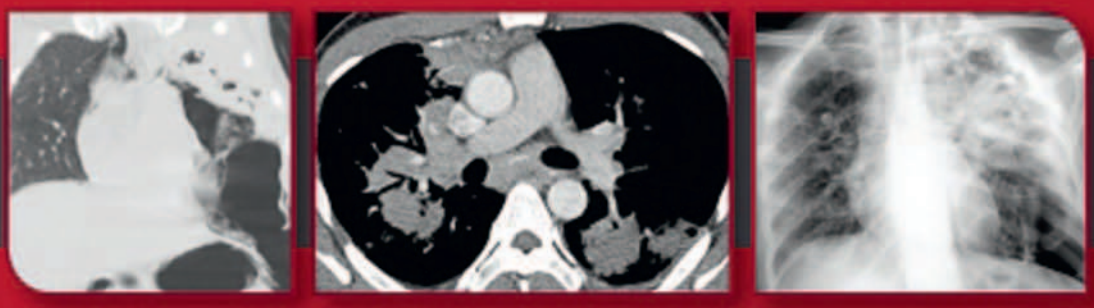
James C. Reed



CHEST RADIOLOGY

Patterns and Differential Diagnoses

Seventh Edition

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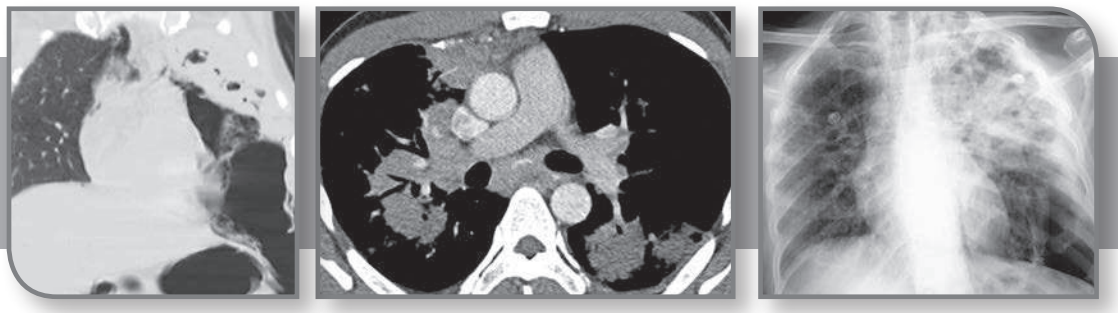

CHEST RADIOLOGY

Patterns and Differential Diagnoses

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Thank you to my wife, Sharon,
for the support and encouragement that have made it possible
for this text to reach a seventh edition.

This edition is dedicated to our grandchildren:
Samantha, Hailey, Zachary, James III, Morgan, Connor, Madeline, and Andrew

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PREFACE

Chest radiology is sometimes considered to be the static part of a radiology practice, but chest radiology has shared the benefits of the imaging revolution. The chest x-ray contains a lot of information that is compressed into one or two images compared with several hundred images in a complete chest computed tomography (CT) examination with axial, coronal, and sagittal images. Chest CT provides a better understanding of chest disease and has become an important part of chest radiology. CT has added new descriptive patterns to our lexicon, including ground glass opacities, ground glass nodules, mosaic perfusion, and crazy paving. Special CT protocols such as high-resolution CT and CT angiography have given us the ability to make more specific diagnoses. The impact of magnetic resonance imaging and ultrasound are more limited because of the air in the lungs, but they also have important thoracic applications.

Continued medical progress and our collaborations with colleagues in medicine, surgery, and pathology have enhanced our understanding of chest diseases. By combining our new understanding of tumor biology with technical advancements, new imaging strategies such as low-dose CT screening for lung cancer have been developed.

Over the course of seven editions of this text there have been many changes in chest radiology, but a patient with chest symptoms still almost always has a chest x-ray as a first examination. Evaluation of the chest x-ray continues to require accurate perception of the abnormalities, recognition of the basic patterns, and development of a working differential diagnosis.

