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Case Report

CT 3D Reconstruction Technology and AI Recognition Technology in the Application of Rib Fibrous Dysplasia: A Case Report

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Abstract

Background: Primary rib tumors are relatively rare and more difficult to diagnose compared to other tumors, leading to a higher risk of misdiagnosis.

Case: The patient was a 23-year-old male who presented with intermittent right-sided chest pain for six months. Six months prior, he developed right chest wall pain without an obvious cause, characterized by dull pain and occasional stabbing sensations, often accompanied by coughing and white mucus production, but no fever, night sweats, nausea, or vomiting. Symptoms would resolve on their own after about a week. CT 3D reconstruction technology and AI recognition suggested a rib tumor, requiring surgical removal. The surgery was successful, and the patient recovered well with no recurrence.

Conclusion: Primary rib tumors are rare. Using CT 3D reconstruction and AI recognition technology can improve preoperative diagnosis and assist in surgical planning.

Keywords: fibrosarcoma, computed tomography, artificial intelligence, surgical procedure, thoracic neoplasm

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1. Introduction

Benign chest wall tumors are rare, originating from the thoracic wall's vessels, nerves, bones, cartilage, and soft tissues. They account for about 2% of tumors in the general population, with approximately 50% being benign in histological classification [1]. The incidence of rib bone tumors ranges between 3–8%, with secondary tumors being more common, most of which are malignant [2, 3]. Primary rib tumors are relatively rare and often benign, typically discovered incidentally. Fibrous dysplasia of bone (FDB), also known as fibrous structural dysplasia, has an unclear cause and is the most common type of bone tumor-like lesion, accounting for about 0.63% of bone tumors and tumor-like lesions [4-6]. Although fibrous dysplasia has typical radiographic features, there is variability in its imaging presentation, and it can resemble other bone lesions. Imaging diagnosis remains one of the most direct and effective means of diagnosing fibrous dysplasia.

The 3D reconstruction technology of CT scans and AI recognition technology play a significant role in the diagnosis and management of rib tumors. CT's 3D reconstruction technology can generate high-resolution three-dimensional images of the ribs and surrounding tissues, helping doctors accurately locate the size and shape of tumors, as well as their relationship with adjacent structures, thus providing strong support for surgical planning. Before surgery, surgeons can use these three-dimensional images for detailed preoperative planning and to choose the best surgical approach. Additionally, CT 3D reconstruction can be employed postoperatively to observe the healing of the ribs and assess the risk of recurrence. Meanwhile, AI recognition technology uses deep learning algorithms to automatically analyze CT images, rapidly identifying rib tumors or abnormal lesions, significantly improving diagnostic efficiency and accuracy. AI can also assist radiologists' judgments, particularly in complex cases, by helping to identify potential lesions. Furthermore, AI models can analyze historical data to assess risk factors associated with rib diseases, providing personalized risk assessments and monitoring recommendations, thereby aiding doctors in formulating individualized treatment plans. The combination of these two technologies not only enhances the diagnostic precision of rib tumors but also optimizes treatment processes, offering more effective management strategies for patients.

2. Materials and Methods

2.1. Patient History

The patient is a 23-year-old male, admitted on March 25, 2024. His chief complaint was pain in the intermittent right-sided chest for six months. Six months ago, the patient developed right chest wall pain without any obvious cause, described it as dull pain with occasional stabbing sensations, often accompanied by coughing and white mucus production, but no fever, night sweats, nausea, or vomiting. The symptoms resolved spontaneously after about one week. The patient denies any history of infectious

diseases such as hepatitis, tuberculosis, or typhoid. No history of hypertension, coronary heart disease, or diabetes. Vaccination history is complete and regular. The patient denies any history of surgery, trauma, blood transfusion, or allergies to drugs or food. The patient was born in Zhangjiakou, Hebei Province, China (originally from Zhangjiakou, Hebei Province). The patient denies exposure to radiation or industrial dust, denies any history of endemic diseases or sexually transmitted infections, and reports no smoking or alcohol consumption. No family history of hereditary diseases.

