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C-arm CT guided percutaneous vertebroplasty for pain release in cancer patient with cervical 1 vertebral metastases: A case report.

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Abstract

OBJECTIVE: To evaluate the efficacy and treatment outcome of C-arm CT percutaneous vertebroplasty in the treatment of cervical 1 (C1) vertebral metastases.
METHODS: This report recruited a male patient diagnosed with hepatocellular carcinoma and C1 vertebral metastases, who had suffered from severe neck pain symptoms and the analgesic showed little soothing effect. Under the guidance of C-arm CT, an 18G coaxial needle was used to puncture the left lateral mass of C1 vertebral metastases from lateral space between thyroid cartilage and the left carotid sheath, with 2 ml bone cement injected.
RESULTS: Postoperative C-arm CT three-dimensional reconstruction scan showed that the bone cement was well filled and distributed in the left lateral mass of C1 vertebral body, and no leakage of bone cement was observed. The neck pain of the patients was significantly relieved one week after the operation.
CONCLUSION: Under the guidance of C-arm CT, cement augmentation using percutaneous vertebroplasty in an anterior cervical direction could serve as a safe and effective pain relief approach for patients with C1 vertebral metastases.

CASE REPORT

INTRODUCTION

Percutaneous vertebroplasty (PVP) is a pain management strategy involving the injection of medical grade cement into a collapsed or weakened vertebra to stabilize the fracture, which has been used for the pain management of patients with osteoporotic vertebral compression fractures and vertebral metastases (Filippiadis *et al.* 2017; Buchbinder *et al.* 2018). The main advantages of PVP include minimally invasion, quick recovery and remarkable curative effect, and it is widely used in clinical practice with CT or C-arm CT as the operation monitoring method (Buchbinder *et al.* 2018). In cancer patients with metastases, the spine is one of the common metastatic sites of malignant tumors, and the destruction of the vertebral body caused by the metastases triggers durable pain (Conti *et al.* 2019). The treatment effect of analgesic drugs is limited for the pain management and the impaired strength of the vertebral body and spine can increase the risk of paraplegia and undermine the life quality of the patients (Conti *et al.* 2019; Chang *et al.* 2020).

Among all spinal metastases, cervical metastases are less common than thoracolumbar metastases, with upper cervical metastases accounting for less than 1% of all spinal metastases (Nguyen *et al.* 2020). Due to the complex anatomical structure of the neck and the adjacent organs such as the neck blood vessels, airway, and digestive tract, invasive operations such as PVP are relatively rarely applied in the cervical spine due to the difficulty and high complication rate (Wang *et al.* 2016; Bao *et al.* 2017). Cervical 1 (C1) vertebral metastases are very rare cases in clinical practice. Due to the particularity of the anatomical location of C1 metastases, the difficulty and risk of PVP procedures are significantly higher than those of other vertebral bodies and there are few reports in the literature of successful PVP operations for patients with C1 vertebral metastases (Yang *et al.* 2015). Here, we reported a successful case of C-arm CT guided PVP cement augmentation for pain release in a cancer patient with C1 vertebral metastases.

METHODS

Case Data

A 43-year-old man was admitted to the Department of Interventonal Medicine at Zhongshan People's Hospital 9 months after diagnosis of hepatocarcinoma, who suffered from neck pain for 1 week with progressive aggravation accompanied by dizziness. Pain intensity was recorded using a Visual Analogue Scale/ Score (VAS) ranging from 0 (no pain) to 10 (extremely severe pain). The VAS was 6 points at admission, which was reduced to 2 points after the administration of 30 mg oxycodone q8h. But the drug effect only lasted for 3 hours, after which neck pain symptoms became worsened. MRI examination revealed abnormal shadowing signal in the atlas and occipital base, suggesting the existence of cervical metastasis (Figure 1, see arrow).

Preoperative preparation

Routine clinical laboratory tests (blood, liver function, renal function, cardiac function, coagulation function, heart color ultrasound examination) were performed. MRI examination was conducted to determine whether there was spinal cord compression in the spinal canal, and assess the direction of cervical blood vessels and the scope of tumor invasion of the vertebral body. The patient was fasted for 8 hours before surgery.

Instruments and bone cement

The C-arm CT technology of DSA (Digital Subtraction Angiography) (Allura Xper FD20, Philips) was used to guide vertebral body puncture and monitor the trajectory of bone cement injection (Surgical Simplex, Stryker, USA). PVP instruments include 13G puncture needle (COOK , USA), 1.0 mL syringe (PVP special syringe, COOK, USA) and 18G coaxial needle (COOK, USA). The bone cement was configured according to a powder-to-liquid ratio (g/mL) of 3:2 (toothpaste shape).

