Cervical cordotomy for the treatment of oncological pain
Cordotomia cervical para tratamiento da dor oncológica.
Revisâo de literatura

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Abstract

Cordotomy consists in the discontinuation of the spinothalamic tract in the anterolateral quadrant of the spinal cord and aims to reduce the transference of nociceptive information in the dorsal horn of the grey matter of the spinal cord (CPME) for rostral units at the neural axis. Many modalities of cordotomy may be employed: anterior transdiscal between C4-C5; endoscopic infra mastoid tip between C1-C2; percutaneous guided by fluoroscopy infra mastoid tip between C1-C2; percutaneous guided by CT infra mastoid tip between C1-C2; open cordotomy by means of laminectomy. The main indication is for patients in advanced cancer disease with severe neuropathic pain bellow the neck in whom the period of survival due to cancer disease is inferior to 3-4 months. The results for immediate pain relieve ranges from 69% to 100% of the cases, while preoperative Karnofsky scores were 20 and 70, respectively versus post operative Karnofsky scores of 20 and 100 respectively; the difference was determined to be highly significant (p < 0.001).

Key words: Cordotomy, spinothalamic tract, thermocoagulation, radiofrequency.

Resumo

A cordotomia consiste na discontinuação do trato espinotalâmico no quadrante ântero-lateral da medula espinal e visa reduzir a transferência de informação nociceptiva no corno dorsal da substância cinzenta da medula espinal (CPME) para as unidades rostrais no neuroeixo. Muitas modalidades de cordotomia podem ser empregadas: transdiscal anterior entre C4-C5; endoscópica inframastoidea entre C1-C2; Percutânea inframastoidea entre C1-C2 guiada por fluoroscopia; percutânea inframastoidea entre C1-C2 guiada por TC; cordotomia aberta por laminectomia. A principal indicação é para pacientes com câncer avançado com dor neuropática severa abaixo do pescoço nos quais a sobrevida devido ao câncer é inferior a 3-4 meses. Os resultados para alívio imediato da dor variavam de 69% a 100% dos casos, enquanto os escores de Karnofsky foram de 20 e 70 no período pré-operatório, para 20 e 100 no período pós-opertaário; a diferença foi estatisticamente significativa (p < 0.001).

Palavras-chave: Cordotomia, trato espinotalâmico, termocoagulação, radiofrequência.

Introduction

Many options of treatment for oncologic pain have been tried in the recent past decades, but the most popularized is the cordotomy. It is based on physiological principles of interruption of anterior spinothalamic pathway by means of thermocoagulation. Thermocoagulation caused by radiofrequency is the aim, and the irreversible character of the procedure brings the necessity of an ideal indication. We have emphasized the procedure for patients in advanced cancer disease with severe neuropathic pain bellow the neck in whom the period of survival due to cancer disease is inferior to 3-4 months.
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Many modalities of cordotomy may be employed: anterior transdiscal between C4-C5; endoscopic infra mastoid tip between C1-C2; percutaneous guided by fluoroscopy infra mastoid tip between C1-C2; percutaneous guided by CT infra mastoid tip between C1-C2; open cordotomy by means of laminectomy.

Definition

Cordotomy consists in the discontinuation of the spinothalamic tract in the anterolateral quadrant of the spinal cord (Figure 1) and aims to reduce the transference of nociceptive information in the dorsal horn of the grey matter of the spinal cord (CPME) for rostral units at the neural axis21. The radiofrequency of cervical percutaneous cordotomy is performed under local anesthesia with the patient awake and sedated. After a perimyelography or stereo tomomyelography procedure, for spinal cord delineation of the dented ligament, one electrode is introduced via lateral, inside the anterolateral quadrant of the spinal cord between the first and second cervical vertebras21,30. After electrical stimulation, lyses of the spinothalamic tract is performed by radiofrequency. An interval of at least three weeks is recommended between procedures in cases of bilateral cordotomy. The open cordotomy is a procedure that consists in an open laminectomy and the exposure of the first and second cervical segments of the cervical spinal cord, or the second and third segments of the spinal dorsal cord, and the section of the anterolateral quadrant of the medulla using a scalpel.

