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Original article

Lateral chest radiography in the screening of pulmonary metastasis in osteosarcoma patients

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Abstract

Background: No previous study has mentioned the value of lateral chest radiography in the screening of pulmonary metastasis from osteosarcoma. We assume that lateral chest radiography gives no additional information that would be clinically significant compared with the frontal view alone.

Objectives: This study aimed to evaluate the value of lateral chest radiography in the screening of pulmonary metastasis in patients with osteosarcoma.

Methods: In total, 400 sets of chest radiographs [posterior-anterior (PA) and lateral projections] were interpreted by a single radiologist for pulmonary mass/nodule, lymph node, and pneumothorax. First, the PA radiographs were interpreted. Thereafter, the PA and lateral radiographs were analyzed together with a specific note made whether any findings were identifiable only on the lateral radiograph or if it was on both views. Then, a determination was made in all cases whether the findings on the lateral radiograph changed the diagnosis made based on the PA radiograph alone.

Results: The PA and lateral chest radiographs showed abnormalities in 80 (20.0%) of the 400 sets of radiographs. There were the abnormalities observed only on the lateral radiographs in 5 sets (6.3%), 4 sets (22.2%), and 0 sets for mass/nodule, lymph node, and pneumothorax, respectively. There was no statistically significant difference between the PA radiographs alone and the combination of PA and lateral radiographs in the detection of abnormalities and in the imaging diagnosis of pulmonary metastasis. However, there are three cases which the abnormalities noted on the lateral radiographs change the diagnosis and alter the further management.

Conclusion*:* Most abnormal findings were identified on the PA images, however, there are the lesions seen only on the lateral images and helped to change the diagnosis and alter further management.

Keywords: Lateral chest radiography, osteosarcoma, pulmonary metastasis.

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Osteosarcoma is the most common primary malignant bone tumor. According to a study in Thai pediatric oncology patients in 2003 - 2005, the age - adjusted incidence rate of osteosarcoma in Thai children aged 0 - 15 years old was 1.6 per million and the 5 - year overall survival rate was 33.7%. [1] A previous study conducted in northern Thailand using data from the 1998 - 2012 reported that the overall annual incidence of osteosarcoma was 1.7 per million with a male : female ratio of 1.4 : 1 and the peak incidence was at 15 - 19 years old for males and 10 - 14 years old for females.[2]

Approximately 15.0% - 20.0% of patients with osteosarcoma have pulmonary metastasis at the first presentation and 80.0% of them have a pulmonary lesion as the metastatic site. Aljubran A, *et al*. reported that the 3 - year post - pulmonary metastasis survival rate was only 16.0% and 38.0% for non-operated and operated patients, respectively.[3] The factors affecting the survival rate of patients with osteosarcoma include the time interval to detection of the pulmonary metastasis, the number of pulmonary metastases, and the distribution of the pulmonary metastases. [4]

The characteristic radiologic findings of pulmonary metastasis from osteosarcoma include the presence of a pulmonary mass or nodule, either non - calcified or calcified, and pneumothorax. [5]

According to the clinical practice guideline of the European Society for Medical Oncology, chest radiography and chest computed tomography are suggested for the initial staging and follow- up detection of metastatic disease. However, neither frontal nor lateral chest radiography is recommended in this guideline specifically. [6] Martins GE, *et al*. reported a high recurrence in 59.6% of patients with osteosarcoma, of which 58.0% were pulmonary related. Therefore, follow - up should be performed at regular intervals. [7] The present clinical practice of Siriraj Hospital recommends both frontal [also referred to as posterior - anterior, (PA)] and lateral chest radiography for pulmonary metastatic surveillance.

