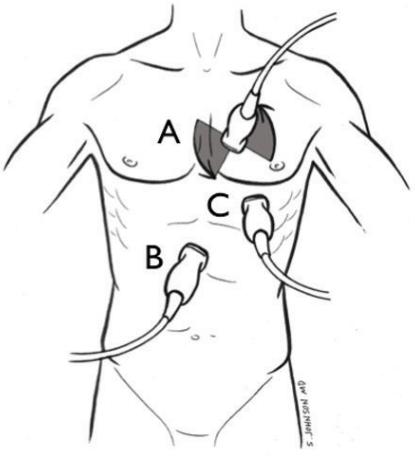
Phillips Perera, MD, RDMS, FACEP
Thomas Mailhot, MD, RDMS
Diku Mandavia, MD, FACEP, FRCPC

Rapid Ultrasound in SHock: The RUSH Protocol

EVALUATION OF THE PUMP: THE PARASTERNAL CARDIAC VIEWS

Last month, we presented an overview of a unified ultrasound protocol for evaluation of the critical patient (Rapid Ultrasound in SHock, or RUSH). The RUSH exam employs bedside ultrasound to rapidly evaluate both the anatomy and physiology of a patient in shock, allowing the emergency physician to better identify the type of shock state and to formulate optimal therapy. The three main components of the exam were introduced: bedside ultrasonography to evaluate the "pump" (ie, cardiac echocardiography assessing for left ventricular contractility, pericardial effusion, and right ventricular strain), the "tank" (assessing the core vascular volume and identifying "fullness" or "leakiness" in the tank), and the "pipes" (assessing for thoracic or abdominal aortic aneurysm or dissection and deep vein thrombosis).

Figure 1. Evaluation of the Pump



A. Parasternal views (long/short axis)

B. Subxiphoid view

C. Apical view

This month, we emphasize the first component of the RUSH exam: the evaluation of the heart using bedside echocardiography. Focused echocardiography is best performed with a small footprint phased-array probe at a frequency of about 3 MHz. The heart is traditionally examined from four views on the anterior chest wall: the parasternal long- and short-axis, subxiphoid, and apical planes (Figure 1). In this article, the parasternal long- and short-axis planes will be examined in more detail.

It is important for the emergency physician to learn and practice visualizing the parasternal views of the heart, as they often allow for a detailed cardiac examination and provide important information about the patient's physiological state. The parasternal views are obtained by first placing the probe on the patient's left chest at intercostal space 3 or 4, lateral to the sternum. Next, the probe is moved into positions along the long and short axes of the heart. The final alignment of the probe depends on the configuration of the marker dot on the ultrasound screen. The probe orientations discussed here for echocardiography in the RUSH protocol will all be configured with the screen indicator to the left (for further discussion, see "Marker Dot Orientation," page 22).

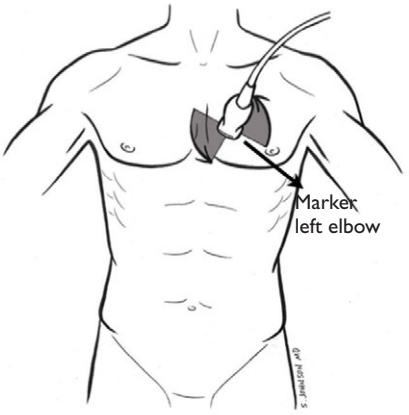
Long-Axis View

Imagine the heart within the chest wall, stretching superiorly from under the top of the sternum to an inferior position at the apex, leftward within the chest cavity. The

