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RESEARCH ARTICLE

Effectiveness of CT-guided percutaneous cordotomy in intractable cancer pain: Experience in 14 patients

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Abstract

Background: Severe and treatment-resistant pain is a major issue for patients with cancer. Cordotomy is an effective approach for addressing severe cancer-related pain. It is based on blocking the transmission of pain by damaging the lateral spinothalamic tract.

Methods: Computed tomography guided cordotomy was performed on 14 patients who did not respond to medical and interventional pain management methods.

Results: Fourteen patients with cancer pain underwent CT-guided percutaneous cordotomy. Pain relief was reported in 86% of the patients. The visual analog scale values before and after cordotomy were compared and a significant difference was found ($p=0.0001$). The improvement in the Karnofsky Performance Scale score of the patients was found to be statistically significant ($p=0.0001$).

Conclusion: We believe that CT-guided cordotomy, performed by experienced hands in a team of experienced individuals and applied to the right patients, is an effective treatment. However, it is crucial to exercise extreme caution regarding potential side effects and serious complications during the cordotomy procedure.

KEYWORDS
cancer, cordotomy, CT-guided, pain

INTRODUCTION

Advances in oncology have extended the life expectancy of cancer patients, but some cancers are progressive and cause increasing pain, impairing quality of life. The side effects and tolerance associated with drug treatments are additional issues that require attention. Cancer-related pain is one of the most common and distressing side effects of cancer, with nearly one-third of patients with locally advanced or metastatic cancer experiencing moderate to severe pain during treatment or in advanced stages of their disease.[1] As such, pain control may be the top priority in caring for individuals with cancer.

Invasive pain management interventions, such as cordotomy, are necessary for managing cancer-related pain. Cordotomy is a useful procedure for patients with unilateral, localized, intractable, somatic cancer-related pain who do not respond adequately to less invasive methods. Cordotomy targets the lateral spinothalamic tract (LSTT) in the anterolateral region of the spinal cord, which is the main pathway for transmitting nociceptive information and responsible for transmitting pain and temperature sensation. The cell bodies of the LSTT neurons are located in the dorsal horn, and most of their axons cross over to the opposite side in the anterior commissure and then ascend upwards through the anterolateral column. Most of the axons cross over to the opposite side 2–5 segments before joining the anterolateral column. Therefore, computed tomography (CT)-guided percutaneous cordotomy is indicated for unilateral pain below the level of C5. The neurons in the LSTT are organized somatotopically, with neurons from distal regions of the body (lower extremities, lumbosacral region) located posterolaterally, and those from proximal regions (upper extremities, thoracic region) located anteromedially.[2]

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The percutaneous cordotomy procedure was developed by Mullan et al.[3] in 1963, and radiofrequency thermocoagulation was used to create lesions by Rosomoff et al.[4] in 1965. The safety and efficacy of the procedure increased with computed tomography (CT) guidance, as described by Kanpolat et al.[5–8]

In this study, we evaluated the effectiveness of CT-guided percutaneous cordotomy in managing cancer-related pain and its associated complications at the University's Pain Clinic.

PATIENTS AND METHODS

We examined 14 patients who gave consent and underwent CT-guided cordotomy between 2019 and 2022. All patients had cancer-related pain that was not effectively managed by other noninvasive or less invasive methods (nerve blocks, radiofrequency (RF) ablation, dorsal root ganglion pulsed RF, epidural injections sympathetic blocks). The cordotomy was performed using the method described by Yücel Kanpolat.[7]

The patients, consisting of 3 women and 11 men, ranged in age from 37 to 71 years. Seven of the 14 patients were diagnosed with lung cancer, two had soft tissue cancer, one had breast cancer, one had prostate cancer, one had cervical cancer, one had bladder cancer, one had rectal adenocarcinoma, and one had renal carcinoma.

All patients had metastases in bone or surrounding organs and were taking high doses of analgesics. Five of the 14 patients had pain in their legs and sacral/lumbar areas, while the remaining nine patients had pain in their arms and upper chest region. The reason for the spread of pain to the extremities or chest wall in these patients was due to the primary cancer metastasizing to the extremities and ribs. Two patients underwent bilateral cordotomy.

