
EDUCATIONAL ADVANCE

Hand Ultrasound: A High-fidelity Simulation of Lung Sliding

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Abstract

Simulation training has been effectively used to integrate didactic knowledge and technical skills in emergency and critical care medicine. In this article, we introduce a novel model of simulating lung ultrasound and the features of lung sliding and pneumothorax by performing a hand ultrasound. The simulation model involves scanning the palmar aspect of the hand to create normal lung sliding in varying modes of scanning and to mimic ultrasound features of pneumothorax, including “stratosphere/barcode sign” and “lung point.” The simple, reproducible, and readily available simulation model we describe demonstrates a high-fidelity simulation surrogate that can be used to rapidly illustrate the signs of normal and abnormal lung sliding at the bedside.

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La Ecografía de la Mano: Una Simulación muy Fidedigna del Deslizamiento Pulmonar

Resumen

La formación mediante simuladores ha sido efectiva para integrar didácticamente el conocimiento y las habilidades técnicas en medicina de urgencias y emergencias y en cuidados críticos. En este artículo, se introduce un modelo nuevo de simulación de ecografía pulmonar y de los hallazgos en el deslizamiento pulmonar y en el neumotórax mediante la realización de una ecografía de la mano. El modelo de simulación consiste en explorar la palma de la mano para crear un deslizamiento pulmonar normal en varios modos de exploración y para imitar los hallazgos ecográficos del neumotórax, que incluyen los signos de la “estratosfera/código de barras” y del “punto de pulmón”. Se describe un modelo de simulación simple, reproducible y fácilmente disponible que es un sustituto muy fidedigno de un simulador que puede ser utilizado para ilustrar rápidamente los signos normales y anormales del deslizamiento pulmonar a pie de cama.

Ultrasound simulation has been shown to improve the skills of users, especially in their ability to identify normal anatomy and perform ultrasound-guided procedures.¹⁻⁵ The simulator-based training allows the novice user to practice a skill and can be used to demonstrate different pathologies. Today, a number of commercial simulator systems are available for ultrasound training. Often these simulators are not readily available for bedside teaching, and their varying ability to demonstrate certain dynamic pleural signs may limit their applications in demonstrating the ultrasound evaluation for pneumothorax.

In this report we propose ultrasound of the hand as a model to generate the features of lung sliding and pneumothorax. This ultrasound simulation model is based on the premise that there is a similarity between the ultrasound appearance of hand anatomy and that of the anterior chest wall, including a parallel bony structure and air–skin and bone–soft tissue interfaces. This live model simulation creates a real-time image with interactive flexibility to generate different features of both normal lung sliding as well as pneumothorax in different ultrasound modes. This easily available model can be used for the purpose of bedside teaching and is especially useful in situations (for example, at the bedside of a patient) where there may not be ready access

to video clips of lung ultrasound and pneumothorax. This model is intended to simulate the presence and absence of lung sliding/pleural sliding, but does not allow for identification of B lines. B lines are an artifact that arise from the pleural–pleural interface and travel down to the edge of the image and are a useful feature that, if identified, help to exclude pneumothorax in patients with poor lung sliding (such as patients with acute respiratory distress syndrome and poor lung compliance).⁶

DISPLAYING THE PLEURAL ULTRASOUND IMAGES

Linear and curvilinear transducers are both useful for this simulation scanning, but a high-frequency linear array transducer provides optimal imaging. The transducer should be positioned on the palm of the hand, perpendicular to the metacarpal bones (resembling the ribs and intercostal space; Figure 1A). In this view, the metacarpal bones are characterized by an echogenic anterior surface, and posterior shadowing represents the rib echoes and shadows seen in lung ultrasound. Gently sliding a finger across the dorsum of the hand in the plane of the ultrasound beam or placing the finger in a fixed position, or in constant contact, with the skin of the dorsum of the hand and moving the dorsal skin of the hand back and forth to

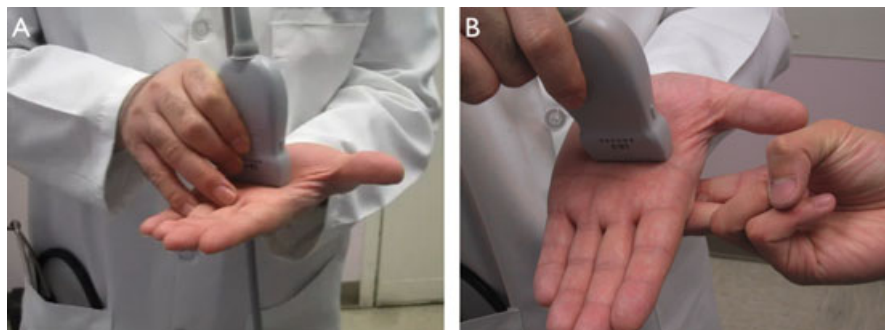


Figure 1. (A) Hand ultrasound: starting probe position against palm. (B) Sliding fingers across the dorsum of the hand or placing the finger in constant contact, with the skin of the dorsum of the hand and moving the dorsal skin of the hand back and forth to create lung sliding and lung point images.