The value of lateral chest radiography is particularly illustrated in three specific locations, namely, the hilar region, anterior clear space, and retrocardiac region, since these areas are not overlapped by the mediastinal soft tissue. [8] Nevertheless, Kluthke RA, *et al*. reported that additional lateral chest radiography showed no diagnostic benefit in the detection of a small pulmonary nodule compared with the frontal view alone. [9]

Moreover, the effective radiation dose from one view of chest radiography to children aged younger than 15 years old is approximately 0.06 - 0.11 mSv, whereas the effective radiation dose from chest computed tomography to children aged younger than 15 years old is approximately 1.9 - 3.3 mSv. [10]

Both frontal and lateral chest radiography are regularly performed to detect pulmonary metastasis in pediatric patients with osteosarcoma in Siriraj Hospital; consequently, pediatric patients receive twice the dose compared to in frontal radiography alone. Furthermore, pediatric patients are more sensitive to radiation and they are at a greater risk than adults from cancer occurrence after radiation exposure. [10, 11]

No previous study has yet mentioned the value of lateral chest radiography in the screening of pulmonary metastasis from osteosarcoma. We hereby assume that lateral chest radiography gives no additional information that would be clinically significant compared with the frontal view alone. This study aimed to evaluate the value of lateral chest radiography in the screening of pulmonary metastasis in patients with osteosarcoma.

Materials and methods

Study population

This retrospective study has been approved by the Ethics Committee of Faculty of Medicine Siriraj Hospital, Mahidol University [no. 194/2562 (EC3)]. The need for informed consent was waived due to the retrospective nature of the study.

The study involved patients with osteosarcoma treated at Siriraj Hospital between January 2009 and December 2018. Initially, 106 patients were recruited in this study with the following criteria: **a)** patients with osteosarcoma aged 0 - 18 years old; **b)** patients who underwent chest radiography in PA and lateral projections.

Patients with an underlying chest abnormality that could interfere with the radiograph interpretation were excluded. Thus, the final population in this study was 106 patients (62 males and 44 females). There were initially 408 sets of chest radiographs involving PA and lateral projections but 8 sets were excluded due to the imaging technique or chest abnormality that could interfere with the chest radiograph interpretation **(Figure 1).**

