

Percutaneous vertebroplasty in the treatment of malignant vertebral compression fractures with epidural involvement

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Abstract

Purpose: To evaluate the safety and the clinical efficacy of percutaneous vertebroplasty (PVP) in treating malignant spinal tumors and malignant vertebral compression fractures with epidural involvement.

Materials and methods: 43 patients with spinal metastatic tumors and malignant vertebral compression fractures with epidural involvement were treated using PVP. American Spinal Injury Association (ASIA) impairment scale results at presentation were used to divide patients into 2 groups. Patients in group A had no symptoms of neurological compression (n = 25); and patients in group B had symptoms of neurological compression (n = 28). A 13G bone puncture needle was placed across the pedicle of the fractured vertebra, and polymethyl methacrylate (PMMA) was injected into the fractured vertebral body under fluoroscopic control. Patients were seen in follow-up at 1, 3, and 6 months after the procedure and every six months thereafter.

Results: PVP was technically successful and well-tolerated in all patients. Clinical assessment at the final follow-up found complete pain relief (n = 19) or good pain relief (n = 14) in 33 patients (62.3%, 95% CI: 49%, 76%). ASIA impairment scale assessment at the final follow-up demonstrated symptoms of neurologic compression in 31 patients and no symptoms of neurologic compression in 22 patients. Symptoms of neurologic compression were found in five group A patients and eight group B patients.

Conclusions: PVP was a safe and moderately effective procedure in the treatment of malignant vertebral compression fractures with epidural involvement.

Keywords: percutaneous vertebroplasty; pain; malignant spinal tumor; metastasis

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INTRODUCTION

Percutaneous vertebroplasty (PVP) is a minimally
invasive technique that has been demonstrated to be
highly effective in reducing spinal pain in patients
with osteoporotic vertebral compression fractures and

metastatic vertebral disease (1-10). There is little experience in the use of PVP in treating malignant spinal tumors and malignant vertebral compression fractures with epidural involvement. A few small reports support the utility of PVP in these patients for the relief of pain and stabilization of the spine (11-14).

There is a concern that breakdown of the posterior cortex of the vertebral body (12,15) could lead to leakage of PMMA into the epidural or paravertebral spaces with impingement on nerves. The aim of this study was to evaluate the safety and efficacy of PVP in the treatment of malignant spinal tumors and malignant vertebral compression fractures with epidural involvement.

MATERIALS AND METHODS

Patients

From October 2009 to December 2012, 53 patients with malignant spinal tumor and malignant vertebral compression fractures with epidural involvement were treated with PVP. This study was approved by the university committee on human investigation, and informed consent was obtained from each patient.

The presence of malignant spinal tumor and malignant vertebral compression fractures with epidural involvement was confirmed by reviewing the patients' history and findings on computed tomography (CT) and magnetic resonance imaging (MRI). Pathologic diagnosis was determined by histological examination of biopsy specimens obtained before or during the procedure.

All patients completed a short questionnaire evaluating the presence, severity, and duration of spinal and radicular pain, etiology of the spinal disease, and presence of neurologic compression symptoms. Patients were eligible for enrollment if they had: 1) a pathologic diagnosis of malignant spinal tumor or malignant vertebral compression fractures with epidural involvement; 2) the percentage of height reduction in the vertebral body less than 50%; and 3) one MRI and clinical follow-up ≥ 3 months after the initial treatment. Patients were excluded if any of the following was present: 1) severe cardiopulmonary comorbidity, 2) untreatable coagulopathy, 3) contraindication for MRI, and 4) any other cancer treatment administered during follow-up.

Interventions

All PVP procedures were performed by two experienced interventional radiologists (C.G.W. and Y.F.G. with 12 and 8 years, respectively, of experience in spinal intervention). A single plane angiography system was used with fluoroscopic guidance.

The patient was placed in a prone position on an operating table. Local anesthesia was administered and a small posterior incision was made with a scalpel. A 13G bone puncture needle (Cook, Bloomington, IN) was inserted and advanced to a transpedicle position in the fractured vertebra. After removal of the inner needle, commercially available polymethyl methacrylate (PMMA) (Osteo-Firm, COOK Medical, Bloomington, IN, USA) was injected into the fractured vertebrae under continuous fluoroscopic monitoring via lateral and anteroposterior projections in order to ensure adequate vertebral body filling and to avoid PMMA leakage or venous injection. PV was also performed to treat additional malignant vertebral metastases at other levels that did not have compression fractures on MRI.