James C. Reed, MD

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James C. Reed, MD

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PART 3 Hyperlucent Abnormalities

PART 1

Chest Wall, Pleura, and Mediastinum

1 INTRODUCTION

The simplicity of performing a chest radiograph often leads to the mistaken impression that interpretation should also be a simple task. Despite the fact that the chest radiograph was one of the first radiologic procedures available to the physician, the problems of interpreting chest radiographs continue to be perplexing as well as challenging. The volume of literature on the subject indicates the magnitude of the problem and documents the many advances that have been made in this subspecialty of radiology. A casual review of the literature quickly reveals the frustrations a radiologist encounters in evaluating the numerous patterns of chest disease. There are as many efforts to define the patterns identified on chest radiographs as there are critics of the pattern approach. Because radiologists basically view the shadows of gross pathology, it is not surprising that the patterns are frequently nonspecific and that those who expect to find a one-to-one histologic correlation of the radiographic appearances with the microscopic diagnosis will be frustrated. It is much more important to develop an understanding of gross pathology to predict which patterns are likely in a given pulmonary disease. With this type of understanding of pulmonary diseases, we are better qualified to use nonspecific patterns in developing a differential diagnosis and planning the procedures required to make a definitive diagnosis.

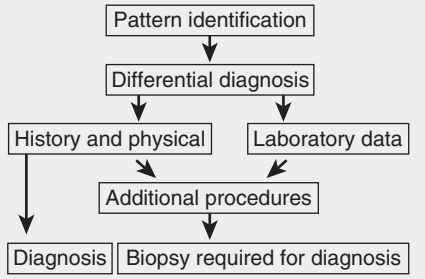
Colonel William LeRoy Thompson of the Armed Forces Institute of Pathology first developed the concept of differential diagnosis based on radiologic findings. Later, Reeder and Felson amplified and popularized the approach in their book *Gamuts in Radiology* by providing an extensive list of the various patterns and the corresponding differential diagnoses.[467]

This manual illustrates the common patterns of chest disease to facilitate recognition. After recognition, the second step in evaluating a pattern is to develop an appropriate differential diagnosis. The complete differential diagnosis must include all of the major categories of disease (Chart 1.1) that might lead to the identified pattern. Next, the differential must be significantly narrowed by (1) careful analysis of the image for additional radiologic findings, (2) consideration of the evolving patterns of the disease by review of serial examinations, and (3) correlation of patterns with clinical and

Chart 1.1 CATEGORIES OF DISEASES

I. Congenital/developmental
II. Inflammatory
III. Neoplastic
IV. Traumatic
V. Vascular
    A. Thromboembolic
    B. Cardiovascular
    C. Collagen-vascular
VI. Iatrogenic
VII. Idiopathic

Chart 1.2 ALGORITHMIC APPLICATION OF CHEST PATTERNS



laboratory data (Chart 1.2). With this narrowed differential, we will be able to function as consultants, suggesting further procedures that may lead to a precise diagnosis. These procedures vary from simple radiographic examinations, such as those taken with the patient in oblique positions, to percutaneous biopsy under fluoroscopic, computed tomography (CT), or ultrasound guidance.

A radiologist should have a thorough understanding of the radiologic differential diagnosis to determine appropriate procedures for investigating diseases of the chest. It should be obvious that the first step in evaluating many abnormalities identified on the standard posterior-anterior (PA) and lateral chest radiograph is to confirm that the abnormality is real. A newcomer to radiology frequently forgets the value of simple techniques such as reviewing examinations taken in oblique positions, PA chest radiographs with nipple markers, fluoroscopy, full chest lordotic views, and, most important, old exams. These simple procedures should be used to confirm the presence of an abnormality before considering more complicated procedures such as radionuclide scanning, arteriography, CT scanning, magnetic resonance imaging (MRI), or biopsy. In fact, the latter procedures are special procedures that should be undertaken to answer specific questions.