Historical remarks

Edinger in 1889 identified the lateral spinothalamic tract (LST) for the first time1. In 1905, Spiller observed the abolition of pain and heat sensations in the contralateral half of the body in a patient with tuberculosis based in the anterolateral quadrant of the spinal cord21. Schüller, in 1910, has performed a section at the anterolateral quadrant of the spinal cord in monkeys and called the procedure chordotomy or cordotomy, and suggested the treatment for gastric pain crises20. Martin at Spiller’s investigation in 1911 performed the first anterolateral cordotomy for pain treatment in humans31, 32. In 1963, Mullan et al, described the cervical percutaneous cordotomy which consisted in an implant of a radioactive strontium needle to interstitially irradiate the anterolateral quadrant of the spinal cord. He observed that such procedure gradually relieved pain. Subsequently, during the procedure, electrical current was used22. Thereafter Mullan began making unipolar, anodal, electrolytic lesions in 196523. In 1965, Rosomoff described percutaneous cervical cordotomy using radiofrequency23. The percutaneous method was performed in lower cervical region by anterior approach by Lin and Gildenberg in 196619. In 1988, Kanpolat et al published the first experience with computed tomography (CT) visualization in a stereotatic pain procedure, later using CT guidance as a visualization method in PC13. Morphological orientation and neurophysiologic evaluation of the target allowed the use of this truly stereotatic method with radiofrequency24,13. Fonoff and Teixeira (2007) demonstrated that it is possible to explore the anterior portion of spinal cord through endoscope by the same tube of needle or by a second hole specific for endoscope between C1 and C2 in order to proceed the percutaneous cordotomy by endoscopic visualization25,33.

Functional Anatomical Basis for the Procedure

The target in cordotomy is the LST, which is located in the anterior portion of spinal cord9,10,24,29,33. The ascendant tract carries information about pain and temperature and relays some tactile information. The distribution of the pain conducting fibers within the anterolateral spinal tract consists of small, ventrally located fibers mainly conducting pain sensation. A functional organization of fibers from outside to inwards follows the sequence: superficial pain, temperature, and deep pain26. The anterolateral sensory system has a somatotrophic relationship, with fibers from higher levels laminating medially and ventrally and fibers from lower levels laminating laterally and dorsally in side the LST24,34,38,39. Segmentation of fibers provides the opportunity for selective cordotomy, given that anteromedial lesions denervate the contralateral arm and upper chest region, whereas posterolateral lesions denervate the sacral and lumbar area. Morphometric researches of spinal cord at the level of surgical approach have provide critical information pertaining to anatomical orientation for cordotomy. Kanpolat et al measured the spinal cord diameters of 63 patients who underwent computed tomographic (CT) guided PC at C1-C2 level at 7.0-11.4 mm (mean 8.66 ± 0.72) anteroposteriorly, and 9.0 to 14.0 mm transversely (mean 10.9 ± 1.56 mm)34. The narrow “safety zone” of white matter is located between the anterior extent of pyramidal tracts and the posterior aspect of the lateral spinothalamic tract. Rarely the dentate ligament is placed outside to its normal place30. Due to variation in size and location of the ventral corticospinal tract, a special care it is necessary to make the lesion adequately. Motor fiber decussation may extend from obex to C1, and a high lesion in this LST can cause contralateral leg weakness34. The ventral spino cerebellar tract is located in the lateral portion of LST, and unfortunately lesions of this tract can cause ipsilateral ataxia of the arm. Autonomic fibers related to bowel and bladder function are found in the lateral...
horn of gray matter. Vasomotor fibers are just behind the autonomic fibers, and their lesions can cause arterial hypotension44. The descending respiratory pathway is located in the medial aspect of LST24. Bilateral lesions of this region may cause sleep induced apnea, the most severe complication of cordotomy.

Indications

In general, the cordotomy is indicated for pain treatment originating by cancer which unilaterally attacks distal segments affecting the cervical rostral region, in other words, lower limbs, hemi perineum, hemi abdomen, or hemi thorax and upper limbs37. It is said that candidates for cordotomy are patients with lateral somatic cancer pain and compression of the plexus, roots or nerves38. In 1996, Tasker defined two types of pain as indications for cordotomy: one is intermittent, neuralgia-like, shooting pain into the leg as associated with a spinal cord injury typically at the thoracolumbar level, the other type is evoked pain-alldynia or hyperpathia-associated with neuropathic pain syndromes that arise from peripheral neurological lesions35,36. The best candidates for CT guided percutaneous cordotomy are those which unilateral localized pain, as seen in mesothelioma of the chest wall or carcinoma of lower extremities11,15,17. Bilateral CT guided cordotomy is selected for the patient with intractable pain localized in the lower part of the body10,13,16.

