Percutaneous Osteoplasty under Fluoroscopy and Cone-Beam CT guidance for Painful Sternal Metastases

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Research Article

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Abstract

Background: Although percutaneous osteoplasty (POP) has been widely accepted and is now being performed for the treatment of painful bone metastases outside the spine, there are only scarced reports regarding osteoplasty in painful sternal metastases.

Case presentation: The paper reported four patients with painful sternal metastasis who underwent POP under fluoroscopic and cone-beam CT guidance. The patients were three men and one woman (mean age, 66.25 years). Primary tumor location in lung is 3 cases, in thyroid is 1 case. In these cases, Pain was measured using a numerical rating scale (NRS), with scores ranging from 0 (no pain) to 10 (worst pain imaginable). The scores on the NRS in the four patients before POP were 9, 8, 8, and 9. After POP, the NRS scores decreased to 2, 3, 2, and 2, respectively, in follow-up at 6 months.

Conclusions: POP is a safe and effective treatment for pain caused by metastatic bone tumors in the sternum. However, care and at tention should be paid to the insertion of a needle and cement distribution for better treatment effect

Introduction

Percutaneous osteoplasty (POP) has been widely accepted and is now being performed for the treatment of painful bone metastases outside the spine. (1–3). The technique consists of inserting a percutaneous needle into the affected bones and the injection of polymethylmethacrylate (PMMA). However, there are only scarced reports regarding osteoplasty in painful sternal metastases (4–8). We present here four patients with painful sternal metastases who were successfully treated by POP under fluoroscopic and cone-beam CT guidance.

Material And Methods

This retrospective study was approved by our institutional review board. The clinical and imaging data of the four cases underwent POP were reviewed. Informed consent for the procedure was obtained from all four patients.

The indication for POP was severe bone pain caused by sternal metastatic disease. The pain was refractory to pain medication including parenteral narcotic treatment. POP was offered as a treatment to the patients with a muti-interdisciplinary consensus among a team of surgeons, oncologists and radiotherapists. POP procedures were performed by interventional radiologists with more than 5 years of experience in bone procedures in a digital subtraction angiography system with cone-beam CT (CBCT). Conscious sedation was achieved just before the procedure and patients were placed in a supine position with neck in slight extension. After chest wall sterile preparation and draping, cone-beam CBCT was performed to identify the margins of the metastases and delineate the most appropriate needle trajectory and needle inclination by a superior to inferior approach. With local anesthesia, a 13-gauge bone-beveled needle was punctured into the sternum, and gently advanced into the lesion under direct real-time

fluoroscopic guidance and cardiovascular monitoring. Depending on the sizes and shapes of lesions, 2–4 needles per lesion were placed percutaneously to get better distribution of the bone cement. Polymethyl methacrylate (PMMA) was mixed to a semiliquid consistency. PMMA injection was performed by means of 1-mL syringes with a maximal possible amount via the needle and the cement contained in the lumen of the needle was delivered into the lesion by introducing a stylet into the needle under real-time fluoroscopic guidance. If cement achieved satisfactory filling in the metastatic area, or reached the anterior and posterior cortical margin, or started to leak, the injection would be stopped. The volume of injected cement was determined and recorded. Additional CBCT or computed tomography (CT) scan was performed to evaluate the distribution of PMMA in the lesions.

A series of clinical assessment for the treatment effect was recoded at pretherapy baseline, and at 1 week, 1 month, 3 months and 6 months after procedure. Pain was measured using a numerical rating scale (NRS) with scores ranging from 0 (no pain) to 10 (worst pain imaginable).

Table 1 shows the clinical characteristics of four patients that included: gender, age, histology of the lesion, number of needles inserted, amount of injected PMMA, changes in pain intensity and pain medication (oral narcotic or transdermal narcotic). Table 2 shows the NRS scores at baseline, and at 1 week, 1 month, 3 months and 6 months after procedure.

Table 1
Patient data are detailed.

