Clnical Study of the Treatment of Patients with a Metastatic Spinal Tumor by Percutaneous Vertebroplasty under the Guidance of DSA

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OBJECTIVE To explore the clinical effect in patients with metastatic spinal tumors treated by percutaneous vertebroplasty (PVP) under the guidance of digital subtraction angiography (DSA).

METHODS A total of 110 cases with a metastatic spinal tumor were divided into 55 cases in the treatment group (group A) and 55 cases in the control group (group B). The general clinical data were statistically analyzed before treatment with the parameters showing no differences. Group A was treated by PVP and chemotherapy as well. Group B was treated by the regular chemotherapy and regular radiation therapy. The same chemotherapy program was used for the same type of disease. All cases were provided with a follow-up survey for 12 months. During the follow-up survey, changes in the quality of life, in evaluation of bone pain and in vertebral column stability as well as adverse reactions were observed.

RESULTS *The statistics showed a significant difference between the 2* groups, specifically changes in the quality of life and evaluation of bone pain (P<0.05, t_1=2.74, t_2=9.02). During the follow-up survey, 5 cases in group A died of other organ complilcations, the death rate being 9.1% (5 out of 55), but all survived more than 3 months following PVP. The vertebral columns of the survivors were kept stable, with no pathological fractures occurring in the vertebral bodies filled with bone cement, there were no obvious adverse reactions, and no paraplegia occurred. Thirteen cases died in group B with a death rate of 23.6% (13 out of 55). Pathological compression fractures in the vertebral bodies occurred in 30 cases, and 12 cases of complicated paraplegia were noted. The incident rate of paraplegia was 21.8% (12 out of 55).

CONCLUSION PVP is a simple operation causing only small wounds and few complications. It can effectively alleviate pain of metastatic spinal tumors in patients, improve quality of life and reduce the incidence rate of paraplegia.

KEYWORDS: percutaneous vertebroplasty, spine, metastatic tumor, intervention, bone cement.

Metastases are the primary complication of malignant tumors. Metastatic spinal tumors are the most commom metastatic bone tumors with 20% of malignant tumors involving bone metastases. In most cases metastatic lesions occur in the thoracic spine, some in the lumbar spinal and some in the cervical spine.[1] There are many therapeutic methods to treat metastatic spinal tumors, but no ideal therapy is known at present. In our hospital since 2003 we have treated 55 patients with metastatic spinal tumors, using percutaneous vertebroplasty (PVP) under the guidance of digital subtraction angiography (DSA). The procedure produced good clinical results which are summarized in this report.

MATERIALS AND METHODS

General

A total of 110 patients with a metastatic spinal tumor were divided into 55 cases in the treatment group and 55 cases in the control group (Table 1). All cases which were chosen met the following criteria: (1) the pathological diagnosis was based on the original focuses or pathological centra; (2) there were no symptoms related to the compression of the spiral cord or nerve roots; (3) all of the patients presented with a combination of neck, back, or waist pain; (4) the number of pathological centra was no more than 3. The clinical data listed in Table 1 showed no statistically significant differences, $P>0.05$. After treatment with PVP, the patients in the treatment group were treated by regular chemotherapy. Patients in the control group were treated by regular radiation therapy at the spinal tumor focuses and whole chemotherapy.

Table 1. The analysis of clinical parameters in 110 patients with metastatic spinal tumor before treatment.

Parameters	Treatment group	Control group	*P* value
Age	62.34 ± 5.60	59.95 ± 9.03	0.728
Gender			0.686
Male	25	26	
Female	30	29	
Original disease			0.762
Colon cancer	9	8	
Hepato carcinoma	8	8	
Breast carcinoma	20	19	
Pulmonary carcinoma	12	24	
Gastric cancer	6	4	
Unidentified	0	2	
Vertebral bodies			0.246
1	32	25	
2	20	22	
3	3	8	
Metaststic area			0.192
Cervical vertebrae	12	23	
Thoracic vertebrae	27	35	
Lumbar vertebrae	35	30	
Sacrum	7	5	
Evaluation of pain	14.3 ± 1.51	14.5 ± 1.84	0.700
Physical agility	85.9 ± 6.71	82.8 ± 7.66	0.122
Mental status	104.8 ± 12.3	104.4 ± 12.1	0.901
Quality of life	166.6 ± 15.01	17.00 ± 16.58	0.435

