Ultrasound
In the critically ill shock patient

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Pt presents speaking partial sentences saturations 78%, confused

What do you do?
Who owns ultrasound?

2004: American Institute of Ultrasound in Medicine (AIUM)

“the concept of an ultrasound stethoscope is rapidly moving from the theoretical to reality”

19 medical organizations in 2004 to 45 last year

Medical schools have implemented courses and hand help equipment for clinical rotations

Challenging Cases

Mortality rates correlated to duration of hypotension

Integration of bedside ultrasound into the evaluation of the patient with shock results in a more accurate initial diagnosis with an improved patient care plan

View it as using one of our senses; as we use touch and hearing to do physical exam, ultrasound can be an extension of our sense of vision

Jones AE et al. Crit Care Med 2004
Classifications

- Hypovolemic
- Distributive
- Cardiogenic
- Obstructive
Which classification?

Physical findings often overlap

Invasive measurements can help differentiate
RUSH protocol

Step 1: The Pump

Step 2: The Tank

Step 3: The Pipes
The Pump

Pericardial effusion?

Global contractility of left ventricle?

Relative size of right ventricle to left ventricle?

The Tank

IVC size and variation with respiration

Jugular veins

Lung

Pleural space

Abdomen

The Pipes

Large arteries and veins

Abdominal and thoracic aorta for aneurysm or dissection

Femoral and popliteal veins for compressibility

Back to the pump

A) Parasternal Views
  Long / Short Axis

B) Subxiphoid View

C) Apical View

RA, RV, LV, LA
Effusion around the pump
Effusion around the pump

Grades

Small less than 10 mm

Moderate 10-15 mm

Large greater than 15 mm
Effusion around the pump

Tamponade or not?

Hallmark: RV free wall inversion, best recognized during diastole

Right atrial inversion during systole (more common and early finding)

Increased respiratory variation of mitral or aortic inflow velocities (greater than 25%)

Dilated inferior vena cava with decreased inspiratory collapse

ASE Committee Recommendations. Am Soc Echocardiography. 2005
Effusion around the pump - tamponade
Squeeze of the pump

Determination of \textit{global} left ventricular function

LV walls: \textit{visual calculation} of \% change from diastole to systole

Ejection Fraction: Radionuclide imaging and visual determination \textit{roughly equivalent}

Amico AF. Am Heart J. 1989
Good contractility: walls almost come together and almost obliterate ventricular cavity during systole

Poor contractility: walls move little and heart may be dilated

Anterior leaflet of mitral valve: in normal state will vigorously touch septum during ventricular filling (best in parasternal long view axis)
Squeeze of the pump

Segmental wall motion abnormalities?
Cardiac Arrest

Presence or absence of cardiac contractions

Present: coordinated movements of mitral and aortic valves? If not....chest compressions needed

Absent: cardiac standstill after prolonged ACLS.... ROSC low

Blaivas M. Acad Emerg Med. 2001
Strain of the pump

Assessment of right ventricular strain

Normal LV:RV = 1 to 0.6

Optimal views: parasternals and apical... Subxiphoid can be used but need to 'fan' through RV

RV dilation: acute pressure rise in pulmonary circuit (large central pulmonary embolus classic example)

Interventricular septum right to left toward LV signal high pressures within pulmonary artery

Jardin F. Chest. 1997
Jardin F. J Am Coll Card. 1987
Strain of the pump

Right Ventricle

Left Ventricle
Strain of the pump

Gradual increase?

Dilation of RV and thickening or hypertrophy of RV wall
Fullness of the tank
Fullness of the tank: M-mode
Fullness of the tank

Small IVC (< 2cm) with collapse greater than 50% correlates with CVP less than 10

Hypovolemia, distributive

Larger IVC (> 2cm) with collapse less than 50% correlates with CVP greater than 10

Cardiogenic, obstructive

Simonson JS. J Am Colleen Card. 1988
Fullness of the tank

Except...

1. Tx with vasodilators or diuretics alters initial physiologic state

2. Positive pressure ventilation: fluid responsiveness correlated with an increase in IVC diameter over time
Also...

Bedside evaluation most accurate when small and collapses

Better to follow changes over time and IVC response to fluids

Can also use jugular veins in similar fashion
Rupture of the pipes

Aortic aneurysm and dissection

Some cases present with shock as only finding

Traditionally pulsatile mass fastest way but sensitivity and specificity poor (29% for AAA 3-4 cm, 76% for 5 cm or larger)

Rapid, accurate, noninvasive, inexpensive, reproducible, non-ionizing, bedside

Rohrer MJ. Arch surgery. 1988
Lederle FA. JAMA. 1999
Rupture of the pipes

Epigastrium to iliac bifurcation

Circular vessel immediately anterior to vertebral body

Left of paired IVC

Outer wall to outer wall; short and long axis

Greater than 3cm abnormal

Thrombus or rupture harder to visualize
Rupture of the pipes

8.8 by 8.6 cm Aneurysm
Rupture of the pipes

Entire course evaluation (infrarenal most common)

Retroperitoneal bleeding (not visualized well on US)

Contrast enhanced may help (microbubbles)

AAA + hypotension ... Consider rupture and plan
Rupture of the pipes

Evaluation for dissection has poor sensitivities (65%)

Aortic root dilation and aortic intimal flap

Parasternal long axis: aortic root > 3.8 cm is abnormal

Suprasternal view placed in suprasternal notch aimed caudally and anteriorly

Color flow can help
Clogging of the pipes

**Venous thromboembolism**

Majority of pulmonary embolism arise from lower extremities

Simple compression US has good sensitivity

Incomplete compression of anterior and posterior portions of vein

Complicated Doppler techniques add little utility

Kearon CK. Ann Intern Med. 1998

Clogging of the pipes

Bernardi et al

Prospectively randomized 2098 pts

2point + d-dimer VS whole leg color flow doppler

Study supports it is equivalent

Initial prevalence of proximal DVT was similar in both groups, suggesting most are common femoral or popliteal
Clogging of the pipes

Proximal femoral vein evaluated first just below inguinal ligament, scanning should continue down to bifurcation into deep and superficial femoral

Second area is popliteal fossa

Can do upper extremity veins also, but lower sensitivity

Can miss calf veins