>> EMERGENCY ULTRASOUND

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

Rapid Ultrasound in SHock: The RUSH Protocol

PRESENTATION

>> A 62-year-old male presents to your emergency department for evaluation of chest pain, cough, and general weakness. He is diaphoretic and appears ill. The paramedics transporting him administered 500 cc normal saline intravenously en route to your facility.

On arrival, the patient is quickly moved to a monitored bed. His vital signs include a blood pressure of 82/60 mm Hg; heart rate, 120 beats/min; respiratory rate, 24 breaths/min; and temperature, 100.8°F. He continues to complain of chest pain with associated back pain radiating to the upper abdomen. He has a history of smoking a half pack of cigarettes daily and reports cough with worsening shortness of breath. He also has a history of hypertension and takes several medications, including lisinopril and metoprolol. Stat ECG shows a left bundle branch block. Physical exam is unremarkable except for some rales in the lung bases, which improve with coughing. A pulse oximetry reading on room air is 92%.

Given this patient's history of chronic hypertension, you quickly realize that his relative hypotension indicates a shock state. In his case, the normal compensatory tachycardia is blunted by the use of beta-blockers. You consider the four classic types of shock: hypovolemic (secondary to hemorrhage or loss of other body fluids), cardiogenic, distributive (resulting from sepsis, anaphylaxis, or neurogenic causes), and obstructive (caused by pericardial tamponade, large pulmonary embolus, or tension pneumothorax). The patient has a history that could point to any of these etiologies. Could he have a large myocardial infarction, a ruptured abdominal aortic aneurysm, a dissecting thoracic aortic aneurysm, pneumonia with sepsis, or one of the causes of obstructive shock mentioned above? Should you treat with a large fluid bolus and hope for the best, or should you actively pursue one of the diagnoses above?

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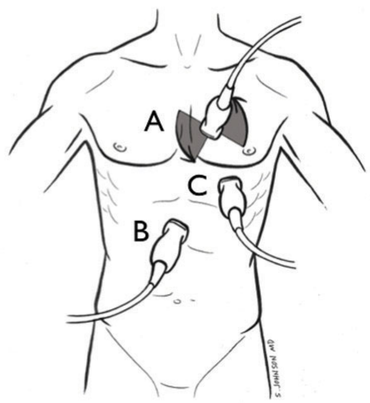
DIAGNOSIS AND DISCUSSION

Figure 1. Evaluation of the Pump

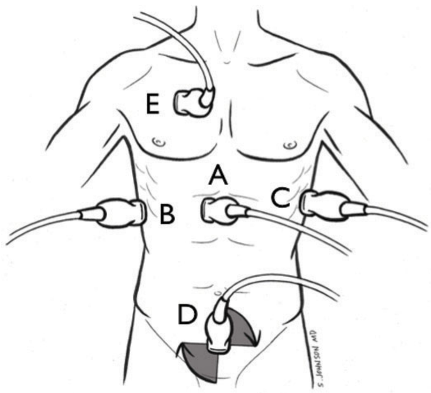


A. Parasternal views (long/short axis)

B. Subxiphoid view

C. Apical view

Figure 2. Evaluation of the Tank



A. Inferior vena cava (long axis)

B. FAST (right upper quadrant, add pleural view)

C. FAST (left upper quadrant, add pleural view)

D. FAST (pelvis)

E. Pneumothorax

FAST = focused assessment with sonography in trauma

>> Cases such as this are challenging for even the most seasoned clinician. Fortunately, ultrasound is available in the emergency department to help you make a rapid diagnosis. In the past, ultrasound was used primarily to assess anatomy and pathology, but its ability to assess critical physiology has become increasingly apparent. The advanced use of emergency ultrasound is invaluable in the resuscitation of the acutely ill or injured patient. This physiological ultrasound assessment has been created by integrating several applications of ultrasound and echocardiography. We have synthesized these individual sonographic exams and simplified the framework to create the **R**apid **U**ltrasound in **SH**ock (**RUSH**) protocol.

RUSH evaluates three main elements: the *pump*, *tank*, and *pipes*. The simple framework allows the clinician to quickly assess and categorize a patient's shock state. Following is an overview:

RUSH first assesses the heart, or *pump*, using bedside echocardiography (Figure 1). The heart should be viewed in the four traditional planes (parasternal long- and short-axis, subxiphoid, and apical views) to gain the maximal data. First, the left ventricle is evaluated for overall contractility, an important gauge of how well the pump is functioning. Cardiogenic pump failure can be quickly identified. In addition, assessment of left ventricular contractility helps the clinician determine how much fluid the patient's heart can handle during resuscitation, as well as when to initiate pressor agents.

The next goal of bedside echocardiography is to evaluate for a pericardial effusion, which can result in cardiac tamponade. If pericardial tamponade is diagnosed, ultrasound-guided pericardiocentesis can be rapidly performed.

The final purpose of bedside echocardiography is to evaluate the heart for right ventricular strain.