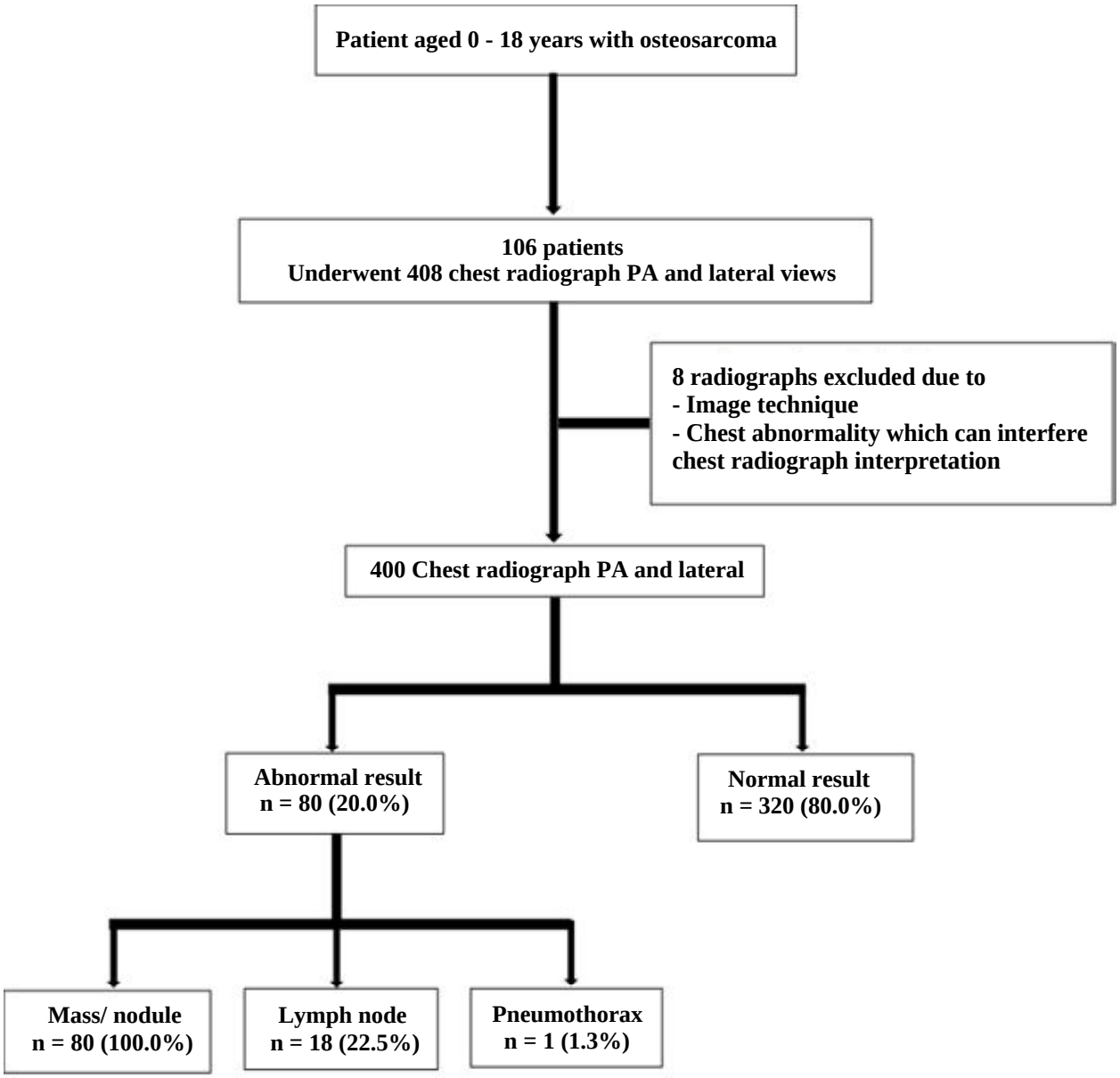

Figure 1. Flow process diagram for the study population. (n, number of sets of PA and lateral radiographs)

Imaging interpretation

All PA and lateral chest radiographs were available for reading at a Picture Archiving and Communication System (PACS) workstation.

The chest radiographs were retrospectively interpreted by a pediatric radiologist (P.N.; with 10 years of experience), who was blinded to the clinical information and the original radiologic report.

The radiologist assessed the radiographs for evidence of pulmonary metastasis using radiographic criteria: a) pulmonary mass or pulmonary nodule; b) hilar or mediastinal lymph node; and c) pneumothorax.

First, only the PA radiographs were interpreted by the radiologist, for image diagnosis of pulmonary metastasis. Thereafter, the PA and lateral radiographs were analyzed together with a specific note made whether any aforementioned finding was identifiable only on the lateral radiograph or if it was on both views.

Then, a determination was made in all cases whether the findings on the lateral radiograph changed the diagnosis made on the basis of the findings on the PA radiograph.

Clinical evaluation

The clinical diagnosis of pulmonary metastasis was confirmed by the following criteria: a) tumor pathologically proven as pulmonary metastasis; b) the later chest computed tomography (CT) images diagnosed pulmonary metastasis; c) the clinical diagnosis of pulmonary metastasis.

Statistical analysis

Data were collected and analyzed with IBM SPSS statistic version 18.

The frequency of positive findings identified separately on the PA and lateral radiographs were noted. For the lateral radiographs, we analyzed how often the image a) revealed an abnormality that was not seen on the PA image or b) changed the interpretation of any abnormality seen on the PA image.

As for statistical analysis, the Chi - square goodness of fit test was used to assess whether the differences between the two imaging techniques in diagnosing pulmonary metastasis were statistically significant. $P < 0.05$ was considered to indicate a statistically significant difference.

Results

The study population consisted of 106 patients, comprising 62 males and 44 females. The mean age at the diagnosis of osteosarcoma was 12.7 years old. Pulmonary metastasis was diagnosed in 55 (51.9%) of the 106 patients.

The PA and lateral chest radiographs showed at least one abnormality (mass/nodule, lymph node, or pneumothorax) in 80 (20.0%) of the 400 sets of chest radiographs. In these 80 sets, a pulmonary mass or nodule was seen in all 80 (100.0%) sets, while a lymph node was observed in 18 (22.5%) sets and pneumothorax was found in 1 (1.3%) set **(Figure 1).**

In terms of the pulmonary mass or nodule, the PA radiographs showed at least one pulmonary mass or nodule in 75 (93.8%) of 80 sets while the lateral radiographs showed no abnormality in 32 (40.0%) sets. A pulmonary mass or nodule was seen on the lateral radiograph in 48 (60.0%) of the 80 sets, with 5 (6.3%) of them seen only on the lateral radiograph **(Figure 2A).** These pulmonary nodules that were seen only on the lateral radiographs were detected at the retro-cardiac region and anterior clear space. There was no statistically significant difference between the PA radiograph alone and the combination of PA and additional lateral radiographs in the detection of a pulmonary mass or nodule ($P = 0.53$).