In the literature there is a current opinion that cordotomy is indicated after long period morphine therapy6,26,27. However other authors prefer to proceed the cordotomy just before the initiation of the narcotic therapy, specially if the patients survival is expected to be more than six months14. Increased use of chronic intrathecal pain medication delivery via implantable pumps has lessened the frequency with which this procedure is performed.

Contra-indications

The patients should be submitted to a preoperative evaluation of e spirometry, demonstrating a pulmonary capacity of 95% of oxygen and 5% carbon dioxide spirometry. Patients with decreasing minute volume are at increased risk of postoperative sleep apnea. Pulmonary function tests if suspect contralateral diaphragmatic dysfunction33. In summary, patients with severe pulmonary dysfunction and in whom partial oxygen saturation is lower than 60% are not suitable candidates for cordotomy16. Patients with neck metastasis could be a contra indication for needle puncture if the compromised area is involved14.

Technical details

a- Percutaneous cordotomy guided by fluoroscopy or CT infra mastoid tip between C1C2

Local anesthesia and gentle sedation must be employed because the patient must be highly cooperative. Patient must be placed in supine position and the level of mastoid process be maintained at the same height as acromioclavicular joint33. A Rosomoff head fix is useful for this procedure. Routine sterile scrub preparation and drape of lateral neck contralateral to patient’s pain, from above mastoid to mid-cervical region are the standard pre preparative procedures.

Lidocaine 1% without epinephrine is used as infiltration into the region contralateral to the pain, 1 cm inferior to mastoid tip. A horizontal 18 gauge spinal needle is inserted to the midpoint between the anterior rim of the C2 spinous process and the posterior rim of C2 body directed at the anterior part of the spinal cord (on CT guidance using 1 mm slice thickness). The needle trajectory is maintained rostral to the lamina of C2 to prevent puncture of the nerve.

After the dura is penetrated 2 ml of cerebrospinal fluid is aspirated and mixed with 2 mL of contrast (Pantopaque or Lipiodol), and air. The mixture is injected into the subarachnoid space and small bubbles are concentrated above the dentate ligament. Another possibility may be the injection of contrast and mixture 20 minutes before the procedure through lumbar space, if the technique be guided by CT. The radiofrequency needle electrode is placed in a point immediately anterior to dentate ligament.

To better evaluate the position of needle the impedance must be measured, being 200 to 400 ohms in CSF, and 800 to 1,000 ohms in the spinal cords (could reach 1,500 ohms). Stimulation from 50 Hz for localization to 100 Hz must be performed and the patient should report contralateral tingling at threshold under 1 volt. If a strong muscle contraction or tetany is observed the lesion should be postponed till the correct insertion of the needle be done. To begin the radio frequency lesioning, the patient has to contract the ipsilateral hand. This way the voltage is increased from zero. The voltage is reduced if hand twitching is detected. The first lesion of 100 degree Celsius is sustained for 30 to 60 seconds and the next step is to perform a second lesion. In between, the patients is examined for regions of anesthesia. Supine position is maintained for 24 hours.

b- Open cordotomy guided by fluoroscopy infra mastoid tip between C1C2

This procedure will be accomplished by means of cervical laminectomy in a ventral position, and general anesthesia. Intravenous antibiotics (cefazolin 2 g) should be given 30 minutes before the incision. The neck must be flexed to open the interlaminar space. The prone position may be used too, but the head must be flexed and a risk of air embolism is possible. The incision is from the inion to C3 in midline. Subperistomal dissection of muscles from posterior rim of the foramen magnum, C1 lamina and C2 lamina. The small interlaminar space between C1 and C2 must be identified, and inferior C1 hemilaminotomy and superior hemilaminotomy C2 must be accomplished. The flavum ligament is incised and then resected. Dura may be incised between C1 and C2 with an 11 blade along the lateral third of hemilaminectomy and care must be taken about epidural veins in this region. The arachnoid is opened and the dentate ligament is identified and its lateral attachment is incised, and its used to rotate spinal cord with prolene sutures. A 11 blade is used to incise the spinal cord anteriorly to the dentate ligament to depth of 5 mm (bone wax may be useful to limit the premeasured depth on the blade). A watertight dural closure should be employed to avoid CSF leak. Bilateral posterior procedures should be performed with a 1 week interval14,15.

