

## EDUCATIONAL FORUM

# New Advances in Emergency Ultrasound Protocols for Shock

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### KEYWORDS

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Shock is a major morbidity in emergency and critical care and is also one of the important prognostic factors affecting in-hospital mortality [1]. Timely diagnosis and treatment of shock reduce the length of stay (LOS) and mortality rate at the emergency department (ED). The early use of the point of care ultrasound (POCUS) can reduce the diagnostic time as well as increase the accuracy of diagnosis [2]. The first protocol Undifferentiated hypotension protocol (UHP) was release on 2001, [3]; and more than 15 subsequent protocols were developed [4]. Most protocols include followings:

### Heart

Evaluate the common causes of shock and heart function. During POCUS exam, we emphasize on “eye balling”, instead of conventional measurements.

### Obstructive shock

#### Pericardial effusion with cardiac tamponade

Use subcostal view as first screen view. Effusion in the pericardial cavity is usually visible (Fig. 1). Moreover, Right



PERICARDIAL EFFUSION IN SUBCOSTAL VIEW

Figure 1 Pericardial effusion.

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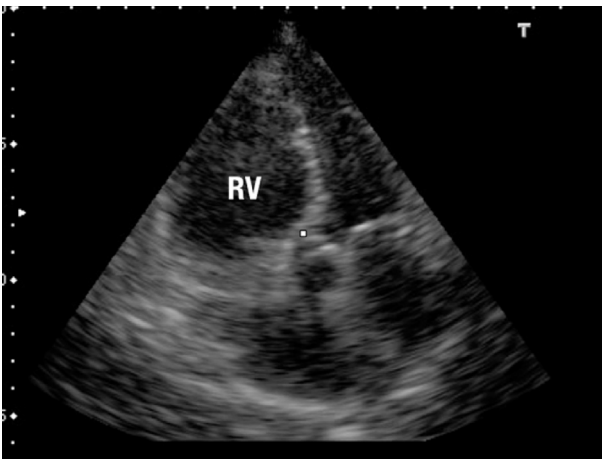
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From Practical guide to Emergency ultrasound, chapter 5

**Figure 2** RA collapse sign.



DISTENDED RV IN APICAL 4 CHAMBER VIEW

**Figure 3** Pulmonary embolism.

atrium or Right ventricle (RV) collapse sign is specific for cardiac tamponade (Fig. 2). As we mention earlier, conventional measurement is not necessary in POCUS, if patient develops clinical shock status with pericardial effusion, cardiac tamponade should be considered.

### Pulmonary embolism

Apical four chamber view is much more accurate for the diagnosis of pulmonary embolism; it provides better visualization of both heart ventricles; in pulmonary embolism, RV is obviously larger than left ventricle (LV) (normal ratio is  $RV:LV = 1:1.5$ ) (Fig. 3). In parasternal short axis view, a D-shape LV (Septal wall shifts toward LV second to pulmonary hypertension) can be found. RV wall thickness is usually  $<0.5$  cm in acute condition; if not, it is usually caused by other chronic condition, such as primary pulmonary hypertension. The presentation of McConnell's sign demonstrates the akinesia of mid RV free wall, but good motion of RV apex.

### Cardiogenic shock

Parasternal short axis view is used for LV contractility and coronary artery supply in different territory. The LV will move inward about 30% to 1/3 during contraction (Fig. 4). The presentation of limited LV contraction could be cardiogenic shock, meanwhile, the occurrence of abnormal motion of regional wall reflects the abnormality of coronary arterial territory.

