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Ultrasound in Emergency Medicine

TWO CASES WHERE BEDSIDE ULTRASOUND WAS ABLE TO DISTINGUISH PULMONARY BLEB FROM PNEUMOTHORAX

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□ **Abstract—Distinguishing large pulmonary bullae from an acute pneumothorax can present a diagnostic challenge in the emergency setting. Plain film radiography of the chest may be inadequate to make the diagnosis. As the management of these two entities varies significantly, a clinical adjunct to aid diagnosis would prove useful. Using emergency department bedside ultrasound, we identified the typical 'comet tailing' phenomenon of the movement of the lung tissue against the pleura during respiration, present in bullous disease but absent if the lung has collapsed. We present two patients, one with bullous emphysema and another with pneumothorax, in whom bedside ultrasound aided in making the diagnosis.** © 2005 Elsevier Inc.

Keywords—ultrasound; bullous emphysema; pneumothorax; pleura

INTRODUCTION

Emphysematous disease of the lungs and its complications account for a significant number of visits to emergency departments in the United States each year (1). An important component of chronic obstructive pulmonary disease, emphysema refers to the abnormal and permanent enlargement of air spaces distal to the terminal bronchial, characterized by hyperinflation and destruction of the alveolar walls. Pulmonary blebs result from the rupture of alveolar air into the interstitium with dissection into the visceral pleura. In late stages, bullae, air-filled, thin-walled spaces greater than 1 centimeter in diameter, may form in the subpleural space, commonly at the apices of the lung. Giant bullae, those that encompass more than one-third of the lung volume, are uncommon but can lead to compression of adjacent normal lung tissue. Hyperinflation, blebs and bullae are commonly visible on chest X-ray studies, with bullae demonstrating areas of absent lung markings and fine wall septation. Progressive dyspnea with decreased exercise tolerance will prompt visits to a primary care physician or to the Emergency Department (ED). A pneumothorax is a collection of air in the pleural space with subsequent collapse of the lung. There are several etiologies of pneumothorax, with spontaneous pneumothorax being the most common. Sudden onset of mild to moderate dyspnea, pleuritic chest pain, cough and anxiety may characterize the presenting symptoms. Chest X-ray studies will classically demonstrate a white linear density (pleura) outlining a distinct area of black pleural space where lung markings are absent. A large pneumothorax will create a convex deformity of the lung tissue that has separated from the pleural interface at the apex. It can be difficult to differentiate bullous emphysema from an acute pneumothorax by chest X-ray studies alone, especially when both entities co-exist. Adding to this difficulty is the fact that most patients who develop a spontaneous pneumothorax will have bullous disease

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identified on computed tomography (CT) scan of the thorax (2). Both pathologies create alterations of normal lung architecture and areas of absent lung markings. A small pneumothorax may not demonstrate the typical convex deformity of lung tissue classically identified on X-ray. Bullae and blebs may rupture spontaneously, creating a pneumothorax in addition to destruction of the normal lung architecture. Contrast-enhanced computed tomography of the thorax has been shown to be useful in distinguishing bullous disease from pneumothorax. The emergency management of these entities varies considerably. Rapid and accurate diagnosis of bullous emphysema vs. pneumothorax would assist in treatment and disposition of patients. The utility of ultrasound in the diagnosis of pleural diseases has been previously described. We present two cases where bedside ultrasound in the ED aided in the diagnosis of bullous disease versus pneumothorax.

CASE REPORTS

Case 1

A 50-year-old man presented to the ED with his daughter, who reported that her father had had shortness of breath, chronic cough and worsening exercise tolerance over the past 2 years. In the past 6 months, the patient had lost nearly 50 pounds and his breathing had worsened to the point of near inactivity at home with dyspnea on exertion from the mere effort of getting out of bed. The patient had resisted seeking medical care and had not seen a health care provider in more than 20 years. The patient reported a greater than 60-pack year history of tobacco use. He denied sputum production, hemoptysis, night sweats, and fever, chills or chest pain. The remainder of the review of symptoms was non-contributory. The patient denied past medical problems, hospitalizations or surgery. He takes acetaminophen for occasional headache. He reported no allergies. He denied alcohol or substance abuse. Physical examination revealed a thin, sallow-appearing male, alert and oriented, speaking in full sentences. Vital signs were: blood pressure of 128/85 mm Hg, pulse 112 beats/min at rest, respiratory rate 28 breaths/min, temperature 35.6°C (96.2°F), and pulse oximetry 95% on room air The chest examination results were: non-traumatic and symmetrical with accessory muscle use noted. The lung examination revealed shallow, rapid respirations with decreased breath sounds in the right upper lobes and poor airflow throughout. No rales were noted. The cardiac examination revealed a rapid rate, but no murmurs or rubs. Peak flow measurements after three handheld nebulizer treatments with Albuterol and Atrovent* was 160. An electrocardiogram (EKG) showed a normal sinus rhythm of 90 beats/min with a normal axis and without evidence of acute ischemia. The chest X-ray study (Figure 1a and 1b) showed large, occasionally septated spaces without lung markings, occupying the entire right upper lobe, consistent with giant bullous emphysema. Blebs were also noted in the left upper lobe. The costophrenic angles were blunted bilaterally. The mediastinal structures were shifted to-