After deciding that an observation is a true abnormality, one of the most important radiologic decisions to be made is to localize the abnormality. Localization to soft tissues, chest wall, pleura, diaphragm, mediastinum, hilum, peripheral vessels, or the lung parenchyma is absolutely necessary before a logical differential diagnosis can be developed. Once the suspected abnormality is localized to a specific anatomic site, it is necessary to classify or describe the pattern. Some of the patterns of parenchymal lung disease considered in this text are nodules, masses, diffuse opacities, cavities, calcifications, and atelectasis. If the pattern is nonspecific, a moderately long differential must be offered. As mentioned earlier, one of the objectives of this manual is to further refine pattern analysis and develop methods of improving diagnostic specificity. For example, in the analysis of parenchymal lung disease, assessment of the distribution—deciding whether the process is localized or diffuse, peripheral or central, in the upper vs. lower lobes, or alveolar vs. interstitial—is extremely helpful. In correlating these features, we are able to eliminate a number of possible diagnoses from initial consideration. Once the differential has been narrowed on the basis of identification of the disease pattern and distribution, examination of old exams is valuable. Unfortunately, a common mistake is oversight of the very dynamic changes in the patterns of chest disease. A typical case history may be as follows:

This is the first admission for this patient, and therefore the first chest radiograph examination. The knowledge that a solitary nodule was present on an exam taken 2 years earlier at another hospital, or even 5 or 10 years earlier at still other hospitals, could completely resolve the problem of how to manage the patient.

It is not always necessary to make a precise diagnosis, particularly in a case such as the one just described. The diagnosis of a healed granuloma, whether secondary to tuberculosis or histoplasmosis, is almost always adequate for the clinical management of the patient. Without old exams, the solitary nodule is a frustrating problem because the differential is long and, more importantly, cancer cannot be ruled out, whereas with a prior comparison exam, the diagnosis may be obvious.[469]

Careful clinical correlation is also important in understanding the evolution of a pulmonary disease. For example, in evaluating a patient with a solitary pleural-based nodule on admission, a history of pleuritic chest pains 6 weeks earlier drastically changes the probable diagnosis. An additional history of thrombophlebitis and multiple episodes of pleuritic chest pain makes the diagnosis of pulmonary embolism with a resolving infarct almost certain.[637]

It is hoped that the 23 problems in differential diagnosis that follow this introductory chapter will be instructive as to how the radiologist can interpret the pattern on a single chest radiograph, consider a moderately long differential diagnosis, narrow the differential diagnosis to a shortlist of most likely possibilities, and make recommendations for further procedures, leading to a definitive diagnosis.

2 CHEST WALL LESIONS

Fig. 2.1

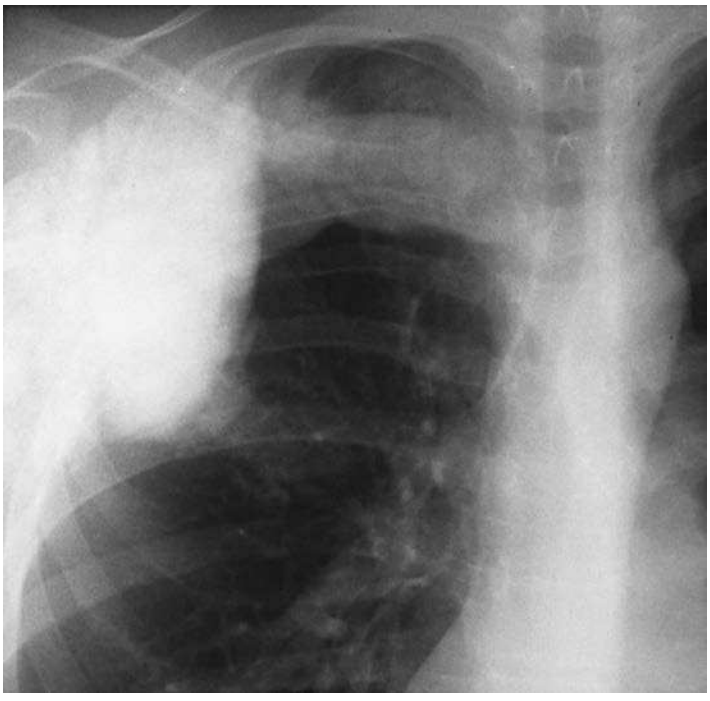


Fig. 2.2

QUESTIONS

1. The most likely diagnosis in the afebrile patient in Fig. 2.1 is:
   a. Neurofibroma.
   b. Lipoma.
   c. Multiple myeloma.
   d. Osteosarcoma.
   e. Chondrosarcoma.

