Case Series

CT-Guided Percutaneous Vertebroplasty of the Upper Cervical Spine Via a Translateral Approach

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Background: The clinical management of spinal hemangiomas and osteolytic metastases involving the upper cervical spine (C1-C3) is challenging. Symptoms vary from simple vertebral pain to progressive neurological deficits. Surgery and radiotherapy have been the treatment options for years. Surgery, however, can result in complications, such as hemorrhage, and may be counter-indicated when the treatment goal is primarily palliative due to multiple metastases, an unfavorable prognosis and/or a poor performance state. On the other hand, radiotherapy carries the risk of inducing secondary sarcomas or producing radionecrosis. Percutaneous vertebroplasty (PVP) was recently introduced as an alternative for treating patients in whom surgery and radiotherapy are counter-indicated. As of yet, there are few PVP case reports.

Objective: This study aimed to evaluate the safety and efficacy of PVP using a computed tomography (CT)-guided translateral approach via the space between the carotid sheath and vertebral artery for hemangiomas or metastatic lesions at C1-C3 under local anesthesia.

Study Design: CT-guided PVP was performed in 15 patients with hemangiomas or metastatic lesions at C1-C3 and clinical outcomes were evaluated.

Setting: An interventional therapy group at a medical center in a major Chinese city.

Methods: Fifteen consecutive patients had a total of 15 cervical vertebral bodies treated with CT-guided PVP via a translateral approach. The patients were followed up for a mean postoperative period of 8.3 months (range, 1-40 months). Pain status was assessed using a visual analog scale (VAS). The presence of complications was assessed preoperatively (baseline) and at 24 hours, 2 weeks, and one, 3, 6, 12 and 24 months postoperatively, or until the patient died or was lost to follow-up.

Results: Fifteen consecutive patients were successfully treated with CT-guided PVP via a translateral approach. Their mean VAS score decreased from 7.7 ± 2.9 preoperatively to 1.4 ± 1.5 by the 24 hour postoperative time point, and was 1.2 ± 1.3 at 2 weeks, 1.2 ± 1.3 at one month, 1.4 ± 1.3 at 3 months, 0.6 ± 0.9 at 6 months, 0.3 ± 0.5 at 12 months, and 0 at 24 months after the procedure. The mean VAS score at all of the postoperative time points differed significantly from the preoperative baseline score ($P < 0.05$). No severe complications were observed. Mild complications included 2 cases (13.3%) of asymptomatic cement leakage into the epidural space, one case (6.67%) of anterior leakage from the vertebral body, and 2 cases (13.3%) of paravertebral leakage.

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

Conclusions: The safety and efficacy of CT-guided PVP using a translateral approach via the space between the carotid sheath and vertebral artery were demonstrated in patients with hemangioma or metastasis in the upper cervical spine. CT-guided PVP via a translateral approach should become a treatment option for such patients.

Key words: CT-guided percutaneous vertebroplasty, upper cervical spine, translateral approach, hemangioma, osteolytic metastasis, pain

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Spinal lesions include osteolytic metastases and symptomatic hemangiomas. Metastases to the cervical spine are thought to be far less common than those to the thoracic and lumbar spine (1). Metastasis to the upper cervical spine (C1, C2, and C3), especially at the craniovertebral junction, is less common, constituting less than 1% of all spinal metastases, and the literature is mostly limited to case reports (2, 3). Hemangioma of the cervical spine is only occasionally diagnosed in the clinic.

Effective management of upper cervical spinal metastases or hemangiomas using surgery, radiation, and/or percutaneous vertebroplasty (PVP) results in significant pain relief and functional improvement in selected patients (3-5). However, there are no uniform guidelines for the management of symptomatic hemangioma and osteolytic metastasis in the upper cervical spine. Surgery is required for patients with spinal canal compression, acute neurological compromise or impending spinal instability (5,6), but most patients with a normal spinal alignment do not require surgery. In addition, considering the palliative purpose, surgery might not be the best choice, especially in those with multiple metastases, an unfavorable overall prognosis, and/or a poor performance status (6).

The indications for radiotherapy of spinal metastases are pain, impending danger of fracture, neurological compression and prevention of local recurrence (6). Radiotherapy has been used for spinal hemangiomas since 1930. The principal goal of radiotherapy is remineralization of osteolytic bone (4). Significant remineralization can be observed several months after the end of radiotherapy (4). However, radiotherapy can induce secondary sarcomas or the development of radionecrosis (7), and therefore might not be suitable for patients with a poor survival prognosis and a short expected life span.