A total of 3–8 mL PMMA was injected into each fractured vertebral body. Injection was stopped when substantial resistance was met or when the cement reached the cortical edge of the fractured vertebral body. Injection was also stopped if cement leaked into extra-osseous structures or veins. Post-procedural fluoroscopic evaluation was performed to ensure optimal filling of the vertebral body and to determine if there was PMMA extravasation.

Clinical outcome evaluation

All patients underwent CT imaging 3 days after PVP to identify the distribution of cement in the lesion, cement leakage outside the vertebral body, or other possible local complications. CT and/or MR imaging were performed at 3 months and every 6 months after the procedure in all patients.

Patients were evaluated clinically before the procedure, at 1, 3, and 6 months after the procedure and every six months thereafter. In cases where clinical examination could not be performed, patients or their family were contacted by telephone every 3 months. Imaging follow-up comprised anteroposterior and lateral spinal radiography at 1 month, 6 months,

and 1 year after the procedure. Each patient was examined by two of the authors.

Data regarding (a) technical success, (b) clinical success, (c) secondary clinical success, and (d) complications were evaluated at the time of the report or patient death. All data were obtained prospectively by completion of clinical surveys by the authors. Technical success was defined as the ability to perform PVP without major complications.

The primary clinical outcome was pain relief as measured by a VAS score ranging from 0 (no pain) to 10 (worst pain ever) and categorized into four types: pain resolved, pain decreased, no change, or pain increased. Primary clinical success was defined as complete resolution of pain, with pain decreased following the procedure. We defined clinically significant pain relief as a decrease in a VAS score of 3 points or more from baseline. Pain-free days were defined as days with a VAS score of 3 or lower.

The secondary clinical outcome was American Spinal Injury Association (ASIA) impairment scale (16) result, which was categorized into four types: full recovery from symptoms of neurological compression that existed before PVP; improved or relieved symptoms; unchanged symptoms; or worsened symptoms. Secondary clinical success was defined as full recovery or improvement from the symptoms of neurological compression following the procedure. We defined clinical improvement of symptoms of neurological compression as a decrease in the ASIA impairment scale score of 1 point or more from baseline. Full recovery was defined as days with ASIA impairment scale of E. Any potential complications following PVP, such as wound infections, nerve injuries, cement leakage, and pulmonary embolism, were recorded.

Further treatments, such as conservative treatment, laminectomy, and internal fixation, were performed if there were initial clinical failure, worsened symptoms, or PVP-related complications during follow-up.

Statistical analysis

Descriptive data were presented as the mean \pm SD. Dichotomous and categorical data were reported as numbers and percentages. The technical endpoint was defined as the failed performance of the procedure. The clinical endpoint was defined as follow-up loss or death during or after the procedure. Statistical analyses were performed using SPSS statistical

software (version 13.0 for Windows, SPSS Inc., Chicago, IL, USA). The *P*-value was considered statistically significant if less than or equal to 0.05.

RESULTS

Patients

Thirty-one men and 22 women with a mean age of 59 ± 12 years (range: 33–90 years) underwent PVP. Their baseline characteristics are summarized in Table 1. Patients were classified into two groups at diagnosis using the ASIA impairment scale. Group A patients had no symptoms of neurological compression ($n = 25$), and group B patients had symptoms of neurological compression ($n = 28$). One of the 28 group B patients presented with complete paraplegia (no motor function, ASIA scale A or B) and 27 presented with incomplete paraplegia (ASIA scale C or D) (Table 1). Level of complete paraplegia was T5 ($n = 1$). Levels of incomplete paraplegia were at T2 ($n = 1$), T3 ($n = 4$), T5 ($n = 1$), T6 ($n = 2$), T10 ($n = 3$), T11 ($n = 2$), T12 ($n = 3$), L1 ($n = 5$), L2 ($n = 2$), L3 ($n = 1$), and L4 ($n = 3$).

Safety

PVP was technically successful and well tolerated in all patients. There were no complications from infection, bleeding, pulmonary embolism, stroke, or cardiac arrest. Twenty-seven patients underwent a

Table 1 Baseline characteristics of patients treated with percutaneous vertebroplasty.