2. The most likely diagnosis in Fig. 2.2 is:
   a. Ewing sarcoma.
   b. Osteosarcoma.
   c. Chondrosarcoma.
   d. Metastatic lung cancer.
   e. Plasmacytoma.

***Mark the following questions* True *or* False:**

3. _____ Chest wall lesions may sometimes be distinguished from pulmonary nodules by identification of an incomplete border.

4. _____ Lipoma is a common chest wall lesion.

5. _____ Neurofibroma of an intercostal nerve will probably cause rib destruction.

6. _____ Rib detail views or computed tomography (CT) scans are rarely needed to identify the rib destruction of a primary bone tumor in the chest wall.

7. _____ Metastases and multiple myeloma are among the most common causes of a chest wall mass with associated rib destruction in an adult.

8. _____ Ewing tumor and neuroblastoma should be considered when a chest wall mass is observed in a child or young adult.

Chart 2.1 PATTERN: CHEST WALL LESIONS

I. Nipples,[387] supernumerary nipples[206]
II. Artifact
III. Skin lesions (e.g., moles, neurofibromas, extrathoracic musculature)[88]
IV. Mesenchymal tumors (muscle tumors, fibromas, lipomas,[137] liposarcoma,[63] desmoid tumor,[109] synovial sarcoma[191])
V. Neural tumors (schwannoma,[459] neurofibroma, ganglioneuroma, neuroblastoma[580])
VI. Hodgkin and non-Hodgkin lymphoma[438]
VII. Vascular tumors (angiosarcoma, glomus tumor, hemangioma, Kaposi sarcoma)[63,352,579,580]
VIII. Benign bone tumors (fibrous dysplasia, osteochondroma, giant cell tumor, aneurysmal bone cyst, fibroma, chondromyxoid fibroma)[579]
IX. Malignant bone tumors (metastases,[325] multiple myeloma, plasmacytoma [solitary myeloma])[580]
X. Ewing sarcoma, chondrosarcoma,[419] osteosarcoma,[191] fibrosarcoma, malignant undifferentiated pleomorphic sarcoma
XI. Hematoma
XII. Rib fractures
XIII. Infection (actinomycosis,[618] aspergillosis,[14] nocardiosis, blastomycosis, tuberculosis, empyema necessitans, osteomyelitis [rare])[210]
XIV. Thoracopulmonary small cell (Askin) tumor[157]
XV. Invasion by contiguous mass (lung cancer)[167,313]
XVI. Lymphangioma (cystic hygroma)

Discussion

Chest wall lesions (Chart 2.1) may arise from both extrathoracic and intrathoracic locations as well as normal and abnormal structures. Common extrathoracic causes of radiographically visible opacities include nipples, moles, and various cutaneous lesions (e.g., neurofibromas of von Recklinghausen disease).[155,535] Extrathoracic chest wall opacities are seen as soft-tissue opacities with an incomplete, sharp border (Fig. 2.3). The border is produced by the interface of the mass with air and is lost where the mass is continuous with the soft tissues of the chest wall. Cutaneous lesions should not have the tapered borders that are seen in Fig. 2.1. The tapered border indicates displacement of the pleura inward by the mass and has been described as an extrapleural sign.[151] Physical examination is also essential in the evaluation of cutaneous lesions. Nipple shadows may be easily identified when they are symmetric and when their borders are incomplete, but caution is warranted.[387] Repeat examination with small, lead nipple markers should be performed if there is any possibility of confusing a nipple shadow with a pulmonary nodule.