2.2. Physical Examination

The thorax is normal in shape, with no deformities. Both nipples are normal, symmetrical, and without masses. A mass is palpable at the 7th rib on the chest wall, measuring approximately 7x4 cm. The mass is hard in texture, with mild tenderness upon palpation but no subcutaneous crepitus. Bilateral chest movements are symmetrical, and the intercostal spaces are normal. Vocal fremitus is symmetrical on both sides. No pleural friction rub is detected. Percussion of both lungs reveals clear sounds. Breath sounds are clear in both lungs, with no dry or moist rales heard. No pleural friction sounds are audible.

2.3. Imaging Examination

CT 3D reconstruction and AI recognition of the ribs showed clear bilateral lung fields, with normal lung structures and no abnormal densities. The mediastinum was in place, and no enlarged lymph nodes were observed. The heart appeared normal, and there were no abnormalities in the pleural cavity. The 7th rib on the right side was enlarged with uneven density. A follow-up recommendation was made for further clinical assessment. The application software used was United Imaging Intelligence, UII (Figure **1**).

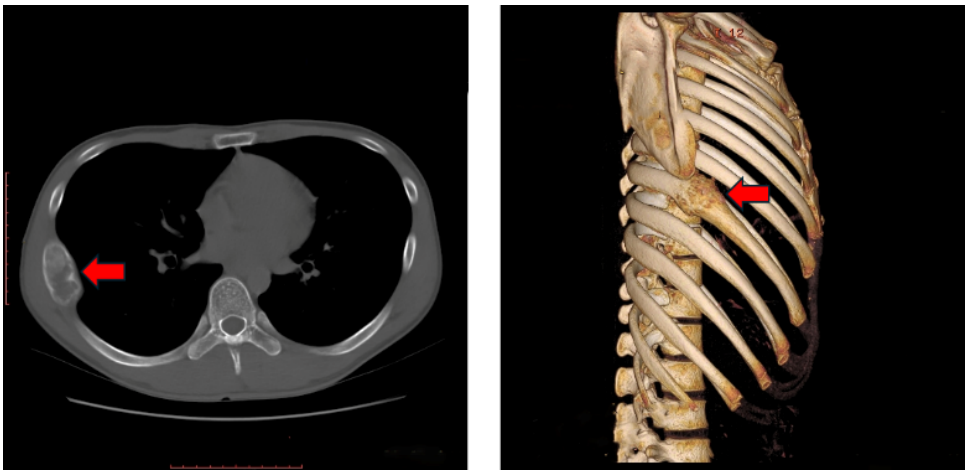

Figure 1: Preoperative CT 3D reconstruction showed that the tumor was located in the 7th rib on the right side.

2.4. Diagnosis and Surgical Method

According to the preoperative examination, no abnormalities were found in the abdominal cavity, including the liver, gallbladder, pancreas, and spleen. No abnormalities were detected in the supraclavicular and cervical lymph nodes. In this case, although preoperative CT 3D reconstruction and AI recognition technology provided a clear radiological display of the rib tumor, the possibility of malignancy could not be entirely ruled out. This limitation arises from the inherent constraints of imaging in determining tumor nature. While CT imaging offers precise information on the tumor's size, shape, density, and its relationship with surrounding tissues, some malignant tumors may exhibit similar imaging characteristics to benign ones, especially in anatomically complex areas like the ribs. Additionally, despite the high resolution of CT, certain subtle cytological features (such as cellular atypia or mitotic figures) cannot be detected through imaging and require further pathological examination for confirmation. Therefore, in this case, imaging played a critical role in preliminary screening and surgical planning but could not serve as the final diagnostic criterion. To accurately determine the tumor's malignancy or benignity, surgical resection was performed, and the excised tissue was sent for pathological examination. Pathological analysis, including histological and immunohistochemical tests, reveals the microscopic structure, proliferative status, and expression of specific markers, providing a definitive diagnosis. Although the CT findings showed no obvious invasive characteristics, pathological examination remains essential for assessing malignancy and guiding subsequent treatment plans. Thus, combining radiological and pathological evaluations ensures the highest diagnostic accuracy and optimal treatment effectiveness. Preoperative diagnosis suggested a tumor of the right 7th rib, with malignancy not excluded. During surgery, a tumor from the 7th rib protruded into the thoracic cavity, with a smooth pleural surface and no lung adhesions. The surgical approach involved exposing the 7th rib through an incision, cutting and removing part of the rib for pathology (Figure **2**). Three months post-surgery follow-up, the rib CT 3D reconstruction indicates good recovery at the resection site (Figure **3**).