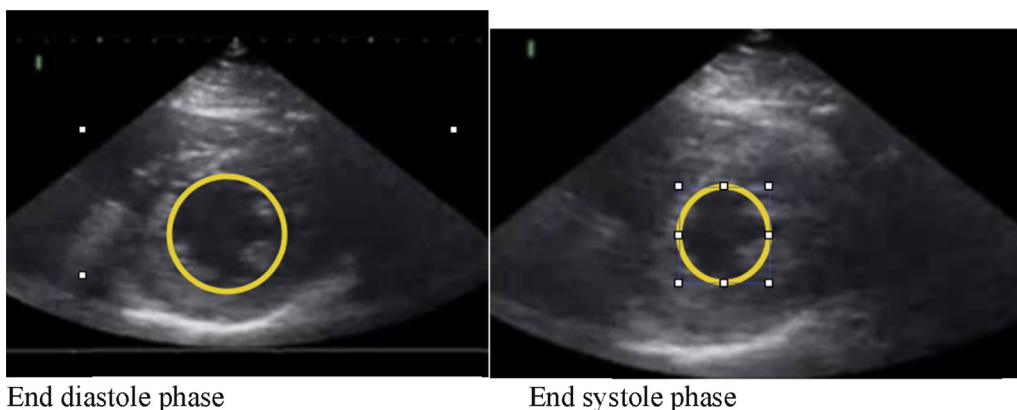
### Hypovolemic shock

Kissing sign (the different walls contact each other during contraction) occurs in hypovolemic shock. It is important to evaluate RV condition and end diastolic volume whenever Kissing sign in hypovolemic shock occurs. For example, pulmonary embolism can cause low volume to LV. In hypovolemic shock, both end diastolic and systolic volume are reduced, but in distributive shock, only end systolic volume is reduced.

### Blood vessels

#### Inferior vena cava (IVC)

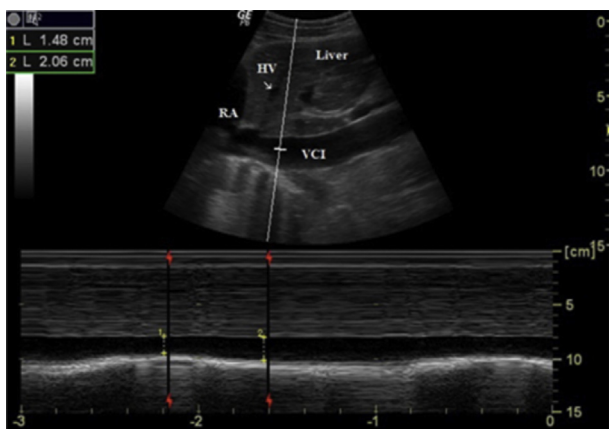
The normal diameter at the end expiratory phase (IVCe) should be 1–2.5 cm, and diameter is reduced during end inspiratory phase (IVCi). The changing diameter of IVC



End diastole phase

End systole phase

**Figure 4** Normal LV contraction.



**Figure 5** Size of IVCe and IVCi (from AJEM 2013; 31:763–767).

during respiration can be used to calculate the caval index,  $(IVCe - IVCi) / IVCe \times 100$ , with a normal range 40–50% (Fig. 5). A IVC diameter is currently used in two extreme conditions.

**Hypovolemic shock**

IVCe <1 cm and caval index >40–50%.

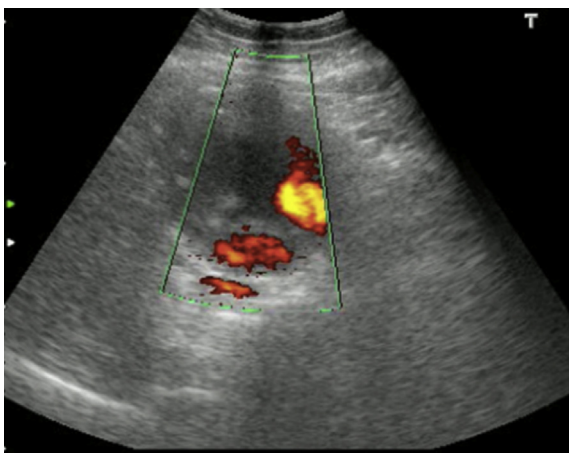
**Obstructive shock/cardiogenic shock**

IVCe >2.5 cm.

In addition, the IVC diameter for fluid responsiveness may be more complicated, especially in patients under mechanical ventilation.

