LEVERAGING CAPNOGRAPHY FOR SAFER PATIENT CARE

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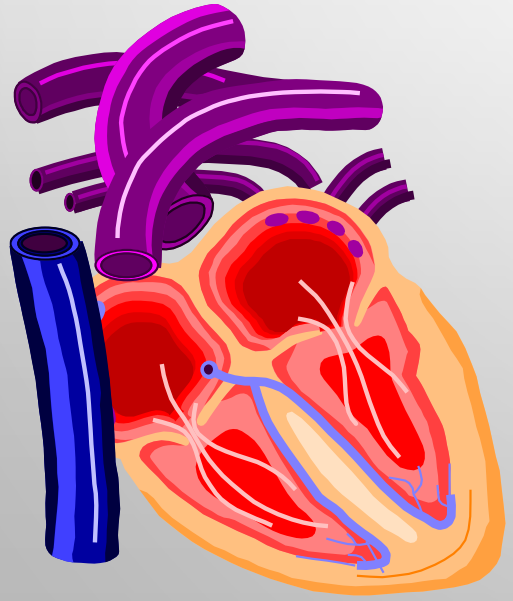
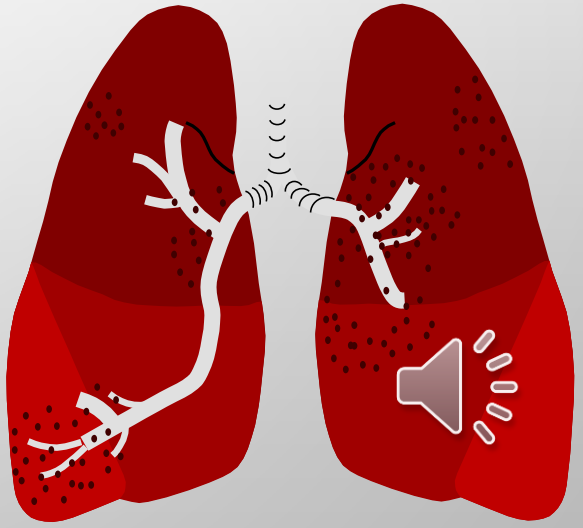
CO-OWNER, A & T LECTURES





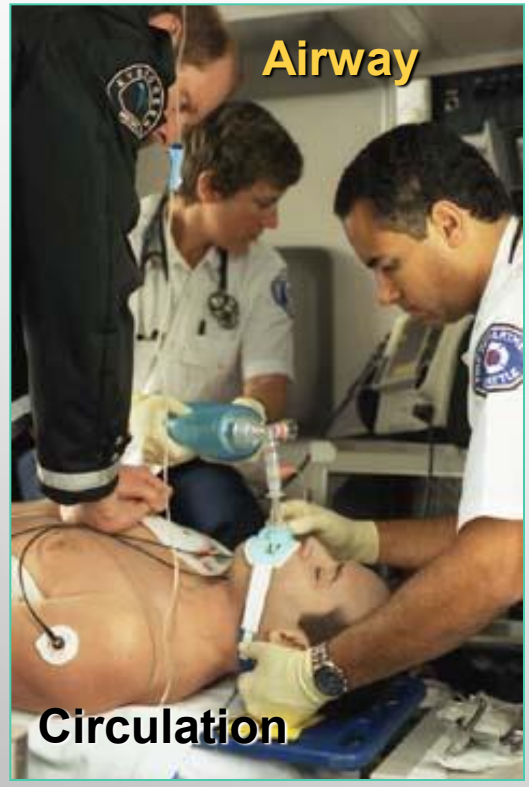
LEARNING OBJECTIVES--ETCO2

- OBJECTIVES
  - EXPLAIN INDICATIONS FOR ETCO2
  - DESCRIBE HOW CAPNOGRAPHY ENHANCES PATIENT SAFETY
  - ILLUSTRATE SOME OF THE EQUIPMENT
  - REVIEW RELATED RESEARCH
  - DEFINE WHAT IS A NORMAL ETCO2 VALUE
  - DEFINE WHAT ARE ABNORMAL VALUES/WAVES & THEIR CAUSES
  - IDENTIFY THE DIFFERENT WAVE FORMS
  - FURNISH ADD'L RESOURCES