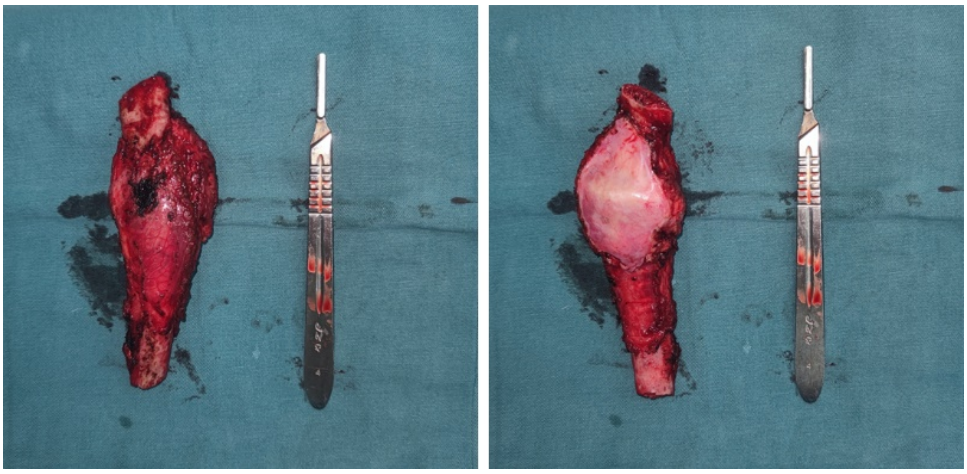

Figure 2: Rib tumor resection with complete tumor resection. (A) The medial side of the tumor, (B) the lateral side of the tumor.

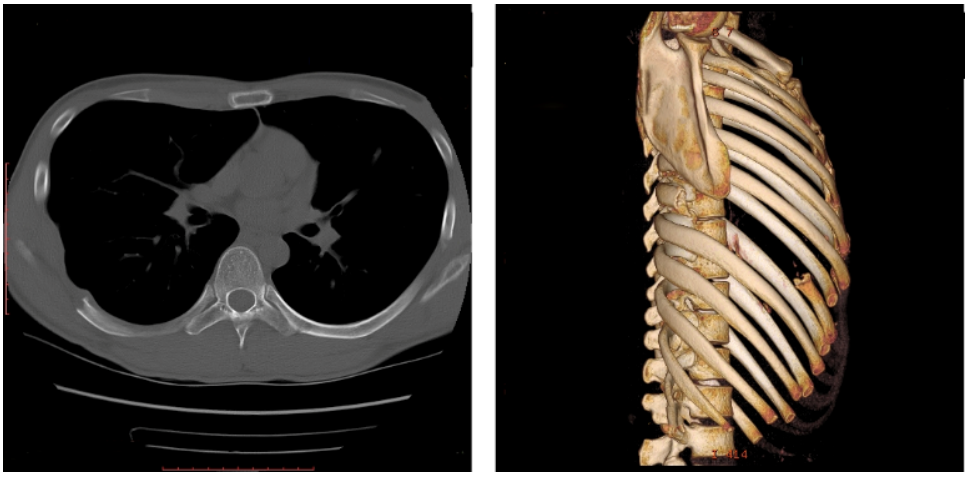

Figure 3: Postoperative CT 3D reconstruction shows that the rib tumor has been completely removed.

2.5. Pathology Report

The morphology was consistent with fibrous dysplasia. Immunohistochemistry results: Vimentin (+), CK (AE1/AE3) (-), Desmin (-), Ki-67 (+1%), S-100 (-), CD68 (+), CD99 (focal +), SMA (focal +), NF (-), EMA (-) (Figure **4**).