PVP was initially performed successfully by Galibert et al (8) in 1984 to treat a patient with a symptomatic hemangioma of the axis. The indications for PVP were subsequently extended to the treatment of vertebral compression fractures due to benign or malignant disorders such as osteoporosis, osteolytic metastasis, hemangioma, and multiple myeloma (9-11). PVP is now a well-established procedure comprising a percutaneous injection of a biomaterial, usually polymethyl methacrylate (PMMA), into a vertebral body. In most cases, this procedure significantly relieves pain and stabilizes the vertebral body. PVP of the upper cervical spine, especially C1 and C2, remains a challenging procedure that is described in only a few case reports; the procedure has been performed via anterolateral, posterolateral, translateral and direct transoral approaches, under general or local anesthesia (12-26).

Since the study of Huegli et al (13), evidence has emerged to show that PVP could be performed on patients with osteolytic metastasis in C1 via a lateral approach (13,14). However, published descriptions of procedures via a lateral approach are limited to case reports, which cannot guide clinical applications and lack information on the clinical pathway. In addition, because of the rarity of the condition, no large-sample study has evaluated the feasibility, efficacy, or safety of CT-guided PVP through a translateral approach in patients with osteolytic metastases. From 2003 to 2011, we evaluated the feasibility, efficacy, safety, and clinical pathways of CT-guided PVP under local anesthesia through a translateral approach via the space between the carotid sheath and the vertebral artery for the treatment of osteolytic metastasis and hemangiomas in the upper cervical spine.

Methods

Case Information

From January 2003 through September 2011, 15 consecutive patients (7 men and 8 women) were treated with PVP under local anesthesia using a computed tomography (CT)-guided translateral approach via the space between the carotid sheath and vertebral artery for hemangiomas or metastatic lesions in the upper spine (C1-C3). The mean age of the study participants was 54 years (range, 30-75 years). A total of 15 vertebral bodies were treated, including 2 hemangiomas and 13 osteolytic metastases (2 cases in C1, 9 in C2, and 4 in C3).

All patients included in our cohort presented with neck pain without neurological deficits that was refractory to conservative treatment for at least 12 weeks. The medical and imaging files of each patient were collected and reviewed before the procedure was performed. Primary lesions included spinal hemangiomas and osteolytic metastases from primary carcinoma of the lung, nasopharynx, breast, liver, colon, cervix, and duodenum. The need for CT-guided PVP was confirmed by a multidisciplinary team including orthopedic surgeons, neuroradiologists, medical oncologists, radiation oncologists, and interventional radiologists, aiming for spinal stability and pain relief. Written informed consent was obtained from each patient before the CT-guided PVP procedure. All relevant tests were performed preoperatively, including blood clotting, CT, and magnetic resonance imaging (MRI). This study was approved by the local ethics committee.

Imaging

All patients were evaluated before the procedure by enhanced or nonenhanced CT and T1- and T2-weighed short inversion time inversion-recovery MRI. The objectives of CT and MRI were to demonstrate the integrity of the posterior wall of the vertebral body, to determine whether the lesions were osteolytic or osteoplastic (Fig. 1A), to evaluate the invasive range or paravertebral soft tissue, and, most importantly, to determine the positional relationship of the carotid sheath and the vertebral artery (Fig. 1B) on enhanced CT. After treatment, nonenhanced CT images were obtained immediately to assess the leakage of PMMA.