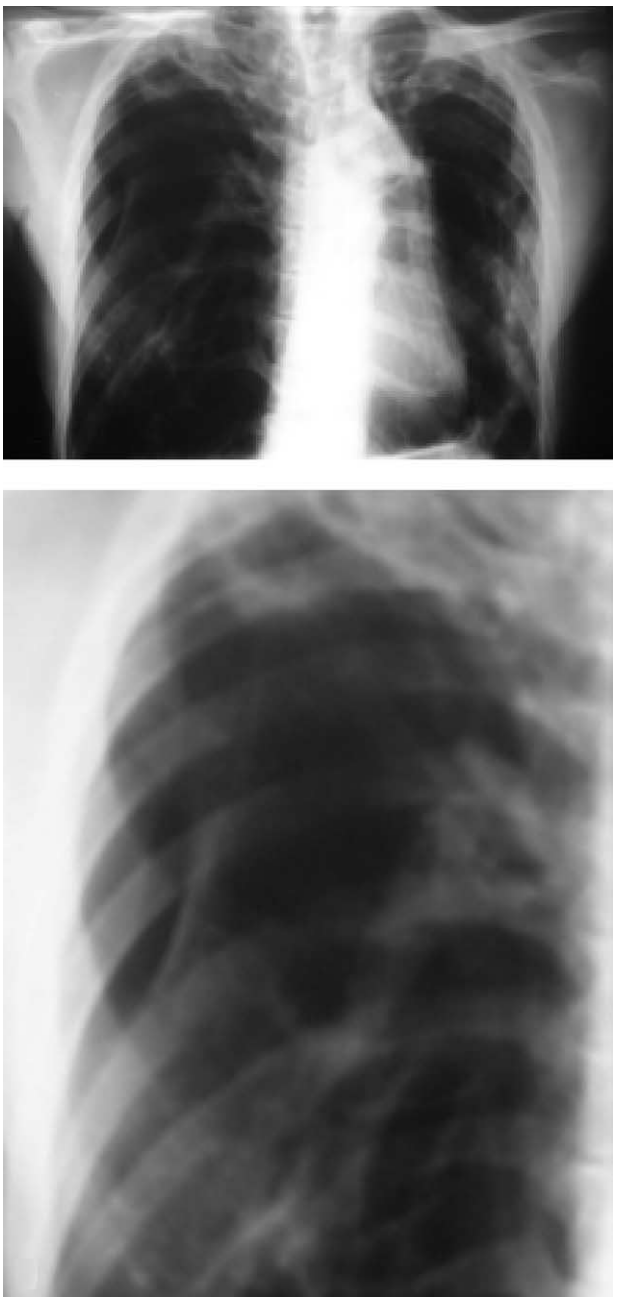

Figure 1. (a,b) Chest X-ray with large, occasionally septated spaces without lung markings, occupying the entire right upper lobe, consistent with giant bullous emphysema. Blebs were also noted in the left upper lobe. The costophrenic angles are blunted bilaterally. The mediastinal structures are shifted towards the left.