Intrathoracic chest wall lesions are radiologically visible because of their interface with aerated lung. Like the cutaneous lesions, their borders are incomplete where they are contiguous with the chest wall.[132] Thus the incomplete border is helpful in distinguishing chest wall lesions from pulmonary lesions (answer to question 3 is *True*), but not in distinguishing cutaneous from intrathoracic chest wall lesions. The tapered superior and inferior borders, however, are valuable signs for confirming an intrathoracic extrapulmonary location. Unfortunately, the tapered border may not be observed if the lesion is seen *en face*; in fact, the lesion may not be visible. Lateral and oblique cone-down views are frequently helpful in eliciting this sign.

Lipomas are common chest wall lesions[313] and may be seen as either subcutaneous or intrathoracic masses (Fig. 2.4, *A*). (Answer to question 4 is *True*.) They may even grow between the ribs, presenting as both intrathoracic and subcutaneous masses.

Fig. 2.3 This large, left mass has a sharp lateral border because it is outlined by air, but has no medial border illustrating the incomplete border sign. The mass is obviously outside of the rib cage and easily identified as a chest wall mass. Physical examination revealed this to be a soft, pliable mass in this neonate, making lymphangioma the most likely diagnosis.

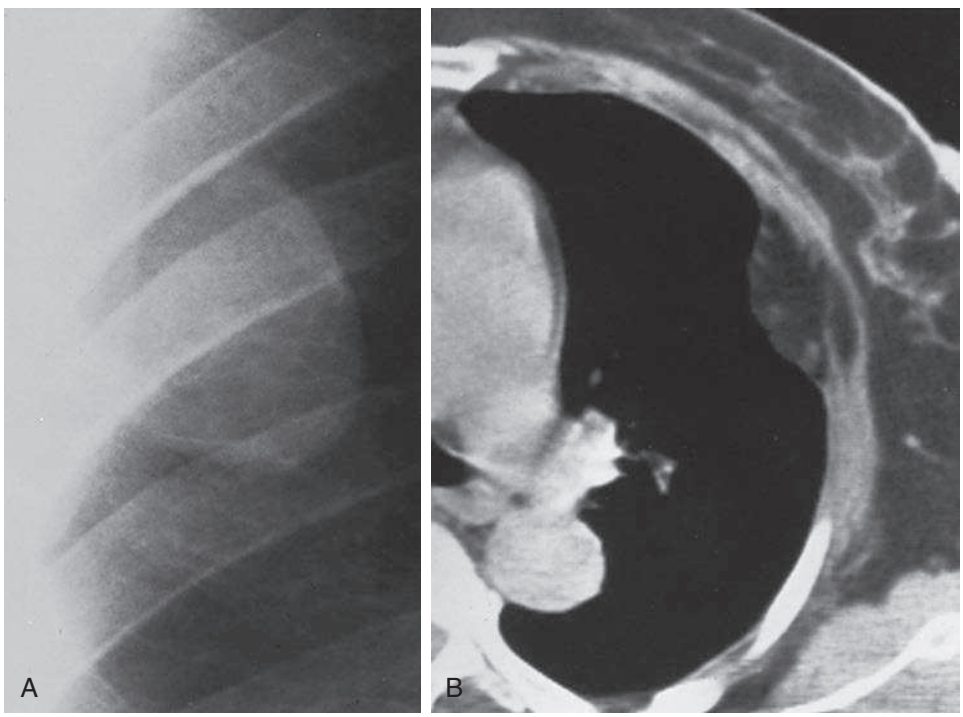


Fig. 2.4 **A,** Chest wall lipoma appears to be of tissue opacity, in contrast to aerated lung. Location of lipoma against the lateral chest wall and its incomplete border (sharp medial but absent lateral border) suggest that it is nonpulmonary. There is no rib destruction to confirm chest wall origin. Both chest wall and pleural masses should be considered in differential. **B,** Computed tomography scan of another patient with a chest wall lipoma shows a mass that is of greater opacity than the aerated lung but less opaque than the musculature of the chest wall. This intermediate fat attenuation mass is shown to extend through chest wall muscles. (Case courtesy of Thomas L. Pope, Jr., M.D.)

