

Received: 2020.04.15
Accepted: 2020.05.04
Available online: 2020.05.28
Published: 2020.07.24

Posterior Decompression Surgery and Radiofrequency Ablation Followed by Vertebroplasty in Spinal Metastases from Lung Cancer

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Manuscript Preparation E
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Source of support: This work was supported by National Natural Science Foundation of China grant number 81872184

Background: Spinal metastases can cause metastatic epidural spinal cord compression (MESCC), which can result in neurological dysfunction and impaired quality of life. This study investigated the safety and effectiveness of posterior decompression surgery and radiofrequency ablation followed by vertebroplasty in spinal metastasis from lung cancer.

Material/Methods: From June 2008 to September 2015, a retrospective analysis was conducted in 15 patients with spinal metastasis from lung cancer. All cases suffered MESCC and underwent posterior decompression surgery to relieve the compression of spinal cord, and had radiofrequency ablation followed by vertebroplasty. All patients received postoperative multidisciplinary therapy. The operative time, blood loss, complications, pain, neurologic deficit, quality of life, and survival were assessed preoperatively and postoperatively.


Results: Patients were followed from 6 to 56 months. The mean time of operation was 154 ± 50 minutes and the mean blood loss was 210 ± 90 mL. In the pre-operation analysis found the mean visual analogue scale (VAS) was 7.86 ± 0.86 . In the post-operation analysis at 3 months, the mean VAS score was 3.51 ± 1.32 . The VAS improved significantly ($t=7.95, P<0.01$). The Frankel grade was improved 1 grade or 2 grades in 14 patients when pre-operation was compared to post-operation. Only 1 patient kept Frankel grade D after surgery. Eight patients with sphincteric dysfunction preoperatively were improved after surgery. The EORTC QLQ-C30 score was 86.13 ± 8.51 preoperatively and 52.21 ± 13.28 postoperatively. The quality of life was improved significantly ($t=11.8, P<0.01$). The median survival time was 11 months.

Conclusions: Through posterior decompression surgery and radiofrequency ablation followed by vertebroplasty, the quality of life was improved significantly. This palliative treatment was effective and safe in spinal metastasis from lung cancer.

MeSH Keywords: Lung Neoplasms • Pulsed Radiofrequency Treatment • Spinal Cord Compression • Vertebroplasty

Abbreviations: MESCC – metastatic epidural spinal cord compression; RFA – radiofrequency ablation; VP – vertebroplasty; PVP – percutaneous vertebroplasty; VAS – visual analogue scale; KPS – Karnofsky Score; TES – total en bloc spondylectomy; SINS – spinal instability neoplastic score; L – lumbar vertebra; T – thoracic vertebra

Full-text PDF: <https://www.medscimonit.com/abstract/index/idArt/925169>

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Background

There are 1.3 million people who have died annually worldwide because of lung cancer [1]. About 65% of patients with lung cancer will have bone metastasis. The most common site of bone metastases is the spine. Metastatic epidural spinal cord compression (MESCC) has been found in 5% to 10% of all cancer patients, and it is a very common complication of spinal metastasis [2]. MESCC is associated with mobility, sphincter function, and so on. The median survival of patients with bone metastases from lung cancer is from 2.1 to 9.9 months [3–5].

In several studies, some patients with spinal metastasis from lung cancer underwent total en bloc spondylectomy (TES), with the median survival 26 to 46.3 months [6,7]. However, many studies have shown that TES may cause excessive morbidity, blood loss, and long surgery time. Murakami et al. suggested that TES should be performed in selected patients with controlled primary lung cancer, localized spinal metastases, and no visceral metastases [7]. In these patients, surgery can improve prognosis through TES. But the complication of TES remains high even in selected patients. So, risks and benefits must be weighed before TES is performed. Only a few selected cases to receive TES; the majority of cases undergo the palliative surgery.

In 1981, Harrington was the first to use cement to strengthen vertebral stability in treating 14 patients with spinal metastasis through an open procedure [8]. In 1987, Deramond was the first to inject bone cement percutaneously in treating spinal hemangioma [9]. Today, percutaneous vertebroplasty is widely used in treatment of spinal metastases, but percutaneous vertebroplasty is associated with higher complication rates especially related to cement leakage [10–13].