Instruments and pharmaceuticals

China-produced instruments for percutaneous vertebroplasty were used, including the puncture needles and the device to increase pressure in the spiral injector (produced by Shandong Longguan Company). The puncture needles were comprised of those for the cervical spine, thoracic or lumbar spine. The needle diameters were 2.5 mm and 3.5 mm respectively ranging in length from 100 to 150 mm and were used to puncture the vertebral bodies to produce a tunnel for the polymethylmethacrylate (PMMA) injection. There was a disposable 10 ml medical injector inside the device to increase pressure in the spiral injector that was used to inject the PMMA (produced by Tianjin synthetic industrial institution). To enhance the development of the PMMA under X-ray, a 75% solution of meglumine diatrizoate was added. The ratio of the power (g) to the liquid (ml) in the contrast agent (ml) was 3:2:1.

The operating method

Prior to the operation, each patient was examined by X-ray, a CT scan (computed tomographic), or by MRI (magnetic resonance imaging), to determine the location and number of vertebral bodies which involved the tumor, the collapse of the vertebral bodies, the degree of osteolytic lesion and the integrity of the spinal cord compression. Examinations on the patient's heart, lung, liver and kidney functions, blood sugar, PT, and test for iodine allergy were conducted prior to the procedure. The patients were given analgesics 15 min before the operation. After determining the indication to operate, the operations in the intervention operating room were conducted under the guidance of DSA.

For the cervical spine : the patient was instructed to lie flat in a supine position with a pillow under his shoulder. The plane of the pathologically changed vertebral body on the screen of the DSA was selected on a lateral fluoroscopy position. The puncture point between the trachea and the vertebral artery was determined according to the mark of the chosen plane. After performing local anesthesia, the middle finger and the forefinger were used to press the front edge of the vertebral body between the space of the trachea and the carotid artery, while pushing the trachea towards the other side at the same time. The puncture needle was placed 0.5 to 1.0 cm to the medial side of the carotid artery. The needle was inserted via the sagittal plane of the vertebral body while maintaining a 15 to 20 degree angle. The needle tip was in 1/3 of the front edge of the vertebral body on a lateral fluoroscopy position (Fig.1).The needle tip was at the center of the vertebral body or deviating to left or right 0.3 cm on the front fluoroscopy position (Fig.2).

For the thoracic and lumbar spine : the patient was instructed to lie flat in the prostrate position. A puncture was made via the pedicle of the vertebral arch approach, the inclination degree of the pedicle of vertebral arch was measured, the distance of the spinal process from the puncture point and the depth from the puncture point to the pedicle of vertebral arch were determined. The puncture point was placed 2 to 3 cm beside the spinal process and local anesthesia of 1% lidocaine was administed. When the puncture needle arrived at the bone cortex, and the depth of the intrusion needle did not exceed the front of the pedicle of the vertebral arch, on the front of fluoroscopy position, the needle tip should be within the "buphthalmos" of fluoroscopy of the pedicle of the vertebral arch (Fig.3). When the puncture needle went through the bone cortex and entered the vertebral body, on a lateral fluoroscopy position, the puncture needle was slowly tapped into the 1/3 of the front of the pedicle of the vertebral arch. It showed that the puncture needle tip had exceeded the center of the pedicle of the vertebral arch on the front fluoroscopy position. It is preferable to use a puncture needle with a beveled needlepoint as it is easier to control the direction of the needle while injecting the fluid. The bone around the puncture point at the sacroiliac joint was damaged most. After finishing the puncture, the syringe piston was removed and 5 ml of contrast medium infused into the injection-tube. The circumfluence of the contrast medium was noted by the DSA. The pressure in the centra was depressed by sucking out the tumor and blood which remained in the centra.

The bone cement was prepared using China-produced PMMA and non-ionic contrast medium. The bone cement was infused into the injection-tube and injected when the bone cement became like paste. The whole process of injection was supervised on a lateral fluoroscopy position to prevent the bone cement from leaking outside of the vertebral body (Fig.4). The point of the needle direction was continuously revolved in order to transfer the bone cement well while pushing the plunger. After injection, the puncture needle was withdrawn to the bone cortex, the syringe piston inserted and the puncture needle turned to prevent the bone cement from sticking. The needle was pulled out before the bone cement hardened. The total volume of injected cement ranged from 2 to 9 ml. The average amounts were 2.5 ml for the cervical spine, 5.5 ml for the thoracic spine, 7.0 ml for the cervical vertebra.[2] The patients were reexamined by CT 15 to 20 min after the injection when the polyreaction of the bone cement had completed (Fig.5).