Fig. 2.5 This elongated tapered mass in the right costophrenic angle has invaded and destroyed a portion of the adjacent rib, which confirms chest wall involvement. These observations narrow the differential to metastasis vs. multiple myeloma or plasmacytoma. The patient's history of renal cell carcinoma confirms the diagnosis of metastasis.

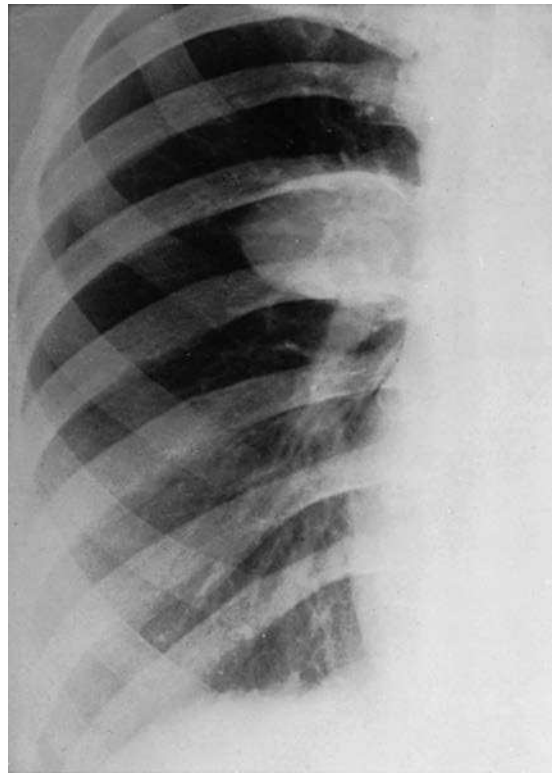


Fig. 2.6 Schwannoma has not destroyed the rib but has eroded its inferior cortex. Note sclerotic border, which virtually ensures the benign nature of the lesion.

Physical examination reveals a soft, movable mass when there is a significant subcutaneous component. CT should show the extent of the mass and, more importantly, confirm that the lesion is of fat attenuation[137] (Fig. 2.4, *B*).

Rib destruction is a key observation in Fig. 2.5.[151] This finding excludes lipoma and other benign tumors, such as neurofibroma, from the diagnosis. Benign neural tumors, such as schwannoma and neurofibroma, may erode ribs inferiorly and even produce a sclerotic reaction (Fig. 2.6). Multiple chest wall masses in combination with rib deformities and inferior rib erosions should suggest neurofibromatosis (Figs. 2.7, *A-C*). Neural tumors should not destroy the rib, as shown in Fig. 2.6. (Answer to question 5 is *False*.) Rib destruction is not always obvious on a frontal examination and may be better visualized with rib detail views or CT scan. (Answer to question 6 is *False*.)

Metastases and small, round cell tumors are the most common tumors to produce the pattern of rib destruction seen in Figs. 2.1 and 2.5. The most common primary tumors to metastasize to the chest wall are lung, breast, and renal cell, but knowledge of a primary tumor is essential because any tumor that spreads by hematogenous dissemination may produce a chest wall lesion. Multiple myeloma, plasmacytoma (solitary myeloma), and Ewing tumors are primary round cell tumors that may arise in the bones of the chest wall. The differential diagnosis in the adult patient with a chest wall mass and bone destruction is most often metastasis vs. multiple myeloma. (Answer to question 7 is *True*.) In a child, however, the pattern is more suggestive of metastatic neuroblastoma or Ewing tumor. (Answer to question 8 is *True*.) Fig. 2.1 shows a typical