Radiofrequency ablation device generates 460 kHz radio frequency current, with high-speed ion vibration and friction generated in the surrounding tissues through the electrodes, which is then transformed into heat energy. When the temperature reaches a certain target temperature, the local tissues and cells will undergo thermal coagulation. Radiofrequency ablation was initially used in the treatment of liver cancer and achieved good therapeutic effect. In the 21st century, radiofrequency ablation combined with vertebroplasty for treatment of spinal metastasis was introduced. Several studies have shown that the combination of radiofrequency ablation with percutaneous vertebroplasty is safe and effective in spinal metastases [14–16]. Radiofrequency ablation performed in spinal metastases can cause coagulation necrosis of tumor cells and reduce the complications of cement leakage.

Considering that the life expectancy of lung cancer patients with bone metastasis is short, the main purpose of surgical

treatment is to relieve pain, improve neurological function, and enhance the quality of life. We studied the safety and effectiveness of posterior decompression surgery and radiofrequency ablation followed by vertebroplasty in spinal metastasis from lung cancer.

Material and Methods

There were 15 patients with spinal metastasis from lung cancer enrolled from June 2008 to September 2015. Patients included in the study meet the following criteria: 1) patients had metastatic epidural spinal cord compression (MESCC) which caused neurological dysfunction or pain or paraplegic for shorter than 48 hours. 2) Life expectancy was at least 3 months. 3) The patients have a general status good enough to undergo surgery. The contraindications to surgery were the following: 1) suitable status for total en bloc spondylectomy; 2) contraindications to general anesthesia; 3) intolerable to potential surgical complications.

In pre-operation assessment, pain, neurologic deficit, and quality of life were evaluated by visual analogue scale (VAS), Frankel grade, and European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 questionnaire, respectively. The biomechanical situation was described using the spinal instability neoplastic score (SINS).

All patients were given routine examinations such as cardiopulmonary function tests, ultrasound, blood routine, blood coagulation routine, blood group, biochemical routine, etc. Patients had magnetic resonance imaging (MRI) and x-ray studies. MRI was used because it can identify spinal cord compression clearly.

Surgery

General anesthesia was used in all patients, and the operation position was the prone position. Under C-arm guidance, we identified the lesion segment and made a median longitudinal incision. We stripped bilateral erector spine muscles to expose lamina, severed the supraspinal ligament and interspinous ligament, and removed spinous process, bilateral lamina, and ligamentum flavum. The spinal cord and nerve roots were fully exposed, the compression of the spinal cord was fully relieved, and the fluctuation of the spinal cord was restored.

After the posterior decompression was finished, radiofrequency ablation was performed in the lesion vertebral body. The radiofrequency ablation device was RITA® 1500 RF electrosurgical generator (RITA Medical Systems, Inc., Mountain View, CA, USA) and Unilate™ Rita RF electrodes (RITA Medical Systems, Inc., Mountain View, CA, USA). The 13-gauge bone puncture needle established the channel through a transpedicular approach