As for the lymph node, the PA radiographs showed a calcified or non-calcified lymph node in 14 (77.8%) of 18 sets while the lateral radiographs showed no abnormality in 7 (38.9%) sets. However, the lymph node was seen on the lateral radiograph in 11 (61.1%) of the 18 sets, with 4 (22.2%) of them seen only on the lateral radiograph **(Figure 2B).** These four cases had hilar lymphadenopathies; nevertheless, they did not change the diagnosis because the radiographs also revealed multiple pulmonary nodules on both the PA and lateral images to indicate pulmonary metastasis. There was no statistically significant difference between the PA projection alone and the combination of PA and additional lateral projections in the detection of a lymph node ($P = 0.33$).

In the aspect of pneumothorax, only one PA radiograph showed pneumothorax while no lateral radiographs showed the abnormality **(Figures 3 - 4).** There was no statistically significant difference between the PA projection alone and the combination of PA and additional lateral projections in the detection of pneumothorax.

On the basis of the final image diagnosis of pulmonary metastasis, the PA and lateral radiographs showed abnormalities (multiple pulmonary nodules/ masses, hilar/ mediastinal lymphadenopathy, or pneumothorax) to suggest pulmonary metastasis in 56 (14.0%) of 400 sets.

In these 56 sets, 53 (94.6%) sets were diagnosed by PA radiographs and 41 (73.2%) sets were diagnosed by lateral radiographs **(Figure 5).** Three (5.4%) of them were diagnosed by only lateral radiographs **(Figure 6).** However, there was no statistically significant difference between the PA projection alone and the combination of PA and additional lateral projections in the image diagnosis of pulmonary metastasis ($P = 0.67$).

