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Initial CT-guided Percutaneous Biopsy of Vertebral Lesions: Evaluation of Its Diagnostic Accuracy and Clinical Value

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Summary: This study aimed to examine the diagnostic accuracy and clinical efficacy of initial CT-guided percutaneous biopsy of the vertebral lesions. A total of 305 percutaneous biopsies of the vertebral lesions were performed under either CT guidance (n=127) or C-arm guidance (n=178). The diagnostic accuracy rate was evaluated by comparing the histopathological diagnosis with the ultimate diagnosis. The histopathological diagnosis was consistent with the ultimate diagnosis in 108 (85.0%, 108/127) cases of CT-guided biopsy and in 135 (75.8%, 135/178) cases of C-arm guided biopsy and there was a significant difference. The accuracy of diagnosis based on biopsies varied with different diseases, including primary benign or malignant tumors, metastatic tumors, inflammatory lesions and fractures. A second biopsy or further examinations were required for patients with negative result obtained in the initial biopsy. The complication rate was 3.1% (4/127) in CT-guided biopsy and 7.3% (13/178) in C-arm guided biopsy. In conclusion, CT-guided percutaneous biopsy is an accurate and safe technique for biopsy of the vertebral lesions.
Key words: computed tomography; biopsy; spine; diagnosis

Even though modern medical imaging techniques have a good predictive value in differential diagnosis of vertebral lesions, an accurate biopsy is still needed to ascertain the histopathologic nature of these lesions[1, 2]. However, open biopsy for vertebral lesions is challenging with significant risk of complications[3, 4]. Traditionally, biopsies for vertebral lesions were usually performed under C-arm guidance, which were also difficult and time consuming. Currently, computed tomography (CT)-guided biopsy, with the advantages of increased diagnostic accuracy rate and reduced complication rate, is extensively used in clinical practice[5, 6]. However, there is a paucity of data about application of CT-guided percutaneous biopsy for vertebral lesions in China. The purpose of this study was to examine the diagnostic accuracy and clinical efficacy of use of CT-guided biopsy for vertebral lesions and compare the outcomes of CT-guided biopsy with those of C-arm guided biopsy.

1 MATERIALS AND METHODS

1.1 Patients' Characteristics

A total of 178 C-arm guided biopsies of the vertebral lesions were performed between July 2011 and June 2013 and 127 CT-guided biopsies of the vertebral lesions between January 2013 and June 2014 in our department. The biopsy data were collected and retrospectively analyzed. Informed consents were obtained from all patients.

1.2 Surgery Preparation

Plain radiography, CT scan, MRI scan, and ECT bone scan were performed to evaluate the vertebral lesions. Patients included in the study presented with either incidentally discovered unknown vertebral lesions or pathologic vertebral fractures.

1.3 Biopsy Technique

Patients assumed the prone position with chest pillow placed according to the involved segments of the spine. All biopsies were performed using specialized bone biopsy needles (STERYLAB, Italy), 3.5 mm in diameter.

For C-arm guided percutaneous biopsy, the best puncture site was chosen according to the X-ray photograph with the skin marked. For CT-guided percutaneous biopsy, a plain CT scanning was conducted to determine the target vertebral lesion. Then a second plain scanning was performed to verify the result and mark the best puncture site with a lead marker. The thickness and interval of the slice of CT scan were set according to the site and size of the lesions: usually 1 mm thickness and 1 mm interval for the cervical spine, 2 mm thickness and 2 mm interval for the thoracic spine, 5 mm thickness and 5 mm interval for the lumbar and sacral spine. In the cases of multiple lesions, a most easily approachable site was chosen for biopsy.

Whenever possible, the needle approach to the lesions was chosen according to a potential future surgical procedure, keeping the biopsy tract easily exercisable. Then all biopsies were performed under local anesthesia by using 1% lidocaine hydrochloride (5–15 mL).

The biopsy needle was inserted from the lateral mass or posterior arch of the atlas to the lesions (fig. 1). Pedicles were applied as biopsy channels for lower cervical vertebras. Because of the narrow pedicles of upper thoracic vertebras, biopsies were carried out via the ped-

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icles or costotransverse joints of these vertebras (fig. 2). Pedicles were the conventional biopsy channels for lower thoracic vertebras and lumbar vertebras (fig. 3). Biopsy needle was inserted along the articulatio sacroiliaca to the sacral vertebra (fig. 4).