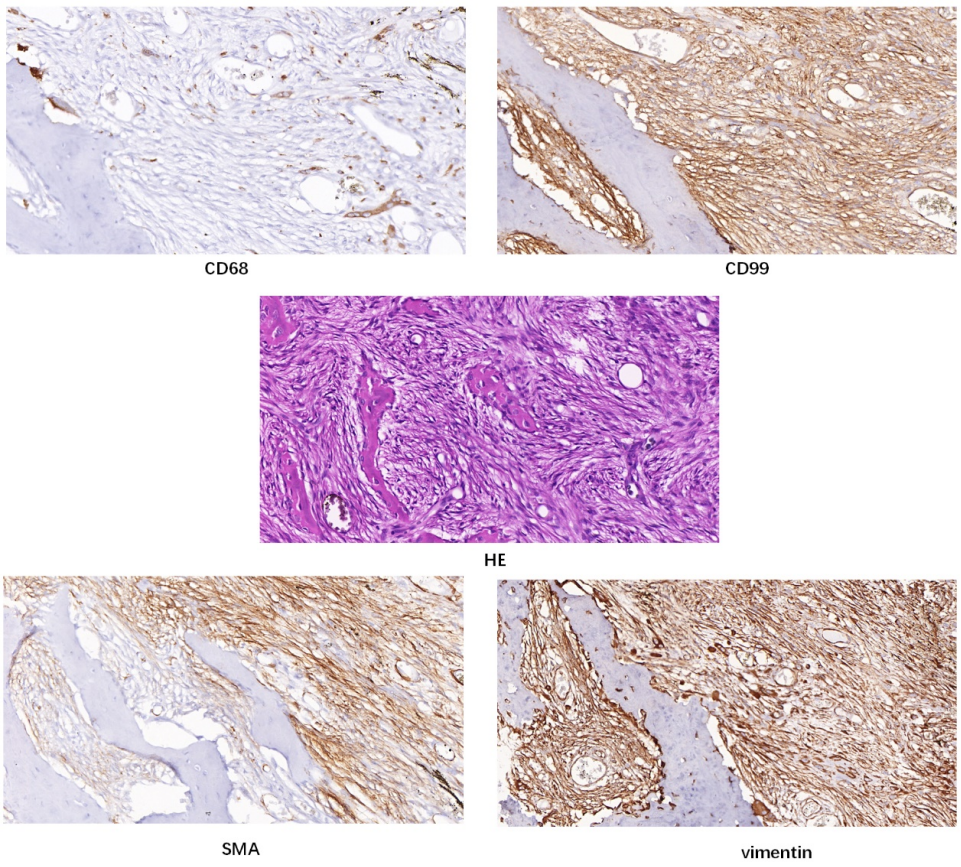

Figure 4: Pathological images of the surgical specimen (magnification ×400).

In this case, CT 3D reconstruction and AI recognition technologies played key roles in both the diagnosis and treatment of the tumor. CT 3D reconstruction provided high-resolution images of the ribs and surrounding tissues, enabling the medical team to accurately assess the size, shape, and location of the tumor and its relationship to nearby structures, which was essential for preoperative planning. These images allowed the surgeons to develop a precise surgical plan, minimizing tissue damage and ensuring complete tumor removal. The AI recognition technology assisted by automatically analyzing the CT images, quickly identifying the tumor, and improving diagnostic efficiency, especially in complex anatomical regions like the ribs, reducing the risk of missed diagnoses. Although AI provided important diagnostic support, pathological examination was still required to confirm whether the tumor was benign or malignant. In this case, the combination of these two technologies not only improved diagnostic accuracy but also optimized surgical planning and enhanced treatment outcomes. However, as demonstrated, pathology remains the definitive method for diagnosis, highlighting the complementary role of CT and AI throughout the diagnostic and treatment process, ultimately improving the patient's prognosis.

2.6. Prognosis

The pathology report confirmed fibrous dysplasia. The patient had a good prognosis, and the follow-up chest X-rays and CT scans showed no abnormalities.