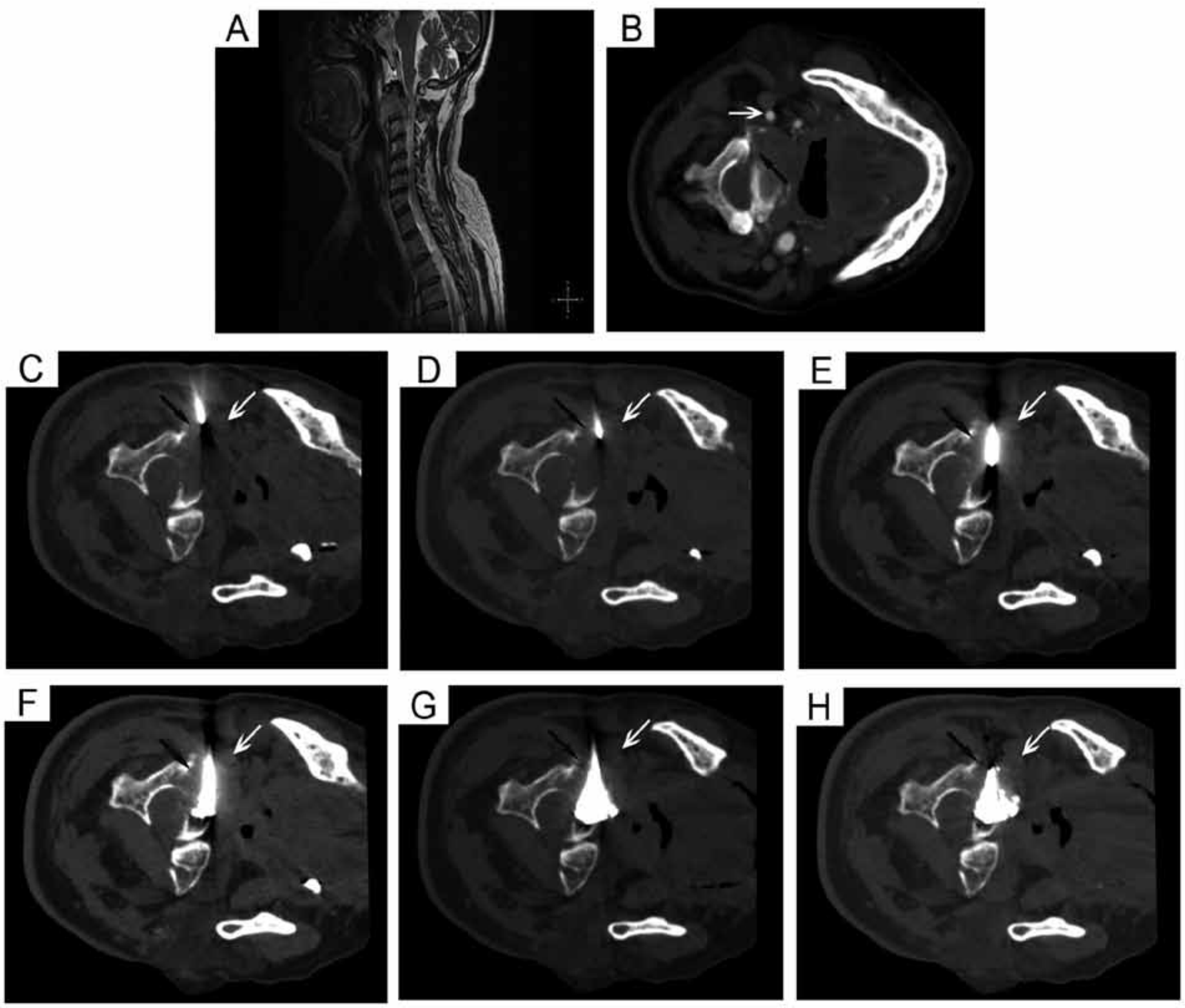

Fig. 1. *PVP using a CT-guided translateral approach via the space between the carotid sheath and vertebral artery in a 48-year-old man with lung adenocarcinoma with metastasis to C2. (A) MRI demonstrates the osteolytic metastasis in C2. (B) Axial enhanced CT shows the relationship of the carotid sheath (white arrow) to the vertebral artery (black arrow). (C-E) The needle has reached the vertebral body between the carotid sheath and the vertebral artery. (F,G) Prepared cement is injected slowly into C2. (H) Immediate nonenhanced CT was performed to determine the distribution of the cement after completion of the procedure.*

Procedure

All procedures were performed in an operating room with a CT scanner. The PVP procedure using a CT-guided translateral approach via the space between the carotid sheath and vertebral artery is conceptually illustrated in Fig. 2. The patients were placed in the left or right (usually left) lateral decubitus position on the CT cradle and a soft cushion was put under the neck and shoulder to slightly overextend the cervical spine. The puncture area was sterilized and local anesthesia of the skin and soft tissues was achieved by injecting 3 mL of 1% lidocaine. A single 13-gauge needle was inserted into the skin, along the posterior rim of the carotid sheath and in the direction of the anterior rim of the vertebral artery.