RELATED TERMINOLOGY

- ***CAPNOGRAPHY***- ANALYSIS OF WAVEFORM (AND OFTEN NUMERIC VALUE) OF EXHALED CO2
- ***CAPNOMETRY***- MEASURING THE NUMERIC VALUE OF EXHALED CO2
- COLORMETRY – DICHOTOMOUS MEASUREMENT—PURPLE VERSUS YELLOW.
  - LESS RELIABLE THAN WAVEFORM!!!
    - IN CPR, IF NO CIRCULATION, LITTLE CO2 REACHING THE ALVEOLI = LITTLE COLOR CHANGE.
    - IF HIGH CO2, COLOR MAY STAY YELLOW AFTER INITIAL CHANGE

CAPNOGRAPHY-INDICATIONS

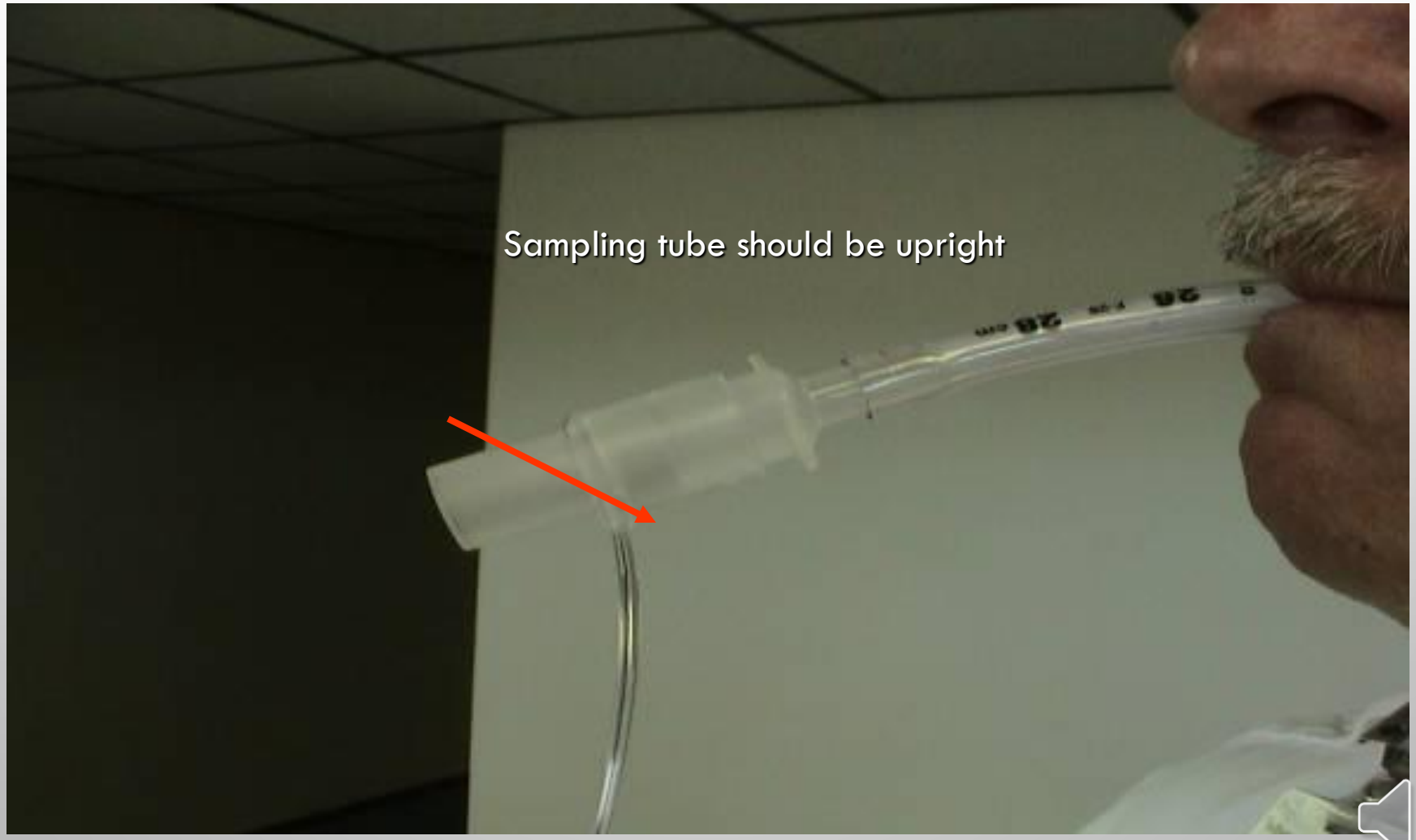


- VENTILATION-ADEQUACY OF VENTILATION & GAS EXCHANGE
- MONITORING MODERATELY SEDATED PATIENTS
- AIRWAY- VERIFICATION OF ET TUBE PLACEMENT
- *CIRCULATION*
  - CHECK EFFECTIVENESS OF CARDIAC COMPRESSIONS
  - MONITOR LOW PERFUSION STATES
- PREDICTOR OF MORTALITY IN ALI/ARDS?

