is placed behind the neck. The head is turned 45 degrees to the left and secured to the table with an adhesive band. The neck is prepared with an antiseptic solution and the skin and deep cervical muscles are infiltrated with \(\frac{1}{2}\) per cent Xylocaine containing 1 drop of Adrenalin per ounce and 1 ampule of Wydase.

*Exposure.* The technique of the anterior cervical operation described previously is followed for exposure of the anterior dura mater.\(^2\) The transverse incision in the skin is made slightly longer than that used for operation on discs and also a larger opening into the spinal canal is required. The trephine hole is made with a \(\frac{3}{8}\) drill directly in the midline and carried down to the posterior cortex of the vertebral bodies. The anterior interspace on one side of the drill hole should be well cleaned of discal material to permit insertion of the vertebral spreader.\(^3\) This is used throughout the operation, to increase the exposure of the dura mater, and to place the dura mater on a stretch which makes it easier to open. The posterior longitudinal ligament is separated from the posterior margin of the vertebral bodies with a small sharp elevator. The cervical punch is used to remove a generous amount of bone completely around the bottom of the drill hole, as far lateral as possible to “square off” the bottom of the drill hole. Bleeding from the side walls of the drill hole is arrested with Gelfoam and thrombin, and subcortical bleeding from bone around the lower margins of the drill hole is arrested with bone wax.

*Posterior Longitudinal Ligament.* The soft-tissue membrane at the bottom of the drill hole is composed of a few remaining posterior fibers of the annulus fibrosus and the posterior longitudinal ligament. If bone has been well removed, the ligament is seen to thin out laterally into areolar tissue containing veins. The ligament must be incised and elevated in a rectangular flap. The vertebral spreader places the ligament on a stretch. A transverse incision is made 1 to 2 mm. from the lower margin of the bony opening, with a pointed scalpel, long dural hook and groove director. Bleeding from small arterial vessels in the edge of the incised ligament is arrested with a weak cautery. The incision is carried as far lateral as the drill hole will permit or until the membrane thins out. In cutting the vertical limbs of the rectangular flap of ligament, venous bleeding may occur. By using the groove director and pressing upward bleeding may be arrested by pressure until controlled with cautery or Gelfoam. Two traction sutures are placed in the inferior margin of the flap of ligament which is turned upward and sutured to the anterior longitudinal ligament at the outer rim of the drill hole.

*Dural Incision.* The location of the incisions into the dura mater is important so that at the end of the operation a water-tight closure can be made. In our first patient a rectangular flap of dura mater was turned back but this proved difficult to close because the sutures tore through the longitudinal dural fibers. A cruciate incision pro-

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Cervical Chordotomy by Anterior Approach

Fig. 1. Drawing from photograph of operative field of anterior cervical chordotomy. Note rectangular flap of posterior longitudinal ligament and four triangular dural flaps. These assure a water-tight closure. The cataract (or chordotomy) knife is shown medially. Incision by a lateral sweep of the knife is preferred.

vides a better exposure of the spinal cord and it is easier to close (Fig. 1). With the dura mater placed on a stretch by the vertebral spreader, it is grasped with a hook in the center of the exposure and a small 3-mm. incision is made with extreme caution so that the arachnoid will not be opened. Rupture of the arachnoid with sudden release of intrathecal pressure may result in epidural hemorrhage. A fine silk suture is placed on either side of the small initial dural incision and used as a traction suture to draw the dura mater anteriorly. This will arrest the epidural bleeding. The groove director is inserted and the first diagonal dural incision is made, extending it as far lateral as the bony opening will permit. Two additional traction sutures are placed on the dural edge before the second diagonal incisions are cut in the opposite direction. Traction sutures should be located at the apex of each of the four dural triangular flaps (Fig. 2). The sutures are secured to the cervical retractor blades or sewed to the longus colli muscle laterally and to the anterior longitudinal ligament, vertically.

The arachnoid is opened, if it has not already been ruptured, and the cerebrospinal fluid is aspirated through a cottonoid sponge. Continual flooding of the operative field may be lessened by removing the fluid from the spinal canal through the previously placed lumbar-puncture needle. One is immediately impressed by the excellent exposure of the anterior surface of the spinal cord. The anterior spinal artery, the anterior pyramidal tracts, the motor rootlets at their exit from the cord which converge to form the motor root which can be followed to its exit in the dura mater, and the dentate ligament on either side are all identified (Fig. 1).

