Vertebroplasty for Treatment of Osteolytic Metastases at C2 Using an Anterolateral Approach

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Background: The clinical management of osteolytic metastases involving C2 is unique, because it is challenging to approach these lesions. Symptoms may vary from local pain to progressive neurological deficit. Surgery or radiotherapy have been the treatments of choice for several years; however, surgery may not be an option for patients with multiple metastases and poor general medical status, and radiotherapy carries the risk of vertebral collapse and consequent neural compression due to delayed bone reconstruction. Through different approaches, vertebroplasty has been introduced into clinical practice as an alternative to traditional surgical and radiotherapy treatments of osteolytic metastases at C2.

Objective: This study aimed to evaluate the safety and efficacy of vertebroplasty with an anterolateral approach for osteolytic metastases at C2 under fluoroscopic guidance.

Study Design: Vertebroplasty in 13 patients with osteolytic metastases at C2 and its clinical effects were evaluated.

Setting: This study was conducted in an interventional therapy group at a medical center in a major Chinese city.

Methods: Thirteen consecutive patients were treated with vertebroplasty via an anterolateral approach. The researchers followed up with the patients for 3 to 12 months, with an average of 9.2 months. The clinical effects were evaluated with the visual analog scale (VAS) pre-operatively and at 3 days, one month, 3 months, 6 months, and 12 months post-operatively.

Results: Thirteen consecutive patients were successfully treated with a satisfying resolution of painful symptoms. Extraosseous cement leakages were found in 5 cases without any clinical complications. VAS scores decreased from 7.6 ± 0.9 pre-operatively to 2.1 ± 1.9 by the 3-day post-operative time point, and were 1.8 ± 1.7 at one month, 1.7 ± 1.8 at 3 months, 0.9 ± 0.8 at 6 months, and 0.6 ± 0.5 at 12 months after the procedure. There was a significant difference between the mean pre-operative baseline score and the mean score at all of the post-operative follow-up points (P < 0.001).

Limitations: This was an observational study with a relatively small sample size.

Conclusions: Vertebroplasty via an anterolateral approach is an effective technique to treat osteolytic metastases involving C2. It is a valuable, minimally invasive, and efficient method that allows quick and lasting resolution of painful symptoms.

Key words: Vertebroplasty, C2, anterolateral approach, osteolytic metastasis, pain
Vertebroplasty is a minimally invasive method for pain control and prevention of the further vertebral collapse and the spinal cord compression in the spinal metastases (1,2). However, vertebroplasty at C2 presents technical difficulties and requires caution to avoid potential injury of the vital structures that surround the C2 vertebra. To the best of our knowledge, there exist only limited data in published literature from case reports and a small number of series describing vertebroplasty as a treatment for osteolytic metastases involving C2. For this report, we reviewed data on 13 patients with C2 osteolytic metastasis treated with vertebroplasty via an anterolateral approach under fluoroscopic guidance, and we evaluate the procedure’s efficacy and safety.

**Methods**

**Patients**

We performed a retrospective review of all patients with C2 osteolytic metastasis who underwent vertebroplasty in our hospital between March 2003 and May 2012. Before the procedure, all patients gave informed consent, and information from patients’ medical records and radiographic studies were acquired with approval from our institutional review board. For this study, 13 patients were included (8 men and 5 women; age range 41 – 73 years; mean age 59.8 years). All of the patients presented with severe pain without neurological deficit that was related to the spinal lesions; various analgesics and chemotherapeutic regimens were given before the procedures. The primary tumors were classified in 5 categories (Fig. 1). Vertebroplasty was performed in patients who were not candidates for surgery due to debilitation or multifocal spinal disease. Radiation therapy was not indicated in 9 patients because the patients had already received the maximum radiation dose for local lesions. In 4 patients, the procedures were performed pre- or post-radiotherapy for rapid stabilization of the vertebrae due to the delayed and incomplete pain control provided by radiation therapy. Eight patients had multiple spine metastases, and 4 of them had more than 2 levels involved in the cervical spine. Rigid cervical collars were prescribed to all patients to prevent the development of neurological deficit due to the high risk of subluxation and angulation of the fracture.

**Imaging Assessment**

All patients were given enhanced computed tomography (CT) and magnetic resonance imaging (MRI) examinations before the procedure to evaluate the lesion type (osteolytic, osteoblastic, or mixed), to determine the lesion invasive range with or without cortical breakthrough, and to identify the positional relationship of the carotid sheath and the vertebral artery to define the anterolateral access path with multiplanar reconstructions. After the procedure, a plain CT examination to assess cement leakage was conducted in all patients.

