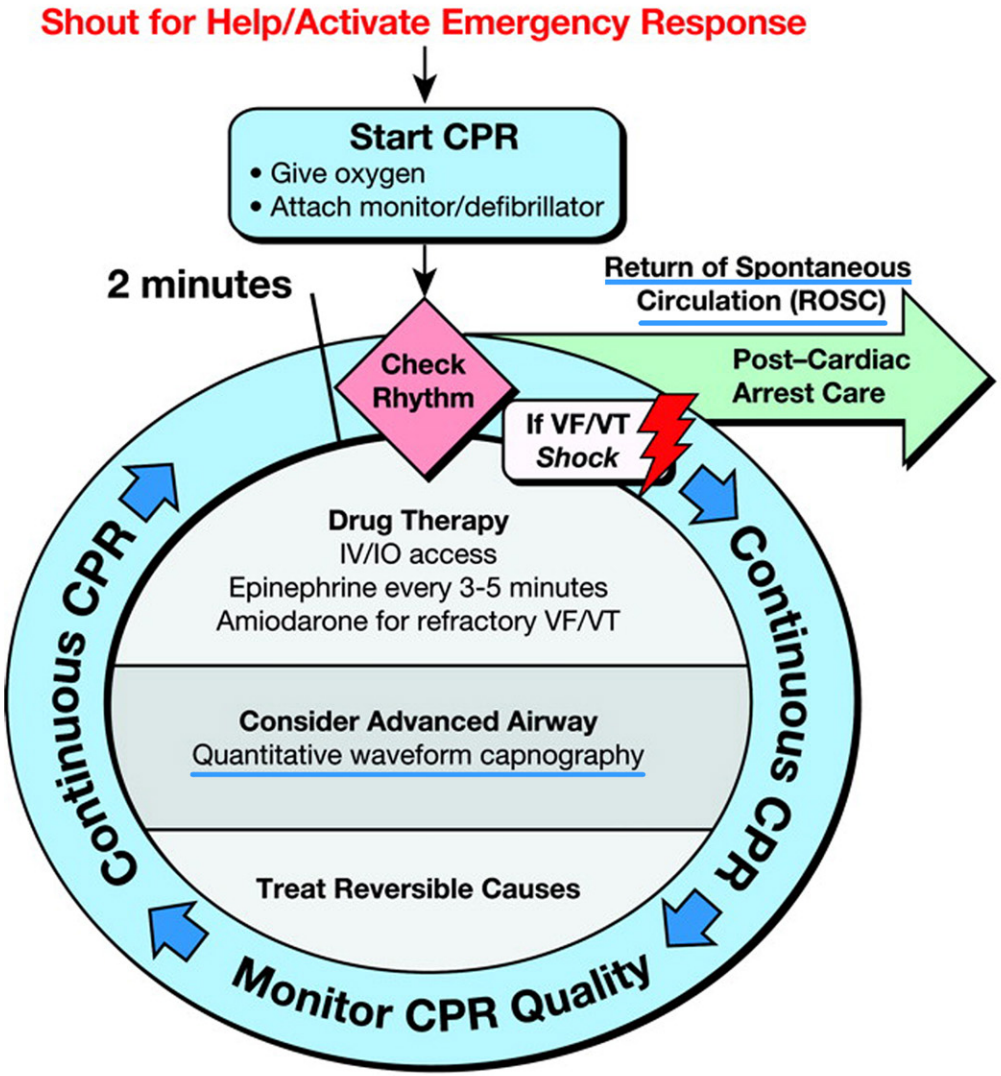
The Role of Quantitative Waveform Capnography

in the 2010 American Heart Association Guidelines for CPR and ECC

Adult Cardiac Arrest



CPR Quality

- Push hard (≥2 inches [5 cm]) and fast (≥100/min) and allow complete chest recoil
- Minimize interruptions in compressions
- Avoid excessive ventilation
- Rotate compressor every 2 minutes
- If no advanced airway, 30:2 compression-ventilation ratio
- Quantitative waveform capnography
  - If P_{ETCO_2} <10 mm Hg, attempt to improve CPR quality
- Intra-arterial pressure
  - If relaxation phase (diastolic) pressure <20 mm Hg, attempt to improve CPR quality

Return of Spontaneous Circulation (ROSC)

- Pulse and blood pressure
- Abrupt sustained increase in P_{ETCO_2} (typically ≥40 mm Hg)
- Spontaneous arterial pressure waves with intra-arterial monitoring

Shock Energy

- **Biphasic:** Manufacturer recommendation (eg, initial dose of 120-200 J); if unknown, use maximum available. Second and subsequent doses should be equivalent, and higher doses may be considered.
- **Monophasic:** 360 J

Drug Therapy

- **Epinephrine IV/IO Dose:** 1 mg every 3-5 minutes
- **Vasopressin IV/IO Dose:** 40 units can replace first or second dose of epinephrine
- **Amiodarone IV/IO Dose:** First dose: 300 mg bolus. Second dose: 150 mg.