During the radiofrequency thermocoagulation, we used a needle and an active radiofrequency electrode with a 2 mm active tip, which was advanced through the needle. The needle was advanced until the cerebrospinal fluid (CSF) was observed, and then it was used as a guide. A 2 mm active tip electrode was used in all cordotomy procedures performed with fluoroscopy or CT guidance.[5–10] This is because there are many important structures around LSTT. The corticospinal tract is located posterior to LSTT. Lesioning this tract can result in ipsilateral motor damage. The spinocerebellar tract is located laterally to LSTT. Lesioning this tract can result in ipsilateral ataxia. The reticulospinal tract is located anteromedial to LSTT. This tract originates from the medulla's respiratory center and maintains automatic respiration. Unilateral damage to this pathway does not cause any problems if lung function is normal, but bilateral damage can cause serious respiratory distress or even fatal sleep apnea. Additionally, damage to the autonomic fibers can cause bowel and bladder dysfunction. Because of the vital importance of these structures near LSTT, the lesion must be minimal and limited to LSTT, and should not cause any damage to surrounding structures.

A water-soluble contrast agent, iohexol (Omnipaque 350 mg/mL), was used during the procedure. This contrast agent made the spinal cord visible.

A *p*-value of more than 0.05 was used to indicate statistical significance.

Intervention

The patients were placed in a supine position with their necks flexed 10°–20°. The head was fixed with plaster. The mastoid process on the opposite side of the painful side was palpated. Local anesthesia was applied just below the mastoid process, usually corresponding to the C1-2 level. The needle was placed vertically against the skin. Then, a CT scan was taken in the lateral view to confirm the needle's position in the C1-2 level (Figure 1). The needle's location, orientation, and distance from the cord were determined in the sagittal view. The target of the needle was the lateral spinothalamic tract located on the anterolateral side of the spinal cord. The needle was advanced towards the target. Each time the needle was advanced, a new CT scan was taken in the sagittal plane to visualize its position. When the needle approached the dura, the stylet was removed. After the dural puncture, CSF was observed. Then, a water-soluble contrast agent (7 mL Omnipaque (350 mg/mL) + 3 mL saline) was slowly injected to make the spinal cord visible. In the axial section image obtained from CT, the spinous process of C2 is seen posteriorly, the vertebral body of C2 is seen anteriorly, the pedicle of C2 is located just lateral to the vertebral body, in the middle of the spinal cord is visualized at the center of the spinal canal, and around

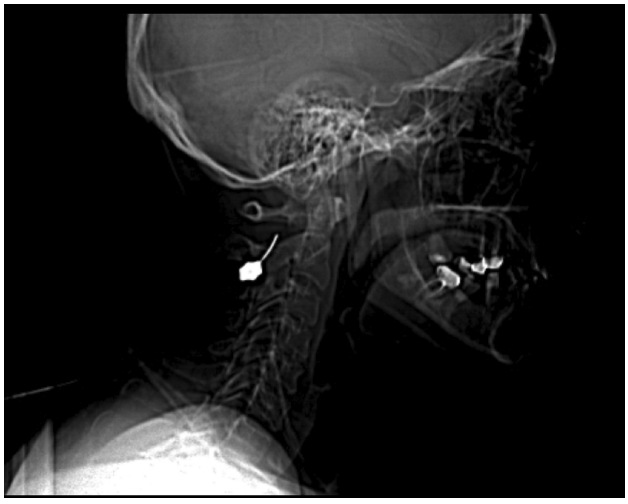


FIGURE 1 Lateral CT digital image showing the needle at the level of C1–C2.

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it, the contrast-filled subarachnoid space is observed (Figure 2). After the contrast agent was injected, electrode was advanced through the needle. This electrode monitored the changes in impedance as the needle was advanced. The impedance was 100–300 Ohm when the electrode tip was in CSF, 300–600 Ohm when the electrode tip touched the spinal cord, and 600–800 Ohm when the needle was inside the cord.