When advanced beyond the internal wall of the carotid sheath on the anteroposterior view, the needle tip may change direction, depending on the rela-

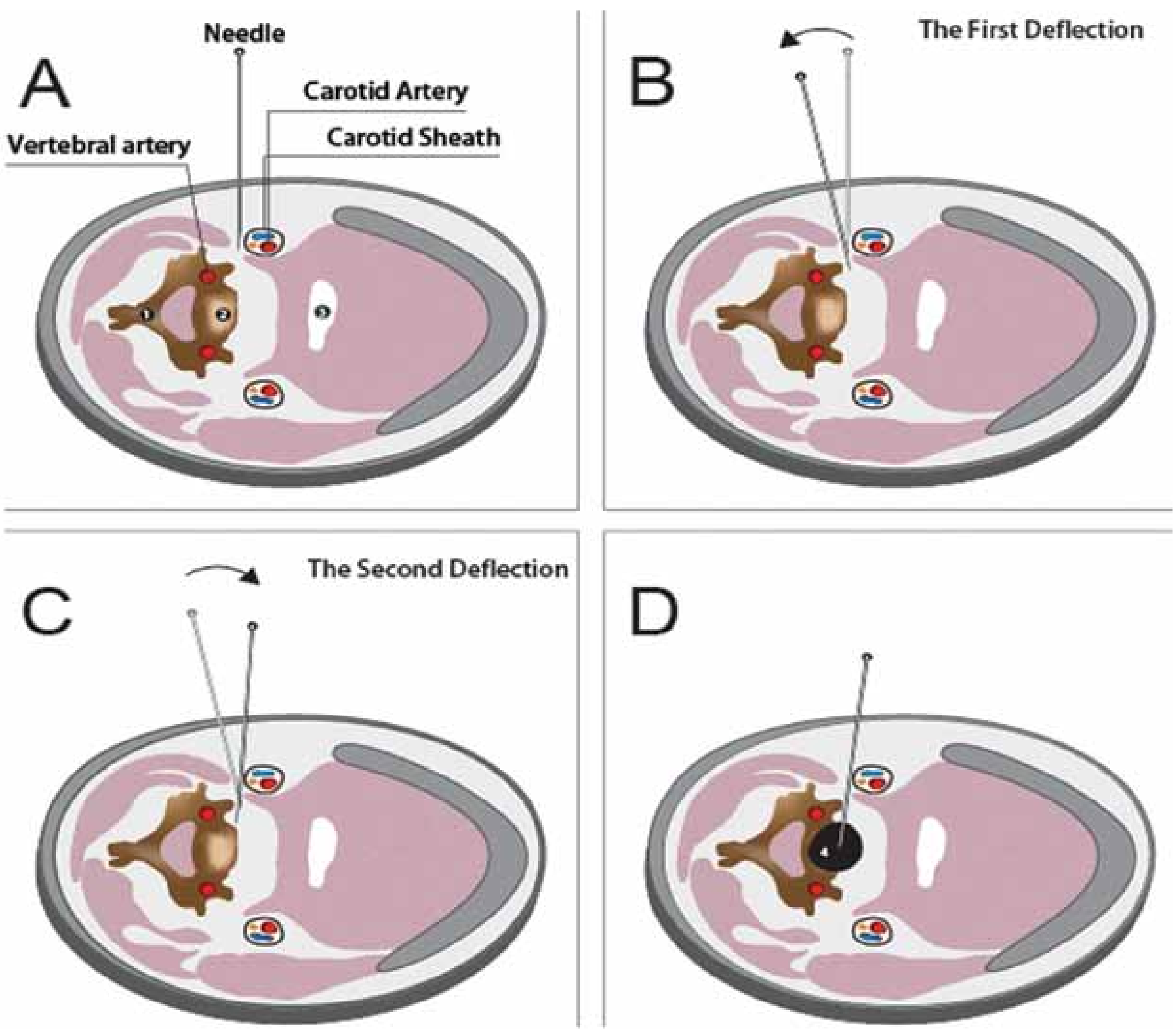

Fig. 2. *PVP procedure using a CT-guided translateral approach via the space between the carotid sheath and vertebral artery [(1) Lamina; (2) Lesion; (3) Airway; (4) Cements injected]. The needle is placed into the skin and advanced along the posterior rim of the carotid sheath and toward the anterior rim of the vertebral artery. (B) When advanced across the internal wall of the carotid sheath from the anteroposterior viewpoint, the tip may change direction (the first deflection) and advance across the anterior rim of the vertebral artery to avoid injury to the vertebral artery. (C) The tip is advanced toward the osteolytic portion of the targeted cervical spine after crossing the posterior rim of the carotid sheath and the anterior rim of the vertebral artery. (D) Bone cement is injected slowly into the cervical spine. The entire procedure is performed under CT guidance.*

