Waveform capnography assesses ventilation by monitoring exhaled carbon dioxide. 

**Basics of Waveform Capnography**

- **Overview**
  - Capnography measures ventilation through exhaled CO₂ (P̄ECO₂).
  - Abnormal morphology can provide important data regarding pulmonary pathophysiology.

- **Clinical Applications**
  - Confirmation of endotracheal intubation
  - Monitoring airway integrity
  - Monitoring cardiac output
  - Monitoring spontaneous respiration
  - Assessing for CO₂ retention
  - Assessing ROSC during CPR by observing a sudden increase in waveform amplitude.

- **ETCO₂ Waveform**
  - **α-Angle**
    - Between II and III
    - >90° = bronchospasm or V/Q mismatch
  - **β-Angle**
    - Between III and IV/0
    - >90° = rebreathing or mechanical obstruction

- **Phase I**
  - Inspiratory baseline
  - P̄ECO₂ = zero

- **Phase II**
  - Beginning of expiration
  - Transition as CO₂ rises when anatomical dead space, then alveolar gas, is exhaled

- **Phase III**
  - Alveolar plateau
  - ETCO₂
  - Peak CO₂ at end of phase III
  - Correlates with PaCO₂

- **Phase IV/0**
  - Start of inspiration
  - P̄ECO₂ rapidly falls to zero

- **Bronchospasm and Rebreathing/Air Trapping**
  - Increase or loss of α-angle (aka "shark fin")
  - Dead space has not finished emptying before next inspiration
  - Increasing level of baseline P̄ECO₂ due to air trapping

- **Emphysema**
  - Arterial CO₂ represented by early peak, not end-tidal, due to hypercompliance and poor gas exchange surface
  - Pattern can also be seen with pneumothorax with air leak

- **Sudden Loss of Waveform**
  - Critical event needing emergency intervention
  - ET tube disconnected, dislodged, kinked, or obstructed

- **Mechanical Airway Obstruction**
  - Fixed mechanical obstruction affects both inspiration (phase IV/0) & expiration (phase II)
  - α-angle and β-angle both >90°

- **Cardiogenic Oscillations**
  - Pulsation transmitted from the heart to the lung parenchyma produces small volume changes that manifest as oscillations
  - Sign of cardiomegaly

- **Downtrending ETCO₂**
  - Decreasing waveform size can indicate:
    - Shock/low cardiac output state
    - Pulmonary embolism
    - Hyperventilation