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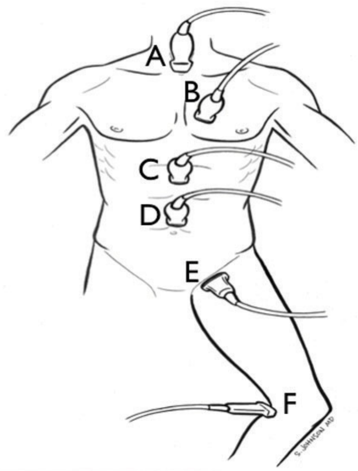
This is often manifested by dilatation of the right ventricle to a size exceeding that of the left ventricle. Acute right heart strain can be a sign of a large pulmonary embolus, and aggressive therapy with thrombolysis may be indicated.

The second part of the RUSH exam is the evaluation of the *tank* (Figure 2), looking for both "tank fullness" and "tank leakiness." The first goal of this part of the exam is evaluation of tank fullness to gain a better evaluation of the core vascular volume. The probe is placed along the long axis of the inferior vena cava (IVC) in the epigastric area just below the xiphoid process of the sternum, aimed distally to the junction of the IVC and right atrium. The size and respiratory dynamics of the IVC are then analyzed. A small-diameter (less than 2 cm) IVC that collapses more than 50% with forced inspiration or a sniff correlates with a low central venous pressure (less than 10 cm H_2O). A large-diameter (greater than 2 cm) IVC that collapses less than 50% with inspiration correlates with a high central venous pressure (greater than 10 cm H_2O). The clinician can also position the patient with the head 30° up to evaluate the size and respiratory dynamics of the jugular veins using the high-frequency probe, corroborating volume status as determined through the IVC evaluation.

Figure 3. Evaluation of the Pipes



A. Suprasternal aorta

B. Parasternal aorta

C. Epigastric aorta

D. Supraumbilical aorta

E. Femoral deep venous thrombosis

F. Popliteal deep venous thrombosis

Next, the tank is evaluated for "leakiness," or loss of integrity in the core vascular circuit allowing extravasation of fluid into the thoracic and/or abdominal/pelvic body compartments. The FAST exam, or focused assessment with sonography in trauma, can be employed using the three main views (right and left upper quadrant and suprapubic) to look for free fluid in the peritoneal cavity. The presence of such fluid can signal blood loss in trauma or fluid loss in a nontrauma patient. The thoracic cavity is also examined for pleural effusion by aiming the probe above the diaphragm from the right and left upper quadrant views.

Lung ultrasound, including evaluation for pneumothorax and for ultrasonic B lines (indicating pulmonary edema) is also part of the tank examination. A

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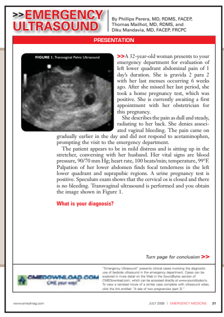
tension pneumothorax will compress the venous return to the heart in the superior and inferior venae cavae, effectively causing severe tank underfilling. The presence of ultrasonic B lines indicates pulmonary edema and tank overload.

The final step in the RUSH exam is evaluation of the *pipes* (Figure 3). First, the arterial side of the central vascular system is evaluated for pathology. The thoracic and abdominal aorta are evaluated for aneurysm or dissection, potential causes of life-threatening hemorrhage. Next, the venous side of the vascular system is examined. Focused evaluation of the femoral and popliteal leg veins can allow rapid diagnosis of a deep venous thrombosis (DVT) and can provide indirect evidence of a pulmonary embolus.

The RUSH exam incorporates traditional elements of bedside ultrasound that focus on patient anatomy with newer techniques that allow real-time interpretation of patient physiology. While the RUSH protocol detailed here is quite comprehensive, the experienced clinician will move through it rapidly, focusing on those elements of the exam that are indicated by the patient's clinical presentation.

As more invasive strategies of hemodynamic monitoring (central venous monitoring and Swan-Ganz catheterization) are used less frequently in the emergency department, bedside ultrasound has "stepped up" to allow a noninvasive means of evaluating the patient's condition. The RUSH exam will allow clinicians faced with a patient in shock, as in the complex case presented at the start of this article, to improve the accuracy of the initial diagnosis and care plan. It will also provide a means for continued hemodynamic monitoring as treatment is rendered.



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PRESENTATION

FIGURE 1. Transvaginal Pelvic Ultrasound

>>A 32-year-old woman presents to your emergency department for evaluation of left lower quadrant abdominal pain of 1 day's duration. She is gravida 2 para 2 with her last menses occurring 6 weeks ago. After she missed her last period, she took a home pregnancy test, which was positive. She is currently awaiting a first appointment with her obstetrician for this pregnancy.

She describes the pain as dull and steady, radiating to her back. She denies associated vaginal bleeding. The pain came on gradually earlier in the day and did not respond to acetaminophen, prompting the visit to the emergency department.

The patient appears to be in mild distress and is sitting up in the stretcher, conversing with her husband. Her vital signs are blood pressure, 90/70 mm Hg; heart rate, 100 beats/min; temperature, 99°F. Palpation of her lower abdomen finds focal tenderness in the left lower quadrant and suprapubic regions. A urine pregnancy test is positive. Speculum exam shows that the cervical os is closed and there is no bleeding. Transvaginal ultrasound is performed and you obtain the image shown in Figure 1.

What is your diagnosis?

Turn page for conclusion >>

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Look for upcoming segments of **"Emergency Ultrasound"** that will present a series of cases illustrating the value of the RUSH protocol and its role in assessing the critically ill patient.

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