3. Discussion

Primary rib tumors are relatively rare, most commonly seen in young and middle-aged adults, who are the primary group affected by both primary rib tumors and tumor-like lesions [7, 8]. Most cases are discovered during routine examinations, while a few patients exhibit localized pain, with the duration of symptoms varying. In this case, the patient was a young adult with intermittent chest pain as the primary symptom. In recent years, with the rise and application of AI, its use in chest CT, particularly in diagnosing rib diseases, has been increasing. For instance, AI technology has improved the detection rate of occult rib fractures. In this case, we applied AI technology in combination with 3D reconstruction techniques to diagnose the condition preoperatively and guide surgical treatment.

FDB is a disease where abnormal fibrous tissue and immature woven bone replace normal bone tissue, and the mechanism of the disease remains unclear [9]. This condition is most common in adolescents and often presents without symptoms in the early stages. Patients typically seek medical attention for pain, local deformities, or pathological fractures. FDB can become malignant, but the malignancy rate is less than 1% [10]. Clinically, it can be categorized as either monostotic or polyostotic, with about 3% of cases presenting as McCune-Albright syndrome, characterized by skin and mucosal pigmentation and endocrine hyperfunction [11]. Diagnosis is typically based on the patient's medical history, the location

of the lesion, physical signs, and imaging studies. FDB needs to be differentiated from other benign and malignant rib tumors, such as fibromas, chondromas, neurofibromas, enchondromas, eosinophilic granulomas, metastatic cancers, giant cell tumors, and osteosarcomas. The primary treatment for rib tumors is surgical resection. Wide excision with above 2 cm margin distance should be attempted to obtain R0 resection margin for chest wall tumor unless the tumor involves vital organs or structures, including the great vessels, heart, trachea, joints, and spine [12]. Surgical treatment for confirmed primary malignant rib tumors involves wide tumor resection. If malignancy is not confirmed, surgery should still include wide resection with tumor-free margins to maximize the chance of cure for both benign and malignant lesions [8]. During the entire preoperative assessment, we believed that the tumor involved a significant area, raising suspicions of osteolytic behavior. Additionally, due to the ambiguous results from the intraoperative frozen section, we could not exclude malignancy. Therefore, we aimed to remove the adjacent bone tissue as much as possible, excising an area approximately 5 cm beyond the tumor, effectively removing nearly the entire 7th rib. After rib resection, care should be taken to monitor for complications such as chest wall softening and paradoxical breathing. In this case, we applied local pressure bandaging after surgery. Six months postoperatively, the patient did not experience chest wall softening or other complications.

CT 3D reconstruction and AI recognition technologies played essential roles in the diagnosis and treatment. The 3D reconstruction provided detailed visualization of the ribs and adjacent structures, enabling accurate evaluation of the tumor's size, location, and morphology. This facilitated precise surgical planning, minimized injury to surrounding tissues, and supported postoperative assessment and follow-up. This is consistent with the findings of Shah et al. [13] and Yu et al. [14], both indicating that CT 3D reconstruction significantly enhances the accuracy of surgical planning and postoperative monitoring. Meanwhile, AI recognition technology utilized deep learning algorithms to automatically analyze CT images, rapidly identify tumors, and improve diagnostic efficiency, particularly in complex anatomical regions like the ribs, significantly reducing the risk of missed diagnoses and supporting the physician's diagnostic and treatment decisions. Blum et al. [15] also demonstrate that AI recognition improves the efficiency and accuracy of medical imaging diagnostics. Although AI recognition technology played an important role in diagnosis, pathological examination remains the definitive standard for confirming the malignancy or benignity of the tumor, highlighting the complementary relationship between CT, AI technology, and traditional diagnostic methods. Overall, the combination of CT 3D reconstruction and AI recognition technology not only optimized the diagnostic and surgical process for this case but also significantly improved patient outcomes, aligning closely with existing research and providing valuable references for future clinical applications in similar cases. We believe that preoperative CT examination combined with AI technology offers several advantages. AI can rapidly process and analyze imaging data, significantly improving diagnostic efficiency compared to traditional manual diagnosis, especially in urgent clinical situations. While imaging alone cannot definitively determine the nature of a tumor and requires

further pathological confirmation, AI technology can provide clinicians with a more accurate preliminary diagnosis, allowing for the development of proactive surgical plans. In this case, based on the preoperative CT examination, we considered the lesion to possibly be a fibrous structural abnormality, which led to the preparation of an appropriate surgical plan. Additionally, when combined with 3D reconstruction, AI technology enables more precise identification of the tumor's location and shape, aiding in more accurate tumor resection and reducing the risk of intraoperative damage. This technology has already been applied in complex surgeries such as lung segment resection, further enhancing the safety and effectiveness of these procedures. Overall, AI technology proves to be a valuable tool in preoperative diagnosis and planning, ultimately improving patient treatment outcomes.