C- CT guided percutaneous cordotomy

Normally neuroleptic analgesia should be given at a dose that will not affect patient cooperation during the procedure14,15. General anesthesia is used by
some surgeons\textsuperscript{7}. Contrast material should be administered into the subarachnoid space of the spinal cord. Pantopaque, lipiodol, and iohexol (7-8 ml) are given 20-30 minutes before the surgery by lumbar puncture. After injection of contrast medium, the table is repositioned to Trendelenburg position for 15 minutes to observe the contrast in the cervical region. If the general condition of the patient does not permit lumbar puncture, contrast material is injected during the procedure at the C1-C2 level\textsuperscript{14,16}. The target is the anterolateral section of the spinal cord where the lateral spinothalamic tract is located.

The patient is placed on the CT table in supine position and has the head flexed and fixed after injection of a local anesthetic. A 20 gauge plastic tube is placed inferior to the tip of the mastoid in a longitudinal plane perpendicular to the axis of the spinal cord. Placement of the cannula at the C1-C2 level can be identified in the lateral scanogram, and direction of the needle is orientated toward the anterior aspect of the spinal cord using axial CT sections. Ideal placement is 1 mm anterior to dentate ligament for lumbosacral fibers and 2-3 mm anterior for cervical and thoracic fibers. After this the needle is ideally positioned, the straight or curved active electrode is inserted\textsuperscript{16}. As similar to others techniques for cordotomy the impedance of CSF is 200 to 400 ohms and when inserted inside the spinal cord the impedance should be more than 700 ohms. The advantage of CT guided is that we can find out about the insertion inside the spinal cord by direct vision on screen\textsuperscript{14,16}. The final confirmation about the position of the needle is the neurophysiological stimulation. With 5 Hz stimulation, motor contraction in the ipsilateral occipital muscles indicates that the electrode is close to the upper cervical anterior gray matter. If the electrode is correctly placed in target, the patient describes a warm or cool sensation and tingling in the sensory dermatomes of the electrode localization with a 50 to 100 Hz high frequency stimulation. Certainly the same voltage as for the other modalities of cordotomy with radiofrequency is recommended (0.2 to 3 Volts). If sensorial response is obtained with lower voltage, it indicates that the electrode is in the target. Lesion test is performed with temperature ranging from 50-60 degree Celsius (over 43 degree Celsius). After that we can achieve the lesion with 70 to 100 degree Celsius. We recommend an electrode kit (KCTE Kanpolat CT electrode Kit, Radionics, Inc. Burlington, MA) with 20 gauge, thin walled needles and plastic hubs designed to avoid imaging artifact problems. Demarcations on the cannula indicate the depth of insertion. The kit also includes two open-tip thermocouple electrodes with 2 mm tips and diameters of 0.3 mm and 0.4 mm (one straight-tip electrode and one curved tip). The smaller caliber electrode (0.3 mm) is usually used for bilateral cordotomy whereas the larger electrode is preferred for unilateral cordotomy\textsuperscript{12}.

d- Cordotomy by transdiscal anterior approach

In the anterior approach, the skin, subcutaneous tissue and paravertebral fascia are infiltrated with local anesthetic. An 18 gauge, thin walled spinal needle is inserted opposite to the cordotomy site, medial to the carotid sheath and lateral to the trachea and esophagus at the C4-C5, C5-C6 or C6-C7 level. With help of X-ray imaging or CT the needle is observed as it passes through the disc space and is placed in the anterior lateral part of spinal cord\textsuperscript{12,19}. After reaching the subarachnoid space, only the anterior part of the spinal cord can be visualized indirectly on air mielogram\textsuperscript{19}. Impedance measurements are important indications of passage into a new medium along the path of the electrode. Impedance values are about 400 ohms in the CSF; an increase of approximately 200 ohms is observed when the electrode gets in touch with the pia. The rating is almost always greater than 1,000 ohms after insertion into the spinal cord. A test lesion should be made at 55 to 60 degree Celsius for 60 seconds before making the final lesions. We should make two or three lesions at a temperature of 70 to 80 degree Celsius for 60 seconds, testing the neurological function taking in concern analgesia level and motor function in each lesion.