The electrode's position was visualized by taking CT scans in the sagittal plane at each step of advancement. The needle's position was confirmed by monitoring impedance and observing CT images. The electrode should be located in the LSTT (lateral spinothalamic tract) on the anterolateral side of the cord (Figure 3). However, the electrode's location within the tract varies depending on the location of the pain. If the pain is in the upper extremity or thorax, the electrode should be located on the anteromedial side of the LSTT. If the pain is in the lower extremity, the electrode should be located on the posterolateral side of the LSTT. Another structure that guides the electrode placement is the dentate ligament. If the pain is in the upper extremity or thorax, the electrode should be 2-3 mm anterior to the dentate ligament. If the pain is in the lower extremity, the electrode should be 1 mm anterior to the dentate ligament. This position should be checked by monitoring impedance and stimulation. Stimulation was started at 100 Hz. If the patient felt tingling or thermal sensation in the painful area on the opposite side of the needle when stimulated with 0.1–0.2 V, it meant the needle was in the LSTT. If the patient felt the sensation at higher voltages, the needle was repositioned with small movements. Then, motor response was checked with stimulation at 2–5 Hz. If a contraction was observed on the same side of the upper or lower extremity in response to stimulation, the electrode was close to the corticospinal tract. In this case, the tip of the electrode was posterior and was considered to be slightly more anterior. Or if a contraction was seen in the ipsilateral trapezius muscle or neck muscles in response to stimulation, the electrode was considered to be close to the anterior horn of the spinal cord. In this case, the needle tip was considered too deep and was withdrawn slightly. If no motor response was obtained with stimulation (0.5–2 V), the location of the electrode was considered correct.

The final position of the electrode was confirmed through impedance and after the stimulation response was confirmed, it was heated to 80 degrees under sedation (0.05 mg/kg propofol) for 10 s, then 20 s, and finally 30 s to create a lesion. After each lesion was performed, the pain level was monitored using the pinprick test. The muscle strength of the extremities on the lesion side was examined. If no complications were observed, the patient was discharged 5–6 h after the procedure was performed.

RESULTS

Cordotomy was performed on 14 patients with cancer-related pain who did not respond to medical and minimal interventional pain treatments at the Algology Clinic of Akdeniz University. 78.6% of the patients were male and 21.4% were female. Of the 14 patients, 7 (50%) had lung cancer, 1 had soft tissue cancer, 1 had breast cancer, 1

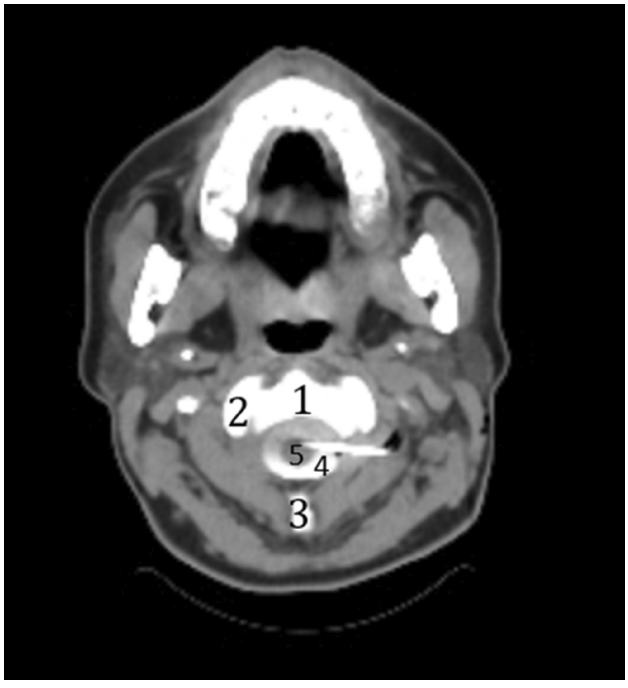


FIGURE 2 Axial CT Image (C2 body level) 1. C2 vertebral body 2. C2 pedicle 3. C2 spinous process 4. Intrathecal contrast in subarachnoid space 5. Spinal cord.

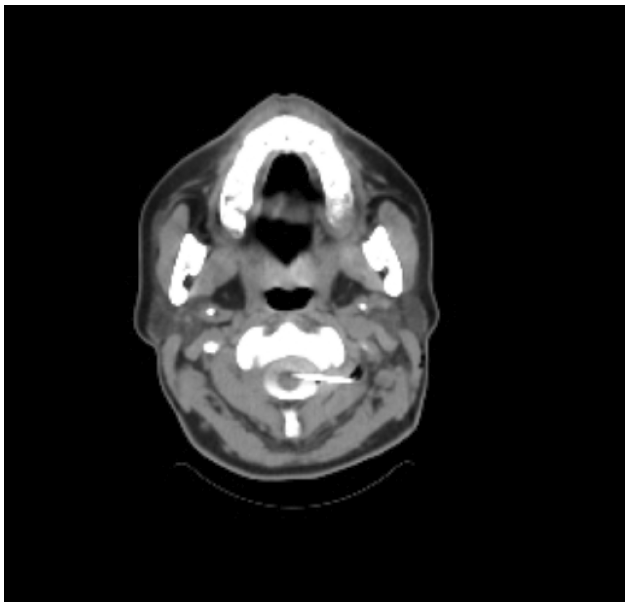


FIGURE 3 Position of the needle in the anterolateral part of the spinal cord after iohexol.

