• Complications during central venous catheterization (CVC) occur 2% - 15% of the time in adults and can be severe\(^1\).

• *Shummer et al.*
  - 1794 cases, critical-care physicians
  - landmark techniques
    - 3.3% complication rate (10 cases pneumothorax/hemothorax and one stroke leading to death)

\(^1\)Domino KB, et al. Anesthesiology 2004;100:1411-8.
• ASA closed claims **13 deaths** from CVC insertion.

• Hemothorax from arterial injury & pneumothorax: major contributors to mortality\(^1\).

• 5 million CVCs are performed every year\(^2\) even low incidence (0.5%) of significant complications would result in 25,000 problems.

\(^1\)Bowdle TA. ASA Newsletter 2002;66.
• The Agency for Healthcare Research and Quality
  – US 1 of 11 practices to improve the patient safety and outcome*.

• 2003, a meta-analysis by Hind, 18 RCTs
  – favored US guidance vs landmark techniques
    – reduced failure rates
    – increased first-attempt success,
    – reduced complication rates and faster procedure time
      (P<0.0001)

Subclavian Vein Approach

- SV offers ideal size for central access.

- Close proximity to the lung, subclavian artery, and brachial plexus can lead to significant morbidity.

- Other challenges for accessing the SV with US are deeper location and the presence of the clavicle.
Femoral Vein Approach

• Baum et al reviewed 100 CT scans

  – FV and the femoral artery overlap in the anteroposterior plane 65% of the time¹.

• Same finding confirmed in US study in 50 ICU patients².

TRANSTHORACIC ECHOCARDIOGRAPHY
Possibilities with Bedside Ultrasound

- **Etiologies of Hemodynamic Decompensation**
  - Vasodilatory/Distributive Shock
  - Cardiogenic Shock
  - Heart Failure
  - Regional wall motion abnormalities

- **Monitor Resuscitation Efforts**
Limited TTE Exam Types

- **FATE** (Focus Assessed Transthoracic Echocardiography),
- **FEEL** (Focused Echocardiographic Evaluation in Life Support)
- **FEER** (Focused Echocardiographic Evaluation in Resuscitation Management),
- **RUSH** (Rapid Ultrasound for Shock and Hypotension),
- **CAUSE** (Cardiac Arrest Ultrasound Exam)
- **BLEEP** (Bedside Limited Echocardiography by Emergency Physician)
Our Exam (FATE)

• Three Anatomic windows

• Four “clock positions:”  10:00, 2:00, 3:00 12:00

• Five scanning views

• In the ideal patient!
Proper probe grasp
Probe Orientation
Parasternal Long Axis View

• Parasternal Long Axis

• Left Upper Sternal Border (3rd-4th interspace)
  – Probe Indicator pointed towards right shoulder (10:00)
Anatomic Correlate
Parasternal Short Axis View

- Parasternal Short Axis
- Left Upper Sternal Border (3rd-4th interspace)
  - Probe Indicator pointed towards left shoulder (2:00)
Anatomic Correlate
Apical View

• Point of Maximal Impulse (PMI)
• Anterior Axillary Line underneath breast
• Probe Orientation: 3:00
  (patient’s left flank)
Anatomic Correlate
Subcostal View

• Probe in subxiphoid region

• Probe orientation: 3:00

• Tilt parallel to back
Anatomic Correlate
IVC View

• Probe in **subxiphoid region**

• Obtain the subcostal view, then rotate the probe

• Probe orientation: **12:00**

• Tilt towards the back
Volume Responsiveness

• **Collapsibility Index** =

\[
\frac{[\text{IVC}_{\text{max}} \text{ (end exhalation)} - \text{IVC}_{\text{min}} \text{ (end inhalation)}]}{\text{IVC}_{\text{max}} \text{ (end exhalation)}} \times 100\%
\]

→ 50-75% or exhaled diameter < 1 cm suggestive of **hypovolemia**

• **Distensibility Index** =

\[
\frac{[\text{IVC}_{\text{max}} \text{ (end exhalation)} - \text{IVC}_{\text{min}} \text{ (end inhalation)}]}{\text{IVC}_{\text{Mean}}} \times 100\%
\]

→ 12% variation: volume responsiveness: 93% PPV; 92% NPV
GASTRIC, OPHTHALMIC, AND PULMONARY ULTRASOUND
Ultrasound for Gastric Content
Three outcomes should be assessed:
1-Identify if the stomach is empty or full
2-Identify if the contents is fluid or solid
3-Identify the volume of the content
3-VOLUME OF THE CONTENT (QUANTITATIVE)

- Mathematical models predict GV based on antral CSA.
  
  \[ \text{GV (ml)} = 27.0 + 14.6 \times \text{right-lateral CSA (cm}^2) - 1.28 \times \text{age (yr)} \]

- Predict volume up to 500 ml.

Optic nerve sheath Ultrasonography for monitoring intra cranial pressure

Optic nerve sheath is a continuation of duramater

Advantages:
- ICP changes transmitted within minutes
- Non-invasive
- No reported complications

Disadvantages:
- Not continuous
- Cannot quantitate CSF pressure
- Operator dependent
- Not widely accepted.
(b) Parasagittal imaging

Distance A-A': 3mm behind optic disc
Distance B-B': diameter of optic nerve sheath

Optic nerve sheath (between two arrows)
FDA approved ultrasound probe and machine for ocular ultrasonography

Requirements:
• Mechanical index < 0.23
• Thermal index < 1.0

Scan 1: longitudinal B-Scan
ONSD greater than 5.0 mm reliably predicts an ICP > 20 mm Hg
Normal Lung

Sliding Sign
Absence of lung-sliding and Comet-tail is 96.5% specific to pneumothorax.
Power slide

A-lines
Pneumothorax

“stratosphere sign” or “barcode sign”

Absent lung sliding and Comet-tail
Diaphragmatic Motion

- Rib cage
- Right lung
- Diaphragm dome
- Zone of apposition of the diaphragm
- Left lung
- Heart
- Abdomen
Neuromuscular Ultrasound for Evaluation of the Diaphragm, Aarti Sarwal et al.
Anterior Subcostal View

A

B

C

D

Liver

Diaphragm
Posterior subcostal view

Subxiphoid view