EQUIPMENT--COLORMETRIC DETECTOR

COMBO CANNULA -- O2 ADMINISTRATION AND ETCO2 MONITORING

LOFLO® AIRWAY ADAPTER KIT



A *NEWER* INDICATION- CAPNOGRAPHY IN CPR

- ASSESS CHEST COMPRESSIONS
- EARLY DETECTION OF ROSC
- OBJECTIVE DATA FOR DECISION TO CEASE RESUSCITATION

ETCO2 & CPR-SOME DATA

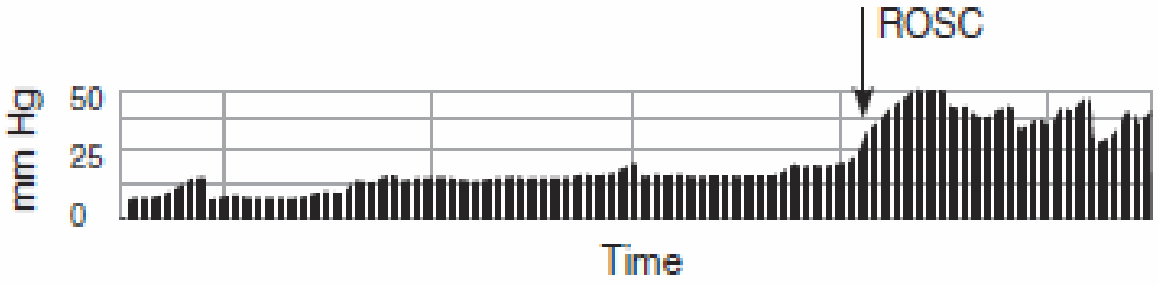
- SANDERS, ET AL, JAMA, 1989- ETCO2 CORRELATES TO OUTCOMES IN CPR.
- A 2005 STUDY COMPARING INTUBATIONS THAT USED CAPNOGRAPHY TO CONFIRM ETT PLACEMENT VS. NON-CAPNOGRAPHY USE SHOWED A 0% UNRECOGNIZED MISPLACED ETT AND 23% IN THE NON-ETCO2 MONITORED GROUP
- ***CONFIRM ETT PLACEMENT WITH WAVEFORM CAPNOGRAPHY!!***

STILL MORE DATA- ETCO2 & CPR QUALITY

- CPR QUALITY:
  - BAD CPR = ETCO2 <15
  - GOOD CPR = ETCO2 >15
- ROSC = ETCO2 INCREASES
  - SUDDENLY BY 15
  - ETCO2 = 35 - 40

GRAPHIC DEPICTION OF ROSC

Figure 6. Capnogram Trend Indicating Return Of Spontaneous Circulation



During cardiopulmonary resuscitation, an abrupt rise in $ETCO_2$ to normal or greater-than-normal levels indicates improved cardiac output and ROSC.

THE OTHER *MAJOR* INDICATION- MONITORING VENTILATION

- SPONTANEOUS BREATHING PATIENTS
  - NEUROMUSCULAR
  - COPD
- MECHANICALLY VENTILATED PATIENTS
  - CONTINUOUS NONINVASIVE
  - APPROPRIATENESS OF SETTINGS
  - WEANABILITY

THE NUMBERS--NORMAL VALUES

- NORMAL VALUES
  - NORMAL RANGE 7.35 TO 7.45
  - NORMAL ETCO2 IS 30-43MMHG
  - NORMAL PACO2 IS 35-45MMHG

ABNORMAL VALUES--ETCO2

- ABNORMAL VALUES
  - ACIDOSIS
    - PH < 7.35
    - PACO2 > 45
    - ETCO2 > 43
  - ALKALOSIS
    - PH > 7.45
    - PACO2 < 35
    - ETCO2 < 30