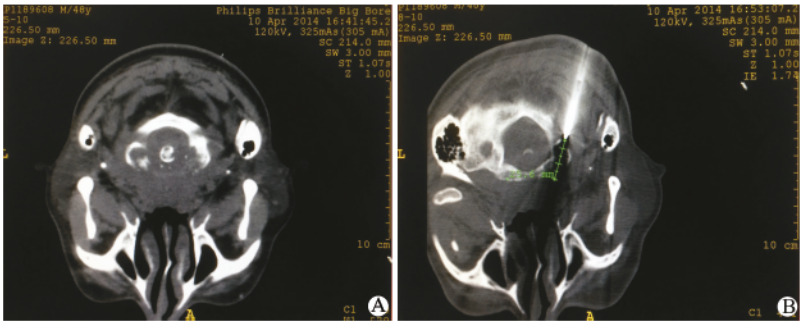

Fig. 1 CT-guided percutaneous biopsy of the atlas lesion via the lateral mass
A plain CT scanning was conducted to determine the best puncture site with a lead marker (A). The biopsy needle was inserted from the right of the lateral mass of the atlas to the lesion (B). The histopathological diagnosis of this case was chronic inflammatory lesion.

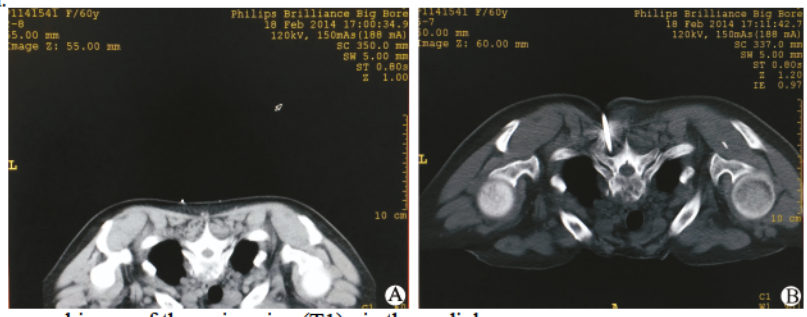

Fig. 2 CT-guided percutaneous biopsy of thoracic spine (T1) via the pedicle
A plain CT scanning was conducted to determine the best puncture site with a lead marker (A). The biopsy needle was inserted from the left pedicle of T1 to the lesions (B). The histopathological diagnosis of this case was metastasis of adenocarcinoma and this case was later diagnosed with lung cancer, confirmed by CT scan of the lung.

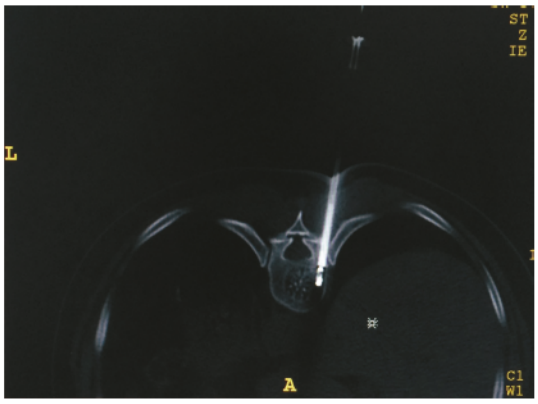

Fig. 3 CT-guided percutaneous biopsy of thoracic spine (T10) via the pedicle
The biopsy needle was inserted from the right pedicle of T10 to the lesions. Fence-like vertebra lesion can be observed in the photograph of CT scan and the histopathological diagnosis was angioma.

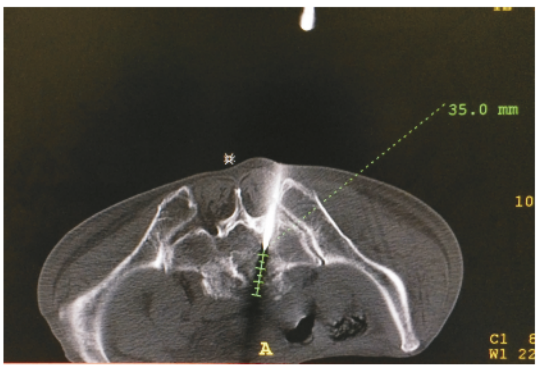

Fig. 4 CT-guided percutaneous biopsy of the sacral vertebra (S1) via the articulatio sacroiliaca
The biopsy needle was inserted from the right articulatio sacroiliaca of S1 to the lesions. Histological diagnosis was metastasis of sarcomatoid carcinoma from the liver.