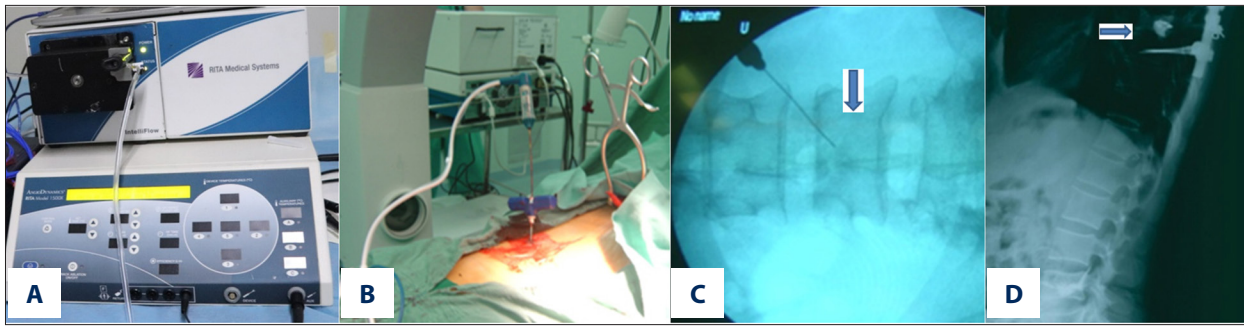


Figure 1. Spinal metastases with Tomita type 7. (A) Radiofrequency ablation device. (B, C) Monopolar electrodes with 2 cm active tip was in L4 vertebral lesion (↓). (D) Posterior surgery indirectly removes spinal cord compression from T8 vertebral lesion (→). After radiofrequency ablation, vertebroplasty was performed, and finally screw rod internal fixation was performed.

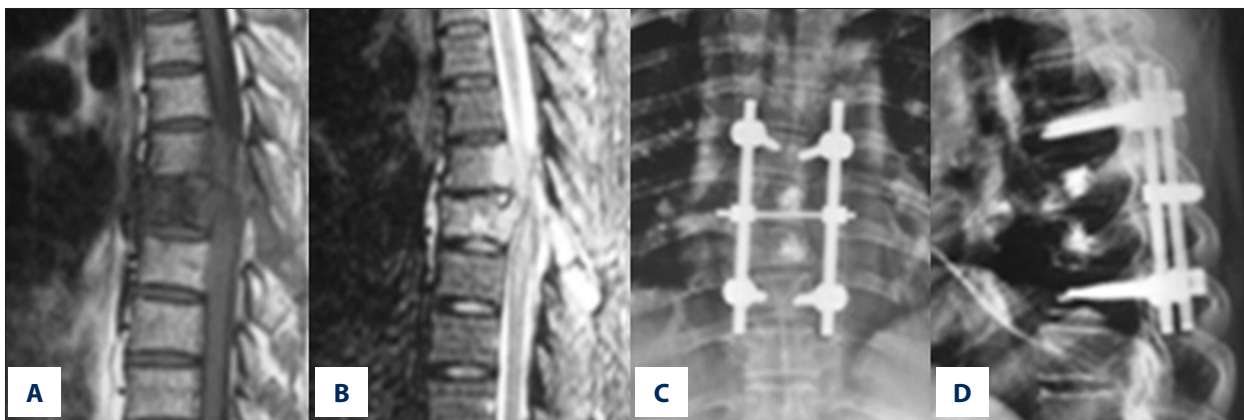


Figure 2. A 52-year-old male with spinal metastases from lung cancer. (A, B) Preoperative magnetic resonance imaging showed spinal metastases in T6 and T7 vertebral body. Spinal cord was compressed. (C, D) Postoperative x-ray photographs showed nodular high-density bone cement images in vertebral body of T6, T7, and L1, posterior screw fixation in T5 and T8 vertebral body. Vertebral collapse and the adjacent intervertebral space narrowed were not seen.

under C-arm guidance. We used monopolar electrodes with 1 cm or 2 cm active tip in the vertebral lesion (Figure 1). The power setting was 75 W. The maximum temperature of the electrode active tip reached 85°C. Radiofrequency ablation lasted for 10 minutes. The monopolar electrode was removed after radiofrequency ablation. Vertebroplasty was done slowly under C-arm guidance. The amount of bone cement was about 3–5 mL. Heart rate, blood pressure, and electrocardiogram were closely monitored during the process. At last, under C-arm guidance, we reconstructed spinal stability with screw-rod internal fixation (Figure 2).

Postoperative adjuvant therapy

All patients received postoperative multidisciplinary therapy including radiotherapy, chemotherapy, targeted therapy, and zoledronic acid. In all, 14 patients received radiotherapy; the total dose was 30–45 Gy given in 10–15 fractions; 8 patients received chemotherapy (4–6 cycles); 7 patients underwent gene detection found epidermal growth factor receptor (EGFR) mutation, received targeted drug treatment; 10 patients received zoledronic acid intravenously every 4 weeks.