Surgical procedures

The patient was placed supine on the DSA examination table, and the jaw was lifted to expose the cervical operative field. DSA fluoroscopic positioning (between the thyroid cartilage and the left carotid sheath) at the head and neck were sterilized and draped, and 1% lidocaine was used to anesthetize the puncture site locally. After locating the puncture point (between thyroid cartilage and left carotid sheath), an 18G coaxial guidance needle was punctured into the C1 vertebra (with the left middle finger pushing the patient's esophagus and airway to the inside and the left index finger pushing the sternocleidomastoid muscle and carotid sheath to the outside to avoid injuries to adjacent organs). A step-by-step puncture manner was then adopted for the needle insertion with the assistance of multiple C-arm CT scans. The depth of each needle insertion was about 1.0 cm, and the angle of the guidance needle was adjusted

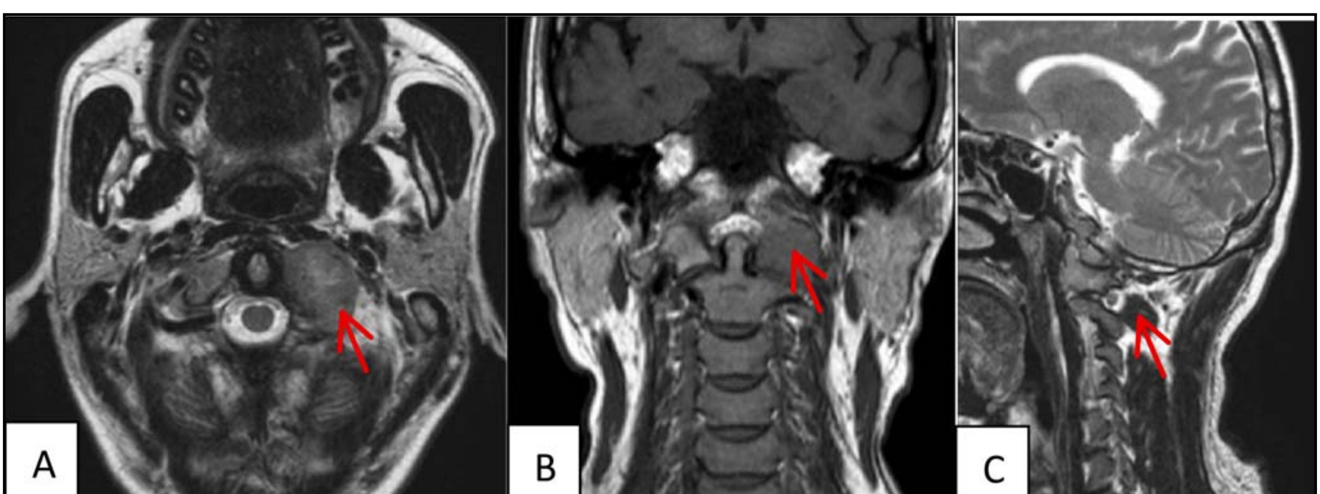

Fig. 1. MRI showing the abnormal shadow signal in the left lateral mass of the atlas of the patient, indicating spinal metastasis. (A). Aerial view; (B). Rear view; (C). Side view.