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TABLE 1 Patient's list.

Patients number	Cancer type	Gender	Age	Pain distribution	KPS before	KPS after	VAS before	VAS after	Opioid before (MED)	Opioid after(MED)
1	Lung ca	M	62	Right rib	40	70	10	2	1320	360
2	Rectal adenoca	M	37	Right hip and leg	40	80	10	0	1080	240
3	Renal ca	M	52	Right shoulder	20	50	10	1	978	258
4	Soft tissue ca	M	60	Right hip	30	60	10	1	1000	180
5	Prostate ca	M	71	Right rib and shoulder	20	50	10	1	880	138
6	Cervix ca	F	49	Right pelvis and leg	40	70	10	0	840	120
7	Bladder ca	M	65	Right leg	30	70	10	0	738	138
8	Lung ca	M	68	Left shoulder and chest	40	70	10	1	858	198
9	Lung ca	M	63	Right shoulder and rib	30	50	10	2	960	300
10	Breast ca	F	49	Right rib, shoulder and arm	60	90	10	1	720	180
11	Lung ca	M	65	Right rib and chest	60	90	10	2	618	138
12	Lung ca	M	69	Left rib and chest	50	80	10	1	840	180
13	Lung ca	F	71	Left rib, chest and shoulder	40	70	10	1	738	158
14	Lung ca	M	55	Left rib and chest	30	70	10	0	778	258

Abbreviations: KPS, Karnofsky Performance Status; MED, Morphine Equivalent Dose; VAS, Visual Analog Scala.

had prostate cancer, 1 had cervical cancer, 1 had bladder cancer, 1 had rectal adenocarcinoma, and 1 had renal carcinoma. There was no significant difference in mean age between patients diagnosed with lung cancer and those diagnosed with other types of cancer ($p=0.58$). The patients' details are shown in Table 1.

The mean visual analog scale (VAS) score of the patients before cordotomy was 10, and the mean VAS score after cordotomy was 1.00±0.67. A significant difference was found between the VAS scores before and after cordotomy ($p=0.0001$) (Table 1). The mean morphine equivalent dose used before cordotomy was 882±178 mg, and after cordotomy it was 206±69 mg. A significant difference was found between the doses used before and after ($p=0.0001$) (Table 1).

The mean Karnofsky Performance Scale score of the patients was 37.85±12.51 before cordotomy and 69.28±13.28 after cordotomy. A significant difference was found between the scores before and after cordotomy ($p=0.0001$) (Table 1). The relationship between lung cancer and other cancer types and the Karnofsky Performance Scale score before and after the procedure was investigated. In patients with lung cancer, the score was 34.28±4.70 before cordotomy and 67.14±5.15 after cordotomy. In patients with other cancer types, the score was 41.42±4.70 before cordotomy and 71.42±5.15 after cordotomy (Table 2). Both groups showed a significant increase, which was parallel to each other. However, a significant difference was found between lung cancer and other cancer types ($p=0.0001$). The rate of increase in Karnofsky Performance Scale score after cordotomy was higher in patients with lung cancer compared to patients with other cancer types (Figure 4).

Unilateral cordotomy was performed on 12 patients (85.7%), and bilateral cordotomy was performed on 2 patients (14.3%). Among the 2 patients who underwent bilateral cordotomy (60-year-old male and 71-year-old female), 1 had lung cancer and 1 had soft tissue cancer. The other side was operated 1 month after the first procedure. Mild headache and neck pain were observed in 1 of these 2 patients.

Mild headache and neck pain were reported by 50% of all patients. No additional treatment was needed. Walking imbalance and opioid withdrawal symptoms were observed in 3 patients (21.4%), and mirror pain was observed in 2 patients (14.3%). Urinary retention was reported in 1 patient. One patient had mirror pain after the first procedure, and another patient had contralateral pain, which was considered a new pain site.