3.1. Highlight Points

The application of CT 3D reconstruction and AI recognition technology improves the accuracy of preoperative diagnosis and assists in surgical planning for rib tumors by providing detailed imaging and aiding in clinical decision-making, ultimately enhancing patient outcomes and reducing the risk of misdiagnosis.

3.2. Recommendations

3.2.1. Integration of Advanced Imaging Technologies

It is recommended that medical institutions continue to adopt and integrate CT 3D reconstruction and AI recognition technologies into their diagnostic protocols for rib tumors and other thoracic conditions. Training radiologists and surgeons in the use of these technologies can enhance diagnostic accuracy and improve surgical outcomes.

3.2.2. Multidisciplinary Collaboration

Establishing a multidisciplinary team approach involving radiologists, oncologists, and surgeons can optimize patient management. Collaborative discussions on imaging findings and treatment strategies will facilitate more comprehensive care for patients with rib tumors.

3.2.3. Further Research and Development

Future research should focus on large-scale studies to evaluate the efficacy of CT 3D reconstruction and AI technologies in various types of rib and thoracic tumors. Exploring these technologies' roles in predicting treatment outcomes and recurrence rates can provide deeper insights into their clinical benefits.

3.2.4. Pathological Confirmation

Emphasizing the importance of pathological examination as the gold standard for diagnosing tumors remains critical. While imaging technologies enhance diagnostic processes, integrating pathology results is essential for accurate tumor characterization.

3.2.5. Patient Education

Educating patients about the diagnostic process and the roles of advanced imaging technologies can improve their understanding and engagement in their treatment plans. Providing clear information about what to expect during imaging and surgery can alleviate patient anxiety.

4. Conclusion

This study emphasizes the important roles of CT 3D reconstruction and AI recognition technology in the diagnosis and management of rib fibrous dysplasia. The combination of these advanced imaging techniques significantly improves the accuracy of tumor characterization, aiding in precise surgical planning and reducing the risk of complications. The case of a 23-year-old male patient demonstrates the role of CT imaging in tumor identification, while AI technology accelerates the diagnostic process and enhances clinical decision-making efficiency. These findings are consistent with prior research, which highlights the benefits of using 3D imaging and AI in evaluating complex thoracic diseases. Overall, the integration of CT 3D reconstruction and AI recognition technologies not only optimizes patient management strategies for rib tumors but also provides a framework for future research to explore their applications across various thoracic diseases. Continued investigation into these technologies will be crucial for improving diagnostic practices and enhancing clinical outcomes.

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Statement of Ethics

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with the Helsinki Declaration (as revised in 2013).

Patient Informed Consent Statement

Written informed consent was obtained from the patient for publication of this article and accompanying images.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Author Contribution

1. Conception and design: Sheng Zhengzuo and Ding Ruiheng.
2. Administrative support: Sheng Zhengzuo and Ding Ruiheng.
3. Provision of study materials or patients: Sheng Zhengzuo and Ding Ruiheng.
4. Collection and assembly of data: Sheng Zhengzuo, Ding Ruiheng, Liu Yushan, Chen Su, Jinghua Fan, and Siyu Chen.
5. Data analysis and interpretation: Sheng Zhengzuo and Ding Ruiheng.
6. Manuscript writing: All authors.
7. Final approval of manuscript: All authors.

Data Sharing Statement

All relevant data are within the manuscript and its additional files. Further enquiries can be directed to the corresponding author.

Artificial Intelligence (AI) Disclosure Statement

During the preparation of this work the authors used Artificial Intelligence to analyze the CT. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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