Results

Cordotomy results in immediate pain relief in 69% to 100% of the cases\textsuperscript{39}. It cannot be completed in about 5.4% of the cases. There is a reduction in the frequency of health improvement from 90.2% to 62.5% during the follow up period ranging from one to fifteen weeks. The results of the neuropathic pain treatment and nociceptive pain, not due to cancer, are disappointing\textsuperscript{37}.

Other results may expressed by visual analogue scale (VAS), and Karnofsky scale in pre and post operative measurement.

Patients may be evaluated in four groups postoperatively according to Kanpolat, 2009: Grade I- no pain; Grade II- partial satisfactory pain relief ; Grade III – partial non satisfactory pain relief; Grade IV- no change in pain. Grades I and II were accepted as successful outcome and grades III e IV as unsuccessful. According to kanpolat series, 2009, he performed 246 CT guided percutaneous cordotomies in 222 patients. The majority of patients suffered from intractable pain related to malignancy. In 12 cases the procedure was bilateral, and in 210 uni-laterally. The malignancy group (n = 207) was composed by 48.3% or 61 cases of pulmonary malignancies, mesothelioma in 24 cases, Pancoast tumor in 15, gastrointestinal carcinoma in 26 cases, metastatic carcinoma in 21 cases, and 60 with miscellaneous malignancies. The results were 92% reported initial pain relief (grades I-II), minimum and maximum preoperative Karnofsky scores were 20 and 70, respectively (mean 45.5 ± 14.3) versus post operative karnofsky scores of 20 and 100 respectively (mean of 64.5 ± 15.5), and the difference was determined to be highly significant (p < 0.001). Mean preoperative VAS score was 7.62 ± 0.68 (minimum 3, maximum 10) versus postoperative scores of 0 and 8, respectively (mean 1.18 ± 1.89), and the difference was determined to be highly significant (p < 0.001).

Complications

The cervical cordotomy should be avoided in patients with respiratory insufficiency. Its most frequent complications are: Claude Bernard-Horner’s Syndrome or Horner’s syndrome, urinary retention, arterial hypotension, sensorial ataxy, hypotony and ipsilateral hemiparesis, but fortunately, temporary or not remarkable. Motor and sphincter or sexual deficits are manifested in less than 10% of the cases.

Other less frequent complications include a respiratory dysfunction and sleep apnea (Ondine’s Syndrome). Be-
ing this last one the most common when the procedure is performed bilaterally or when analgesia is related to the brachial dermatomes.

In 207 cases of patients submitted to a cordotomy by Kanpolat series, 2009, temporary motor paralysis was observed in 5 cases, ataxia in 5 cases, and no mortality. In bilateral cordotomy temporary hypotension and temporary urinary retention occurred in 3 and 2 cases respectively. The only permanent complication was dysesthesia in four cases (1.8%)\(^{17}\).

According to Lahuerta et al, 1985\(^{18}\) complications usually occurred when the lesion of cordotomy had an extension over 20% of the spinal cord.

Myelopathic pain manifests in less than 20% of cases on the site of preoperative pain (neuropathic oncologic pain), or where previously there was no pain (spinothalamic fiber injury), or as a recovery of a painful sensitivity in painless sites (loss of efficacy in the procedure). Eventually, contralateral pain from the original pain (mirror pain) can manifest itself after unilateral surgery\(^{27}\).

Bilateral cordotomy is not recommended for upper trunk pain because of the risk of respiratory complications\(^{33}\).

The surgeon who performs cordotomy and controls pain successfully must remember not to stop morphine therapy suddenly. Most patients reduce their dosages progressively and discontinue morphine use over time.

**Conclusions**

Many options of treatment for oncologic pain have been tried in the recent past decades, but the most popularized is the cordotomy. Edinger, Spiller, Rosomoff were some of the researches committed with the development of cordotomy. It consists in the discontinuation of the spinothalamic tract in the anterolateral quadrant of the spinal cord. Many modalities of cordotomy may be employed. Nevertheless complications and results are similar with any of them. The results are exciting, achieving immediate pain relieve in 69% to 100% of the cases, and mainly temporary or no remarkable complications.

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