	PVP (n = 53)
Age (years) (mean \pm SD)	59.51 \pm 12.1
Male/Female (No.)	31/22
Duration of symptoms (weeks)	9.11 \pm 6.03 (Range: 1–26)
Primary tumor	
Lung cancer	29
Breast cancer	5
Colon cancer	1
Prostate cancer	3
Thyroid carcinoma	6
Liver cancer	3
Renal cancer	1
Multiple myeloma	2
Gastric cancer	1
Thymic carcinoma	1
Pancreatic cancer	1
Number of levels treated per patients	
1	27
2	10
3	10
4	6

single-level PVP, and 26 patients underwent multiple level PVP treatments. CT showed cement leakage in 55 (51.9%) of the 106 treated vertebral bodies. Leakages were observed in the intervertebral disk ($n = 11$), puncture site ($n = 6$), paravertebral space ($n = 14$), and veins ($n = 23$). Cement was observed in the spinal canal of one patient who developed new complete paraplegia. The mean postoperative hospital stay after treatment was 6.43 ± 1.01 days (range: 5–9 days), and the thirty-day mortality rate was zero.

Seven patients experienced excellent pain relief (20%), 32 patients had good pain relief (72%), and 14 patients had no improvement (8%) at the time of discharge. Of the 28 patients in group B, 16 had improved or relieved neurological compression symptoms and 12 had no change at the time of discharge.

Follow-up clinical results

Follow-up was available in 53 patients. Mean clinical follow-up was 15 ± 8 months (95% CI: 13, 17 months; range: 4–43 months). All patients were followed-up and assessed at 1 and 3 months, 51 at 6 months, and 33 at 1 year. Three patients had more than 2 years of follow-up.

Clinical assessment at the final follow-up found complete excellent pain relief ($n = 19$) or good pain relief ($n = 14$, Figure 1) in 33 patients with a pain relief rate of 62.3% (95% CI: 49%, 76%). In 39 patients with excellent or good pain relief at the time of discharge, 29 maintained that level of relief of the pain, eight had unchanged pain intensity, and two had worsening of their pain. In the 14 patients without pain relief at the time of discharge, four had good pain relief, four were