Evaluation of the therapeutic effect

Changes in quality of life after treatment

We used a short-form health survey (SF-36) to survey quality of life.[3] The form included 11 items with each item including many questions. The score was calculated based on the answers chosen and the final score adjusted by a formula with a higher score representing healthier patients. Among the items, a score of no. 1, 3, 4, 7, 8 and 11 referred to physical agility, a score of no. 5, 6, 9 and 10 referred mental status. The score of physical agility + the score of mental status =the total score of quality of life.

Relief of bone pain after treatment

The degree of the relief of bone pain was based on the evaluation of pain which was calculated as pain degree × pain frequency. The degree of pain and frequency was based on the UICC standard. The degree of pain sorted into 5 classes, i.e. 0, 1, 2, 3, 4.[4] The patients' degree of pain and frequency were written down when getting up and going to bed, and the score of pain calculated. The evaluation of the analgesic effect and the standard classes of pain relief were :0 for no relief, I for light relief, II for moderate relief, III for high relief, IV for complete relief.

Statistical treatment

SPSS 10.0 statistical software was used for statistical analysis. The *t*-test was used for measurement data and the χ^2-test used for enumeration of the data.

RESULTS

The patients in the treated group were operated smoothly. There were 57 vertebral bodies injected via one side and 24 vertebral bodies injected via both sides. Regular chemotherapy was given to the patients after the operation and regular radiation therapy and chemotherapy were employed for the patients in the control group. Evaluation of the therapeutic effect was done subsequently.

The changes in the quality of life and evaluation of bone pain

According to the evaluation of quality of life by the SF-36, there was no significant difference in the quality of life between the 2 groups before treatment. After treatment, the quality of life in the treatment obviously improved, whereas quality of life in the control group declined. A significant difference in the quality of life between the 2 groups is shown in Table 2 (P<0.05). Bone pain was relieved in both groups after treatment, but in the treated group, bone pain stopped in 6 to 72 h post operation, with an effective rate of 100%. And the degree of pain relief was significantly higher than that of the control group (P<0.05, Table 2).

Patient outcome

All patients were given the follow-up survey for 12 months. During the follow-up period, 5 patients died because of other organ complications in group A. The death rate was 9.1% (5 out of 55). Shift of the vertebral bodies was not found. There were changes in the physiological arch and angulation. Olisthe of the vertebral bodies that had existed before treatment did not develop. There were no further vertebral body compressions, spinal cord or nerve compressions or paraplegia. Treatment of the vertebral bodies permanently eliminated the pain. Thirteen patients died in group B resulting in a death rate of 23.6% (13 out of 55). Pathological compression fractures in the vertebral bodies occurred in 30 cases and 12 cases were complicated in group B with paraplegia. The incidence rate of paraplegia was 21.8% (12 out of 55).

Complications

Six patients with a metastatic spinal tumor developed a pathological compression fracture after treatment with PVP and the PMMA leaked to the front of the vertebral bodies. Since there were no clinical symptoms, no further treatment was needed. There were no complications of spinal cord compression, pulmonary embolism or nerve root compression.

DISCUSSION

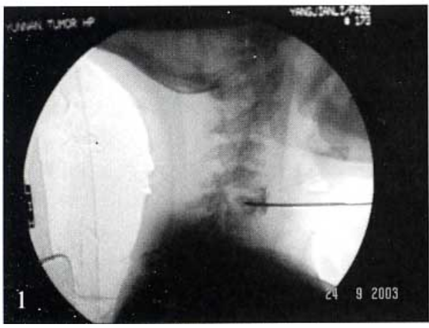
The vertebral column is where metastatic bone tumors occur most frequently. At the metastatic site, the tumor cells produce osteoclastic-activating factors which activate osteoclasts, causing enhancement of the bone absorption and induction of bone lesions.[5] The injury of the metastatic focus to the vertebral body and its accessories induce a vertebral column pathological fracture causing the stability of the vertebral column to decline. This results in severe back pain, even nerve function disorders and a predisposition to pathological fracture. Some mental symptoms such as depression and irritability may occur, severely affecting the quality of life.