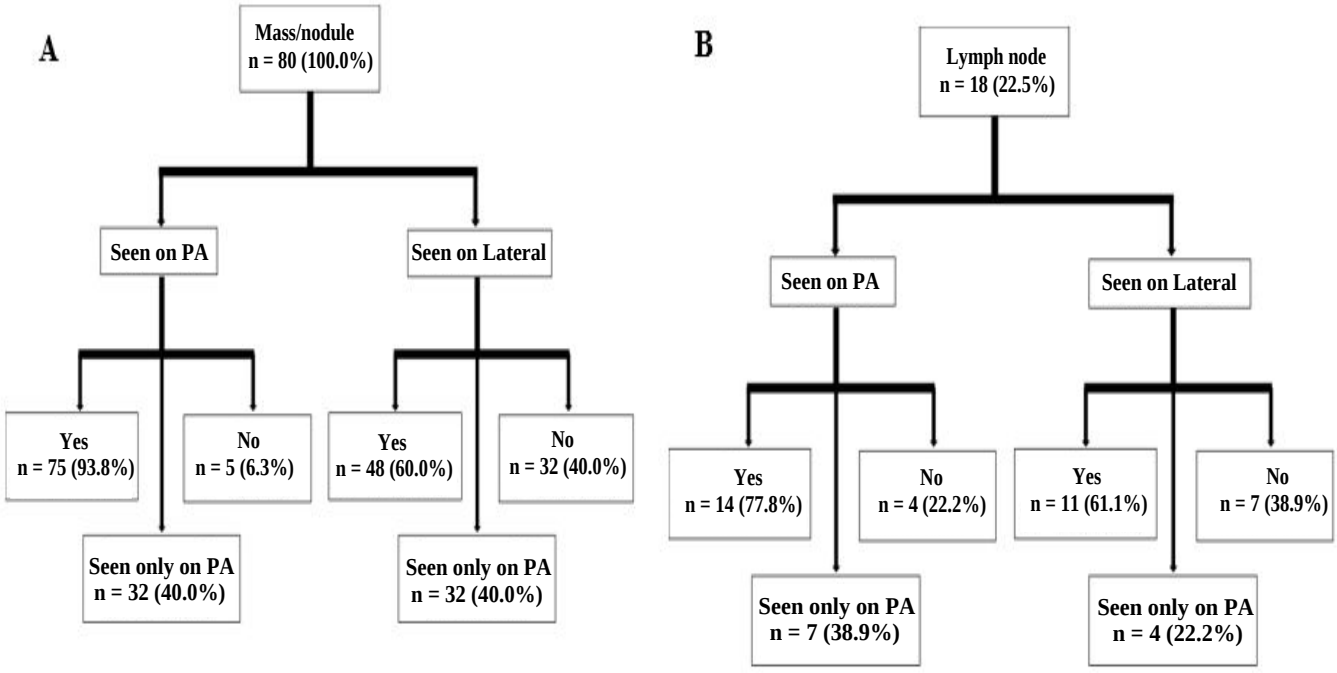

Figure 2. Pulmonary mass or nodule **(A)** and; lymph node **(B)** detected on the PA radiographs and the lateral radiographs. (n, number of sets of PA and lateral projections from the chest radiography).

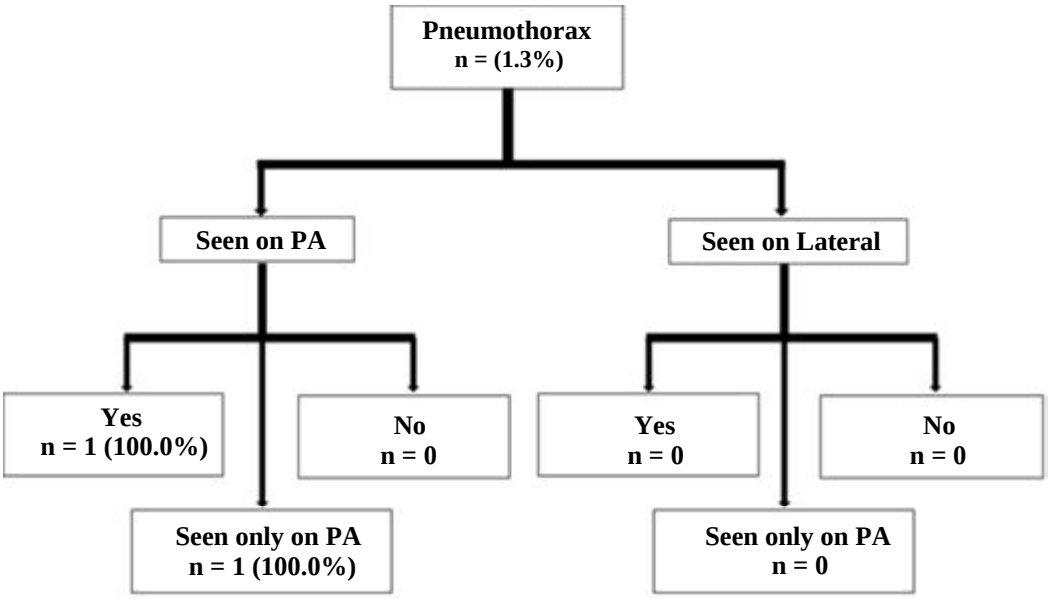

Figure 3. Pneumothorax detected only on the PA radiograph. (n, number of set of PA and lateral projections from the chest radiography).