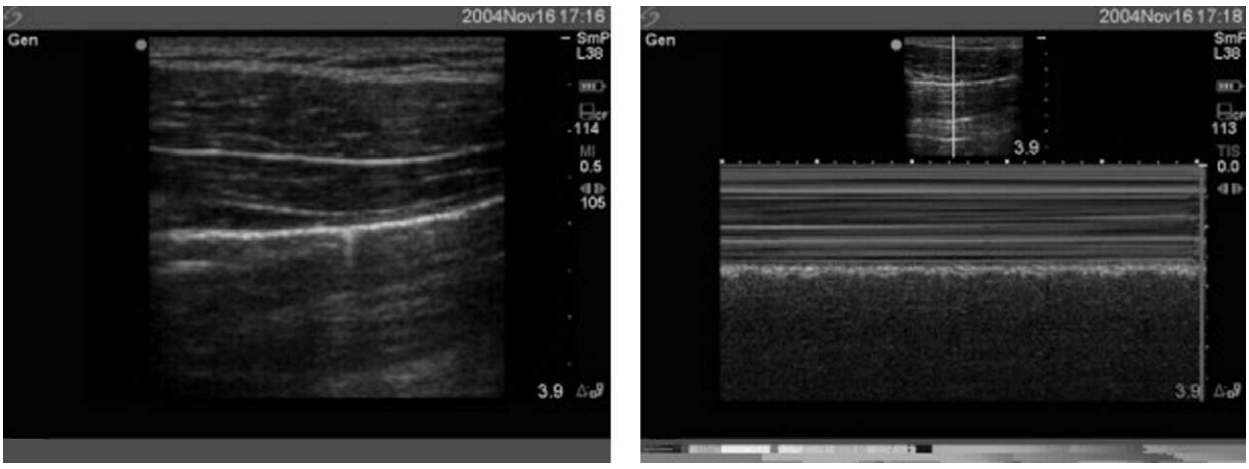

Figure 2. (a) Standard 2D ultrasound image: bedside ultrasound demonstrating the 'comet tailing' phenomenon and the 'sliding sign' (see video) consistent with the ultrasound findings described when *no* pneumothorax is present. (b) M mode ultrasound: (motion is demonstrated by granularity, lack of motion appears as a series of horizontal lines). Below the pleural line there is homogenous granularity typical of normal lung and pleura (no pneumothorax).

wards the left (Figure 1). A bedside ultrasound examination (Figure 2a and 2b) was performed that revealed the 'comet tailing' phenomenon and the 'sliding sign' consistent with the ultrasound findings described when *no* pneumothorax is present. This finding supported the diagnosis of giant emphysematous bullae without pneumothorax.

Case 2

A 37-year-old man, treated for pneumonia 2 weeks prior, presented with acute onset of shortness of breath that began earlier in the day. The patient stated he had been improving until today. He reported intermittent chest pain with the shortness of breath for 1 day. He was taking no medicines. He reported an allergy to sulfa drugs and penicillin, with an unknown reaction. His past medical history included completed treatment for tuberculosis and a history of a spontaneous pneumothorax 1 year ago. He had a 10-pack year history of tobacco use but reported quitting 1 year prior. The remainder of the history and review of systems was non-contributory. Physical examination revealed a tachypneic, pale, ill-appearing man, speaking in two- to three-word sentences. Vital signs were: blood pressure of 141/97 mm Hg, pulse rate of 144 beats/min, respiratory rate of 28 breaths/min, temperature of 37.5°C (99.6°F). Pulse oximetry on room air was 90%. The lung examination revealed decreased breath sounds on the right side. Cardiac examination revealed tachycardia without murmurs or rubs. The remainder of the physical examination was unremarkable. Intravenous access was obtained; blood drawn and handheld nebulizer treatments of Albuterol and Atrovent were given. The patient received morphine sulfate i.v. for pain control, solumedrol 125 mg i.v., Cefuroxime 1.5 g, and Doxycycline 100 mg i.v. An EKG revealed a sinus tachycardia at 130 beats per minute, right axis deviation but no evidence of acute ischemia. The chest X-ray study (Figure 3a and 3b) showed hyperinflation with decreased lung markings throughout, but most dramatically on the right. However, no clearly identifiable pleural line was visible. A bedside ultrasound examination (Figure 4a and 4b) was performed that failed to reveal the typical 'comet tailing' and 'sliding' phenomenon described above, suggesting that the lung tissue was separated from the pleura. This supported the diagnosis of pneumothorax in this patient.

DISCUSSION

Difficulty distinguishing between pneumothorax and bullous disease is common. Experienced radiologists can struggle differentiating the two entities. Avascular bullae or thin-walled cysts can easily be mistaken for a pneumothorax. The pleural line caused by a pneumothorax usually is bowed at the center toward the lateral chest wall. Unlike in pneumothorax, the inner margins of bullae or cysts usually are concave rather than convex and do not conform exactly to the contours of the costophrenic sulcus. Adding to the difficulty and complexity, pneumothorax associated with pleural adhesions also may simulate bullae or lung cysts (3).