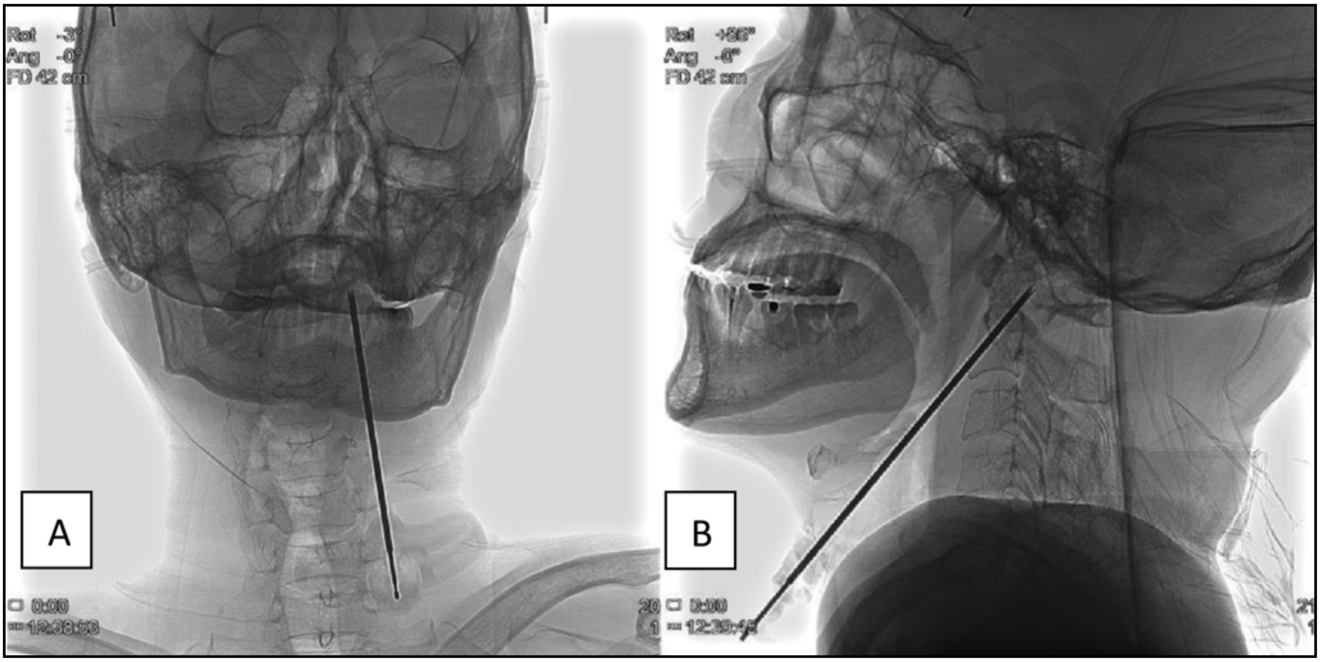

Fig. 2. 13G puncture needle was inserted into the left lateral mass of the C1 vertebral metastasis body through the body surface puncture point. Images were derived from multiple C-arm CT scan. (A). Front view; (B) Side View.

to avoid injuries to blood vessels and adjacent organs (Figure 2). After the three-dimensional reconstruction of C-arm CT confirmed the accuracy and safety of the puncture channel, the bone cement needle (13G puncture needle) was punctured at the edge of the left lateral mass of the C1 vertebral body along the path of guidance needle (a similar step-by-step puncture method was adopted), and the coaxial needle was removed. The bone cement needle was adjusted to enter the left lateral mass of the C1 vertebral body. The puncture accuracy of bone cement needle into the left lateral mass of the atlas was validated by C-arm CT 3D reconstruction (Figure 3). The prepared bone cement was injected into the C1 vertebral body under fluoroscopy. The presence of extravasation of the bone cement was closely monitored, and a total of 2 ml of bone cement was injected. Then the 13G puncture needle core was punctured 1/4 into the injection site and three-dimensional reconstruction of C-arm CT was performed to ensure that the bone cement was completely deposited in the left lateral mass of the atlas. After the removal of 13G puncture needle core, three-dimensional reconstruction of C-arm CT was performed again to check the integrity of bone cement (Figure 4). After 5 minutes, the 13G puncture needle was rotated 360°, and then the puncture needle was slowly pulled out. Three-dimensional reconstruction scanning under C-arm CT was performed to observe the distribution of bone cement. The patient was kept still until the cement became completely solidified and hardened. The pain experience and complications of the patient were closely monitored for 6 hours after the operation.

RESULTS

C-arm CT scan after PVP operation showed that bone cement was well filled and evenly distributed in the left lateral mass of C1 vertebral metastases, and there was no bone cement extravasation. After the surgery, the patient was instructed to rest in bed for 12 hours in a supine position to facilitate the solidification of bone cement and minimize the disturbance of the puncture site. 24 hours after the PVP, the pain of the patient was not significantly relieved, which may be due to the edema or the dehydration of the surrounding tissue after the operation. Although there was no leakage, the neck could barely move at the time point due to the pain. However, the pain of the patient was significantly relieved three days after PVP, and the VAS score was reduced to 2 points in the absence of analgesic drug treatment. At this time point, the patient could slightly move the neck and rotate the head with mild pain. The neck pain completely disappeared 1 week after the PVP operation without serious complications, and the patient was able to move the neck freely without feeling pain.

