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CASE REPORT

Cervical vertebroplasty under sedoanalgesia using combined ultrasonography and fluoroscopy guidance: a novel technique

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Abstract
Purpose The aim of this report was to describe a case using combined USG and fluoroscopy for cervical VP via a percutaneous route under sedoanalgesia.
Methods A 70-year-old male patient had severe neck pain for 6 weeks because of metastatic mass lesions in C6. After the decision to VP, the patient was placed on the operating table and 2 mg midazolam and 75 µg fentanyl were administered for conscious sedation. Localisation of the carotid artery, internal jugular vein, and trachea had been determined with USG. 3 mL of 2% lidocaine was infiltrated after proceeding a needle from the axis of the trochar to the C6 vertebra corpus. The trochar entered into the vertebra corpus between the carotid artery and trachea right-antero-laterally under C-arm and USG guidance. 6 mL of PMMA was injected into this field. Then C6 VP procedure had been completed without complications.
Results This case has three differences from studies in the literature. First, cervical VP was conducted under sedoanalgesia. The second important feature of this case is that cervical VP was performed via a percutaneous route. A third important feature of this case is that it was performed under USG guidance for the first time in the literature.
Conclusion We consider that the combined use of C-arm fluoroscopy and USG should improve success rates and prevent vascular and neural injuries and dura perforation.

Keywords Vertebroplasty · Cervical · Cancer pain · Ultrasound · Conscious sedation

Introduction

Vertebral fractures, a common health problem, impair the quality of life. The prevalence of vertebral fractures has been estimated at 26% among women >50 years; it reaches 80% in patients >80 years [1]. Osteoporosis and metastatic bone lesions are the most common causes of vertebral fractures, and >100 million individuals worldwide are estimated to be at risk for fracture development [2].

Kyphoplasty (KP) and vertebroplasty (VP) are widely used in the treatment of patients with osteoporosis and vertebral pathologic lesions, especially in those with metastatic bone lesions. VP is a special invasive treatment technique that is used for the treatment of pathological fractures, damage due to cancer, or congenital vascular diseases in the vertebral body. VP is done with an injection of a chemical of polymethyl methacrylate (PMMA), which is also known as bone cement, into the damaged vertebra to reinforce the bone. KP was first introduced in 1998 and has similar characteristics to VP; the only difference is the use of a balloon [3]. For KP, a special balloon is inflated after insertion into the fractured bone to restore the lost vertebrae height, and then PMMA is injected into the vertebrae following removal of the balloon. Percutaneous VP (PVP) in the cervical spine is technically more challenging than in the thoracic and lumbar spine due to the unique anatomical features and may be performed by anterolateral approaches. The cervical spine is adjacent to the

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cephalad spinal cord, carotid/vertebral vessels, nerve roots, the anterior esophagus, and trachea. PVP should be performed with good quality image intensification (fluoroscopy, computed tomography, or combination of the two techniques) to allow safe injection particularly in cervical and high thoracic procedures. It is important to monitor the advancement of needle-to-disk space during the procedure. However, X-ray fluoroscopy cannot be sufficient for confirmation of the correct position of the needle tip where vascular injury can occur if the needle comes into contact with an artery or a vein.

Ultrasonography (USG), first used under anesthesia by La Grange et al. [4], is usually preferred in peripheral nerve blocks; however, it has been used increasingly in the treatment of pain. Previous studies of USG and peripheral nerve block revealed increasing success and decreasing complication rates with a combination of nerve stimulation and imaging [5]. High-resolution USG enables prevention of intra-neural or intra-vascular injection and injuries through the discrimination of tissue layers, various soft tissues, particularly arteries and nerves, and concurrent observation of the needle's progress. Studies conducted worldwide suggest that USG-guided applications are safer, faster, less costly, more comfortable, and more effective than conventional methods [5–7].

In this case report, we present a patient who had severe pain due to metastatic lesions in the C6 and Th9 vertebrae and for whom general anesthesia presented a high risk. As an alternative, a percutaneous cervical VP procedure was used under sedoanalgesia and USG guidance; this approach has yet to be reported in the literature.