Follow-up

All the patients received follow-up. In pre-operation evaluation and postoperative 3-month follow-up, pain, neurologic deficit, and quality of life were evaluated by visual analogue scale (VAS), Frankel grade, and EORTC QLQ-C30 questionnaire, respectively. Urinary sphincter function was observed as well.

Statistical analysis

VAS and EORTC QLQ-C30 scores were analyzed with paired-samples *t*-test. Survival analysis used Kaplan-Meier method. *P*-value <0.05 was considered statistically significant.

Results

From June 2008 to September 2015, 15 cases who met the inclusion criteria were enrolled, including 9 males and 6 females. The average age was 50.1 years (range 40–68 years). All patients were assessed by Tomita score and Tomita classification. Tomita

Table 1. The comparison of clinical data between pre-surgery and post-surgery.

Symptom/feature	Pre op (%)	Post op (%)
VAS	7.86±0.86	3.51±1.32
Sphincteric dysfunction	86.7% (13/15)	26.7% (4/15)
EORTC QLQ-C30	86.13±8.51	52.21±13.28
Frankel C	60.0% (9/15)	0 (0/15)
Frankel D	40.0% (6/15)	60.0% (9/15)
Frankel E	0 (0/15)	40.0% (6/15)

VAS – visual analogue scale; EORTC – European Organization for Research and Treatment of Cancer (EORTC).

score was 6–7. The spinal instability neoplastic score (SINS) was 12.1. Tomita classification [10] was as follows: Tomita type 4 (3 patients), Tomita type 5 (4 patients), Tomita type 6 (4 patients), Tomita type 7 (4 patients). Patients were followed from 6 to 56 months. No patients were lost during follow-up.

Operative time, blood loss, and bone cement leakage

There were 15 patients who received posterior decompression surgery to relieve compression of the spinal cord, and radiofrequency ablation followed by vertebroplasty. At the same time, the spinal stability was reconstructed with screw-rod internal fixation. The mean time of operation was 154±50 minutes and mean blood loss was 210±90 mL. Cement leakage was observed in 2 patients. The rate of polymethylmethacrylate (PMMA) leakage was 13.3%. One patient had peri-vertebral soft tissue leakage and the other patient had adjacent disc leakage. There were no clinical symptoms caused by leakage.

Visual analogue scale (VAS)

All patients reported that pain was markedly relieved through surgery. In the pre-operation evaluation, the mean visual analogue scale (VAS) was 7.86±0.86. In postoperative 3-month evaluation, the mean VAS score was 3.51±1.32. The VAS improved significantly (t=7.95, P<0.01) (Table 1). One patient progressed in 8 months and had pain that was severe again; he received radiotherapy and the pain was controlled.

Frankel grade and KPS

Neurologic deficits were evaluated by Frankel grade (Table 1). In the pre-operation assessment, 9 patients had Frankel grade C and 6 patients had Frankel grade D. In the post-operative assessment at 3 months, no patient had Frankel grade C, 9 patients had Frankel grade D, and 6 patients had Frankel grade E. Frankel grade was improved 1 grade or 2 grades in 14 patients.

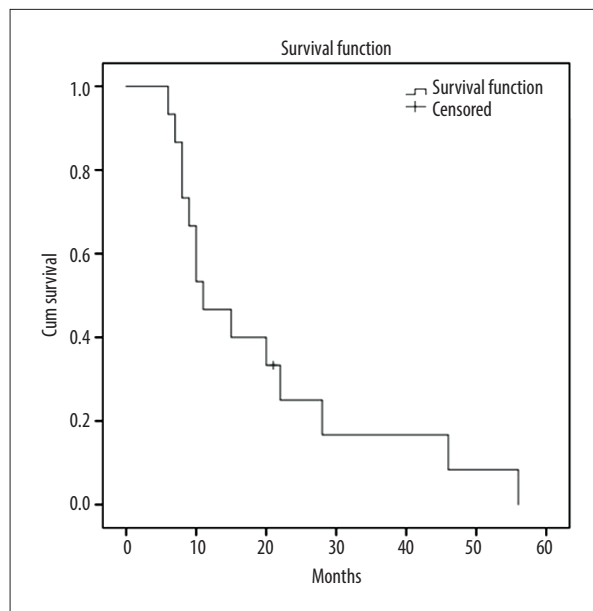


Figure 3. The follow-up period of the patients ranged from 6 to 56 months. The mean survival was 19.6 months. The median survival time was 11.0 months.