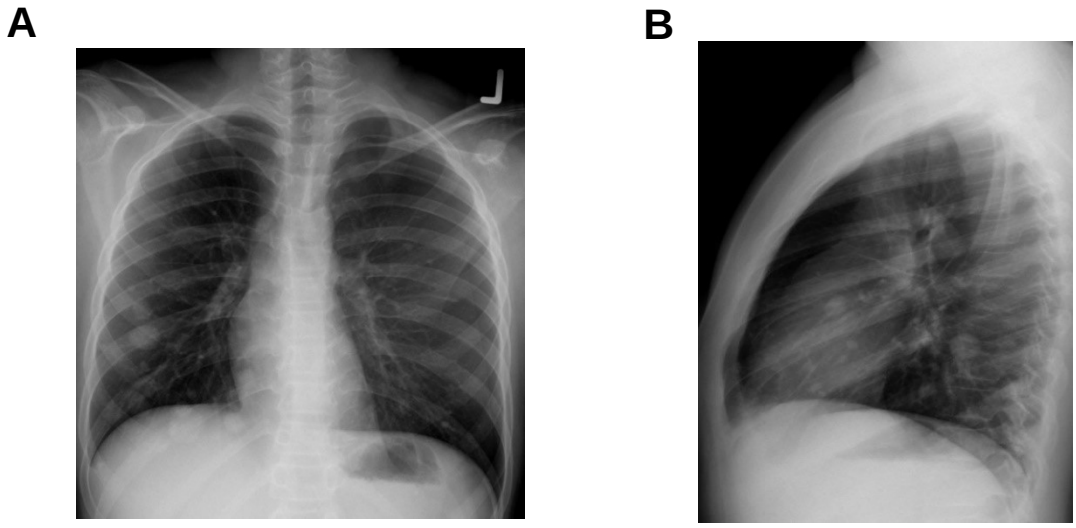

Figure 4. Chest radiograph of a 14-year-old girl with osteosarcoma at the right tibia. (**A**) PA image showing pneumothorax at the left hemithorax; (**B**) Lateral image did not show this abnormality.

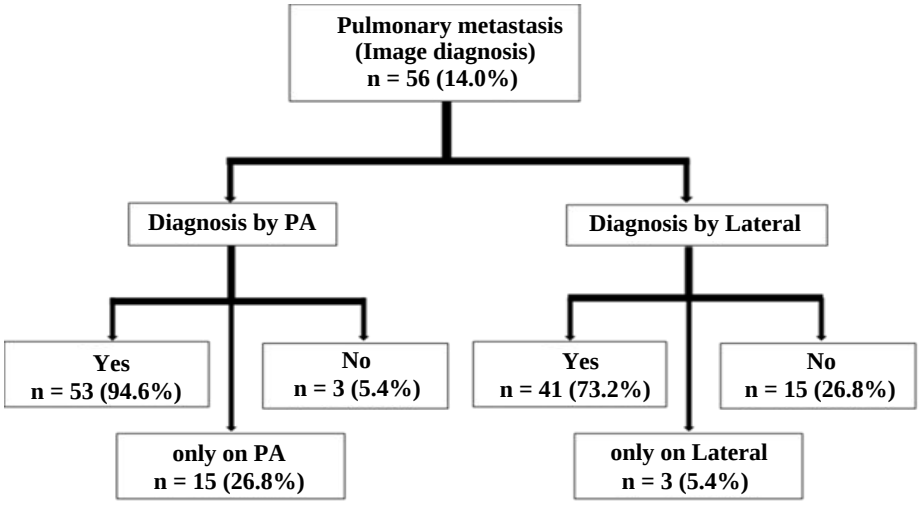

Figure 5. Image diagnosis for pulmonary metastasis by the PA radiographs and lateral radiographs (n, number of set of PA and lateral projections from the chest radiography).