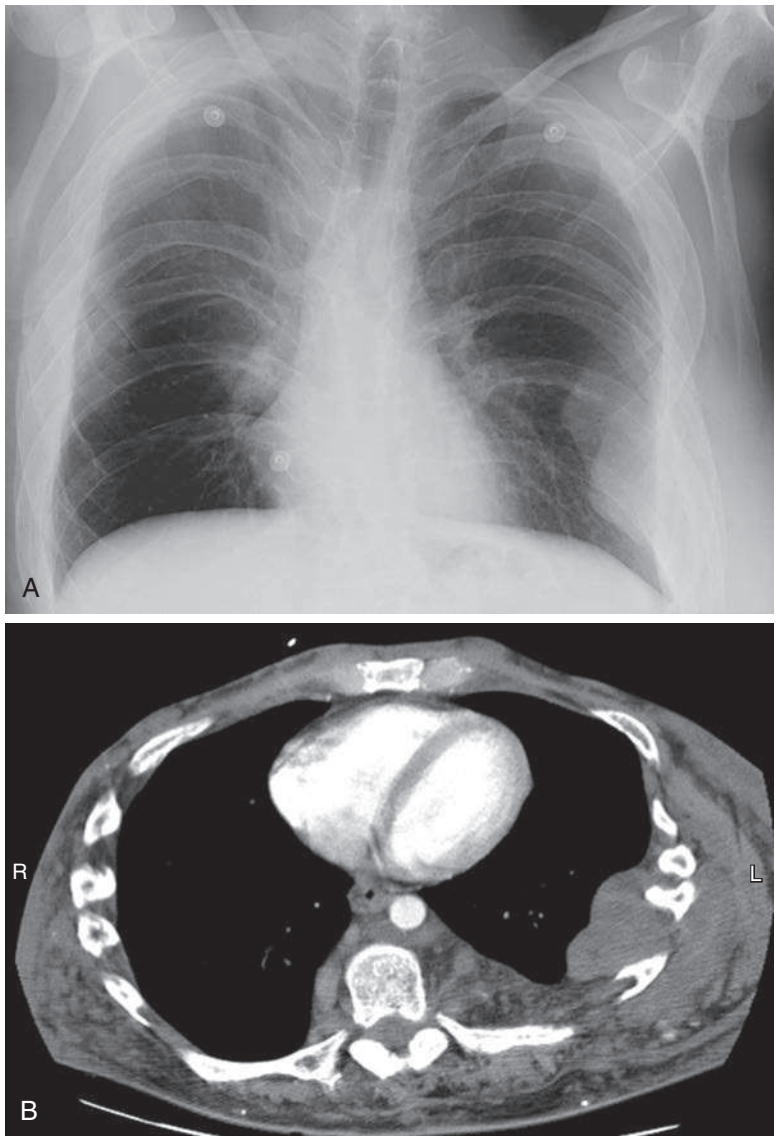


Fig. 2.7 **A,** This patient with neurofibromatosis has bilateral, elongated, tapered, smooth, peripheral masses, and multiple ribs are inferiorly eroded. **B,** Computed tomography confirms the peripheral masses with extension of the left lateral mass through the chest wall. The posterior extension of the mass was not suspected from the radiograph.

example of multiple myeloma (answer to question 1 is *c*), but there are a number of common variations. Myeloma (Figs. 2.8, *A-C*) may occur with complete loss of a rib, large expanded ribs, or only a small, ill-defined area of bone destruction. The patient may even present with a pathologic fracture of the involved rib. Occasionally, the soft-tissue mass may be rather large and the bone lesion minimal. Lymphoma is another tumor that may infrequently produce a peripheral soft-tissue mass with incomplete or tapered borders and extend through the chest wall.[438] This indicates an advanced stage of lymphoma and is not an expected abnormality at the time of presentation. The chest wall extension may not be seen on the chest radiograph, but it can be confirmed with a CT scan (Figs. 2.9, *A* and *B*). Extrathoracic subcutaneous metastases are more likely to be detected by physical exam than on the chest radiograph. Subcutaneous metastases are often best shown by CT (Fig. 2.10)