The data that support the findings of this study are available from the corresponding author upon reasonable request.

DISCUSSION

CT-guided percutaneous cordotomy is a useful and effective pain management method for severe unilateral

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TABLE 2 Karnofsky score and type of cancer.

Procedure	Lung cancer	Range	Other types of cancer	Range
Before cordotomy	34.28±4.70	24.0–44.53	41.42±4.70	31.18–51.67
After cordotomy	67.14±5.15	55.92–78.36	71.42±5.15	60.20–82.65

Note: $p=0.0001$, $p<0.05$.

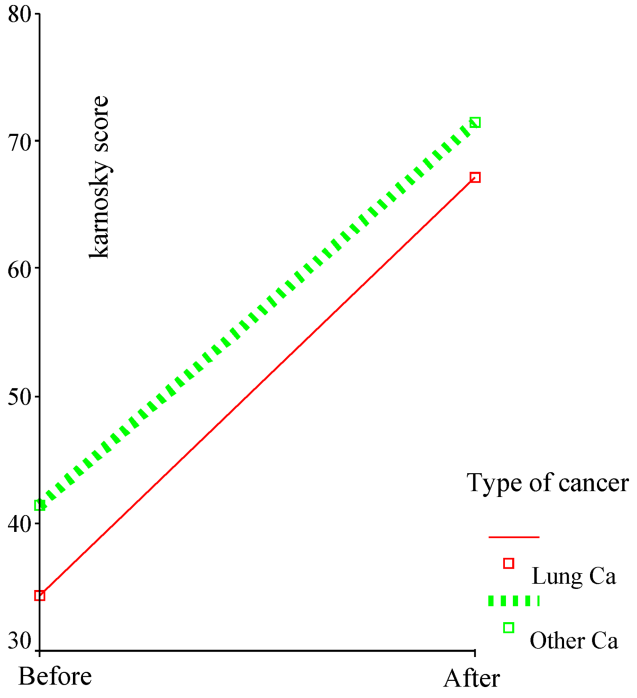


FIGURE 4 The relationship between lung cancer and other cancer types and Karnofsky performance score before and after the procedure.

cancer-related pain that cannot be adequately treated with medical and minimally invasive methods. The aim of this intervention is to prevent the transmission of pain by creating a lesion in the pain transmission pathways. In this study, all patients who underwent cordotomy had different types of advanced cancer diagnosis, with 50% of the patients being diagnosed with lung cancer. Studies on cordotomy have confirmed that patients diagnosed with lung cancer are more likely to undergo cordotomy than those with other types of cancer.[2,8]

Of the 224 patients with cancer diagnosed by Kanpolat et al. who underwent cordotomy, 108 had lung cancer. No mortality or major morbidity was observed after cordotomy in this series of patients with lung cancer. The cordotomy was effective and provided pain palliation in patients with severe pain diagnosed with lung cancer.[2] Excellent results were also obtained in 92% of patients with Pancoast tumor and thoracic malignant pain, as reported by Ischia et al. in their series of patients undergoing unilateral percutaneous cervical cordotomy.[11] In our patient group, a significant reduction in pain was observed in patients diagnosed with lung cancer.

Two studies of end-stage cancer patients with pain showed an 83%–86% reduction in pain and a 40%–83% increase in Karnofsky Performance Scale score.[11,12] There is also a GRADE 1c recommendation for cordotomy to treat patients with poorly controlled cancer pain.[13–15] In our case series, The Karnofsky Performance Scale score increase rate after cordotomy was higher in patients with lung cancer than in those with other cancer types, and the scores improved significantly after cordotomy ($p=0.0001$) (Table 2).

Gybels reported that patients undergoing cordotomy should have a life expectancy of at least 2–5 months.[16] In this study, all patients who underwent cordotomy had severe pain complaints. A significant decrease in pain and a significant increase in the Karnofsky Performance Scale score were observed in all patients after cordotomy. One of the 14 patients died 6 weeks after the procedure, but spent the last 6 weeks without pain. It is not possible to know the exact survival of all cancer patients, and therefore, it is not appropriate to evaluate the remaining life expectancy of patients as a criterion for cordotomy. All patients with pain have the right to spend their last days without pain, even if they only have a few weeks to live.