**Procedure**

All procedures were performed in an angiography suite with a C-arm digitalized x-ray system (Angiostar, Siemens, Erlangen, Germany; Innova 4100, GE, USA). Before the procedure, all patients were given intravenous antibiotic prophylaxis (2 g of cefazolin; Qilu Pharma, China), which continued post-procedure for 3 to 5 days. The patients were in the supine position with a soft cushion underneath the neck and shoulder that slightly hyperextended the cervical spine. Conscious sedation and analgesia were obtained with IV flunitrazepam (Versed, Roche Pharmaceuticals, Shanghai, China) and buprenorphine hydrochloride (Institute of Pharmaceutical Research, Tianjin, China). The patients were kept alert enough to state whether any pain developed during the procedure. Local anesthesia was given at the selected needle-puncture site, which was at approximately one cm below the edge of the mandibular angle and at the ventral edge of the sternocleidomastoid muscle. Turning the patient’s head away from the side of entry and thrusting the jaw superiorly lessened some of the angulation. The carotid pulse was palpated.
by the operator’s index and middle fingers, and the carotid sheath structures were displaced posterolaterally by manual palpation. Atropine (0.6 to 1.0 mg) was administered intravenously to prevent a vasovagal response related to compression of the carotid body receptors before this maneuver. Initially under continuous anteroposterior fluoroscopy, the needle puncture was made between the carotid sheath and the airway. A 14-gauge, 10-cm-long beveled needle (LADI (T) 2002 No. 2040120, Guanlong, Jinan, China) was introduced in front of the fingertips used to displace the carotid sheath in an oblique (posterior, cranial, and medial) direction. The needle was then positioned with its tip in the anteroinferior vertebral wall of C2. After confirming the correct position of the needle tip with anteroposterior and lateral fluoroscopy, the needle was rotated and advanced to be placed in the middle of the vertebral body (Fig. 2).

Once the needle was in place, bone cement (polymethyl methacrylate, [PMMA]) was prepared by mixing powder cement polymer with barium sulfate powder and liquid monomer until it formed a high-viscosity paste (MAIT 2000 No. 302176, Tianjin, China). The cement was loaded into a screw-type 10 mL syringe for further usage, while care was taken to expel air from the syringe. The cement was incrementally injected into the lesion with 0.5 mL aliquots under continuous lateral fluoroscopic guidance (Fig. 3). The injection was stopped when the bone cement filled up the lesion, or when any epidural leakage occurred. If any paraspinal leakage of cement occurred, the injection was
temporarily halted to allow the cement to harden, after which the injection was resumed, with a changing of direction of the bevel and the position of the needle tip. The volume of injected cement was determined and recorded using a graduated syringe. A routine biopsy was performed before cement injection.

Pain Evaluation

Patients’ pain levels were assessed according to the visual analog scale (VAS) score; a score of 0 indicated no pain, and a score of 10 indicated the most pain imaginable. The appraisal standards of pain relief included:
1. complete relief (CR): no pain remained after treatment;
2. partial relief (PR): pain improved compared with before treatment and was now moderate, and general sleep was not disturbed;
3. moderate relief (MR): pain improved but was still apparent, and sleep was disturbed;
4. no relief (NR): pain did not significantly change compared with that before treatment.

The patients maintained the previous doses of narcotic drugs for 48 hours after the procedure. Thereafter, the patients were permitted to discontinue their medical treatment gradually according to the decrease in pain. Pain was considered improved when pain relief was complete or partial and the narcotic drugs were completely stopped. VAS scores were established at pre-operation as a baseline. All patients had clinical re-evaluation, which was repeated at 3 days, one month, 3 months, 6 months, and 12 months post-operatively, or until the patient died.

Statistical Analysis

Data were analyzed using a commercially available statistical software package (SPSS for Windows, version 12.0, 2003; SPSS, Inc., Chicago, IL, USA). Data was expressed as mean ± SD. The results at all of the study’s time points were compared using a paired t-test, with a P value of less than 0.05 considered statistically significant.

Results

Vertebroplasty was successfully performed with an anterolateral approach in 13 patients. The amount of cement injected per level varied between 2.0 and 4.0 mL (mean 3 ± 0.8 mL). Cement deposition in all lesions was satisfactory. Cement leakages were detected in 5 treated vertebrae and localized to the anterior epidural space (n = 1) (Fig. 4), the pre- or paravertebral space (n = 3) (Fig. 5), and the epidural venous plexus (n = 1). No clinical complications were observed in any of these patients. At 3 days after the procedure, complete relief of pain was achieved in 7 patients, partial relief in 4 patients, and moderate relief in 2 patients. Mean VAS score decreased from 7.6 ± 0.9 pre-operatively to 2.1 ± 1.9 by 3 days after the operation. During the clinical follow-up for all 13 patients, 2 died within 3-4 months, 6 died within 8-11 months, and 5 were still alive after 12 months. Mean VAS score remained low throughout the follow-up period, with 1.8 ± 1.7 at one month, 1.7 ± 1.8 at 3 months, 0.9 ± 0.8 at 6 months, and 0.6 ± 0.5 at 12 months, respectively. There was a significant difference between the pre-operative baseline and each time point of the post-operative follow-up (P < 0.001) (Table 1). It is worth noting that 4 patients exhibited mild odynophagia after the procedure. The symptom gradually disappeared over approximately 3 days. All 4 cases suffering from multiple metastases of the cervical spine underwent multi-level punctures in the one-stage operation.