tive positions of the carotid sheath and the vertebral artery. The needle was further advanced beyond the anterior rim of the vertebral artery to avoid injury to the vertebral artery and consequent bleeding. Beyond the posterior rim of the carotid sheath and the anterior rim of the vertebral artery, the needle was advanced toward the osteolytic portion of the targeted cervical spine. Throughout the puncture process, the needle was advanced gradually under CT guidance, with a slice thickness of one mm, a pitch of 1.5 mm and a slice increment of 1.5 mm, through the space between the carotid sheath and the vertebral artery until it reached the center of the vertebral body (Figs. 1C-E).

About 0.5 mL of prepared bone cement (20 g PMMA powder mixed with 10 mL monomer until suitable for injection) was then injected prior to scanning (Fig. 1F). CT scans were obtained after every injection to monitor the leakage of cement. Cement injection was terminated when the CT showed epidural/intraforaminal leakage or satisfactory filling of the osteolytic region (Fig. 1G). Immediately, a nonenhanced CT scan was then performed to determine the distribution of the cement (Fig. 1H) after withdrawal of the needle and completion of the CT-guided PVP. Antibiotics were administered one day before and for 3 days after the procedure.

Assessment indices

All patients rated their pain status on a visual analog scale (VAS) before and after the procedure; a score of 0 indicated no pain and a score of 10 represented maximal pain. This rating was repeated 24 hours after the operation. A researcher trained to conduct interviews then contacted the patients to conduct clinical interviews in person, via telephone, or via mail at fixed intervals after their treatment sessions (at 2 weeks and one, 3, 6, 12, and 24 months) or until the patient died or was lost to follow-up. The interviews were used to collect information about treatment response, mainly in terms of degree of pain. The analgesic efficacy of PVP was recorded, based on 50% or greater improvement in pain versus baseline. All complications of the procedure, including severe complications (i.e., pulmonary embolism, septic shock, cardiogenic failure, respiratory failure, or death) and mild complications (i.e., infection and asymptomatic cement leakage) were recorded in this series.

Statistical analysis

Data are presented as means ± standard deviations. The results at all of the study time points were analyzed using Student's t-test with SPSS statistical software, version 11.5 (SPSS, Chicago, IL). $P < 0.05$ was considered statistically significant.

Results

CT-guided PVP via a translateral approach was successfully performed in 15 patients (seven men and eight women). All procedures were completed within 30-40 min. A mean volume of 1.55 mL cement was injected in C1 (range, 1.1-2.0 mL), with little extraosseous reflux leakage. The mean amount of cement injected into C2 was 1.8 mL (range, 1.3-2.0 mL), and a mean of 1.95 mL was injected into C3 (range, 1.5-2.2 mL). All of the upper cervical vertebral bodies were filled satisfactorily. Asymptomatic cement leakage was detected in the epidural space in 2 patients, anteriorly from the vertebral body in one patient and paravertebrally in 2 patients. None of these 5 patients had clinical symptoms related to the procedure. No severe complications were discovered during a 24 month follow-up period. Three patients were lost to follow-up 3 months after the procedure.

VAS scores decreased from 7.7 ± 2.9 preoperatively to 1.4 ± 1.5 by 24 hours after the operation. The VAS scores remained low throughout the follow-up period: 1.2 ± 1.3 at 2 weeks, 1.2 ± 1.3 at one month, 1.4 ± 1.3 at 3 months, 0.6 ± 0.9 at 6 months, 0.3 ± 0.5 at 12 months, and 0 ± 0 at 24 months. Mean VAS differed significantly from the preoperative baseline at each postoperative time point. All P values were < 0.05 (Table 1).