When plain films cannot clearly provide the answer, CT scan of the chest is recommended. However, even CT scan, arguably the best tool available, may be unable to clearly distinguish between the two entities. Additionally, in the ED where patients may be in extremis and need a treatment decision made rapidly, time and insta-

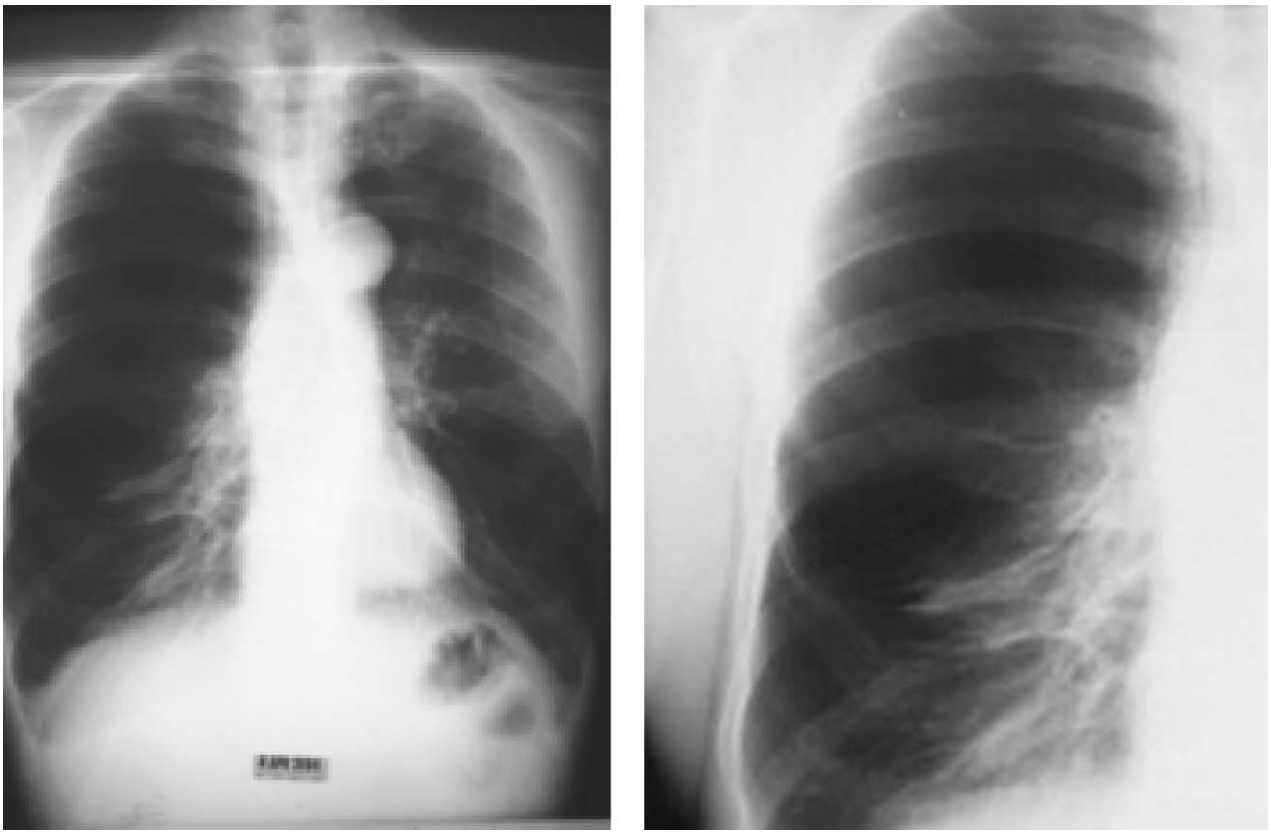

Figure 3. (a,b) Chest X-ray study showing hyperinflation with decreased lung markings throughout both lung fields but most dramatically on the right. However, no clearly identifiable pleural line is visible.

bility may not be conducive to sending the patient to the 'scanner' or to wait while one debates the interpretation of the films and scans. We report two cases in which we utilized ultrasound to distinguish the two entities. One study exploring the utility of ultrasound to detect traumatic pneumothorax did identify one false positive in a patient with bullous disease (4). In the final analysis of our two cases, the ultrasound findings were consistent with the ultimate interpretation made by the radiologists on the CT scan and by the clinical course of the patients.

In patient #1, it was clear that there was serious underlying bullous disease, but it was very difficult to determine whether there was also a pneumothorax. Despite his tachycardia and hypoxia he was stable enough to wait for assistance from radiology, where it was ultimately determined that he did not have a pneumothorax. The concern