Materials and methods

A 70-year-old male patient was admitted to the pain clinic with severe neck and back pain lasting for 6 weeks. In his medical history, metastatic mass lesions of unknown origin were identified in two vertebrae (C6 and Th9 corpus). During his physical examination, he reported severe neck and back pain despite having received paracetamol, nonsteroidal anti-inflammatory drugs (NSAIDs), and opioid treatment; the pain increased with movement. Pain severity was 100 according to a visual analogue scale (VAS; use a 100-mm visual analog scale to quantify patients' subjective change in pain as well as follow the changes in pain over time). The scale classifies pain from no pain (0) to intolerable pain (100) [8]. No spinal cord pressure or neurological symptoms were observed. Mild collapse on X-ray images and wide osteolytic lesions on spinal computed tomography (CT) screening were detected in C6 and Th9 on preoperative evaluation (Fig. 1). KP was selected for reduction of the kyphotic deformity because loss of vertebral height was ≥50% in Th9. The patient's VAS scores were 100 (intolerable pain) for both cervical and thoracic

Fig. 1 **a** Sagittal computed tomography (CT) image of a C6 vertebral osteolytic lesion. **b** Axial CT image of a C6 vertebral osteolytic lesion. **c** Sagittal CT image of a T9 thoracic vertebra osteolytic lesion. **d** Axial CT image of a T9 vertebra osteolytic lesion

levels with no prior response to pharmacological treatment. Therefore, a kyphoplasty of the Th9 and a vertebroplasty of the C6 in the same session was planned using percutaneous approach under sedation.

This study was approved by the Local Ethics Committee, and written informed consent was obtained from patient. The patient was informed in detail about the procedures, and was asked to sign a consent form after he agreed to these percutaneous procedures under sedation.

Routine laboratory tests revealed normal serum electrolytes and blood values. The patient was prepared for the operation. First, 1 g ceftriaxone was administered intravenously 1 h before the operation. No other premedication was administered. The patient was placed on the single-plane fluoroscopy table in prone position for KP, and the procedure was performed in the X-ray suite with a C-arm system (Spinel 3G, Gemss Medical, Korea) under sterile conditions.

Continuous monitoring of pulse oximetry and heart rate was done. Blood pressure was monitored and recorded at 5-min intervals throughout the procedure. Two milligrams midazolam and 75 μg fentanyl were administered in gradually increasing amounts for sedation after intravenous vascular access had been established with an 18-gauge (G) cannula. A cannula (Medinaut$_{TM}$-I ICD System ICD Kit, Imedicom Co., Ltd, Korea), KP balloon (Medinaut-X IBE System Balloon Catheter, Imedicom Co. Ltd., Korea), and inflatable bone expander syringe (Medinaut-X IBE System Inflatable Bone Expander Syringe, Imedicom Co. Ltd., Korea) were used for the procedure. After the biopsy,

the PMMA bone cement (Kyphon ActivOs® Bone Cement with Hydroxyapatite, Medtronic, Inc.) filled in. No complications such as new fracture development or dislocation of cement into the spinal canal occurred, and the Th9 vertebra KP procedure was completed.

The procedure of C6 vertebroplasty

The patient was then placed in a supine position and cushions were put under the patients' shoulders to extend the neck slightly to facilitate the puncture. The procedure was carried out under conscious sedation with 1 mg midazolam and 50 mcg fentanyl. The operation area on the right side of the neck region was prepared using aseptic precautions, including skin preparation and the use of full surgical attire. Following skin antisepsis, localization of the cervical level C6 spine was determined with C-arm fluoroscopy in both antero-posterior and lateral images. USG with high frequency (6–15 MHz) linear ultrasound probe (MyLabFive, Esaote SpA, Genoa, Italy) was attached to the 2D image display of the USG. The localization of carotid artery, internal jugular vein, and trachea had previously been determined with an ultrasound machine (MyLabFive, Esaote SpA, Genoa, Italy) in short axis view, preferably in the center of the screen. The entry point of the puncture spinal needle (27 gauges, 10 cm) was identified. The spinal needle proceeded from the axis of the trocar to the C6 vertebra corpus between the trachea and carotid artery under real-time USG imaging, and removed at the end of 3 mL of 2% lidocaine infiltration (Fig. 2).