With the development of tumor therapy, more attention has been paid to the improvement of the quality of life which is a measure of the therapeutic effect. [6] There are many therapeutic methods to treat metastatic spinal tumors, such as radiation therapy, chemotherapy, radioisotope therapy, biphosphonate therapy, analgesia therapy and palliative operations. Choice of a therapeutic method depends on the histological type of the primary tumor, the nerve function situation before treatment, the number of vertebral bodies involved, the degree of spinal canal compromise, the patien's physical status, the degree of pain, and so on. The degree of pain relief can be more than 75% by radiation therapy, but it takes 1 to 2 weeks to produce an effect. The biggest weakness of radiation therapy is that it does not resolve the problem of instability of the vertebral column caused by tumor damage, but increases the danger of vertebral body collapse and nerve compression.[7] A surgical operation is suitable for patients with spinal cord compression, but it results in big wounds and many complications and is not suitable for nonadjacent multiple vertebral body metastatic tumors.[8]

In recent years, along with the rapid development of interventional techniques, PVP has become one of the focuses in spinal surgery. It results in only small wounds and thus is gaining the attention of more surgeons.[9-12] PVP is used in treating metastatic spinal tumors in our hospital as it is effective in relieving the patient's pain and improving the quality of life. Both Cotton et al.[13] and Cortet et al.[14] reported that by treat-

Table 2. The comparison of quality of life and evaluation of pain between the 2 groups after treatment ($x \pm s$).

Groups	n	Physical agility	Mental status	Total quality of life	Evaluation of pain
Treated	55	160 ± 76	185 ± 87	345 ± 152	6.4 ± 2.2
Control	55	112 ± 71	130 ± 73	242 ± 134	12.3 ± 1.7
t_l		2.49	2.58	2.74	9.02
P		<0.05	<0.05	<0.05	<0.05



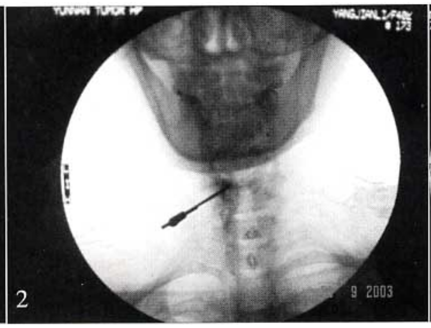
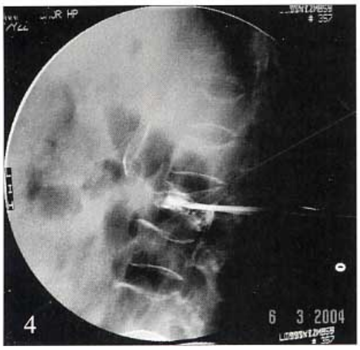


Fig.1. An image on a lateral fluoroscopy position shows the needle tip is in 1/3 of the front edge of the vertebral body.
Fig.2. An image on a front fluoroscopy position shows the needle tip is deviating to right of the center of the vertebral body.
Fig.3. An image on a front fluoroscopy position shows the needle tip is within the "buphthalmos" of fluoroscopy of the pedicle of the vertebral arch.



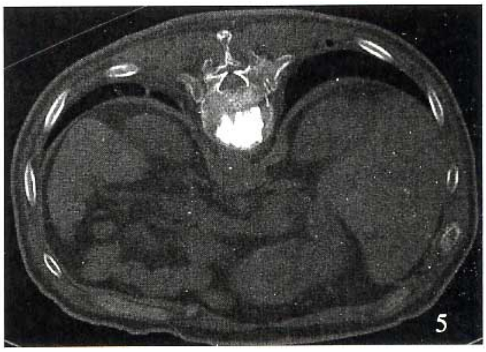


Fig.4. An image on a lateral fluoroscopy position shows injected bone cement into the vertebral body.
Fig.5. A T12 metastatic breast carcinoma postinjection computed tomographic image shows the cement filling the focus of the vertebral body.