Chordotomy Incision. The principal advantage of making the chordotomy incision by the anterior approach is that the operator can visualize directly the anterolateral quadrant of the cord from the midline to the dentate ligament and the incision in the cord is made under direct vision with complete control of its exact size, length and depth. Fine capillaries of the corona radiata in the line of the incision may be obliterated with a weak, cutting current of the electric coagulation unit using the "cautery hook." The dentate ligament is not divided as is done routinely by the posterior approach but left intact. Its attachment
to the dura mater anchors the spinal cord firmly in position which secures the cord when the incision is made. The operator may choose one of several varieties of knives to make the incision in the cord: a cataract knife, a special chordotomy knife, a No. 11 scalpel blade on a long handle, or a broken fragment of a razor blade. The latter is preferred. A pointed fragment of the edge of a razor blade is held in a long-handled needle-holder having a narrow tip. The blade is placed so that 4 to 6 mm. project. This will limit the depth of the incision.

In the conventional chordotomy by laminectomy, the incision in the cord is made by inserting the knife into the lateral surface of the cord at the attachment of the dentate ligament and the cut is made medially and forward. This method of incision may be used in the anterior approach if the Hamby* and Bucy* right-angle chordotomy is employed. It is preferable and easier, however, to make the incision in a lateral direction. The point of the cutting blade is stabbed into the spinal cord at a spot just medial to the exit of the filament of motor nerve root and to a depth of 3 to 4 mm. The knife is passed laterally making the initial one-third of the incision. The lateral two-thirds of the cut is facilitated by inserting the cautery "hook" into the medial end of the incision and pulling the cord medially. This puts the cord and dentate ligament on a stretch, while moving the area to be incised to a more accessible position in the center of the operating field. The knife can then be rapidly and easily swept laterally through the remainder of the anterior quadrant to exit at the attachment of the dentate. Small pledget of Gelfoam is packed in the incision should any bleeding occur. If the surgeon stands on the patient's right side, the left side of the cord is better visualized and the incision in the left cord is made more easily. If the operator finds mechanical difficulty in executing the incision in the right cord, this can be facilitated by standing above the patient's head and by using the technique with knife and "hook" described above. If the operation is done bilaterally the incisions are made at the same level of the cord.

A differential section of the tract may be made, but experience has shown that sensory function usually returns in these cases.

In some of our patients who survived the operation 6 months or longer, a drop in the sensory level and a return of pain and sensation of temperature in the previous analgesic area were fre-

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Fig. 2. Artist's concept of operation in sagittal plane demonstrates bony opening through vertebral bodies and exposure of anterior and lateral surfaces of the spinal cord.
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quenty encountered. Since a deep incision into the spinothalamic tracts had been made under direct vision it was suspected that the return of sensory function was caused by regeneration and re-establishment of the continuity of the divided tracts. To obviate this, therefore, it recently was decided to include in the anterior cervical chordotomy the insertion of a foreign body into the incision in the cord to prevent or delay possible regeneration of tracts. A small triangular strip of thin tantalum foil is used for this purpose. Being somewhat rigid it can be slipped between the lips of the incision and into the spinal cord. A fine silk suture may be placed in the arachnoid on the edges of the incision in the cord to hold the tantalum within the cord. However, this usually is not necessary as the small metallic foreign body disappears readily into the soft substance of the cord and remains in situ. A tiny strip of polyethylene film may be used in place of tantalum foil.

Dural Closure. A watertight closure of the dura mater obviously is important. It is accomplished in the following manner: The vertebral spreader is removed from the interspace. If this does not relax the dura mater sufficiently to permit closure, the head is placed temporarily in a flexed position. If the cruciate incisions have been made carefully the four dural flaps can be easily brought together at the center point. The apexes of the vertical flaps are first sutured and tied. A small strip of cottonoid (Telfa) placed on the remaining triangular opening will prevent blood from entering the spinal canal should further epidural bleeding ensue when traction on the lateral dural flap is released. Using a small full curved eye needle, fine interrupted silk sutures are placed to obtain a water-tight closure of the dura mater.

The flap of the posterior longitudinal ligament is turned down over the dura mater and secured with two sutures. A small pad of Gelfoam is placed in the bottom of the drill hole and covered with a thin layer of the bone dust. During the drilling process, all bone dust is saved in a sterile basin containing a small amount of penicillin. The patient’s head is extended again to open the interspace for insertion of the bone graft.

Fusion. A tight-fitting dowel of bone is necessary to fill the large drill hole. It is obtained from the bone bank or secured from the patient’s anterior ilium with a 17.5-mm. dowel cutter. If the dowel is larger than this, requiring too great a spread of the interspace for its insertion, excessive vertical traction on the dura mater may separate the dural incision sufficiently to cause a spinal-fluid leak. A larger dowel may be trimmed so that it can be inserted without excessive spreading of the interspace or excessive pounding and still obtain a snug fit. The dowel is inserted level with or slightly below the anterior surface of the vertebral bodies (Fig. 3). Bone dust is packed into the opening in the interspace on each side of the dowel.