The trocar was then advanced into the vertebra corpus between the carotid artery and trachea right-antero-laterally until contact was made with anterior vertebral body cortex of C6 (where a creaking was felt) under the C-arm and in-plane technique of USG guidance (Fig. 3). Than continued with the osteo introducer stylet, the cannula and the precision drill of cement dispenser system (Medinaut$_{TM}$-I ICD System ICD Kit, Imedicom Co., Ltd, Korea). A biopsy was performed upon reaching the osteolytic part. After the biopsy, the PMMA bone cement (Kyphon ActivOs® Bone Cement with Hydroxyapatite, Medtronic, Inc.) was prepared at room temperature, and 6 mL of PMMA was injected into this field. Special care was taken to prevent leakage or induce a pressure fracture or dorsal fragment from dislocating into the spinal canal, and to continuously control fluoroscopy in biplanar images (Fig. 4). The patient was taken to the post-anesthetic care unit after the C6 VP procedure had been completed. There were no complications (such as intravascular injection or neural injury).

Post-procedural surveillance

The operation time was 32 min with no post-operative complications. The patient was monitored for 1 h in a post-anesthetic care unit and then transferred to the pain ward with an Aldrete recovery score of 9 [9].

The post-procedural evaluation of the cement distribution and any possible cement leakage was performed with AP and lateral radiography. X-ray results showed a good vertebral cement filling and no extra vertebral cement leakage. After an overnight stay in the hospital, the patient was free from pain and had no problems. The day after the procedure the cervical spine was immobilized in a soft collar for 1 week, and the patient was discharged from the hospital.

Fig. 2 Ultrasonography image when entering the C6 vertebra corpus

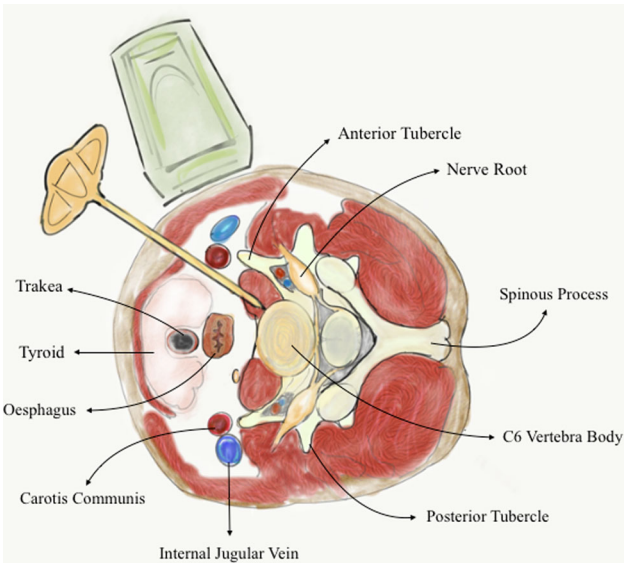

Fig. 3 Anatomic drawing of trochar' trajectory

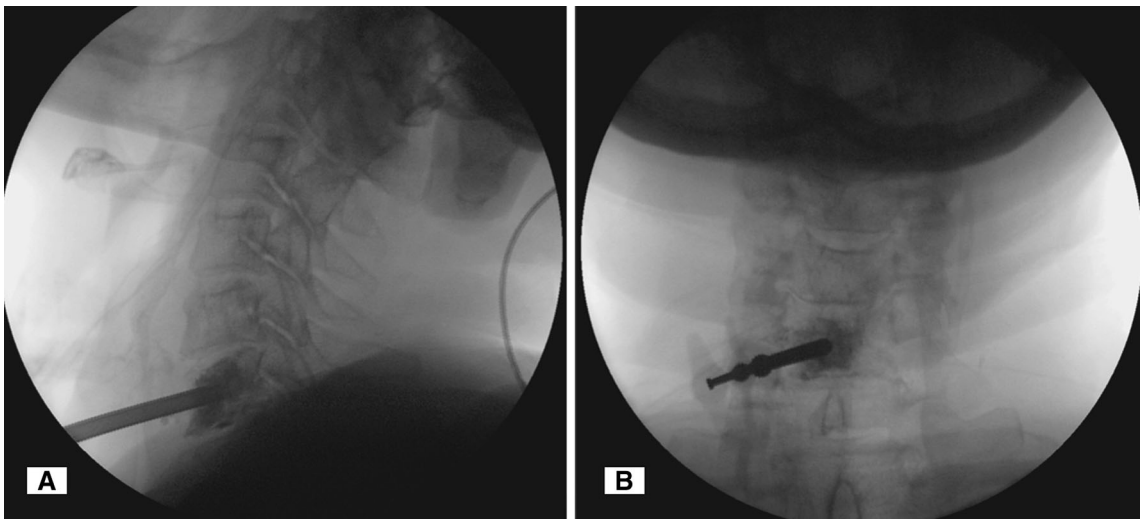

Fig. 4 **a** Lateral fluoroscopy image when polymethylmethacrylate (PMMA) was being injected. **b** Antero-posterior fluoroscopic image when PMMA was being injected