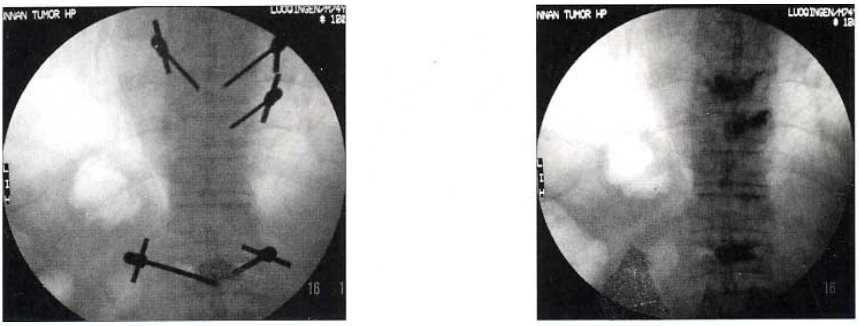


Fig.6. An X-ray image shows a T9-T10 and L1 metastatic pulmonary carcinoma pretreatment and posttreatment with PVP.

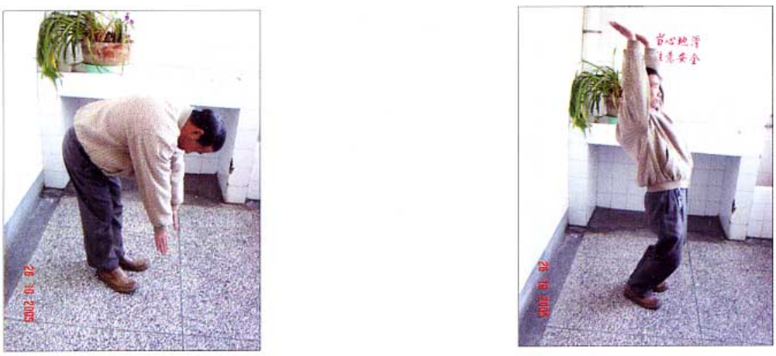


Fig.7. A follow-up of T9-T10 and L1 metastatic pulmonary carcinoma after PVP 12 mon.

ment of metastatic vertebral body tumors with PVP, the rate of eliminating pain and relieving pain significantly was 67.5% and 68.5% respectively, whereas the rate of relieving pain partially was 30%. The effective rate of relieving pain in our research was 100%.

The location of the centra, which were cured through PVP, did not shift, namely the change of the original physiological bend and the other abnormal changes including angularity, slide and so on did not become worse. It did not appear that the symptoms including the centra were futher compressed, the spinal cord or the nerve roots were not subjected to stress and did not lead to paralysis, as well as the cured centra developed no ache again. So this indicates that the spinal column stability is good after PVP. Most of the vertebral bodies involved with a tumor were filled uniformly by the bone cement, which could delay tumor development and provide constructional substitution, thus possibly prevent further lesion of the vertebral bodies, collapse and vertebral cord compression.[15] In 6 patients with a metastatic spinal tumor, pathological compression fractures developed after performing PVP. The PMMA leaked to the front of the vertebral bodies, but there were no clinical symptoms and no other complications occurred. The results demonstrated that PVP is a safe operation resulting in only small wounds.

This study revealed the following: the most outstanding feature of the technique is to cure intractable pain caused by a metastatic spinal tumor. The procedure improves the stability of the vertebral column and significantly improves quality of life. Performing the operation under the guidance of DSA can enhance its safety. Repeatedly sucking out the centra contents can effectively lower the pressure inside it and allow the bone cement to fill well. Use of a puncture needle with a beveled point allows better control of the direction of the needle during the procedure. Adjusting the needlepoint direction continuously while pushing in the bone cement permits good filling and reduces the leakage rate of the bone cement.

In summary, we consider that PVP can relieve pain effectively caused by osteolytic metastatic spinal tumors. It can enhance the strength of the vertebral bodies and improve the stability of the vertebral column. It is a safe and easy operation causing only small wounds and is without a systemic toxic effect. It is suitable for multiple metastatic spinal tumors (Figs.6,7). Therefore, PVP is an effective treatment for mestastatic spinal tumors. It will achieve a better therapeutic effect if combined with radiation therapy, chemotherapy and other complex treatments. At present, PVP is the most appropriate therapy for patients whose pathologic change from a metastatic spinal tumor results in a difficult excision and if there is no compression symptoms of the spinal cord and nerve roots.

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