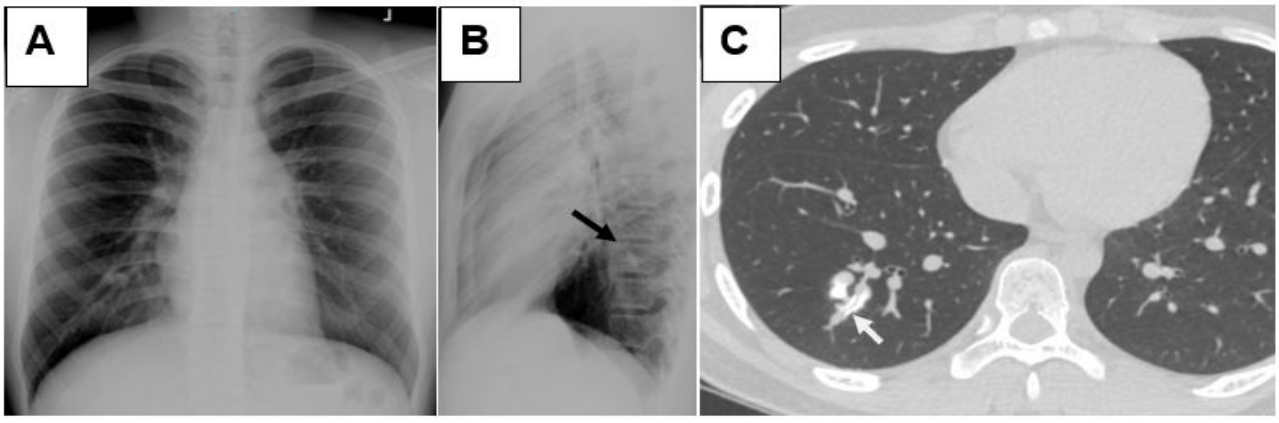

Figure 6. Chest radiograph of a 16-year-old boy with osteosarcoma at the right femur. At first there was no nodule detected on the PA radiograph **(A)** but the lateral radiograph; **(B)** helped detect a nodule overlying the spine (black arrow); and **(C)** Chest CT images showing endobronchial metastases at the lateral basal segment of RLL (white arrow). Tissue diagnosis from wedge resection confirmed pulmonary metastasis from osteosarcoma.

Discussion

The common radiologic findings of pulmonary metastasis from osteosarcoma include calcified or non - calcified pulmonary nodule, mediastinal lymphadenopathy (including hilar lymphadenopathy), and pneumothorax. [5] In our study, pulmonary nodules and lymphadenopathy were found on both PA and lateral projections, while pneumothorax was detected only on the PA view.

No previous study has yet addressed the value of lateral chest radiography in pulmonary metastatic surveillance in patients with osteosarcoma.

In our study, most abnormal findings were identified on the PA radiographs and the abnormalities detected on the lateral radiographs only served to confirm the findings on the PA projections. However, there were three sets in which the nodules were identified only on the lateral radiographs and helped to change the diagnosis and alter further management. Pulmonary metastasis was confirmed in these cases by later chest CT or tissue diagnosis.

Feigin DS. suggested that the lateral chest radiograph provided additional information, especially in the hilar region, anterior clear space, and retro-cardiac region, showing that these areas are not overlapped by the mediastinal soft tissue. [8]

On the other hand, Kluthke RA, *et al*. reported that the additional lateral chest radiograph showed no diagnostic benefit in the detection of a small pulmonary nodule compared with the PA image alone. [9] Eisenberg RL, *et al*. also reported that the lateral chest radiograph provided no additional detection of calcified lymph node, peripheral granuloma, and non - calcified nodule. It also gave no additional diagnostic value in the chest screening examination performed in patients with a positive PPD skin test. [12]

In terms of the lymph node, some lymphadenopathies were visualized on both projections. Para-tracheal lymphadenopathy was obviously detected on the PA chest radiograph, but the lateral image could not show this abnormality. In our study, there were four cases showing some hilar lymphadenopathies that were seen only on the lateral chest radiograph; nevertheless, these findings did not change the diagnosis as pulmonary nodules were also detected to indicate pulmonary metastasis.

Our study has several limitations to note. First, there was only one radiologist who interpreted the chest radiographs in this study. Second, a possible cause of bias was that the radiologist focused only on the aspect of pulmonary metastasis. A third bias could have occurred since the radiologist was not blinded to the PA chest radiograph results while interpreting the lateral chest radiographs. However, this practice represented the actual clinical practice of radiology in which both PA and lateral chest radiographs are interpreted together.

Conclusion

Most abnormal findings were identified on the PA radiographs, however there are the lesions seen only on the lateral images and helped to change the diagnosis and alter further management.

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Conflicts of interest statement

Each of the authors has completed an ICMJE disclosure form. None of the authors declare any potential or actual relationship, activity, or interest related to the content of this article.

Data sharing statement

Data sharing statement. All data generated or analyzed during the present study are included in this published article. Further details are available for noncommercial purposes from the corresponding author on reasonable request.

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