Follow-up

After leaving hospital, the patient was followed up for 10 days as an outpatient. There were no neurological problems, including paresthesis, dysesthesis, or motor deficits, related to the treated levels in his early and later neurological examinations. The patient regained complete cervical mobility without limitations. A CT scan at the end of the follow-up period revealed stable conditions by showing cement was inserted into the vertebral corpus properly with no extra-vertebral cement leakage or new fractures. The patient stated that his pain decreased rapidly just after the procedure, and his VAS score was 1–2 for the cervical and thoracic regions. The corresponding improvement in Karnofsky performance score was from 30 preoperatively to 80, and the Oswestry Disability Index (ODI) score was from 41 to 7 that were significant. Histopathologic examination revealed metastatic carcinoma in bone biopsy. The patient received palliative radiation therapy and chemotherapy. The patient died in 8 months.

Discussion

Bone metastases may lead to destructive lesions in the skeletal system such as spinal cord compression or vertebral fracture [10]. Metastatic skeletal diseases cause great difficulty for a patient by leading to direct invasion and osteolysis-related pain in addition to causing functional disorders and impaired quality of life. The VP and KP techniques have gradually gained increasing importance in the treatment of this pain.

From our point of view, this case has three differences from previous studies in the literature. First, cervical VP was conducted combined with USG and fluoroscopy guidance for the first time. Fluoroscopy and USG were applied in combination in this patient. C-arm fluoroscopy was used to identify the C6 vertebra in both antero-posterior and lateral images, and USG was used to localize the carotid artery, internal jugular vein, and trachea, and then to follow the needle as it moved between the trachea and carotid artery. We believe that the combined fluoroscopy and USG approach was helpful for the completion of the procedure without complications regarding positioning along the spine or needle progression to the corpus. USG has begun to be a more widely used approach in chronic pain intervention and has replaced fluoroscopy and CT in many chronic pain treatment procedures [11]. USG enables the direct visualization and observation of various soft tissues and the needle concurrently with no radiation exposure [12]. Thus, it is a favorable option for injections in the cervical region that contains critical soft tissue structures and rich vascular structures [13]. Iama et al. imaged the route of the needle in venous catheter insertion procedures using concurrent USG and reported that USG reduced complication risks [14]. Karkitsos et al. obtained the same results in a similar study [15]. Narouze et al. compared patients who underwent USG-guided cervical nerve root injections and controls who underwent fluoroscopy-guided injections and reported a vascular injection rate of 0% with USG and 20% with fluoroscopy [13]. Jee et al. found a vascular injection rate of 0% with USG and 9% with fluoroscopy in a similar study [16]. Obernauer et al. compared cervical nerve root injection procedures using USG or CT with regard to accuracy, time efficiency,

safety, and pain reduction; they reported accuracy under USG-guidance to be 100%, with a fivefold shorter mean duration required to reach the nerve root with the needle and the same level of pain reduction with both techniques [17]. Narouze et al. suggested that USG-guided cervical spinal procedures have many visual advantages when compared with techniques using fluoroscopy and stated that USG was promising [13].

Shah [18] reported the use of KP using fluoroscopy and USG together in palliative treatment of sternal metastases. He verified the placement of the KP balloon under fluoroscopy and USG guidance. USG enabled clear determination of cortical margins and thoracic soft tissues; fluoroscopy enabled clear visualization in anterior–posterior and lateral projections. This subsequently facilitated the steps of localization, entrance point determination, trocar advancement and stabilization, balloon insufflation, and cement placement. Shah reported that the combination of minimally invasive intervention tools and these imaging methods improved the safety, correct application, and efficacy of KP and VP procedures.