Wound Closure. The vertebral spreader and self-retaining retractors are removed from the wound, the tissues of the neck are permitted to fall back together and the wound is closed with fine interrupted chromic catgut sutures in the platysma muscle and subcutaneous layer. One small rubber-tissue drain is left in the wound down to the bone graft to drain off the excess blood and serum and possibly cerebrospinal fluid. Silk sutures are no longer used to close the skin; instead we use sterile strips of Micropore Surgical Adhesive* which result in an almost invisible scar.

Postoperative Care. Recovery from this operation is surprisingly smooth and uneventful. If the patient is able to ambulate, and has no headache from loss of spinal fluid, he is permitted out of bed the day of the operation to go to the bathroom. The preoperative pain, relieved by the chordotomy, and minimal operative pain make the use of analgesics almost unnecessary. If operative pain does occur, it is located across the top of the shoulders and apparently originates in the C4 nerve root. Most chordotomy patients, however, have received narcotics preoperatively and may require them in decreasing doses to prevent withdrawal symptoms. An ice collar is used about the patient’s neck for local comfort. Slight segmental edema of the esophagus from retraction may make swallowing difficult for the first day or two, requiring a soft or liquid diet, but this symptom rapidly disappears. The drain is removed from the wound the day after operation and a single black silk suture previously placed at the site of the drain is tied. The transverse strips of surgical tape are removed and replaced with a single strip to cover the entire wound which is the only dressing required, and this is removed together with the suture on the 4th or 5th postoperative day. The patient should be able to leave the hospital free from pain within 3 to 5 days after operation if only the morbidity of the operation is considered.

Postoperative Complications

The only complication encountered with the procedure was drainage of cerebrospinal fluid through the operative wound. If closure of the dura mater is not water-tight, quantities of spinal fluid will escape via the rubber-tissue drain. This occurred in our first patient. He seemed to suffer no ill effects from loss of a considerable quantity of spinal fluid even though he was up and about the ward. When the drainage did not stop after 3 days,

* Manufactured by Minnesota Mining & Mfg. Co. (3M) Tape #1399, St. Paul, Minn.
a lumbar puncture was performed, and 25 cc. of spinal fluid were removed from the spinal canal. The patient was required to remain flat in bed for 24 hours. The spinal-fluid leak stopped and did not drain thereafter. No postoperative cerebrospinal-fluid drainage has occurred in subsequent patients in whom the cruciate dural incision was used.

Summary and Conclusions

A new operation for performing a chordotomy for relief of pain is described. It consists of an anterior surgical approach to the ventral surface of the cervical cord through a large trephine hole made between two vertebral bodies. A cruciate incision in the dura mater gives excellent exposure permitting incision of the spinothalamic tracts under direct vision. For bilateral pain both incisions are made at the same level of the cord without causing impairment of motor function of the lower extremities or bowel and bladder. A high level of analgesia is obtained initially. The surgical opening in the spine is filled with a bone dowel at the end of the operation which results in a fusion of the two vertebral bodies.

The results of this operation performed 11 times on 10 patients, followed over an 18-month period, are briefly as follows: All but 1 of the 6 patients operated upon for relief of pain caused by malignant disease died from 1 to 8 months after chordotomy. One patient is still alive 13 months after operation; the pain was relieved for 3 months and the patient has required narcotics since. Three were pain-free until death, and 3 were partially or temporarily relieved. One of these had a second chordotomy later by laminectomy, again with only temporary relief of pain. In 4 patients operated upon for pain of nonmalignant origin, 1 was free from pain for 8 months. A second anterior cervical chordotomy failed to relieve his pain. He died from a ruptured duodenal ulcer. One patient remains free from pain after 11 months. But in 2 patients sensation returned in 4 months and 7 months respectively, and the preoperative pain recurred in each case.

It is apparent from these results that even

![Fig. 3. Postoperative roentgenogram showing large dowel used to fill the surgical opening in the spine. Arrows indicate size of exposure of spinal cord for anterolateral chordotomy.](image-url)
though a surgically adequate section of the spinothalamic tract is made under direct vision, one can expect a change of the sensory deficit with return of sensory function and pain in a high percentage of patients who live 6 months or longer after operation. The cause of this has not been explained. Some surgeons think there is either regeneration or re-routing of the spinal-cord pathways after section.

Experiences with this operation to date justify the following conclusions:

1) Cervical chordotomy by the anterior approach has a much lower morbidity and fewer complications than the conventional procedure by laminectomy.

2) A more complete section of the spinothalamic tract is possible because the incision is made under direct vision.

3) A differential section of the tract with sparing of sensation in nonpainful areas is possible by this approach.

4) An opportunity is provided to test the theory of regeneration of tracts, and a method to accomplish this is proposed.

5) This approach to the anterior surface of the cervical cord at any level makes possible physiological investigation, stimulative experiments and possibly therapeutic surgical procedures on motor and sensory pathways located in the anterior half of the spinal cord which heretofore have been inaccessible surgically.

References

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