Discussion

Our findings showed an important improvement in the management of patients with symptomatic hemangiomas or osteolytic metastases in the upper cervical spine (C1, C2, or C3). From January 2003 through September 2011, 15 patients were successfully treated with CT-guided PVP through a translateral approach via the space between the carotid sheath and the vertebral artery. No severe complications were observed during a 24 month follow-up period. Asymptomatic cement leakage was detected in 5 of the 15 patients. Analgesia was achieved by PVP in most patients in this series, similar to the findings in other reports of this procedure. This translateral approach was thus shown to be feasible, safe and effective. We report here the operative procedure and thereby provide a clinical pathway for patients with hemangiomas or metastatic lesions in the upper cervical spine.

Comparison with other studies

Management of spinal hemangiomas and osteolytic metastases in the upper cervical spines is a clinical challenge. The primary end points are palliative, to achieve pain relief and restore spinal stability, to improve or maintain neurologic function, and to obtain local cancer control (5). Because approximately 90% of metastatic tumor deposits are found in the ventral portion of the spine (5), the principal method of surgical treatment is ventral decompression with corporectomy, vertebral body replacement, and ventral stable-angle plate osteosynthesis. In addition, evidence from clinical series has confirmed the role of posterior instrumentation in providing durable fixation (27-32). However, most patients with normal spinal alignment do not require surgery. Furthermore, considering the palliative aims, surgery might not be the best choice, especially in those with multiple metastases, an unfavorable overall prognosis and/or poor performance status (5).

Radiotherapy is another proven modality in the management of spinal hemangiomas and osteolytic metastases in the cervical spine. Various regimens have been compared in randomized trials, including single- and multi-fraction regimens (4). Substantial pain relief is reported in 60–90% of cases, but pain relief takes 10-14 days after the start of radiotherapy in 70% of patients (5). The role of radiotherapy in relieving pain is limited by the sensitivity of tumor cells to ionizing radiation, the long time taken to achieve its effects, and its role in stabilizing the vertebral body. Remineralization, which is pivotal for the prevention and treatment of pathologic fractures, is more commonly observed in multi-fraction regimens than in single-fraction regimens (4). Remineralization of osteolytic metastases can be observed 2-3 weeks after radiotherapy (20-30 Gy) and reaches its peak at 2 months (5). Therefore, radiotherapy might not be suitable for patients with a poor survival prognosis or short expected life span. In summary, the roles of surgery and radiotherapy are limited in patients with spinal hemangiomas or osteolytic metastases of the upper cervical spine.

Comparison with other approaches

The cervical vertebrae are located deeper than the thoracic and lumbar vertebrae. Compared with the transpedicular approach commonly used in the thoracic and lumbar spine, all other approaches in the cervical spine are more difficult due to potentially dangerous complications related to the carotid sheath and the vertebral artery. In addition to its use in treating osteoporotic vertebral fractures, PVP has gained popularity for the relief of pain due to tumoral osteolysis and spinal hemangiomas by stabilizing the cervical vertebrae, as in the thoracic and lumbar vertebrae (5-7). Since the 2002 study of Wetzel et al (12), which was the first report of PVP of C1, and the 2000 study of Tong et al (17), which was the first report of PVP of C2, evidence has emerged to show that PVP of C1 through a translateral approach and C2 through a transoral approach can be performed safely and with satisfactory clinical results. However, studies have been limited to case reports and thus lack details on the clinical pathway for treating such patients. Here, we summarize and compare all PVP approaches, except the conventional transpedicular approach.

1. Anterolateral approach (12,14,22)

This approach requires appropriate overextension of the cervical part of the spine. The carotid sheath is located and then pushed laterally. The needle tip is placed approximately one cm beneath the mandibular angle between the carotid sheath and the trachea. Attention should be paid to avoiding injuries to the submandibular gland, carotid artery, jugular vein, and cranial nerves during the procedure. The anterolateral approach can be used under local anesthesia, but in our experience, maintaining overextension is difficult for obese patients and for those in severe pain. In such cases, the anterolateral approach is still possible, but it is more difficult due to the increased oblique angle and the distance through which the needle must be passed.