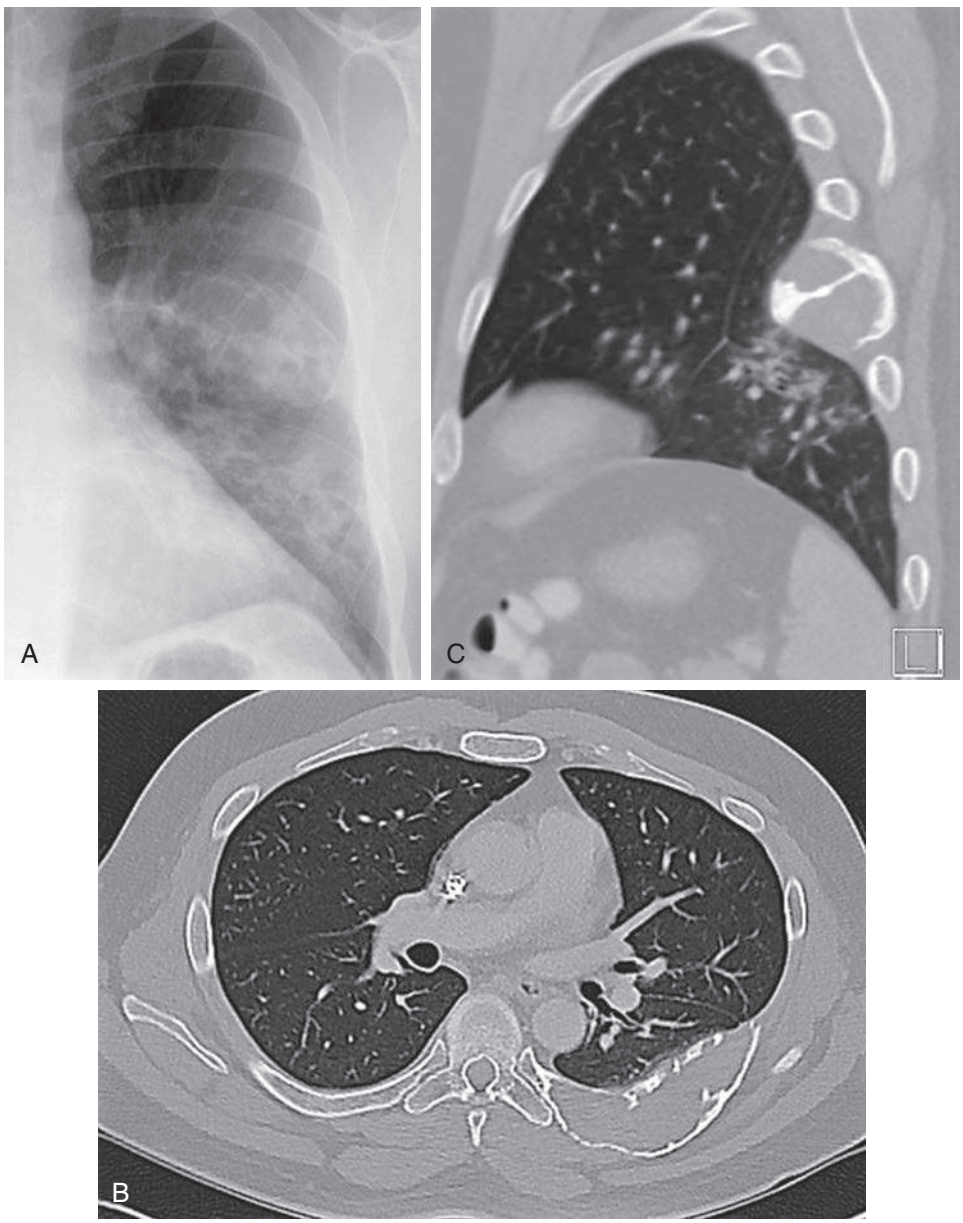


Fig. 2.8 **A,** PA chest radiograph shows a large elongated mass with expansile destruction of a posterior rib. **B,** Axial computed tomography confirms the large mass with expanded rib cortex. **C,** Sagittal reconstruction shows destruction of the anterior rib cortex and a large soft-tissue mass with tapered superior and inferior borders. These findings could result from metastasis, but this is another case of multiple myeloma.