After the trocar was introduced, the needle was coaxially inserted. Then, the trocar was left inside the lesion and suspected sample was obtained by the bone biopsy needle.

A specimen longer than 1 cm was obtained for each case. For most cases, a specimen, 2 cm long, was harvested. The collected specimens were fixed in 10% formaldhyde for further histopathological examination.

1.4 Postoperative Management

The final diagnosis was established based on the combination of histopathological diagnosis, the clinical and radiological manifestations. If the histopathological diagnosis was not consistent with the clinical and radiological manifestations, further clinical laboratory examinations and analyses were carried out to help diagnose the disease. Multidisciplinary consultation of orthopaedic surgeons, pathologists and radiologists was necessary when the diagnosis was difficult to make. If no typical pathological findings were obtained after the initial biopsy, a repeated percutaneous biopsy or incision biopsy

was needed to carry out.

1.5 Statistical Analysis

Descriptive analysis of continuous and categorical data was performed using means, standard deviations and rates. Student's *t*-test was used to compare the diagnostic accuracy rates. Statistical significance was set at $P<0.05$.

2 RESULTS

2.1 Time for the Procedure

The time for the procedures varied from 15 to 40 min (median 24 min) in CT-guided biopsy group and from 20 to 60 min (median 37 min) in C-armed guided biopsy group. CT-guided biopsy was less time-consuming than C-armed guided biopsy ($P<0.05$).

2.2 Accuracy Rate of Diagnosis

The sites and types of vertebral lesions are summarized in tables 1–3. The histopathological diagnosis was consistent with the final diagnosis in 108 (85.0%) of 127 cases of CT-guided biopsy, which is in line with previous studies, with the diagnostic accuracy rate varying from 70% to 93%[7–12], and in 135 (75.8%) of 178 cases of C-arm guided biopsy. The diagnostic accuracy rate in the CT-guided biopsy group was greater than that in the C-arm guided biopsy ($P<0.05$). The diagnostic accuracy rate of CT-guided biopsy and C-arm guided biopsy according to the different types of diseases are summarized in tables 1 and 2.

Table 1 Detailed vertebral lesions and accuracy rate of the 127 CT-guided biopsies

Lesion location	Primary benign tumors	Primary malignant tumors	Metastatic carcinoma	Inflammatory lesions	Vertebral fractures
Cervical vertebra	2	0	3	2	0
Thoracic vertebra	13	11	21	7	3
Lumbar vertebra	4	14	26	9	2
Sacral vertebra	0	2	7	1	0
Total cases	19	27	57	19	5
Accuracy rate (%)	84.2	85.2	89.5	68.4	100

Table 2 Detailed vertebral lesions and accuracy rate of the 178 C-arm guided biopsies

Lesion location	Primary benign tumors	Primary malignant tumors	Metastatic carcinoma	Inflammatory lesions	Vertebral fractures
Cervical vertebra	0	1	2	0	0
Thoracic vertebra	9	23	35	15	3
Lumbar vertebra	4	15	39	9	3
Sacral vertebra	0	4	11	5	0
Total cases	13	43	87	29	6
Accuracy rate (%)	69.2	81.3	80.4	51.7	100

Table 3 Detailed sites and types of vertebral lesions

Lesion types	CT-guided biopsies	C-arm guided biopsies
Primary benign tumors		
Hemangioma	16	11
Fibrous dysplasia	2	2
Eosinophilic granuloma	1	0
Primary malignant tumors		
Myeloma	22	34
Lymphoma	5	9
Metastatic carcinoma	57	86
Inflammatory lesions		
Tuberculosis	13	20
Purulent infection	3	5
Aseptic infection	3	4
Vertebral fractures	5	6