Rapid Ultrasound in SHock: The RUSH Protocol

long axis of the heart is thus best approximated by drawing a line from the sternal notch down to the left elbow. In the parasternal long-axis view, the probe is positioned at intercostal space 3 or 4 with the marker dot down toward the left elbow (Figure 2). The optimal cardiac view will differ from patient to patient, since the ultrasound image is dependent on the relative orientation of each individual's lungs and heart. As ultrasound waves are poorly conducted by the air-filled lung, the best parasternal views will be achieved where the heart is not covered by lung. In the barrel-chested chronic emphysema patient, the lungs may be hyperexpanded, and it may be necessary to position the probe one or more intercostal spaces inferiorly in order to obtain the best image of the heart. Conversely, in patients with a distended abdomen, the diaphragm may be pushed upward, which will require the physician to place the probe superiorly. If it remains difficult to view the heart from the parasternal long-axis plane while the patient is in a recumbent position, it may be helpful to move the patient into the left lateral decubitus position, which will move the heart closer to the chest wall and thus improve the view.

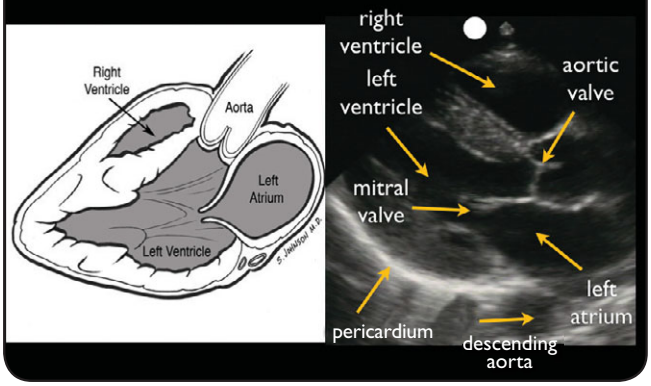
Figure 2. Parasternal Long-Axis View of the Heart



- Probe placed left of sternum, intercostal space 3 or 4
- Marker to left elbow
- Ultrasound screen indicator to left
- Left lateral decubitus may help positioning

The chambers of the heart seen in the parasternal long-axis view include the right ventricle anteriorly and the left atrium and left ventricle posteriorly (Figure 3). The right atrium is not well visualized from this plane. The mitral valve will be seen moving between the left atrium and left ventricle. The aortic valve and aortic outflow tract can be seen just to the right of the left ventricle. Parts of the aorta are seen from this position: the ascending aortic root distal to the aortic valve, and the descending aorta, seen as a cylinder in cross-section posterior to the left atrium. It is possible to assess contractility by looking closely at the left ventricle and observing the percentage change from diastole to systole of the inner endocardial walls. Hearts with strong contraction will have a large percentage change between the two phases, while those with cardiomyopathy will move little. Pericardial effusions can best be seen initially by looking at the posterior pericardium, as fluid tends to layer posteriorly when the patient is recumbent. It is helpful to first look for the descending aorta as a landmark in evaluation

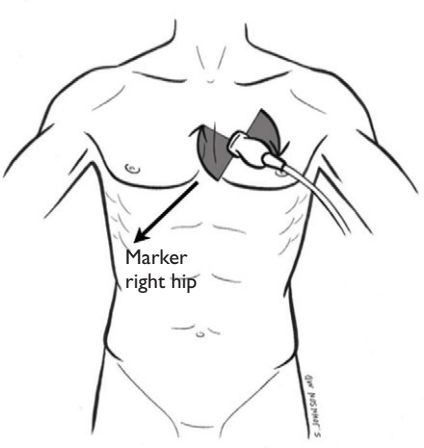
Figure 3. Cardiac Echocardiography Parasternal Long-Axis View



