Lecture Objectives

- Introduce the unique ultrasonic technique associated with echocardiography
- Present the basic ultrasonic “views” of the heart
- Discuss the most useful indications of cardiac ultrasound as performed by the EM physician with limited training
Introduction
Introduction

- ED Echocardiographic exam
  - Goal-directed assessment
  - Adjunct to general clinical evaluation
Introduction

- Common applications
  - Pericardial effusion
  - Unexplained hypotension
  - Cardiac Arrest
  - Cardiac procedures
  - Cardiac trauma
Introduction

- Applications not commonly performed by Emergency physicians with Transthoracic Echo
  - Aortic disease
  - Endocarditis
  - Valvular abnormalities
  - Cardiac masses
Technical Considerations
Technical Considerations

- Two types of grey-scale images
  - M-mode
  - B-mode
Technical Considerations

- M-mode
  - One dimension wave across moving tissue
  - “ice pick” view
  - Permits precise measurements
    - Heart Rate
    - Walls
    - Valves
Technical Considerations

- B-mode, real-time
  - “pie” image
  - Anatomic representation
    - Wall-motion abnormalities
    - Pericardial disease
    - Cardiac masses
    - Many others
Technical Considerations

- Doppler echocardiography
  - Uses changing frequencies of moving blood to calculate blood-flow velocity
  - Provides noninvasive determination
    Stroke volume
    Cardiac output
    Pressure gradients across valves
Technical Considerations

- **Probe selection**
  - Smaller “footprints”
    - Allows for visualization between ribs
  - 2.5 MHz for above-average body size
  - 3.5 MHz for normal-sized adults
  - 5.0 MHz for children
Technical Considerations

- Orientation
  - Cardiology orientation is opposite that used for standard ultrasound
  - Screen oriented to left
  - Probe marker points to patient’s left
  - Therefore, in transverse plane, the screen will be oriented similar to standard ultrasound

- Trauma/abdominal orientation with screen marker and probe oriented to the patient right
  - Images will look the same; you will be holding the probe 180 degrees from the cardiology rotation
  - We will show both orientations. You decide how you want to perform
Technical Considerations

- Cardiac Orientation

  Screen marker pointed to left

  Probe marker pointed to patient’s left

  right

  anterior

  posterior

  left
Technical Considerations

- Abdominal/Trauma Orientation
  - Screen marker to the patient’s right
  - Probe oriented to the patient’s right
Technical Considerations

- Patient/Sonographer positioning
  - Patient is *usually* supine
    - May be placed in left lateral decubitus
  - Sonographer *may be* at patient’s left side
  - Transducer *may be* held in left hand
Technical Considerations

- “Standard” echocardiographic study
  - Subcostal
  - Parasternal long axis
  - Parasternal short axis
  - Apical four-chamber
Technical Considerations

“In the emergency department, where constraints of time and patient compliance may abbreviate the study, there is no such thing as a standard echocardiogram.”

Eric Snoey

Ultrasound in Emergency and Ambulatory Medicine
Primary Echocardiographic Axes

Long Axis

Short Axis
Primary Echocardiographic Axes

Coronal Axis
Subcostal Four-Chamber View

- Most consistently available view
- Away from neck and chest
- Patient may be supine or sitting
- Transducer in subxiphoid area very parallel to chest
- Probe aimed at left shoulder
  - May need to point to head to use left lobe of liver
- Marker
  - Cardiology Orientation = patient’s left
  - Abd/Trauma Orientation = patient’s right
Subcostal Four-Chamber View

- Frequently yields information regarding:
  - Cardiac function
  - Chamber size
  - Presence of pericardial fluid
  - Inferior vena cava
  - Interventricular septum
Subcostal Four-Chamber View
Subcostal Four-Chamber View

Emergency Cardiac Ultrasound - 7
Subcostal Four-Chamber View

Liver

RV

LV

RA

LA

anteriort

right

posterior

left

Emergency Cardiac Ultrasound - 7
Subcostal Four-Chamber View
Parasternal Long-Axis View

• Probe in the left second or third intercostal space
• Point the probe to
  • Cardiology Orientation = the right shoulder
  • Abd/Trauma orient = left hip
Parasternal Long-Axis View
Parasternal Long-Axis View
Parasternal Long-Axis View

Mitral Valve

Aortic Valve

Caudal or Apex

Cephalad or Base

posterior

anterior

Emergency Cardiac Ultrasound - 7
Parasternal Long-Axis View
Parasternal Long-Axis View
Parasternal Short-Axis View

- Same probe position as PSLA
- Point probe towards
  - Cardiology Orientation = left shoulder
  - Abd/Trauma orientation = right hip
Parasternal Short-Axis View
Parasternal Short-Axis View
Parasternal Short-Axis View

Mitral Valve

Anterior

Right

Posterior

Left

RV

LV

Emergency Cardiac Ultrasound - 7
Parasternal Short-Axis View
Parasternal Short-Axis View
Parasternal Short-Axis View

- RV (right ventricle)
- LV (left ventricle)
- Anterior
- Right
- Posterior
- Left
Parasternal Short-Axis View
Parasternal Short-Axis View
Parasternal Short-Axis View

Emergency Cardiac Ultrasound - 7
Parasternal Short-Axis View
Apical Four-Chamber View

- Probe at the PMI
- Direct probe at right shoulder
- Probe marker to
  - Cardiology orientation = the patient’s left axilla
  - Abd/Trauma orientation = right hip
Apical Four-Chamber View
Apical Four-Chamber View
Apical Four-Chamber View

- Tricuspid Valve
- Caudal or Apex
- Mitral Valve
- Cephalad or Base
- Right
- Left