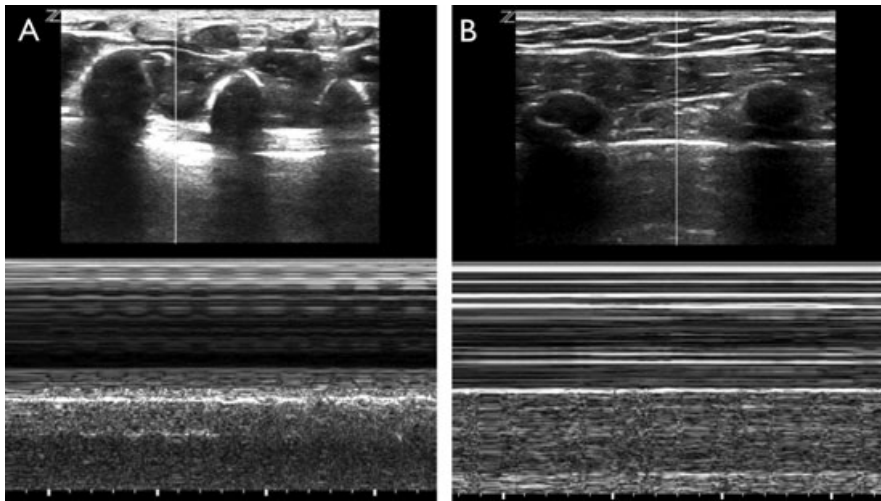


Figure 2. (A) Hand ultrasound: displaying a normal “seashore sign” by sliding a finger against the dorsum of the hand, mimicking back-and-forth motion of the lung below the pleural line seen on M-mode imaging in the lung ultrasound (B).

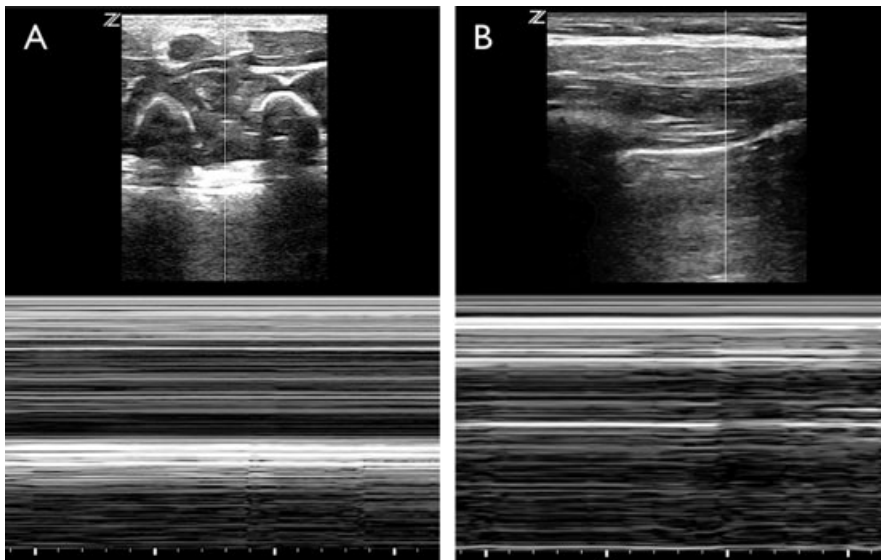


Figure 3. (A) Hand ultrasound: performing a hand ultrasound in M-mode without rubbing or moving the dorsum of the hand displays a “barcode/stratosphere sign” (A) that mimics the lack of lung sliding on M-mode imaging of the lung in patient with pneumothorax (B).

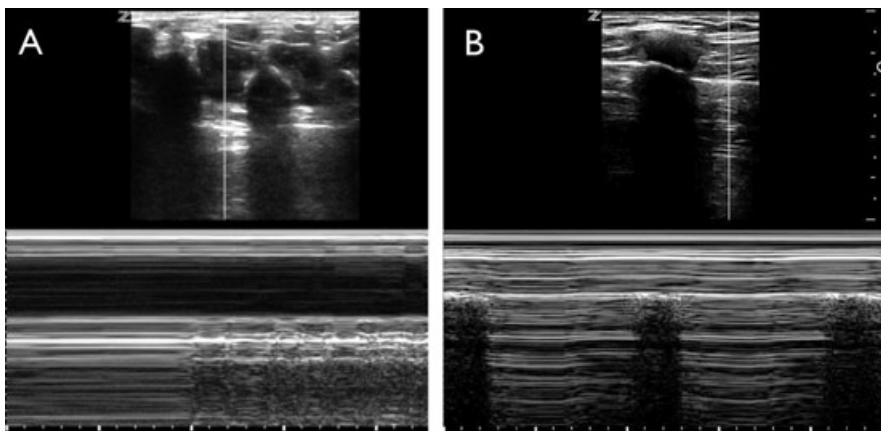


Figure 4. (A) Hand ultrasound: displaying a “lung point” image in the M-mode ultrasound of the hand by limiting the dorsal hand rubbing to the half-width of the transducer, mimicking the characteristic “lung point” sign in the presence of pneumothorax (B).

