>>EMERGENCY ULTRASOUND

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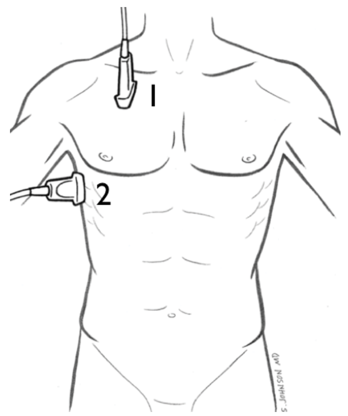
Rapid Ultrasound in SHock: The RUSH Protocol

Figure 1. Lung Ultrasound for B-Lines (Lung Rockets)



- Use a 3- to 5-MHz probe
- Position 1: anterior chest view
- Position 2: lateral chest view
- Use a 3- to 5-MHz probe

EVALUATION OF CORE VASCULAR VOLUME

This month, our discussion of the RUSH evaluation of the “tank” continues with a review of lung ultrasound applications that can be helpful in assessing the core vascular volume of a patient in shock. In the March issue, we discussed the focused assessment with sonography in trauma (FAST) exam and the addition of thoracic windows to the abdominal/pelvic windows. Now, we further consider the detection of pleural fluid, a finding that may signal a pleural effusion in the medical patient or a hemothorax in the trauma patient. In addition, we present lung ultrasound techniques that may demonstrate pulmonary edema. The following case defines the utility of these techniques when they are applied at the patient’s bedside.

CASE PRESENTATION AND ANALYSIS

A 65-year-old woman calls 911 for acute shortness of breath and midsternal chest pain. She has a history of hypertension and congestive heart failure (CHF), although her last formal echocardiogram at your institution showed an ejection fraction of 40%, suggesting predominance of a diastolic component to her heart failure. In addition, she has chronic obstructive pulmonary disease (COPD) and currently smokes a half pack of cigarettes per day. Paramedics arrive to find her in respiratory distress with diffuse wheezing. Nebulized bronchodilators are administered for presumed COPD, and furosemide and sublingual nitroglycerin are given for presumed CHF. She is then transported to your ED and arrives with a blood pressure of 84/68 mm Hg; heart rate, 120 beats/min; respiratory rate, 30 breaths/min; temperature, 37°C; and oxygen saturation level, 92% on nebulizer with oxygen. She appears to be in respiratory distress with diffuse wheezing. A chest radiograph, ECG, and laboratory tests are ordered, as is bilevel positive airway pressure (BiPAP) ventilation. Next, the RUSH exam is performed using bedside ultrasound.

The initial part of the RUSH exam, the evaluation of the pump, reveals a heart with a hypertrophied left ventricle that appears to be contracting normally. There is an absence of pericardial effusion, and the right ventricle is smaller than the left ventricle. Moving on to evaluation of the tank, you note that the inferior vena cava appears small in diameter (<2 cm) and collapses by more than 50% with inspiration. The jugular veins also appear small in caliber, with a closing level low in the neck, confirming a low central venous pressure (CVP) at this time. The paramedics are watching your RUSH exam with interest, and you ask them how many sublingual nitroglycerin tablets were given to the

“Emergency Ultrasound” presents clinical cases involving the diagnostic use of bedside ultrasound in the emergency department. Cases can be explored in more detail on the Web in the SoundBytes section of CMEDownload.com, which can be accessed directly at www.sound-bytes.tv. Instructional videos detailing the components of the RUSH exam are available for download.

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patient during transport. They report that she received a total of four tablets.

During bedside echocardiography from the substernal planes, using a 3-MHz probe, you note that the lung intermittently comes into view. The lung has an interesting appearance, with multiple white lines that project posteriorly off the sliding pleura, all the way down across the display. These white lines are known as *ultrasound B-lines*, or *lung rockets*, and are the sonographic equivalent of Kerley B-lines on the chest radiograph. As the lung accumulates increasing amounts of fluid in worsening stages of pulmonary edema, formation of more numerous ultrasonic B-lines may be seen when the probe is placed either anteriorly or laterally on the chest (Figure 1). Lung rockets are best observed as the patient breathes and the pleura slides back and forth (Figure 2). It is important to emphasize that lung rockets are best evaluated with a 3- to 5-MHz probe, ie, at a lower frequency than that of the typical 10-MHz probe usually selected for evaluation of the lung for pneumothorax. Lung rockets characteristically project from the pleura completely across the ultrasound image. In contrast, comet tail artifacts, which are best visualized with a 10-MHz probe, are commonly seen in normal lung and project only a small distance posteriorly off the pleura. Ultrasonic B-lines can be simulated by placing an intact 3-MHz probe under running water; the result will be the appearance of white lines on the ultrasound screen.