Only 1 patient kept grade D after surgery. The neurologic deficit of the spinal cord was improved significantly.

Sphincteric dysfunction

In all, 13 patients had sphincteric dysfunction. The urinary sphincter function of 2 patients was continent. At 3-months postoperatively, 8 out of 13 patients (61.5%) who were incontinent before surgery recovered by this treatment, but still 5 patients suffered from sphincteric dysfunction. Two patients who were normal before the operation were continent after the operation (Table 1).

EORTC QLQ-C30 score

All the patients completed the EORTC QLQ-C30 questionnaire. The EORTC QLQ-C30 score was 86.13±8.51 preoperatively and 52.21±13.28 postoperatively. The quality of life was reported to be improved significantly (t=11.8, P<0.01).

Survival

One patient was lost to follow-up and the other patients died. The mean survival was 19.6 months. The median survival was 11.0 months; the 1-year survival rate was 53.3%; the 2-year survival rate was 26.7%; the 3-year survival rate was 20.0% (Figure 3).

Complications

No patient died during the treatment. Three patients felt pain around the injection site, which subsides after 48 hours. The cement leakage percentage was 13.3%, but there were not clinical symptoms caused by leakage. One patient had an incision infection and one patient had a urinary tract infection.

Discussion

Expected survival for patients with bone metastasis from lung cancer is short. It is controversial whether such patients should undergo surgical treatment. First of all, we must estimate the life expectancy accurately. At the same time, we must fully weigh the risks and benefits of surgery. The aim of treatment is to relieve symptoms rapidly and improve the quality of life. In this study, 15 patients had lung cancer with spinal metastasis. The life expectancy of these patients was more than 3 months. All patients underwent posterior decompression surgery and radiofrequency ablation, followed by vertebroplasty. The quality of life of patients was improved significantly. We found that this palliative operation was effective and safe for patients with spinal metastases from lung cancer, and the procedure had acceptable postoperative complications and mortality rates.

It is well accepted that surgical treatment can only be considered when the patient's expected survival time is more than 3 months [17]. In our study, 15 cases underwent palliative surgical intervention to manage axial pain and spinal instability. First of all, in our patient cases, the compression of spinal cord was indirectly decompressed. Then spinal stability was restored by vertebroplasty and instrumental spinal fixation. All patients reported that pain was rapidly relieved through this palliative surgery. Frankel grade was improved by 1 grade or 2 grades in 14 patients. Only 1 patient kept a grade D after surgery. The neurological deficit of the spinal cord was improved significantly as well in our patient cases. At 3-months postoperatively, 8 out of 13 patients (61.5%) who were incontinent before surgery recovered. The EORTC QLQ-C30 score was 86.13 ± 8.51 preoperatively and 52.21 ± 13.28 postoperatively. The quality of life was enhanced markedly ($t=11.8$, $P<0.01$). These findings were consistent with several previous studies [18,19].

As we know, total en bloc spondylectomy (TES) is associated with excessive morbidity, blood loss, and long surgery time; TES is appropriate in patients with controlled primary lung cancer, localized spinal metastases, and no visceral metastases [7]. Even if patients with surgery indications can undergo TES, the incidence of complications remains high. However, the survival time of spinal metastasis from lung cancer is limited. The treatment should be palliative rather than invasive [20]. Laufer et al. [21]

suggested that treatment of spinal metastases must emphasize durable tumor control while minimizing treatment-related complications and morbidity, while giving consideration to effective chemotherapy, radiotherapy, and surgical treatment options to achieve this goal. Wu et al. [22] proposed that posterior decompression and occipitocervical fixation followed by intraoperative vertebroplasty was a safe and valuable method with less invasion to treat spinal metastasis. In our study, the Tomita score of most patients was 6–7 and life expectancy was limited. TES is known to be highly invasive in nature. TES was not considered suitable in these patients because of the potential high operative-related complications and morbidity with short predicted survival. Thus, we performed palliative surgery to relieve compression of the spinal cord and reconstruct spinal stability. The mean time of the palliative operation was 154 ± 50 minutes and the mean blood loss was 210 ± 90 mL. At the same time, the pain, function, and quality of life of patients were improved with less complication, less blood loss, and lower morbidity.