Emergency Cardiac Ultrasound - 7
Apical Four-Chamber View
Technical Considerations

- Difficulty performing cardiac ultrasound
  - Obesity
  - Emphysema
  - Mechanical ventilation
  - Lack of patient cooperation
  - Presence of injuries to the chest wall
  - Ongoing procedures
Clinical Applications

Pericardial Disease
Pericardial Disease

- Often presents with limited symptomology
- Beck’s triad are late findings
- Ultrasound is the test of choice
Pericardial Effusion

- US appearance = Anechoic collection between the parietal and visceral pericardium
- Separation of usually opposed pericardial layers
- Ant and posterior pericardium must be visualized
- Echogenic effusions
  - Blood
  - Malignancy
  - Infection
Differential of Pericardial effusion

- Descending aorta
  - In PSL – circular structure with echogenic wall in sulcus between Left atrium and left ventricle
Differential of pericardial fluid - Peritoneal fluid

- In Subcostal view, subhepatic fluid may be seen next to diaphragm and pericardium
- Other potential false positives
  - Pericardial cysts
  - Aneurysmal disease of any cardiac chamber or aorta
  - Dilated Esophagus
Clinical Applications

Unexplained Hypotension
Unexplained Hypotension

- Echocardiography can provide assessment of:
  - Evidence of etiology of hypotension
  - Cardiac Function
  - Volume status
Cardiac Tamponade

- Pericardial Effusion (required)
- Signs of Tamponade
  - IVC and Hepatic veins dilated with no respiratory variation (elevated R sided Heart pressures)
  - Right ventricular diastolic collapse
  - Right atrial systolic collapse
  - D shaped septum flattening towards LV
  - Hyperdyamic LV
Cardiac Tamponade
Unexplained Hypotension

- Cardiogenic shock due to LV failure

- Emergency Physicians can accurately determine gross LV function in hypotensive patients

- US appearance
  - Dilated left ventricle
  - Hypocontractile
  - Lack of contraction
  - Lack of thickening towards the center of chamber
  - Differential
  - Cardiac ischemia
  - Valvular failure
  - Inotropic failure
  - Pacer failure
  - Drug related toxicity
Unexplained Hypotension

Cardiogenic shock due to LV failure
Unexplained Hypotension

- Volume-depleted heart
  - Small size
  - Near-complete ventricular emptying
  - Flat inferior vena cava
    - Exaggerated respiratory variation
- Differential includes
  - Volume depletion
  - Sepsis
  - Anaphylaxis
Unexplained Hypotension

- Right Ventricular Dilation
  - Dilated right ventricle (>0.5 diam of LV)
  - RV hypokinesis
  - Normal LV function
  - Enlarged, “stiff” IVC

- Differential
  - Massive Pulmonary Embolus
  - Echo does not play a prominent role in stable without right ventricular dilation.
  - Right Ventricular Infarction
  - Cor Pulmonale
  - Pulmonary Hypertension of other etiology
RV dilation
Unexplained Hypotension

- Other causes are difficult for the sonographer with limited training and equipment to identify but clues on grey-scale 2D echo include:

  - Acute valvular problems
  - Dilated chambers
  - Floating leaflets or chordina
  - Outflow tract obstruction
  - Septal hypertrophy or masses at the inflow, outflow, or valve
  - Septal rupture
  - Dilated Right ventricle
  - Cardiac rupture
  - Pericardial effusion
Clinical Applications

Arrhythmias
Arrhythmias

- Identification of PEA
- Identification of asystole
- Identification of ventricular fibrillation
- Documentation of capture during cardiac pacing
PEA

• Goal: differentiate
  • “pseudo-PEA” = true ventricular contraction
  • true PEA = no mechanical activity but electrical activity

• Pseudo-PEA is essentially an extreme hypotensive state
• Differential is same as Hypotension
  • Tamponade
  • Volume depletion
  • LV dysfunction
  • RV dysfunction
• US prognostic?
  • Blaivas et al
  • Salen et al
Asystole

- Lack of ventricular contractions
- US appearance
  - True “cardiac standstill”
  - Pooling of blood in cardiac chambers
  - Agonal valvular contractions
- US may be prognostic
  - Blaivas et al
  - Salen et al
Ventricular and atrial arrhythmias

- Ventricular fibrillation
  - Usually a ECG diagnosis
  - Asystole versus ventricular fibrillation can be identified
- Atrial arrhythmias
  - Can be helpful as adjunct
Torsades as seen on US
Clinical Applications

Penetrating Cardiac Trauma
Penetrating Cardiac Trauma

- Physician’s ability to assess is poor
- Beck’s Triad
  - Dependent on patient cardiovascular status
  - Late findings
Penetrating Cardiac Trauma

Emergency Department Echocardiography Improves Outcome in Penetrating Cardiac Injury


“Since the introduction of immediate ED two-dimensional echocardiography, the time to diagnosis of penetrating cardiac injury has decreased and both the survival rate and neurologic outcome of survivors has improved.”

Emergency Cardiac Ultrasound - 7
Penetrating Cardiac Trauma

- Factors of pericardial effusion that cause cardiac compression
  - Size of the effusion
  - Rate of formation
  - Consider repeating exam with repeat CXR in 6hrs
Penetrating Cardiac Trauma

- Echocardiographic signs of rising intrapericardial pressure
  - Collapse of RV free walls
  - Dilated IVC and hepatic veins
Cardiac Tamponade s
Summary

- Anatomy and orientation are confusing
- Primary applications for ED
  - Pericardial effusion
  - Hypotension
  - Cardiac arrest
  - Cardiac Trauma
Questions?