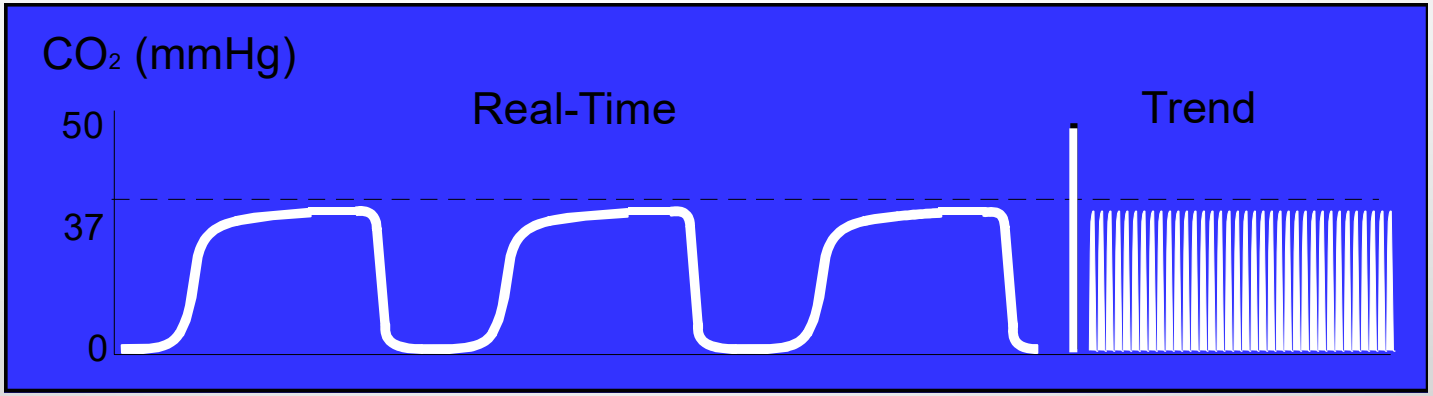
OUR RESPONSE TO ABNORMAL ETCO2

- HOW DO WE STABILIZE ABNORMAL ETCO2 VALUES?
  - BY ADJUSTING MINUTE VENTILATION
    - IF ETCO2 IS HIGH - ↑ **V**ENTILATION
    - IF ETCO2 IS LOW - ↓ **V**ENTILATION

WHEN TO ADJUST VT VS. RATE?

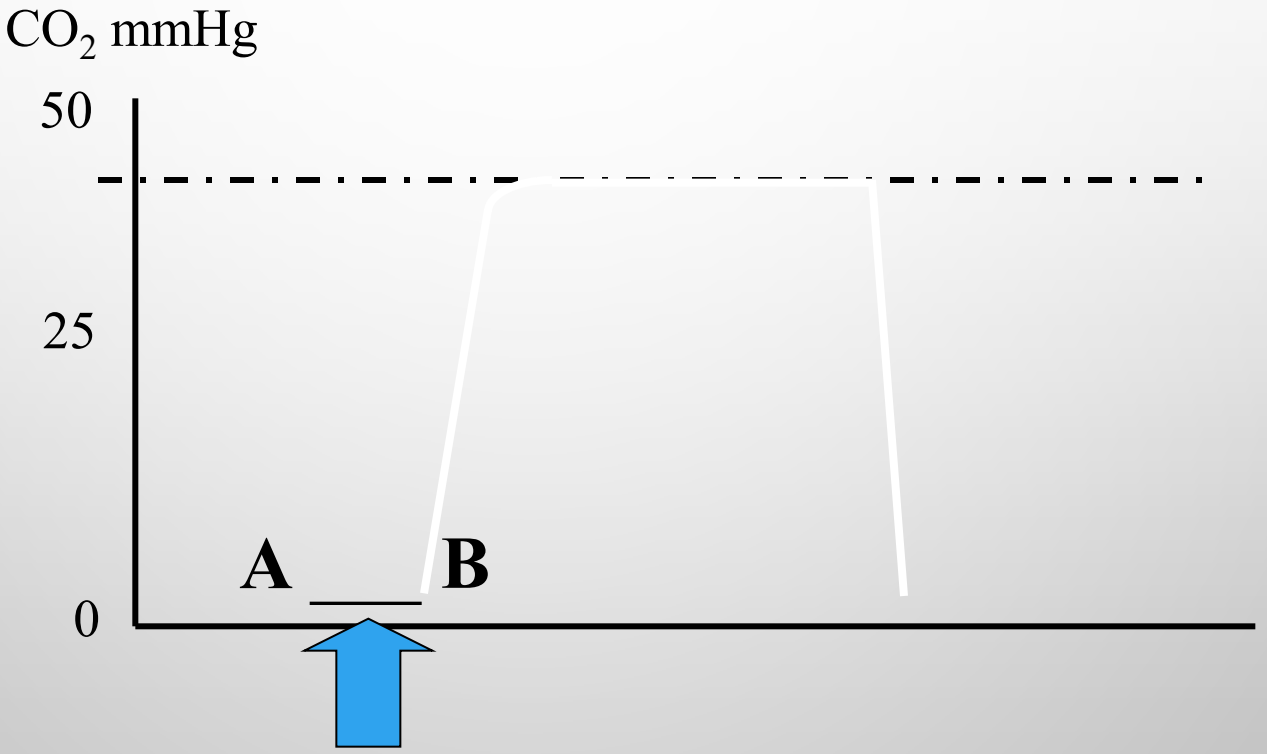
- HOW DO WE DECIDE TO FOCUS ON VT OR RR?
  - EXAMINE CURRENT VT, RELATIVE TO RECOMMENDED 5-8 ML / KG.
    - EXAMPLE: IF SEEKING TO DECREASE ETCO2, AND VT IS CURRENTLY AT/NEAR 4-5 MLS / KG, CONSIDER INCREASING VT.
  - EXAMINE CURRENT RR, RELATIVE TO VARIABLES SUCH AS NORMAL RANGE (8-30), I:E RATIO, EVIDENCE OF AUTO-PEEP.