2.3 Pathological Results

In CT-guided biopsy group, no positive histopathological findings were found in 19 cases. Of these cases, 3 cases, with no abnormal vessels observed in the specimens, were diagnosed with hemangioma according to the clinical manifestation and radiologic characteristics. No plasmacytoma cells were seen in 4 cases which were later diagnosed with multiple myeloma, and 3 of them were confirmed by serum protein electrophoresis and/or bone marrow biopsy, and the left case by a repeated percutaneous biopsy. No neoplastic lesions were found in 6 cases which were later diagnosed with metastatic tumor. In the 6 cases, 3 were confirmed by a repeated percutaneous biopsy, another 3 were diagnosed according to the clinical manifestation and radiologic characteristics. It was difficult to distinguish between tumors, tuberculousis or other lesions in 6 cases, in which, 2 of them were diagnosed with purulent infection after a repeated percutaneous biopsy, and another 4 cases were diagnosed with tuberculousis according to the clinical manifestation, laboratory examination and radiologic characteristics.

In C-arm guided biopsy group, no positive pathological findings were found in 43 cases. Of these cases, 4

cases, with no abnormal vessels observed in the specimens, were finally diagnosed with hemangioma according to the clinical manifestation and radiologic characteristics. No plasmacytoma cells were noticeable in 7 cases which were suspected to be multiple myeloma, and all of them were confirmed by serum protein electrophoresis and/or bone marrow biopsy. One case suspected to be lymphoma was confirmed by a repeated percutaneous biopsy. Seventeen cases had no neoplastic lesions found in the specimens. But, of them, 7 were eventually diagnosed with metastatic tumor by a repeated percutaneous biopsy, and 10 had the same diagnosis according to the clinical manifestation and radiologic characteristics. In 14 cases, which are difficult to distinguish between tumors, tuberculousis or other lesions, the final diagnoses were confirmed at surgery in 11 cases, including 8 cases of tuberculosis and 3 cases of purulent infection. The other 3 cases were diagnosed with tuberculousis according to the clinical manifestation, laboratory examination and radiologic characteristics.

Inflammatory lesions were very difficult to diagnose. In CT-guided biopsy group, 19 cases were diagnosed with inflammatory lesions, in which, only 9 were found to have granulomatous lesions, 6 cases had positive T-spot examination results and only one case was positive for acid-fast bacilli. Each sample that was suspected to be inflammation was sent for bacterial culture, with no positive result detected. Three cases that had neutrophile granulocyte infiltration were diagnosed with purulent infection. Similarly, in C-arm guided biopsy group, biopsy revealed granulomatous lesions in only 9 cases and only one case had positive acid-fast bacilli. Samples that were suspected to be inflammation were sent for bacterial culture, and there were no positive results. Five cases were found to have neutrophile granulocyte infiltration.

2.4 Complications

In CT-guided biopsy group, leg numbness was reported during the operation in 3 cases (2 lumbar cases and 1 sacral case), which might be explained by nerve root stimulation. Besides, hematoma was found in 1 case after the biopsy, which was metastatic carcinoma with osteolytic lesions. In C-arm guided biopsy group, leg numbness occurred in 7 cases, including 3 thoracic cases, 2 lumbar cases and 2 sacral cases. Hematoma was found in 6 cases after the biopsy, and most of the cases were metastatic carcinoma with osteolytic lesions. The corresponding complication rate was 3.1% (4/127) in CT-guided biopsy group and 7.3% (13/178) in C-arm guided biopsy group.

3 DISCUSSION

For most vertebral lesions with unknown nature, a histopathological study is required to make a definitive diagnosis. Both fine needle aspiration (FNA) and core needle biopsy (CNB) can be applied to the percutaneous biopsy of vertebral lesions[1, 12]. The diameter of FNA needles is less than 1 mm, and that of CNB needles is more than 1.5 mm. FNA is only suitable for cytological study due to the architecture of the tissues, which makes the histopothological diagnosis less accurate. Furthermore, sampling errors may occur in FNA due to the little material obtained[1]. Mounting evidence demonstrates that CNB for obtaining diagnostic specimens is superior to FNA[1, 13–15]. A successful CNB can obtain adequate specimens, which is the basis to make an accurate histopathological diagnosis. Therefore, in our study, CNB was applied in each case. Besides, the bone biopsy needle (STERYLAB, Italy) we used was a special type of the core needles, which was equipped with a patent designed cutter, and able to break through the hard cortical bone.