Advanced Airway

- Supraglottic advanced airway or endotracheal intubation
- Waveform capnography to confirm and monitor ET tube placement
- 8-10 breaths per minute with continuous chest compressions

Reversible Causes

- **H**ypovolemia
- **H**ypoxia
- **H**ydrogen ion (acidosis)
- **H**ypo-/hyperkalemia
- **H**ypothermia
- **T**ension pneumothorax
- **T**amponade, cardiac
- **T**oxins
- **T**hrombosis, pulmonary
- **T**hrombosis, coronary

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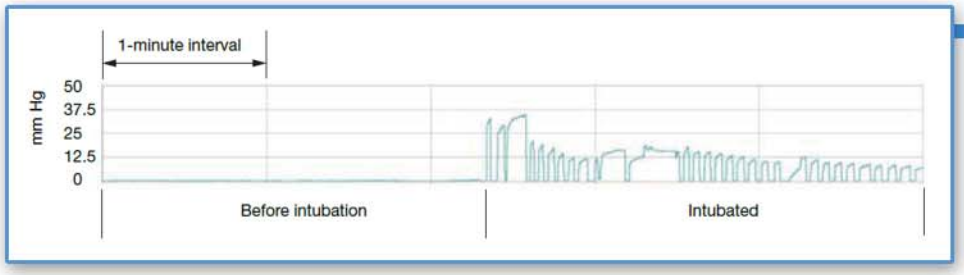

figure 1

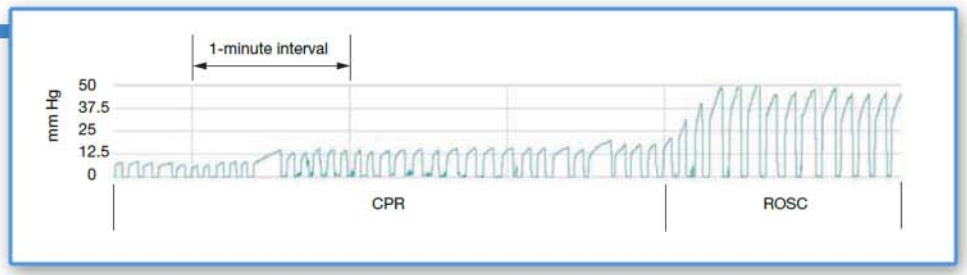

figure 2

Capnography to confirm endotracheal tube placement

This capnography tracing displays the partial pressure of exhaled carbon dioxide (Petco2) in mm Hg on the vertical axis over time when intubation is performed. Once the patient is intubated, exhaled carbon dioxide is detected, confirming tracheal tube placement. The Petco2 varies during the respiratory cycle, with highest values at end-expiration.

Capnography to monitor effectiveness of resuscitation efforts

This second capnography tracing displays the Petco2 in mm Hg on the vertical axis over time. This patient is intubated and receiving CPR. Note that the ventilation rate is approximately 8 to 10 breaths per minute. Chest compressions are given continuously at a rate of slightly faster than 100/min but are not visible with this tracing. The initial $Petco_2$ is less than 12.5 mm Hg during the first minute, indicating very low blood flow. The Petco2 increases to between 12.5 and 25 mm Hg during the second and third minutes, consistent with the increase in blood flow with ongoing resuscitation. Return of spontaneous circulation (ROSC) occurs during the fourth minute. ROSC is recognized by the abrupt increase in the $Petco_2$ (visible just after the fourth vertical line) to over 40 mm Hg, which is consistent with a substantial improvement in blood flow.

Advanced Cardiac Life Support (ACLS) Capnography Recommendation

2010 (New): Continuous quantitative waveform capnography is now recommended for intubated patients throughout the periarrest period. When quantitative waveform capnography is used for adults, applications now include recommendations for confirming tracheal tube placement and for monitoring CPR quality and detecting ROSC based on end-tidal carbon dioxide ($Petco_2$) values.

Why: Continuous waveform capnography is the most reliable method of confirming and monitoring correct placement of an endotracheal tube. Although other means of confirming endotracheal tube placement are available, they are not more reliable than continuous waveform capnography. Patients are at increased risk of endotracheal tube displacement during transport or transfer; providers should observe a persistent capnographic waveform with ventilation to confirm and monitor endotracheal tube placement.

Because blood must circulate through the lungs for CO2 to be exhaled and measured, capnography can also serve as a physiologic monitor of the effectiveness of chest compressions and to detect ROSC. Ineffective chest compressions (due to either patient characteristics or rescuer performance) are associated with a low Petco2. Falling cardiac output or rearrest in the patient with ROSC also causes a decrease in $Petco_2$. In contrast, ROSC may cause an abrupt increase in $Petco_2$. (figure 2)

Pediatric Advanced Life Support (PALS) Recommendations for Monitoring Exhaled CO_2

2010 (New): Exhaled CO_2 detection (capnography or colorimetry) is recommended in addition to clinical assessment to confirm tracheal tube position for neonates, infants, and children with a perfusing cardiac rhythm in all settings (eg, prehospital, ED, intensive care unit, ward, operating room) and during intrahospital or interhospital transport (figure 1). Continuous capnography or capnometry monitoring, if available, may be beneficial during CPR to help guide therapy, especially the effectiveness of chest compressions (figure 2).

Why: Exhaled CO_2 monitoring (capnography or colorimetry) generally confirms placement of the endotracheal tube in the airway and may more rapidly indicate endotracheal tube misplacement/displacement than monitoring of oxyhemoglobin saturation. Because patient transport increases the risk for tube displacement, continuous CO_2 monitoring is especially important at these times.

Animal and adult studies show a strong correlation between $Petco_2$ concentration and interventions that increase cardiac output during CPR. Petco2 values consistently <10 to 15 mm Hg suggest that efforts should be focused on improving chest compressions and making sure that ventilation is not excessive. An abrupt and sustained rise in Petco2 may be observed just before clinical identification of ROSC, so use of Petco2 monitoring may reduce the need to interrupt chest compressions for a pulse check.