EXAMPLE: NORMAL CAPNOGRAM



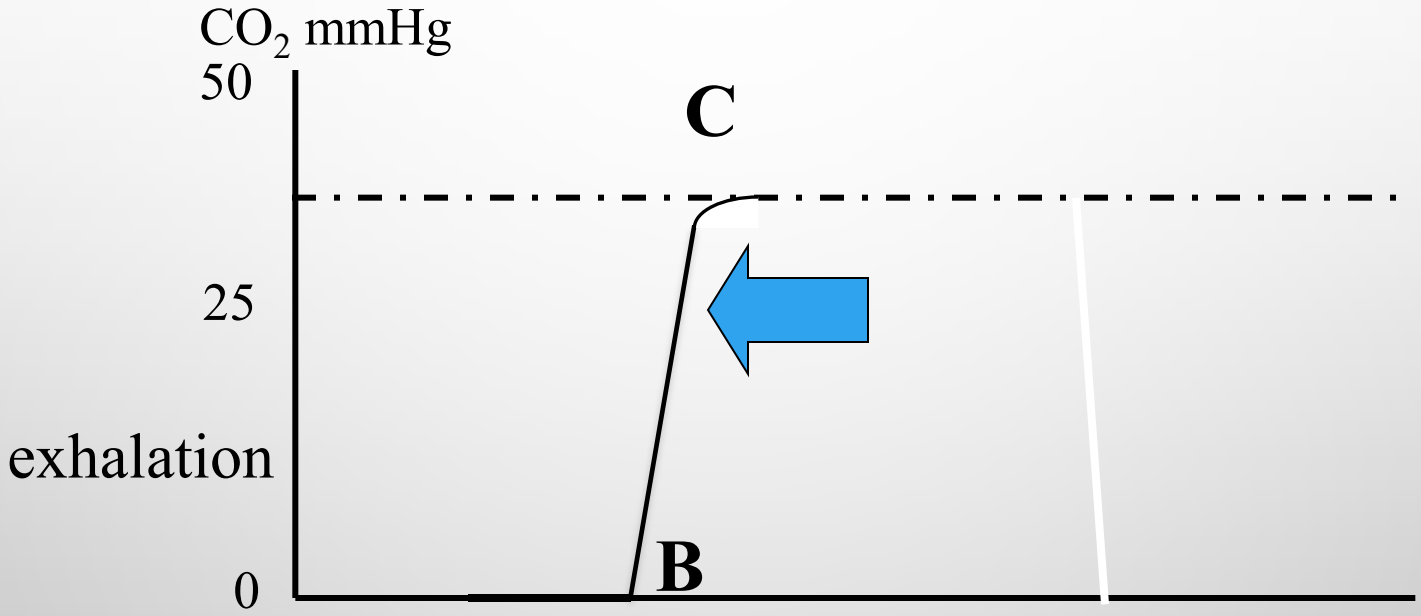
Normal capnogram, stable trend
$ETCO_2$/PaCO2 gradient 4 mmHg