Case	VAS before	primary tumour	VAS before	Previous analgesic therapy	needle number	Amount of injected PMMA (ml)	Analgesic therapy after procedure
1	M/71	Squamous cell carcinoma of the lung	9	Oral narcotic	2	2.5	none
2	F/57	Adenocarcinoma of the lung	8	Oral narcotic	3	4.5	none
3	M/72	Squamous cell carcinoma of the lung	8	Transdermal narcotic	2	1.5	none
4	M/65	Papillary carcinoma of the thyroid	9	Transdermal narcotic	2	2	none

Table 2
Numerical rating scale (NRS) scores of patients at preoperative and each postoperative follow-up point

Case	Pre-procedure	Poste-procedure			
		1 week	1month	3months	6months
1	9	4	3	3	3
2	8	3	2	2	2
3	8	4	3	3	3
4	9	3	2	2	2

Case Presentation

Case 1

A 71-year-old man complained of persistent pain and braced himself, when coughing. Upon examination, there was pinpoint tenderness over the sternum. On CT scan, there was a lesion measured 5.4 × 4.7 × 3.9 cm in left lung hilum with an osteolytic destruction of the sternal manubrium. The biopsy of lung lesion confirmed squamous cell carcinoma. The patient had a NRS score of 9, and no symptom improvement was obtained with oral narcotic. POP was performed with three needles inserted, and 2.5 ml of PMMA was injected into the sternal lesion (Fig. 1). After the procedure, he gained a significant pain relief, and the NRS scores decreased to 4, 3, 3, and 3, respectively, in follow-up at 1week, 1month, 3month, and 6 month.

Case 2

A 57-year-old woman had a five-year history of right pulmonary adenocarcinoma and treated with neoadjuvant chemotherapy followed by radiotherapy. One month ago, she had severe pain in the anterior chest wall that often affected her sleep. The patient had a NRS score of 8, and the pain was refractory to oral narcotics. CT scan showed multifocal destructive osteolytic lesions of the sternal body and manubrium. POP was performed with three needles inserted and 4.5 ml of PMMA was injected (Fig. 2). After the procedure, she gained pain relief and was able to sleep well, and the NRS scores decreased to 3, 2, 2, and 2, respectively, in follow-up at 1week, 1month, 3month, and 6 month.

Case 3

A 72-year-old man had persistent pain of the anterior chest wall that worsened with body position change. The patient had a NRS score of 8, and the pain was refractory to transdermal narcotic treatment. On CT scan, there was a lesion measured 3.7 × 5.5 × 4.3 cm in left lower lung with an osteolytic destruction of the sternal body. The biopsy of lung lesion confirmed adenocarcinoma. POP was performed with two needles inserted and 1.5 ml of PMMA was injected (Fig. 3). After the procedure, he

obtained pain relief, and changing body position didn't cause pain. His NRS scores decreased to 4, 3, 3, and 3, respectively, in follow-up at 1 week, 1 month, 3 month, and 6 month.

Case 4

A 65-year-old man underwent a thyroidectomy 19 years ago for an undifferentiated carcinoma. He was hospitalized for his anterior chest wall severe pain with NRS score of 9, and no pain relief was gained with transdermal narcotic. His focal anterior chest wall pain corresponded to an osteolytic sternal body metastasis on CT scan. POP was performed through two needles insertion and 2 ml of PMMA injection. The patient achieved pain relief after the procedure (Fig. 4), and the NRS scores decreased to 3, 2, 2, and 2, respectively, in follow-up at 1 week, 1 month, 3 month, and 6 month.

Discussion

Osseous metastases are usually seen in cancer patients at advanced stage. It usually causes intractable pain, functional impairment, and worsening quality of life. Because most of the patients with intractable painful metastases are usually at the end stage of disease at the time of presentation, the goals of treating these patients should be the alleviation of pain, and improvement of life quality. The patients are usually not surgical candidates, and have complications for routine analgesic medications. Currently, radiation is recognized as the most effective treatment, however, 20–30% of patients with painful bone metastases are nonresponders (9). Furthermore, sternal radiation may result in devastating cardiac complications due to its proximity to the heart and large vasculatures. Patients can also develop acute pneumonitis and esophageal complications during and after radiation therapy (10, 11).