Continued on next page >>

Rapid Ultrasound in SHock: The RUSH Protocol

Figure 4. Parasternal Short-Axis View of the Heart



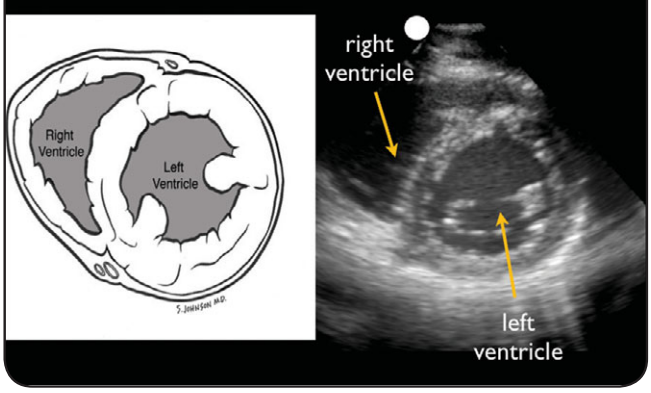
- Probe placed left of sternum, intercostal space 3 or 4
- Marker to right hip
- Ultrasound screen indicator to left
- Left lateral decubitus positioning may help imaging

of fluid near the heart. The posterior pericardial reflection is located anterior to this landmark and is visualized as a thin bright line, allowing the physician to determine whether fluid is pericardial or pleural. A pericardial effusion will initially be seen anterior to the posterior pericardium. As it increases in size, the effusion may wrap anteriorly around the heart. In contrast, pleural effusions, which can be confused with pericardial fluid, will be located posterior to the posterior pericardial line. Finally, the size of the left ventricle relative to the right ventricle can be well evaluated from this plane. A dilated right ventricle is often a sign of right ventricular strain and in certain clinical scenarios may be a sign of pulmonary embolus.

Short-Axis View

The parasternal short-axis view is known as the "ring" or "doughnut" view of the heart. For this exam, keep the probe in the same position as for the parasternal long axis. Swivel the probe 180° clockwise, facing the probe indicator toward the patient's right hip (Figure 4). To optimally image in this plane, the probe may be moved slightly inferiorly and laterally from the parasternal long-axis plane to become more in-line with the ventricles. The parasternal short-axis view slices the heart in cross-section and images the ventricles as cylindrical chambers (Figure 5). This view is optimal for determining global left ventricular contractility: during a strong contraction, all walls of the ventricle should move inwards with a large percentage change from diastole to systole. Conversely, in the heart with poor contractility, the ring of the left ventricle will move little throughout the cardiac cycle. Cardiologists often use this view for analysis of segmental wall motion abnormalities; however, this is an advanced exam that is beyond the scope of RUSH.

Figure 5. Cardiac Echocardiography Parasternal Short-Axis View



Marker Dot Orientation

Controversy exists concerning the relative alignments of the marker dots on the ultrasound screen and on the probe during bedside echocardiography. Most emergency physicians use bedside ultrasound for a range of applications other than echocardiography (eg, abdominal, procedural) and are comfortable maintaining a leftward orientation of

Rapid Ultrasound in SHock: The RUSH Protocol

the indicator dot on the ultrasound screen. However, in traditional cardiology-performed echocardiography, the screen indicator is positioned to the right. To simplify the situation and to avoid having to switch the indicator dot back and forth from opposite sides of the ultrasound screen, many emergency physician sonographers maintain the screen indicator dot to the left, whether they are performing abdominal or cardiac exams. The screen and probe orientations discussed earlier are configured with the screen indicator dot to the left. Thus, the probe is placed in the same positions on the chest as in traditional echocardiography, only the alignment of the probe marker dot will differ between approaches. The result is that both orientations will produce images in which the heart chambers are configured similarly, allowing for conformity in the position of the final image and ease of interpretation by all specialties.

>>Look for next month's discussion of the RUSH exam, detailing subxiphoid and apical views of the "pump."

Dr. Perera is an assistant clinical professor of emergency medicine at Columbia University College of Physicians and Surgeons and Weill Cornell Medical College in New York City. He is also director of emergency ultrasound at NewYork-Presbyterian Hospital in New York City. **Dr. Mailhot** is clinical instructor in emergency medicine and assistant residency director at Los Angeles County-USC Medical Center in Los Angeles, California. **Dr. Mandavia** is a clinical associate professor of emergency medicine and director of emergency ultrasound at Los Angeles County-USC Medical Center and an attending staff physician at Cedars-Sinai Medical Center in Los Angeles.