Research shows that the diagnostic accuracy rate of biopsy is influenced by the nature of the lesions, the site, and the radiologist's experience[1]. For high grade malignant bone tumors and metastasis, CT-guided needle biopsy has an accuracy rate of more than 90%, and the accuracy rate is around 80% for low grade malignant and benign tumors[12]. Infections, especially chronic nonspecific diseases, are difficult to diagnose, with a low accuracy rate of 50%[9]. Similar results were observed in our study. In our cases, CT-guided CNB had an overall accuracy rate of 85.0%. The accuracy rate was 84.2% for primary benign tumors, 85.2% for primary malignant tumors, 89.5% for metastatic carcinoma, and 100% for vertebral fractures. A lower accuracy rate of 68.4% occurred in inflammatory lesions. Besides, a specimen longer than 1 cm may lead to a significant result in terms of adequacy and sensitivity[16].

The puncture method chosen based on the characteristics of the lesions helps increase the positive rate of biopsy, which can be further increased by careful preoperative preparation, especially by examining the radiological images preoperatively. Osteoblastic specimens could be obtained directly by cutting the lesions. As it was difficult to harvest osteolytic lesions by cutting them, the syringes could be used to aspirate the specimens. Besides, we cut the bone at the edge of the osteolytic lesions to improve the positive rate.

If the histopathological finding after a CT-guided percutaneous biopsy was negative or not consistent with the clinical diagnosis and/or radiological imaging, further examination was usually considered. The diagnostic accuracy rate of biopsy could be improved by a strict collaboration and communication among orthopedic surgeons, radiologists and pathologists. A repeated CT-guided percutaneous biopsy or incision biopsy could be performed to confirm the diagnosis when necessary.

The most common type of diseases in our study was metastatic tumors, which were observed in the spine more often than any other sites of the bony skeleton[17]. Since most metastases occur after the detection of the primary tumors, the clinical diagnosis of a spinal metastatic tumor can often be made from the patients' history. Nevertheless, if the primary tumor is unknown, the tumor origin may be more difficult to determine. Although CT-guided biopsy of vertebral lesions would increase the diagnosis of spinal metastasis of unknown origin, the primary tumor was confirmed at the initial diagnosis in 0.5 to 7% of the oncologic patients[18, 19]. In 15% to 25% of such cases, the primary site can not be identified even by necropsy[19].

The skeleton is a common metastatic site for visceral tumors[17]. According to the literatures, 60% of spinal metastasis is from lung, breast, or prostate carcinoma among adults[16, 17, 20]. It has been reported that a spinal malignancy of unknown origin is often derived not only from solid tumors, but also from hematologic tumors[20]. In our cases, metastasis of lung cancer, breast cancer, prostate cancer, thyroid cancer, colorectal cancer, esophageal cancer, liver cancer, and cholangiocarcinoma were observed as well as that of unknown origin. Of

these lesions, metastasis of lung cancer was most common.

Multiple myeloma is a kind of monoclonal gammopathy, which is a common etiology for spinal malignancy of unknown origin[20, 21]. Therefore, serologic evaluations, such as serum protein electrophoresis and bone marrow examination, should be considered to make the final diagnosis in such patients. We should remain vigilant about negative results of biopsy and serum protein electrophoresis, which can not exclude the possibility of myeloma.

According to the literatures, the complication rate following CT-guided percutaneous biopsy of the spine is low, ranging between 0% and 6.4%[22, 23]. Hemorrhagic complications, including localized hematoma, inadvertent aortic injury and psoas hematoma, occasionally occur, and they are usually self-limiting. Other complications, including infection, pneumothorax, fracture and neurological injury, such as nerve root or spinal cord damage, are also observed[23]. Tumor seeding along the biopsy tract is another possible complication. However, a recent report suggested that the potential is very low or negligible[24]. Rare complications were observed in CT-guided percutaneous biopsy in our study and the complication rate was low as described before.

In conclusion, CT-guided percutaneous biopsy is a fast, accurate and safe technique. It is considered the procedure of choice for biopsy of the vertebral lesions. To increase the diagnostic accuracy rate of initial CT-guided percutaneous biopsy of the vertebral lesions, accurate positioning and adequate specimens are of vital importance. A repeated percutaneous core needle biopsy or incision biopsy is necessary if the histopathological diagnosis is still doubtful or the result is not consistent with the clinical diagnosis or radiological imaging.

Conflict of Interest Statement

The authors declare that there is no conflict of interest with any financial organization or corporation or individual that can inappropriately influence this work.

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