The second important feature of this case was that it was conducted under sedoanalgesia. General anesthesia was not chosen for our patient because supine and prone positions were used in the same session; airway control is more difficult in the prone position, and difficulties in the early recognition of potential complications such as neurological damage that may develop over the course of the procedure. For patients, the procedure can be scaring, uncomfortable (due to the neck area), and sometimes unsafe due to anatomical structures of the neck. This is generally experienced as a stressful and uncomfortable situation. Therefore, an effective sedoanalgesic regimen is necessary. The patients were asleep during the procedure, but were cooperative when required; moreover, there was no report of respiratory depression. In this patient case, sedation provided a high level of patient comfort, as well as good operator comfort, without any clinically relevant adverse events. Bruggen et al. [19] evaluated the comfort of the patients and the surgeon with the satisfaction of the sedation application. They reported that the scores were high on patient satisfaction, patient comfort, and operator comfort. No respiratory depression or other complications.

We considered that sedoanalgesia was safer due to patient co-morbidities, impaired general status, and potential pulmonary problems in VP and KP patients, some of whom have metastatic bone cancer or who are old. Although thoracic and lumbar region VP and KP applications may be performed with sedation, general anesthesia is more commonly described in the literature. However, to the best of our knowledge previous VP and KP applications in the cervical region were done under general anesthesia [20]. It has been stated that the reason for choosing general anesthesia was that elderly patients, in particular, were unable to tolerate the prone position this study conducted in 94 KP patients [20]. Majd et al. preferred general anesthesia in 95% of a total of 360 patients, of whom 222 were osteoporotic; local anesthesia was used in 5% due to medical co-morbidities [21]. They observed 10 medical complications due to underlying cardiac, pulmonary, and hepatic diseases, and three surgical complications consisting of delayed wound recovery in one patient who underwent spinal surgery with KP, cement leakage in one patient, and infection at the KP level in one patient.

A third important feature of this case was that cervical VP was performed via a percutaneous route. Blondel et al. performed cervical KP with a 2-cm incision, which they defined as less invasive, in a total of six patients with a mean age of 63.5 years [22]. They reported an average of 2 days for the hospital stay. Druschel et al. followed a patient who underwent C2 and C5 cervical vertebra KP with a 2 cm minimally invasive incision under general anesthesia, was in an intensive care unit for a few hours, and then discharged 6 days later [23]. A percutaneous approach for VP and KP appears to be more advantageous than a surgical method due to the shortened duration of the hospital stay and lower post-operative morbidity [2]. Faster recovery from pain, faster return to daily activities, and fewer operative risks are other advantages of this method. Although a conventional percutaneous technique was used for thoracic KP in our patient, cervical VP was performed via a percutaneous approach, with no surgical complication such as hemorrhage was encountered. This has been rarely described in the literature [24]. That was the motivation behind doing the percutaneous technique under sedation. Mobilization of the patient on the same day allowed for discharge on the next day.

Anselmetti et al. [25] preferred local anesthesia in 97.2% of 284 patients who underwent thoracic VP. Of these patients, 74.5% had osteoporosis and 17.6% had bone metastases. They reported complications such as cement leakage in 11 patients and a severe hematoma in one. Heini reported that mobility could not be preserved due to the significant amount of cement leakage in the C5–C6 disc space in the patient who underwent C5 vertebra KP [26]. Our patient did not experience complications such as cement leakage, dural tears, intra-vascular or epidural injection, spinal canal injection, neurological damage, or newly developing vertebral or pedicular fractures.

Performing VP and KP procedures via a percutaneous route under sedoanalgesia may help to prevent complications of open surgery such as hemorrhage, infection, and delayed wound healing. When general anesthesia is not required, early mobilization would shorten the duration of the hospital stay. We consider that the potential complications of general anesthesia such as respiratory distress,

late awakening, and intensive care need could be avoided when sedation is preferred, particularly in elderly and debilitated patients.

An anterior approach is preferred during percutaneous cervical VP or KP application because the anatomical structure of the cervical vertebra complicates a transpedicular approach. Fluoroscopy enables visualization of different geometric planes (sagittal and axial), while USG provides visualization of different structures (bone and tissues). Thus, we consider that the combined use of C-arm fluoroscopy and USG should improve success rates and prevent vascular and neural injuries and dura perforation.

Author contributions SGB: Manuscript preparing and writing, manuscript editing. HS: Manuscript writing. MEİ: Manuscript editing and English translate. MO: Data and figure collection.

Compliance with ethical standards

Conflict of interest Disclosure of benefit is a declaration that the authors have no conflicting interests, not supported or funded by any Drug Company.

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