Figure 2. Lung Ultrasound: B-Lines

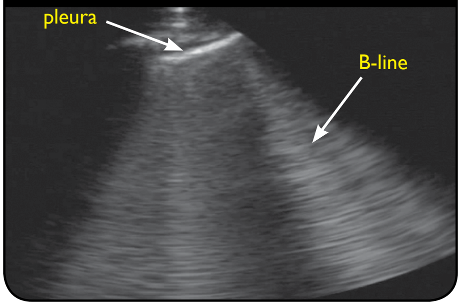

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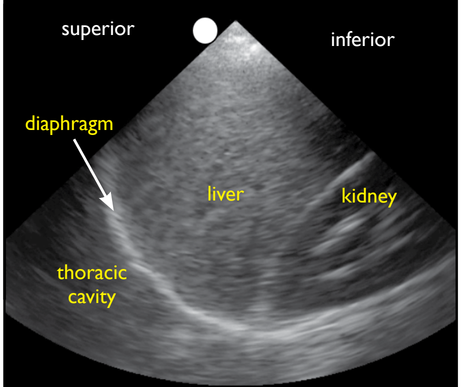
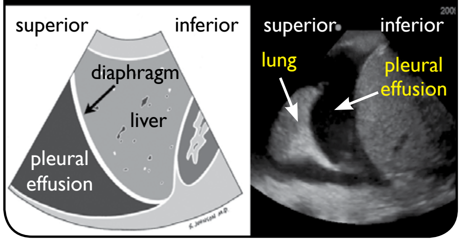
Figure 3. Right Upper Quadrant: Pleural Exam



Mirror artifact reproduces liver above diaphragm.

Figure 4. Pleural Effusion



Lung ultrasound also demonstrated the presence of bilateral pleural effusions in our patient. Recall that sonographic detection of pleural effusions is part of the extended FAST exam, in which the probe is angled upwards from the right and left upper quadrant positions to enable the sonographer to look above the diaphragm. Because of the dense composition of the diaphragm and the resultant reflection of sound waves, the normal appearance of the thoracic cavity involves a finding known as *mirror artifact*: the liver seems to appear above, as well as below, the diaphragm (Figure 3). As fluid accumulates in the chest cavity, the mirror artifact is replaced by the finding of dark, or anechoic, fluid areas above the diaphragm (Figure 4). As the pleural fluid volume increases, the sonographer can slide the probe superiorly to investigate the full extent of the fluid collection. Positioning the patient with the head of the bed raised 30° to 40° will cause the fluid to layer inferiorly above the diaphragm; this may result in improved sonographic detection of pleural effusions.

CONCLUSION

In our patient, there were some disparate findings. The paramedics, surmising that CHF was responsible for her respiratory distress, administered furosemide and nitroglycerin accordingly. But your RUSH exam revealed a heart that was contracting well, in addition to evidence of a low CVP on vascular assessment. So you were led to ponder how the prehospital administration of these medications may have altered the patient's physiology, making it more difficult for her underlying condition to be diagnosed correctly. Nitroglycerin is a known potent venodilator, and it is likely that the small inferior vena cava and jugular veins are highly reflective of this medication's effect. However, the presence of the ultrasound B-lines and pleural effusions in this patient pointed to pulmonary edema and CHF as the underlying conditions. These findings may remain present even after a patient's physiology has been altered by medications. BiPAP ventilation and gentle diuresis caused rapid improvement in our patient's condition. She was admitted to the medical service and released home 3 days later.

>> Look for discussion of the RUSH evaluation of the "pipes"—specifically, the aorta—in an upcoming issue.

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