**Aorta**

The ultrasound scan can effectively diagnose the abdominal aortic aneurysm (AAA) larger than 5 cm, with good sensitivity (99%) and specificity (98%) (Fig. 6). Scan from the upper abdominal aorta to the iliac artery bifurcation is difficult to differentiate the rupture of the AAA or not; but AAA > 5 cm has more chance to be ruptured. Patient with shock and AAA > 5 cm is mostly due to ruptured AAA. In



**Figure 6** AAA > 5 cm.



**Figure 7** Intima flap over abdominal aorta.

addition, check the aorta for flap to confirm the aortic dissection; it has moderate sensitivity (67–80%) and good specificity (94%) (Fig. 7).

**Femoral vein and popliteal vein**

Deep vein thrombosis is one of the causes of PE. Compress the ultrasound probe on the femoral/popliteal vein. Normally, the veins can be compressed by the probe; and the occurrence of uncompressed veins indicate a positive finding of deep vein thrombosis (Fig. 8).

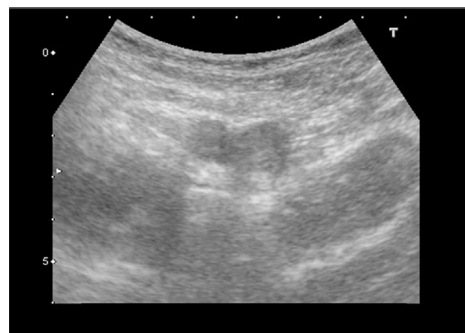
**Abdomen**

**Hypovolemic shock**

Check the hepatorenal/splenorenal junction and Douglas pouch for free fluid. If free fluid is present, internal bleeding should be considered (Fig. 9). Especially if homogenous echogenic substance occurs within free fluid.

**Septic shock**

Look for common sites of infection, for example, liver abscess and cholecystitis.



Femoral vein can't compress during compression test, and visible echogenic thrombosis inside vein

**Figure 8** Deep vein thrombosis.



Echogenic free fluid over Douglas pouch

**Figure 9** Hemoperitoneum in Douglas pouch.



M-mode show Barcode sign

**Figure 10** Barcode sign in pneumothorax.

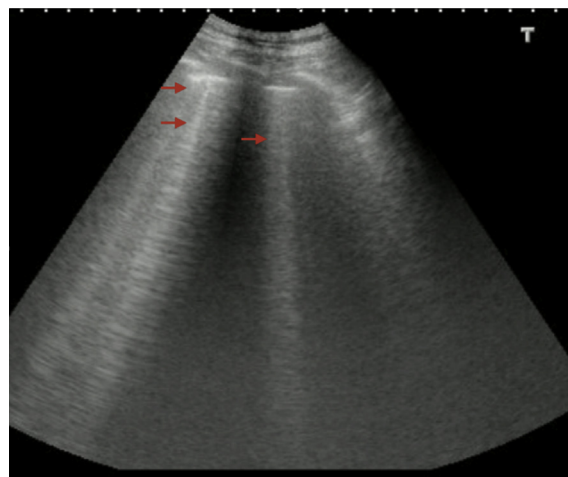
## Lung

### Obstructive shock

In tension pneumothorax, place the probe on highest area over chest for the absence of lung sliding sign and barcode sign (Fig. 10) and try to identify the lung point.

### Hypovolemic shock

Check the free fluid at the base of the lungs.



**Figure 11** Multiple B line (arrow) in cardiogenic shock.

## Cardiogenic shock

Numerous B lines in bilateral lungs (Fig. 11).

## Future and discussion

Most currently available protocols are focused on diagnosis. Blanco et al. suggested that an ultrasound scan should also assess the efficacy of treatment [5]. For example, the use of velocity time integral (VTI) of LVOT to measure the responses to fluid and inotropic agent to help further management. Point of care ultrasound is a powerful tool in emergency setting. The emergency ultrasound procedures for shock can reduce the LOS at the emergency department. Therefore, POCUS is an essential skill for personnels in the emergency department and critical care units.

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