Simultaneously, a decrease in the side effects of high-dose opioid analgesic drugs, such as constipation, loss of appetite, nausea, and drowsiness, was observed in patients whose pain was reduced after cordotomy. We attribute the increase in the Karnofsky Performance Scale score to not only the reduction of pain but also the reduction of these side effects. In determining the cost-effectiveness of the procedure, we predict that the evaluation of patient survival times on a larger patient group and the reduction of analgesic doses will be meaningful.

We believe that cordotomy should only be applied to patients with a life expectancy of <12 months as the exact duration of pain palliation after cordotomy cannot be predicted. The spinothalamic tract may regenerate after a certain period, leading to the recurrence of pain, which may resemble neuropathic pain seen after spinal cord injury.[17] However, there have been no reports of neuropathic pain in a case study of patient followed up for 5 years after cordotomy.[18] Our follow-ups after cordotomy did not show any symptoms of neuropathic pain.

In this study, one patient who underwent cordotomy survived for 16 months after the procedure. The pre-cordotomy VAS score was 10 and after cordotomy, the VAS score dropped to 2. No neuropathic pain was observed in

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the patient, who continued to live with a VAS score of 2. However, these types of cases are limited and more long-term follow-up of many patients is needed. Cordotomy can cause serious complications such as permanent urinary retention, urinary incontinence, paresis, motor weakness, and loss of mobility. Therefore, it is only suitable for patients with a life expectancy of <12 months.

The most limiting factor in the application of cordotomy is the potential for complications to arise. After cordotomy, pain occurred in the contralateral side in two of the 14 patients. One of the patients, had mirror pain after the first procedure, and another patient had contralateral pain, which was considered a new pain site. Mirror pain is responsible for prolonged pain following cordotomy.[7,19] This apparently new pain is ipsilateral to the lesion. It was previously assumed that unmasking of preoperative discomfort that the more acute pain on the opposite side had overshadowed was the cause of this pain. The evidence also shows that pain is caused on the opposite side of the spinal cord due to continuing stimulation in the treated area through some type of new synaptic sprouting.[20]

Other complications we encountered after cordotomy in our patients were headache, urinary retention, light walking imbalance, and opioid withdrawal symptoms. Head and neck pain was the most common complication with a frequency of 50%. All complications were temporary and did not require additional treatment. Urinary retention disappeared 2 days later, and light walking imbalance, headache, and neck pain disappeared after 3–4 days. No major complications were observed in any patient.

Serious complications were observed during the first period of the cordotomy procedure. In the case series reported by Ischia et al., immediate sequelae as a result of the spinal lesion were observed, such as permanent urinary retention, urinary incontinence, paresis, motor weakness, and loss of walking.[21] Cases of sleep apnea have been reported after fluoroscopy-guided cordotomy.[22–24]

CT-guided cordotomy allows visualization of the spinal cord, in addition to the location, direction, and depth of the needle. Another advantage of CT-guided cordotomy is the possibility of use of water-soluble opaque matter. During cordotomy performed with fluoroscopy guidance, an oily contrast agent, lipiodol, was used. This agent was used to make the ligamentum dentatum visible. It is not possible to visualize the ligamentum dentatum when using a water-soluble contrast agent. The visualization of the ligamentum dentatum is not required during CT-guided cordotomy.[8] The cases of arachnoiditis have been reported after myelograms using oily contrast media.[25–27] Many experimental studies have been published on arachnoiditis caused by oily contrast media.[28–32] Lipiodol can cause inflammatory changes, as it is slowly absorbed by the body and encapsulated, thus there is also a possibility of forming pseudotumors. Lipiodol can be used intra-arterially in the liver for hysterosalpingography, lymphography, and tumor imaging. A case report has also been submitted describing a patient who developed arachnoiditis due to lipiodol and became paraplegic after fluoroscopy-guided cordotomy 2 months later.[33]

CONCLUSION

In conclusion, we believe that CT-guided cordotomy is more advantageous than fluoroscopy-guided cordotomy due to the safety of the contrast agent used and the ability to directly visualize the spinal cord and needle. In experienced hands, with the help of an experienced team and in properly selected patients, we believe that CT-guided cordotomy is an effective treatment. However, it is crucial to exercise extreme caution regarding potential side effects and serious complications during the cordotomy procedure.

CONFLICT OF INTEREST STATEMENT

The authors declared that there is no conflict.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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