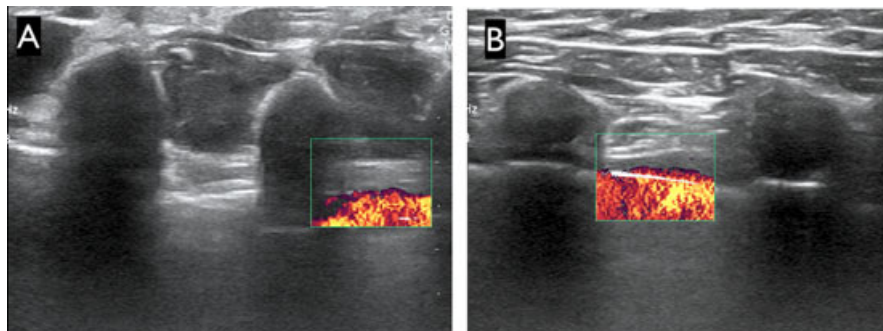


Figure 5. (A) Hand ultrasound: displaying a normal “power sliding sign” by rubbing the dorsum of the hand against the probe, mimicking back-and-forth motion of the lung below the pleural line seen on color power Doppler mode imaging in the lung ultrasound (B).

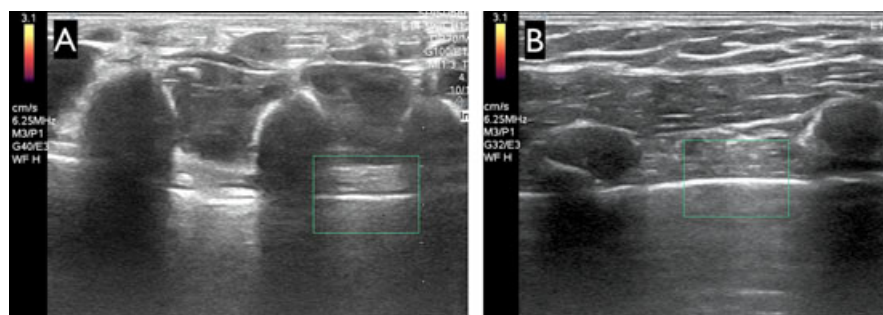


Figure 6. (A) Hand ultrasound: absence of a “power sliding sign” while the color power Doppler is on, this mimics the lack of power sliding on color power Doppler mode imaging of the lung in patients with pneumothorax (B).

skin of the hand back and forth with the finger creates a realistic real-time “sliding sign” (Figure 1B). This method does not require gel or fluid to be applied to the back of the hand. Performing this simulation “model” is easier with a second person performing the “sliding” of the fingers on the dorsum of the hand under the ultrasound probe. In M-mode, a “seashore sign” can be seen, characterized by motionless interdigital tissue above the factitious “pleural line” (skin-air interface at the dorsum of the hand) and a “sandy seashore” sign generated deep to the “pleural line” (Figures 2A and 2B actual lung images).

DISPLAYING THE PNEUMOTHORAX IMAGES

To mimic the ultrasound appearance of pneumothorax, the finger sliding across the dorsum of the hand is lifted off the skin. On B-mode scanning, this will result in a suddenly motionless “pleural line” devoid of lung sliding characteristic of pneumothorax. In M-mode, a “stratosphere or barcode sign” is now present (Figures 3A and 3B show actual lung images). Limiting the finger sliding or dorsal hand skin motion to the half-width of the transducer simply creates a “lung point” feature in the hand scanning (Figures 4A and 4B show actual lung images). Application of color power Doppler to the “pleural line” demonstrates a flash of color that accompanies finger sliding across the dorsum of the hand, which ceases when the sliding finger is

removed (Figures 5A, 6A, 5B, and 6B show actual lung images).

CONCLUSIONS

We present a novel model of hand ultrasound to simulate the features of lung sliding and pneumothorax for training purposes. The model demonstrates ultrasound characteristics of lung sliding and pneumothorax in varying modes of scanning and is simple, real-time, reproducible, and always available to generate interactive visualization of lung sliding and pneumothorax features for training purposes.

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