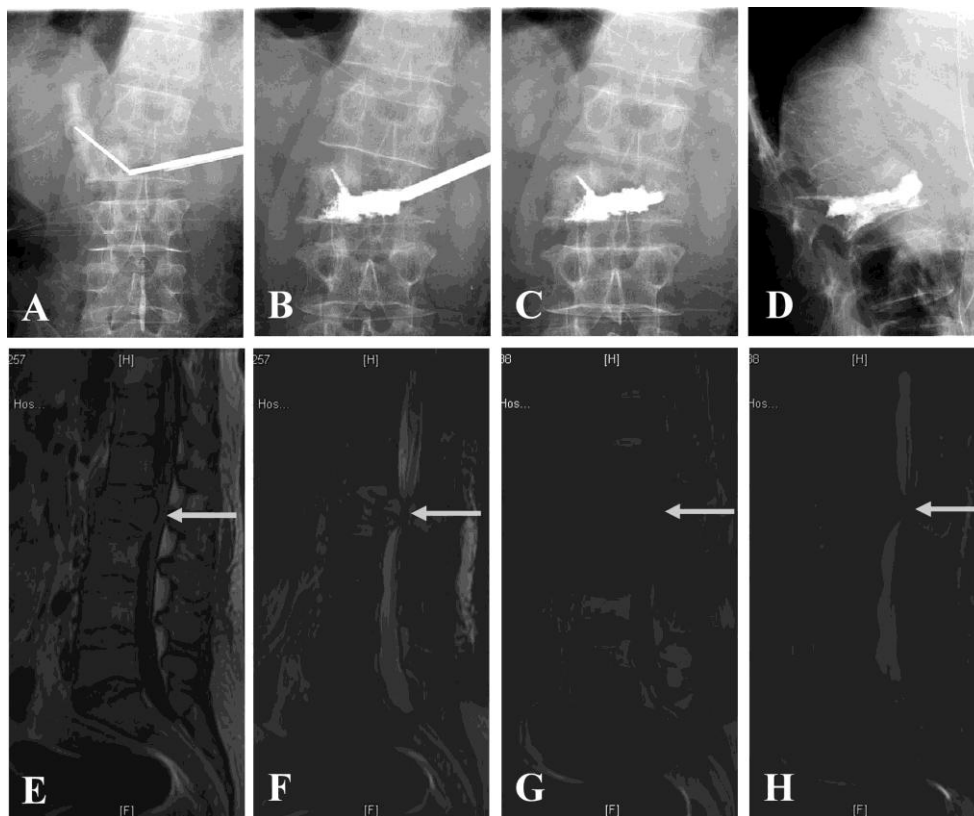


Figure 1. A 54-year-old male patient with a malignant vertebral compression fracture of the L2 vertebra from lung cancer presented with spinal pain and symptoms of neurologic compression. (A) Bone puncture needles were inserted into the L2 vertebra body bilaterally. (B) Polymethyl methacrylate (PMMA) was injected into the vertebral body bilaterally through the bone puncture needle. (C, D) The postero-anterior and lateral views immediately after treatment show PMMA in the L2 vertebral body and leakage at the puncture site. (E, F) Sagittal T1WI and T2WI MR imaging showed malignant vertebral compression fractures of the L2 vertebra (arrow) with spinal cord compression and rupture of the posterior wall prior to admission. (G, H) Sagittal T1WI and T2WI MR images 6 months after PVP show spinal cord compression at L2 (arrow). The compression fracture was stabilized and there was an improvement of neurologic symptoms.