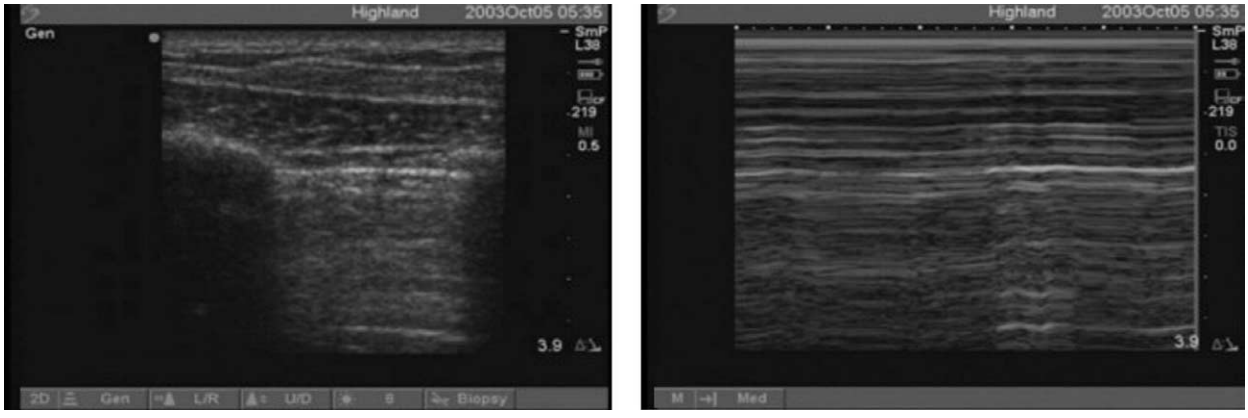

Figure 4. (a) 2D ultrasound (positive for pneumothorax): bedside ultrasound demonstrating the absence of comet tailing and sliding (see video). (b) M mode ultrasound (positive for pneumothorax). Below the pleural line there are a series of wavy horizontal lines commonly seen with lack of movement or in this case when movement is not seen because there is air in the pleural space.

of the emergency providers was whether to place a chest tube if the patient deteriorated while in the ED.

In patient #2, the plain films suggested a pneumothorax, but the presence of bullous disease added an element of confusion. The findings on ultrasound were very consistent with the described appearance of pneumothorax, providing additional supporting evidence for our ultimate diagnosis and clinical actions.

Performing and interpreting bedside ultrasound for the presence or absence of pneumothorax in most patients is not difficult. Several studies now describe the process and the utility (4–6). One recent study found the sensitivity and negative predictive value of ultrasound for pneumothorax to be 100% (3). Multiple probes can be used for this application, but the principle of using the highest resolution probe is a good place to begin. In most patients a small parts probe with 7–10 megahertz will work best. But in thick-chested individuals better penetration may require a probe with 3–5 megahertz. With the patient in the supine position, the probe is placed in the third to fourth interspace in the mid-clavicular line. As seen in the still image provided (Figure 2a), one will see the amorphous appearance of the subcutaneous tissue nearest the probe. Just deep to this tissue is the distinct echogenic appearance of the pleura (distinct white slightly curvilinear line). The principle goal of the sonographer is to study the line for to and fro movement (sliding), and for distinct echogenic white streaks that 'shoot' off the pleura (comet tailing) (Figure 2a). These appearances are identified in the traditional 2D ultrasound mode. Sliding is normally observed as the parietal and visceral pleura move against one another. In the patient with a pneumothorax, air separates these two layers and obscures visualization of the visceral pleura, so sliding is not seen. Comet tailing is the result of hyperechoic reverberation artifacts that arise off the visceral pleura. Because air prevents the propagation of sound waves, air in the pleural space will obscure the visceral pleural and the appearance of the reverberation artifacts. One can also look for changes in M mode (motion mode). In M mode ultrasound, motion will produce a grainy snowstorm appearance, whereas the absence of motion will be displayed as a series of horizontal lines. Therefore, when pleural sliding is present, tissues deep to the pleura will appear grainy (Figure 2b). When sliding is not present, tissues deep to the pleura will be visible as a series of horizontal lines (Figure 4b).

Understanding the physics of sound wave transmission and the physiology of blebs and pneumothorax, one might predict the findings identified with ultrasound. The discussion above explains the changes seen when air has leaked from the lung into the pleural space. Blebs are non-functioning cyst-like structures, but those located in the periphery will abut against the parietal pleural. Intuitively one might suspect that sliding may be minimal because there may be little or no movement of the visceral pleura that covers the non-functioning cyst. However, because there is no free air in the pleural space the reverberation artifact that produces comet tailing is likely to be present.

When a large number of patients are studied we may learn that the distinction between pneumothorax and uncomplicated bullous disease may be subtler than we found in our two patients. Yet, given the difficulty in making a firm diagnosis and the therapeutic ramifications of the treatment options, ultrasound may add clinically useful data to the decision-making process. Clearly a large study needs to be completed to determine how reliably ultrasound can help distinguish uncomplicated bullous disease from patients with co-existing pneumothorax.

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SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at doi: 10.1016/j.jemermed.2005.04.009.

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