DISCUSSION

The pain-relieving effect of cement augmentation by cervical PVP in the patient with atlas metastases is encouraging in our report. Previous studies also reported that PVP operation relieves pain in cervical spine metastases and C1 osteolytic lesions via lateral approach under fluoroscopic guidance (Bao *et al.* 2017; Yang *et al.* 2021). The pain-relieving mechanism of PVP

Fig. 3. The three-dimensional reconstruction of C-arm CT scan confirmed that the 13G puncture needle was located in the left lateral mass of the C1 vertebral metastases without injuries to adjacent organs. (A). Front view; (B). Rear view; (C). Side view. (D) Aerial view.

may be attributed to the following factors: ①Thermal effect: the heat resulted from bone cement solidification has a negative effect on the surrounding tumor cells and pain-sensing nerve endings; ②Mechanical effect: the injection of bone cement can improve the biomechanical properties of the spine by fixing the microscopic fractures, reducing the micro-displacement of fracture ends, strengthening the support force of the vertebral body and eliminating the effect of extrusion and friction between tissues; ③The bone cement may block the blood supply to the local tissues, thereby damaging tumor cells and desensitizing the nociceptive peripheral nerve; ④Chemical toxicity of bone cement: cytotoxic effects of bone cement may be detrimental to tumor cells and surrounding nerve cells (Yimin *et al.* 2013; Yang *et al.* 2011).

Due to the complex structure of the cervical spine, PVP procedures are difficult to apply due to the proximity of important organs. The PVP procedures close to cervical spine could be summarized as the following four categories: ①Anterior approach: anterolateral approach of the cervical spine where the puncture needle passes between the carotid sheath and the thyroid cartilage. The approach is complex since many neurovascular structures are located within the puncture path, such as important blood vessels (internal jugular vein and vertebral and carotid arteries), nerves (vagal, spinal, accessory, lingual, hypoglossal, marginal mandibular, and laryngeal) and the submandibular gland (Sun *et al.* 2013); ②Transoral approach: The operation is performed under general anesthesia and endotracheal intubation, which requires multidisciplinary cooperation (Kaminsky *et al.* 2013). Of all the methods, this is the only appraoch that requires general anesthesia and intubation. The transoral route is difficult to sterilize and there is an increased risk of infection. Once the infection of the posterior oropharyngeal spreads along the cervical fascia and the meningeal layers, it could lead to devastating complications including retropharyngeal abscess, meningitis and encephalitis (Higashi *et al.* 2022). ③Posterior approach: according to whether the needle entry channel is parallel to the long axis of the lateral mass, the posterior approach is further divided into the posterolateral approach and the direct posterior approach. Posterior PVP is the most direct and targeted approach to avoid damage to neurovascular structures in the carotid sheath. Nevertheless, occipitalneuralgia was reported as a complication after posterior PVP operation [8]. ④Translateral approach: the key to this approach is to bypass the carotid sheath and vertebral artery. A step-by-step puncture manner under the guidance of C-arm CT can avoid direct injuries to important