NORMAL CAPNOGRAM - PHASE I



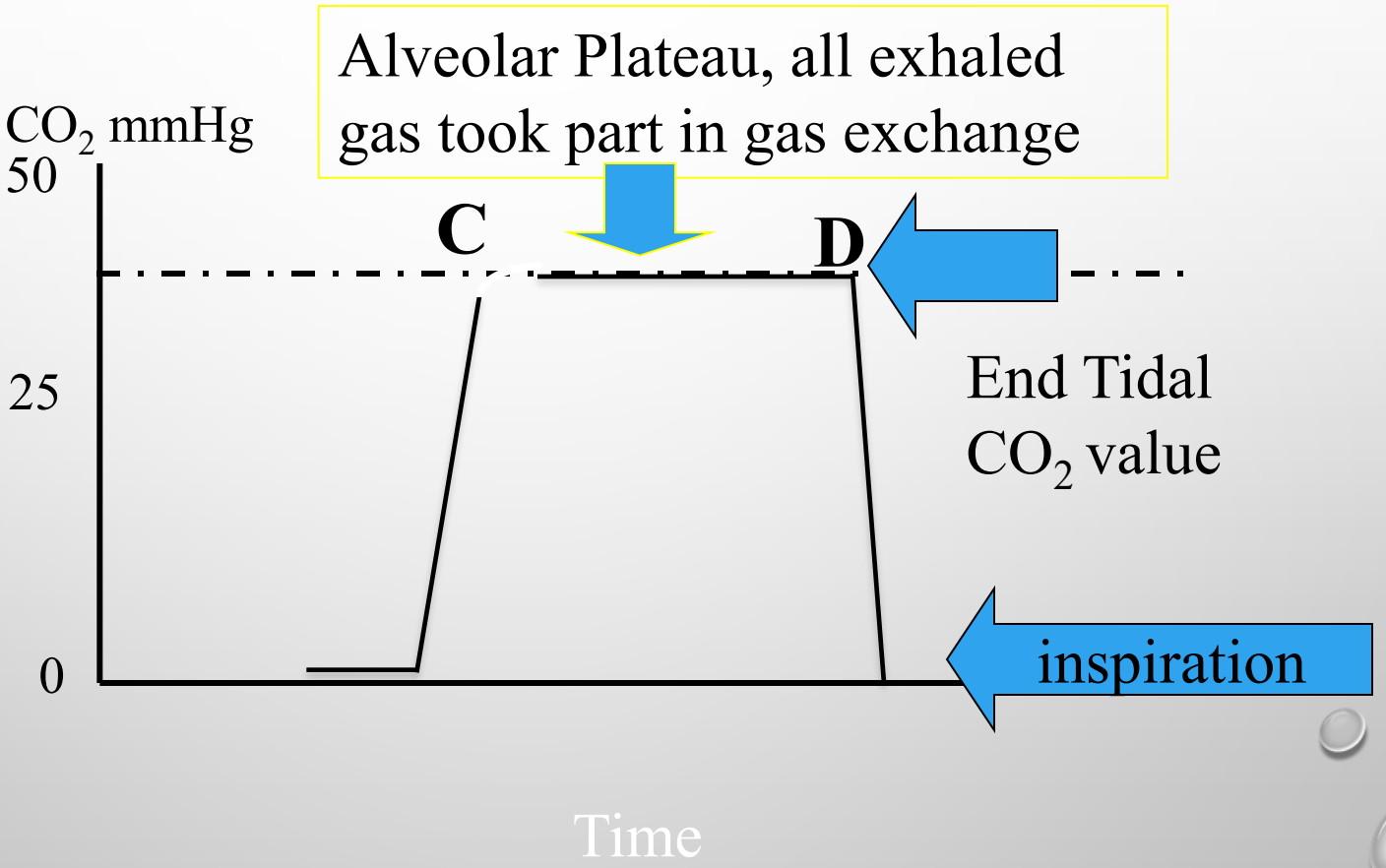
Beginning of expiration = anatomical deadspace with no measurable CO_2

NORMAL CAPNOGRAM - PHASE II



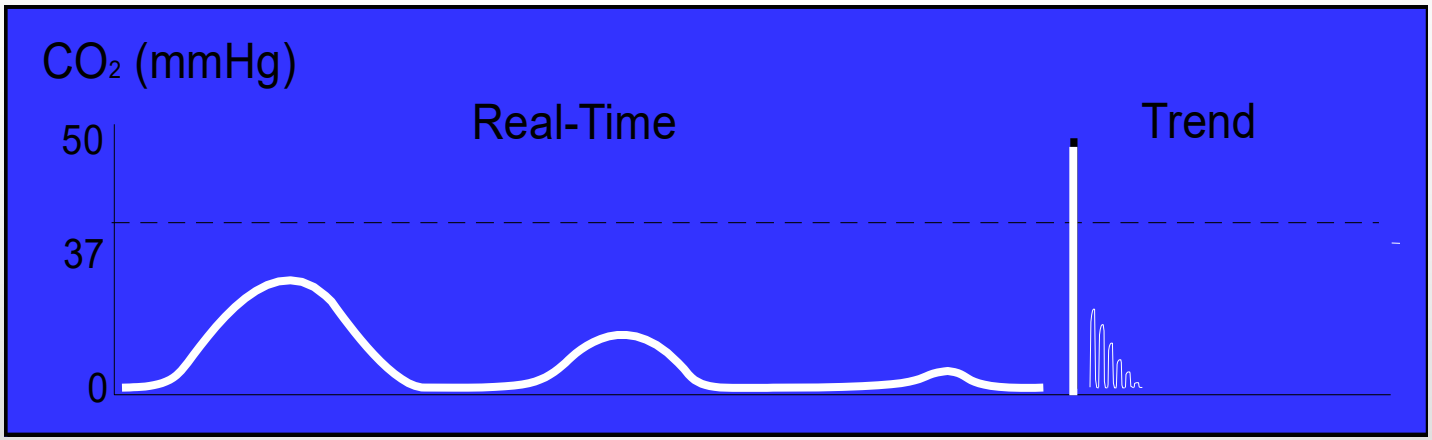
Mixed CO_2, rapid rise in CO_2 concentration