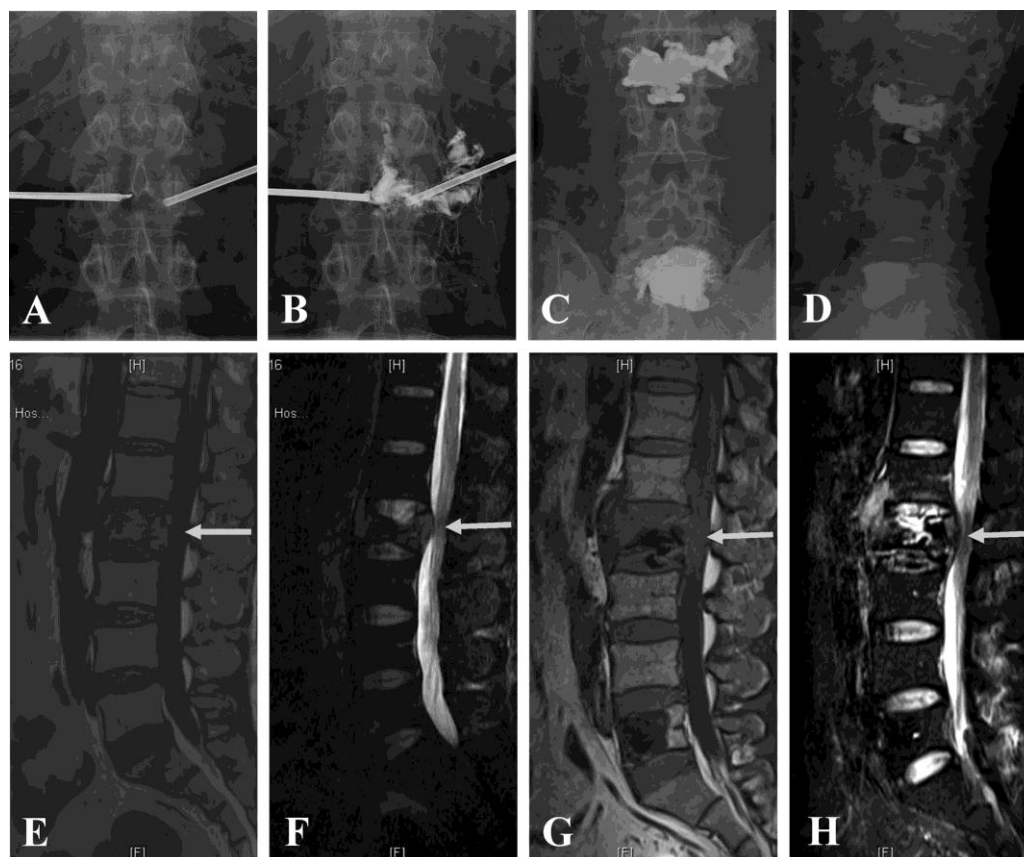


Figure 2. A 51-year-old male patient with a malignant vertebral compression fracture of the L2 vertebra from metastatic lung cancer presented with spinal pain and symptoms of neurologic compression. (A) The bone puncture needles were inserted into the L2 vertebra body bilaterally. (B) Polymethyl methacrylate (PMMA) was injected into the vertebral body bilaterally through the bone puncture needles. PMMA was seen to leak into the paravertebral space and intervertebral disk. (C, D) Postero-anterior and lateral views immediately after the procedure showed PMMA in the L2 and L5 vertebral bodies with leakage at the L1 level. (E, F) Sagittal T1WI and T2WI MR images showed malignant vertebral compression fractures of the L2 vertebra (arrow) with spinal cord compression and rupture of the posterior wall prior at presentation. (G, H) Sagittal T1WI and T2WI MR images 7 months after PVP show worsening of the spinal cord compression at L2 (arrow). The patient had continued pain due to massive PMMA leakage.

unchanged, and 6 had worsening of their pain (Figure 2). Worsening of pain was experienced in eight patients at last follow-up due to the progression of the vertebral metastases and spinal cord compression.

ASIA impairment scale assessment was performed at the final follow-up. Five group A patients exhibited symptoms of neurologic compression and 20 had no symptoms of neurologic compression. Symptoms of neurologic compression were due to progressive malignant vertebral compression in all patients. In group B, 26 patients had symptoms of neurologic compression and 2 had no symptoms. Of the group B patients, 2 had full recovery, 10 improved (Figure 1), 8 had no change in symptoms, and 8 had worsening of their symptoms (Figure 2).

Twenty-three patients continued with follow-up health care after the procedures and were alive with the improvement of pain and symptoms of neurologic compression at the time of this report. Thirty patients died from metastatic disease, unrelated to PVP. The mean and median survival periods were 22 ± 2 months (95% CI: 18–26) and 21 ± 3 months (95% CI: 15–27), respectively (Kaplan-Meier analysis).

Cement filling and stability

The mean cement filling volume was 5.00 ± 1.33 mL (range, 2–8 mL) in 53 treated vertebrae. Among the 53 vertebrae, the vertebral filling was considered good in 38% (20/53) of cases, mild in 49% (26/53), and insufficient in 13% (7/53).

DISCUSSION

Metastatic spinal cord compression (MSCC) is a serious complication of metastatic cancer that requires immediate diagnosis and treatment. Treatment is largely palliative and aims to achieve relief of pain and return of function. Affected patients have an immunocompromised immune system from ongoing chemotherapy, poor nutrition, and comorbid medical conditions and cannot tolerate curative surgical methods.

Minimally invasive spinal interventions like PVP are a reasonable alternative to treat spinal metastatic disease. This procedure generally results in minimal soft tissue trauma, little blood loss, and short hospitalization times. These methods rarely interfere with adjuvant treatments. The morbidity from these treatments is considerably lower than that of conventional spine surgery. PVP appears to be a promising option in these patients for relief of pain and stabilization of the spine (11-14).

There are problems associated with the use of PVP. Destruction of the posterior cortex of a vertebral body by the tumor can lead to PMMA leakage and poor resulting vertebral support. Leakage of PMMA into the epidural space or paravertebral space can also result in nerve impingement (12,15). The lack of stability found with massive leakage is generally associated with minimal pain relief and continued compromise of neurologic function (17,18). Unfortunately, the injection of a small volume of PMMA may not be sufficient to prevent further vertebral body collapse.

The incidence of pain relief or pain improvement in patients treated here was 62%, lower than the reported range of 73–100% found in similar patients (3,4,8,12,19-21). Moreover, further compression of involved vertebrae was found in 13 (25%) patients we treated. Unsatisfactory results in our patients were mainly attributed to the use of smaller volumes of PMMA.

One limitation of this study was the number of patients treated and the lack of a control group who underwent surgical treatment. The lifespan of these patients was limited and death due to the rapid progression of the disease might have masked both benefits and adverse effects of this localized treatment. Better controlled clinical trials are needed to better define the clinical benefit of PVP.

In conclusion, treatment with PVP was safe and moderately effective in patients we treated. PVP was effective in the treatment of malignant compression fractures when symptoms of neurological compression were present.

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