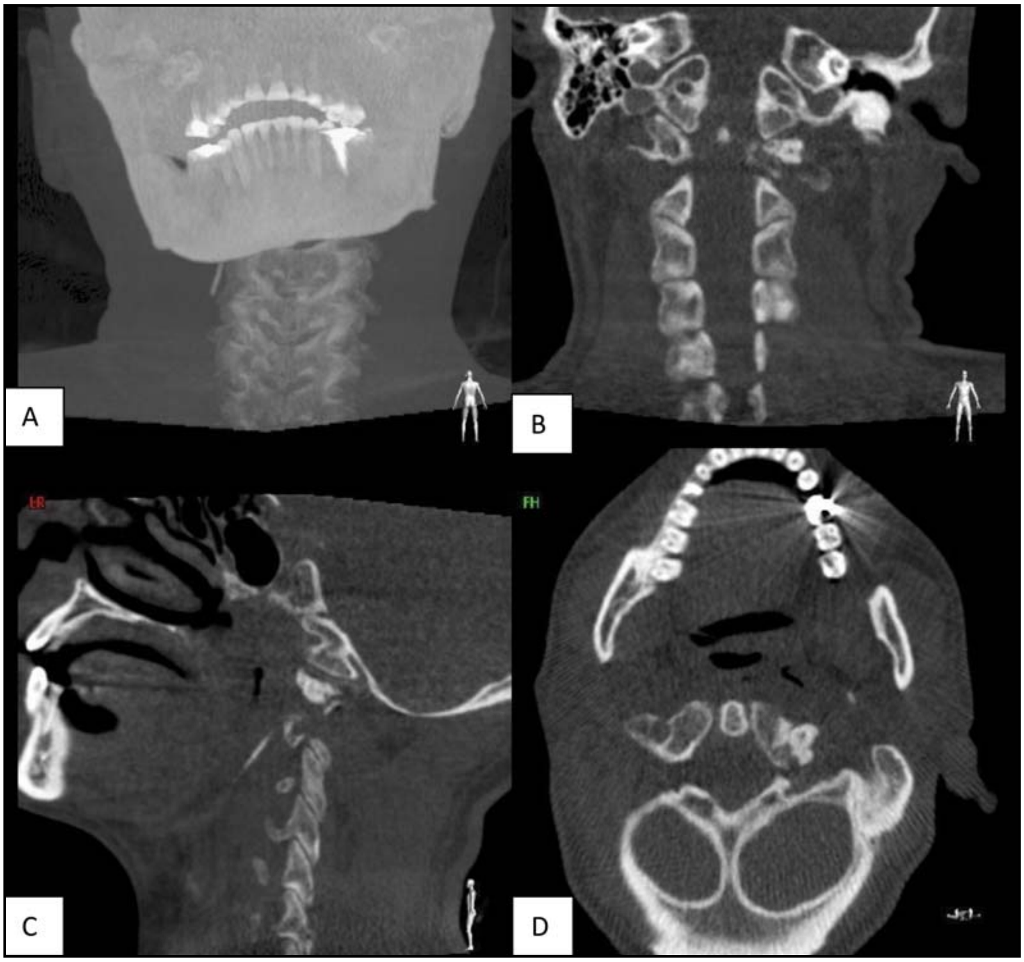

Fig. 4. Postoperative three-dimensional reconstruction of C-arm CT showed the even distribution of bone cement in the left lateral mass of C1 vertebral metastases, without bone cement extravasation. (A). Front view; (B). Rear view; (C). Side view. (D) Aerial view.

structures adjacent to the puncture path. The needle trajectory should be adjusted along the posterior rim of the carotid sheath and in the direction of the anterior rim of the vertebral artery (Yang *et al.* 2015). This approach can minimize the potential damages imposed to the surrounding organs during the puncture and injection.

The most common complication of PVP is bone cement leakage. Cement leakage and extravasation in the cervical spinal canal can compress the cervical spinal cord and cause serious complications such as neurological damages or high paraplegia (Jing *et al.* 2021). This case report suggests that cement augmentation in cervical canal could be successfully completed through PVP under close fluoroscopic monitoring throughout the puncture and bone cement injection processes. During the injection of bone cement, the 1/4 bone cement was injected first and C-arm CT three-dimensional reconstruction was performed to exclude the cement leakage, and then the bone cement needle was completely inserted under fluoroscopy. However, the DSA with C-arm CT post-processing function is not popular at present. We recommend that conventional CT can be combined with C-arm CT to monitor PVP procedures, which will take advantages of the two imaging devices to improve the density resolution of the anatomical structures around the cervical spine. The combination of the two machines can also monitor the intraoperative cement flow in real time and reduce the risk of serious complications caused by cement leakage or extravasation.

In addition, we also recommend that the operation be performed under local anesthesia and basic anesthesia. Adequate local anesthesia before PVP, covering the cervical fascia, anterior longitudinal ligament and anterior periosteum, combined with intravenous analgesia, can improve the patient's tolerance and reduce the pain of the surgery. In the meanwhile, the patient can communicate with the surgeon throughout the procedures in case of any neurological symptoms or complications. In addition, the position of the patient's mandible can be adjusted to clearly reveal the socket and lateral mass under C-arm fluoroscopy. To minimize the damages to blood vessels and surrounding organs during PVP, we suggest the use of an 18G coaxial needle to puncture the edge of the lateral mass of the C1 vertebral body before cement injection. The cement needle is then approached along the optimized path of 18G coaxial needle. After the cement needle was close to the lateral mass of the C1 vertebral, the 18G coaxial needle can be pulled out and the angle of the cement needle needs to be adjusted to deposit the cement into the lateral mass of the C1 vertebral. The use of a thinner coaxial guidance needle is expected to greatly reduce the risk of complications during the puncture approach.

CONCLUSION

In this case report, cement augmentation by C-arm CT-guided PVP for C1 vertebral metastases was successfully implemented to reduce the neck pain of a patient. It has been demonstrated to be technically feasible and safe, with an effective pain relief outcome, which is in line with the expectation of PVP.

FUNDING

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ETHICS APPROVAL AND CONSENT TO PARTICIPATOR

This study was approved by the Medical Ethics Committee of Zhongshan People's Hospital and written informed consent has been obtained from the patient.

CONSENT FOR PUBLICATION

Not applicable.

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None.

CONFLICTS OF INTEREST

The authors declare that there is no conflicts of interest associated with this manuscript.

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