Discussion

The C2 is a part of a complex biomechanical system in the upper cervical spine. It is surrounded by a number of delicate neurological and vascular structures, and it participates in the cranial movement in different planes: extension, flexion, rotation, lateral bending, axial loading, and distraction (3). Thus, having osteolytic metastases involving C2 is a threatening condition. Clinical management of the lesions includes open surgery, radiotherapy, and vertebroplasty. However, open surgery may not be an option in patients with multiple metastases and poor general medical status (4). Radiotherapy is the standard palliative treatment for metastatic bone tumors, reducing pain in 60 – 90% of patients within 10 – 14 days after the start of therapy, and maximum benefit is obtained after 12 – 20 weeks (5). The late onset of pain alleviation after the therapy is not acceptable for patients with unbearable pain. More importantly, radiotherapy can result in minimal and delayed (2-4 months after the start of irradiation) bone reconstruction, and this delay in bone reconstruction increases the risk of vertebral collapse and consequently of neural compression (1). Moreover, additional radiotherapy cannot be performed again in patients with recurrent pain in whom radiotherapy has already been performed, due to the dangers of radiation-induced myelopathy. Therefore, radiotherapy might not be the best choice for patients with a poor overall prognosis and a short expected life span.
Vertebroplasty is a minimally invasive technique that can provide pain relief and produce immediate bone strengthening and vertebral stabilization when the lesion threatens the stability of the spine (6,7). The procedure can be proposed as part of the local treatment in association with radiation therapy or a systemic

Fig. 4. Pre- and post-operative sagittal and axial CT images of the upper cervical spine. Pre-operative sagittal (a) and axial (b) CT images show osteolytic lesions in C2 and C5 (arrows). Post-operative sagittal (c) and axial (d) CT images show satisfactory cement distribution over the osteolytic lesion in the body of C2 and cement leakage in the anterior epidural space (arrows). Satisfactory cement filling in C5 osteolytic metastases is also seen.
therapy (hormonotherapy, chemotherapy, and bisphosphonates) (8). Vertebroplasty of C2 can be performed using anterolateral, posterolateral, translateral, and direct transoral approaches under fluoroscopic and/or CT guidance (9-12); from a technical point of view, the procedure is more challenging than those in the thoracic and lumbar spine because of potential dangerous complications related to the local unique anatomical features. In normal anatomy, many neural and vascular structures pass through the C2 vertebral body on their way to supporting functions throughout the body; C2 is surrounded by the larynx and pharynx anteriorly, the carotid space laterally, the vertebral artery and cervical nerve posterolaterally, and the thecal sac posteriorly. It is crucial to avoid these structures during interventional procedures. The local anatomic structures related to the different vertebroplasty approaches are shown in schematic illustrations (Fig. 6), which focuses on the important osseous, muscular, vascular, and neural structures. The transoral approach is the most straightforward

Table 1. VAS scores of patients at pre-operative and each post-operative time point of follow-up.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Pre-op (N = 13)</th>
<th>Post-op 3 days (N = 13)</th>
<th>Post-op 1 month (N = 13)</th>
<th>Post-op 3 months (N = 13)</th>
<th>Post-op 6 months (N = 11)</th>
<th>Post-op 12 months (N = 5)</th>
</tr>
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<tbody>
<tr>
<td>Mean ± SD</td>
<td>7.6 ± 0.9</td>
<td>2.1 ± 1.9</td>
<td>1.8 ± 1.7</td>
<td>1.7 ± 1.8</td>
<td>0.9 ± 0.8</td>
<td>0.6 ± 0.5</td>
</tr>
<tr>
<td>Versus Pre-op</td>
<td>-</td>
<td>( P &lt; 0.001 )</td>
<td>( P &lt; 0.001 )</td>
<td>( P &lt; 0.001 )</td>
<td>( P &lt; 0.001 )</td>
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Fig. 5. This post-operative CT image shows cement leakages in the prevertebral space (arrow).

Fig. 6. Anatomic schematic illustrations of the needle trajectories to C2 body/dens lesions. Anatomic structures are shown on the right side of the diagram; the needle trajectories are shown on the left side. TA: transoral approach; LA: lateral approach; PA: posterolateral approach (a); AA: anterolateral approach (b).
Vertebroplasty in C2 Metastasis

A limitation of this study was the small size of the patient sample. In addition, most patients were in the late stage of the disease, a fact that limited the generalization of our data and long-term follow-up. However, to the best of our knowledge, this study represents the largest series of patients with metastasis yet published, demonstrating the benefit of vertebroplasty for the treatment of osteolytic metastases at C2 using an anterolateral approach. A much larger group of patients might reveal a higher complication rate, especially treatment failure. However, although our initial study design was more susceptible to the effects of bias, we believed it was a practical way to evaluate the efficacy of this technique because the current opportunity to perform the procedure was so limited.
CONCLUSION

Vertebroplasty using an anterolateral approach is safe, feasible, and effective in the treatment of patients with osteolytic metastasis in C2. Considering the higher risk of complications of the procedure in this region, it is strongly recommended that the treatment be carefully performed by an experienced specialist who is familiar with local anatomy.

REFERENCES