The sternum is a long flat bone, only 2–3 cm in depth. Percutaneous insertion of a needle into the sternal lesion can be a challenge because of the contour deformity and the bony landmarks sabotage by lytic tumor. To meet this challenge, some imaging guidance technology has been applied to accurately and precisely perform insertion of a needle through minimally invasive means with use of both CT and fluoroscopic guidance with sonography or CBCT (7, 12–15). We prefer to use the fluoroscopy and CBCT guidance to improve preprocedural trajectory planning, needle advancement tracking of and cement distribution through the sternum, to reduce the complexity of multiple device applications.

Physical and chemical properties of cement injected alone into osteolytic lesions can provide mechanical resistance to axial compressive forces, but less so to tension and torques stresses (16–18). Hence, several techniques for bone metastases were reported that included the use of cemented screws, nails, catheters and metallic mesh (19–23). Additionally, some studies showed feasibility and effectiveness for the treatment of painful bone metastases with kyphoplasty, radiofrequency thermal ablation or microwave ablation and cementoplasty (4–6). Because of the non-weight-bearing sternum and the advanced disease at the time of presentation, we think POP can be used instead of above more expensive and complicated techniques, achieving the pain palliation and life quality improvement with less complication.

To perform POP for sternal metastatic lesion, multiple puncture may be necessary to get a more adequate coverage of the bone lesion. In this study, all patients had great pain caused by osteolytic lesion in the sternum and the invasion of the cortex, and often exaggerated by respirational motion of the rib cage. Our use of POP on sternal metastases resulted in satisfying clinical outcome regarding analgesic therapy management, pain control and mobility improvement. The analgesic efficacy was maintained at 6-month follow-up in all four cases. The POP was technically successful in all cases, and without severe complications.

At present, POP technique with the advantage of rapid relieve pain has been used to treat osteolytic lesions in clinical practice. The analgesic effect may be attributed to the stabilization of microfractures of the bone, the destruction of nerve endings through the exothermic reaction and cytotoxicity (24, 25). However, these are still unclear that the detail analgesic effect and the optimal volume of injected PMMA. The patient 3 obtained good pain relief in the present series, POP only injected 1.5 ml PMMA into the larger lesion area. The result may verify Yamada' study that a small amount PMMA can still achieved pain relief (26).

In conclusion, we described good pain-relieving effects following POP in four patients with metastatic tumors in sternum. POP to sternal metastases may be an effective and safe palliative therapy for reducing pain and improving patients' quality of life and mobility.

Declarations

Ethics Approval And Consent

This retrospective study was approved by the review board of the 960th Hospital of Joint Logistics Support Force of PLA (No: ChiCTR2000032667). Informed consent for the procedure was obtained from all the four patients.

Consent for publication

Written informed consent for publication (including images, case history and data) was obtained from all the four patients.

Availability of Data and materials

The manuscript data can be copied and redistributed.

Competing interests

The authors declare that they have no competing interests.

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No specific funding was obtained for this study.

Authors' contributions

GS designed the research project. XL and ZW prepared the manuscript. PJ and LY collected the data and analyze the data. All authors read and approved the final manuscript.

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Figures

Figure 1

(A) CT sagittal image demonstrated an osteolytic metastatic lesion in the sternal manubrium. (B) Radiograph showed the first needle inserted into the center of the lesion. (C) CT sagittal image, PMMA distribution.

Figure 2

(A) CBCT sagittal image showed a diffuse osteolytic lesion of the sternal body and manubrium. (B) Radiograph showed the third needle inserted into the center of the lesion. (C) CBCT sagittal image showed PMMA distribution.

Figure 3

(A) CBCT sagittal image showed a diffuse osteolytic lesion of the sternal body and manubrium. (B) Radiograph showed the second needle inserted into the center of the lesion. (C) CBCT sagittal image showed PMMA distribution.

Figure 4

(A) CBCT sagittal image showed a diffuse osteolytic lesion of the sternal body and manubrium. (B) Radiograph showed the third needle inserted into the center of the lesion. (C) CBCT sagittal image showed PMMA distribution.