2. Transoral approach (17-21,23,25,26)

The transoral approach is the most direct route for

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

	Pre-op	Post-op 24 hours	Post-op 2 weeks	Post-op one month	Post-op 3 months	Post-op 6 months	Post-op 12 months	Post-op 24 months
	(N = 15)	(N=15)	(N 15)	(N = 15)	(N = 8)	(N = 5)	(N = 4)	(N = 3)
Mean ± SD	7.7 ± 2.9	1.4 ± 1.5	1.2 ± 1.3	1.2 ± 1.3	1.4 ± 1.3	0.6 ± 0.9	0.3 ± 0.5	0
Versus Preop		$P = 0.00001$	$P = 0.00001$	$P = 0.00001$	$P = 0.00001$	$P = 0.00001$	$P = 0.0001$	$P = 0.00004$

PVP of C2, with less strict body position requirements. The visual field in the pharyngo-oral cavity is widened using a diastomotris and retractor. The puncture is performed directly after tracheal intubation. This procedure generally has to be performed under general anesthesia and the postoperative infection rate is potentially higher than that of the anterolateral approach, so prophylactic antibiotics are used routinely.

3. Posterolateral approach (12,15,24)

Under local or general anesthesia, the needle is inserted through the posterior cervical space and advanced in the anterior, cranial, and medial direction. The posterolateral approach has the advantage that lesions in the lateral mass and the posterior arch of the atlas are aligned with the access route. However, there is a risk of injury to the vertebral artery. In addition, this route is not suitable for lesions in the anterior arch of the cervical spine.

4. Translateral approach (13,14)

There are only 2 pertinent reports in the literature of PVP of C1 via a translateral approach. Both procedures used combined fluoroscopic and CT guidance. In our study, we reviewed the cross-sectional anatomy and CT of the cervical spine to identify a potential internal space between the carotid sheath and the vertebral artery lateral to the C1-3 level. However, the placement of the needle directly through this space may not be possible in some patients due to anatomical variations in its location. In such circumstances, the needle could be turned oblique to the posterior surface of the carotid sheath, and then turned slightly to the anterior side to create sufficient space. This procedure can be performed under local anesthesia, and does not have strict body position requirements. Under local anesthesia the patient can speak to the operator throughout the procedure, allowing immediate detection of any neurological symptoms or complications. However, this approach still has some limitations: 1) the use of CT guidance precludes continuous observation. It is critical that the operator take great care as the needle is advanced, moving slowly and making step-by-step adjustments to avoid injury to the great vessels; 2) when guided by CT, the procedure takes longer; and 3) the bone cement polymerizes rapidly. We added Lipiodol Ultra-fluide (Guerbet 16-24, Aulnay-Sous-Bois, France) to the cement to prolong the time it existed as a flowing mixture from 1.5-2.5 minutes to 4-7 minutes, which is an adequate time for injection.

Postoperative observation showed no severe complications. Pain and vertebral stability were significantly improved. Although there are risks of complications, PVP of the upper cervical spine can be successful with experienced and careful operational skills and safe operative routes.

Strengths and limitations of study

We recognize several limitations to our study. First, in this observational study our patients were recruited from a single center, and the sample size was small, mainly due to the scarcity of cases of hemangioma or metastasis of the upper cervical spine. Second, some patients died during the follow-up period. Although we doubt that these deaths impair the generalizability of our findings, other interventional or pain management centers need to examine the safety, feasibility, and efficacy of PVP in a larger population. Finally, we did not perform an arm-to-arm study, comparing CT-guided PVP with surgery or radiotherapy.

This study highlights the safety, feasibility, and efficacy of CT-guided PVP by a translateral approach. No study has compared CT-guided PVP with surgery or radiotherapy. In this observational study, CT-guided PVP by a translateral approach via the space between the carotid sheath and the vertebral artery can lead to significant pain relief without severe complications.

Conclusions

There are several implications of our study. Although PVP does not represent a cure for osteolytic cervical metastasis, significant pain relief is a principal goal of PVP, similar to other treatment strategies. In our study, pain was relieved significantly. In conclusion, we have shown that CT-guided PVP by a translateral approach via the space between the carotid sheath and the vertebral artery is safe, feasible, and effective in the treatment of patients with hemangiomas or osteolytic metastasis in the upper cervical spine. It is especially suitable for obese or short-necked patients with lesions in the anterior arch, and for those in whom an anterolateral/posterior/transoral approach is unsuitable. However, familiarity with local anatomy, experience, and skill are prerequisites for success. Our findings will help to inform physicians of the appropriate management of their patients.

Conflicts of Interest

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