Currently, percutaneous vertebroplasty is mainly used in treatment of spinal metastases, but percutaneous vertebroplasty is associated with higher complication rates such as cement leakage [10–13]. The most serious cement leakage complication associated with percutaneous vertebral augmentation is cement extravasation into the epidural space and neural foramina leading to spinal cord compression and radicular pain. Malignant vertebral body lesions are often associated with epidural extensions or posterior cortical disruption, which may increase the risk of cement leakage. Percutaneous vertebroplasty also can cause physical displacement of tumors, which may lead to tumor cells advancing through physical holes in the vertebral body or via vertebral veins.

Combining radiofrequency ablation with percutaneous vertebroplasty in spine metastases has been described previously in several studies [23,24]. These studies showed that if radiofrequency ablation was performed before percutaneous vertebroplasty, the risk of cement leakage was reduced [25,26]. Georgy [27] found that combining radiofrequency ablation with percutaneous cement augmentation seemed to be effective in treating painful metastatic vertebral pathological fractures. Moreover, radiofrequency ablation can destroy sensory nerve fibers, reduce the lesion volume, and kill tumor cells. In our study, cement leakage was observed in 2 patients. The cement leakage percentage was 13.3%. One case of leakage was perivertebral soft tissue leakage and the other case was adjacent disc leakage. There were no clinical symptoms caused by either leakage. We found that radiofrequency ablation could reduce the complication of vertebroplasty-associated bone cement leakage.

Patients with spinal metastases from lung cancer have short survival expectancy. Spinal instability may lead to pathological

fractures and further paraplegia. Fortunately, palliative posterior decompression surgery with stabilization and postoperative multidisciplinary treatment have been shown to be effective in such patients [28,29]. With multidisciplinary therapy in lung cancer, the patient's survival time can be significantly prolonged [30,31]. In our study, 14 patients received radiotherapy, 8 patients received chemotherapy (4–6 cycles), 7 patients received targeted therapy, and 10 patients received zoledronic acid. The median survival time was 11.0 months. The 1-year survival rate was 53.3%. The 2-year survival rate was 26.7%. The 3-year survival rate was 20.0%. Survival of patients was longer than the preoperative life expectancy in some patients. Prolonged survival may be associated with improved quality of life by treatment with palliative surgery and multidisciplinary therapy. Perhaps, the existing scoring system should be improved in the future. We suggested that postoperative adjuvant therapy including medication and radiation should be routinely administered in patients who receive palliative posterior decompression and stabilization surgery.

There were several limitations to this study. According to the criteria for enrollment, only 15 patients were enrolled in 7 years. In this study, the sample was small, which precluded valid analysis of these results. However, some patients received different treatments including radiotherapy, chemotherapy, targeted-therapy, and bisphosphonates before or after surgery. It was difficult to analysis prognosis for a limited sample and there were other interference factors. This study was a retrospective analysis without a control group. A randomized controlled trial is required to verify the results of our study.

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Conclusions

In the present study, we found that posterior decompression surgery and radiofrequency ablation followed by vertebroplasty was effective and safe in relieving pain and neurological deficit, and improved quality of life. We believe that survival of patients will be significantly prolonged with the introduction of new targeted drugs for lung cancer. Patients with spinal metastasis from lung cancer should be evaluated for multidisciplinary therapy. Posterior decompression surgery and radiofrequency ablation followed by vertebroplasty may be a suitable option for patients with MESCC.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The present study was approved by Tianjin Medical University Cancer Institute and Hospital (Tianjin, China) and it conforms to the provisions of the Declaration of Helsinki. Written informed consent was obtained from all individuals in the present study.

Conflict of interests

None.

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