NORMAL CAPNOGRAM - PHASES III & IV



ABNORMAL CAPNOGRAPH WAVES

ENDOTRACHEAL TUBE IN ESOPHAGUS

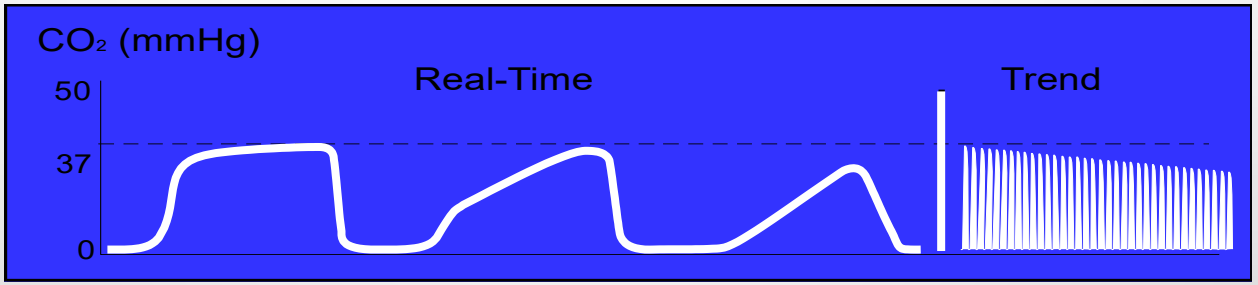


Possible Causes:

- Missed intubation
  - When the ET tube is in the esophagus, little or no CO2 is present
  - A normal capnogram is the best indication of proper ET tube placement

ABNORMAL CAPNOGRAPH WAVES

OBSTRUCTION IN AIRWAY OR BREATHING CIRCUIT

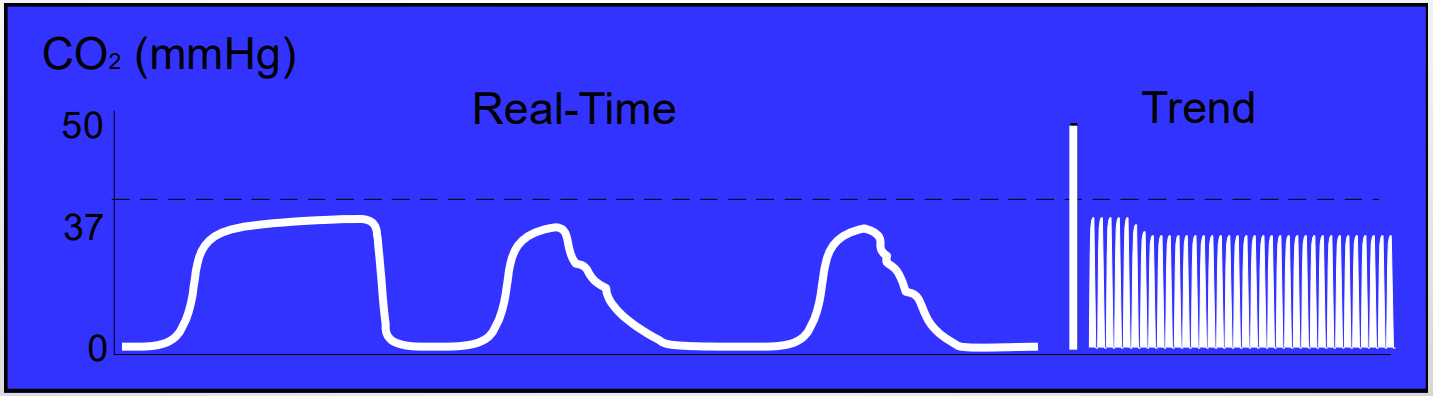


Possible Causes:

- Partially kinked or narrowed artificial airway
- Presence of foreign body in the airway
- Obstruction in expiratory limb of breathing circuit
- Bronchospasm

ABNORMAL CAPNOGRAPH WAVES

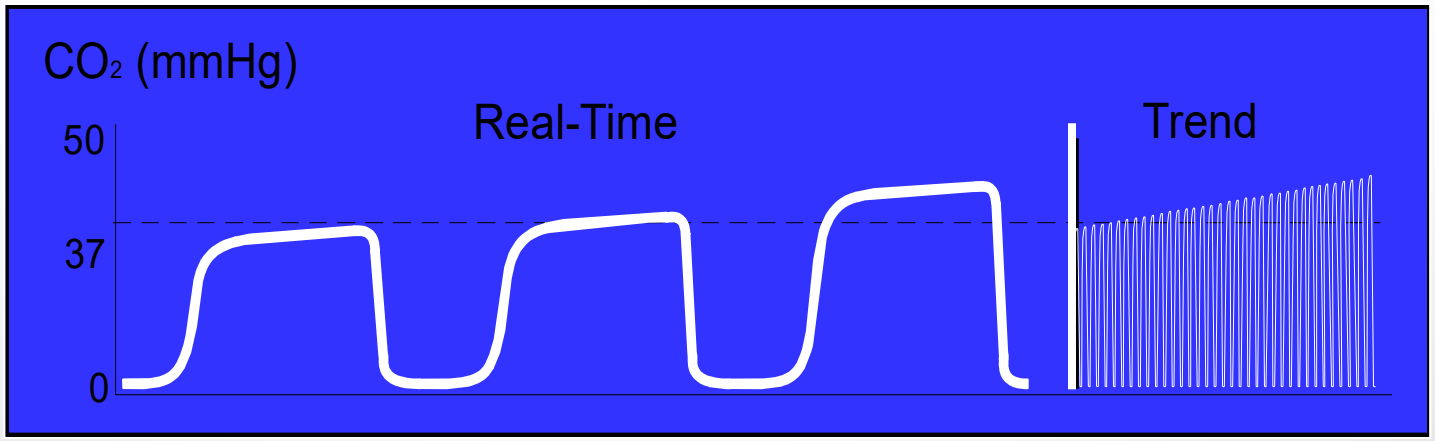
INADEQUATE SEAL AROUND ET TUBE



Possible Causes:

- Leaky or uncuffed endotracheal or trach tube
- Artificial airway that is too small for patient

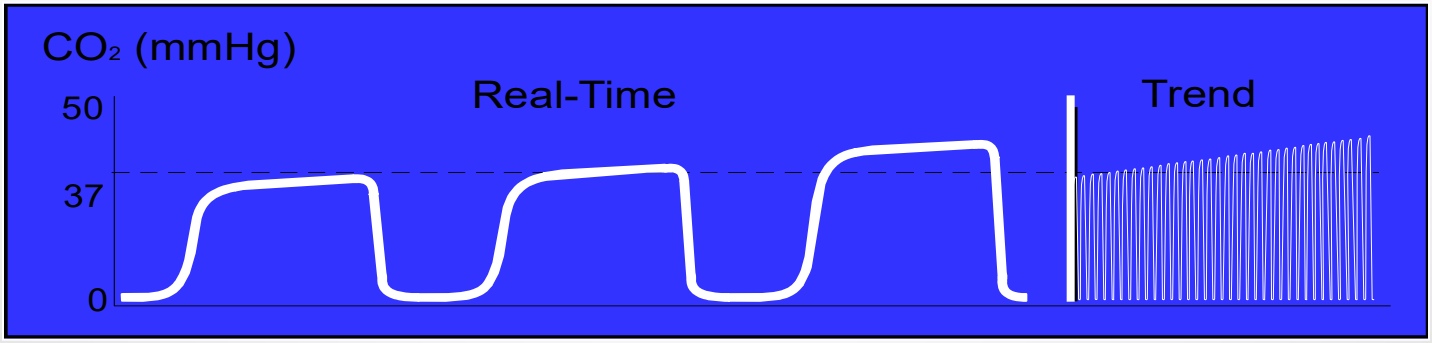
ABNORMAL CAPNOGRAPH



Possible Causes:

- **Decrease in minute ventilation**
- **Increase in metabolic rate**
- **Rapid rise in body temperature**
- Less Common:
  - Absorption of insufflated CO2 from laparoscopy
  - Release of a tourniquet from a surgical limb

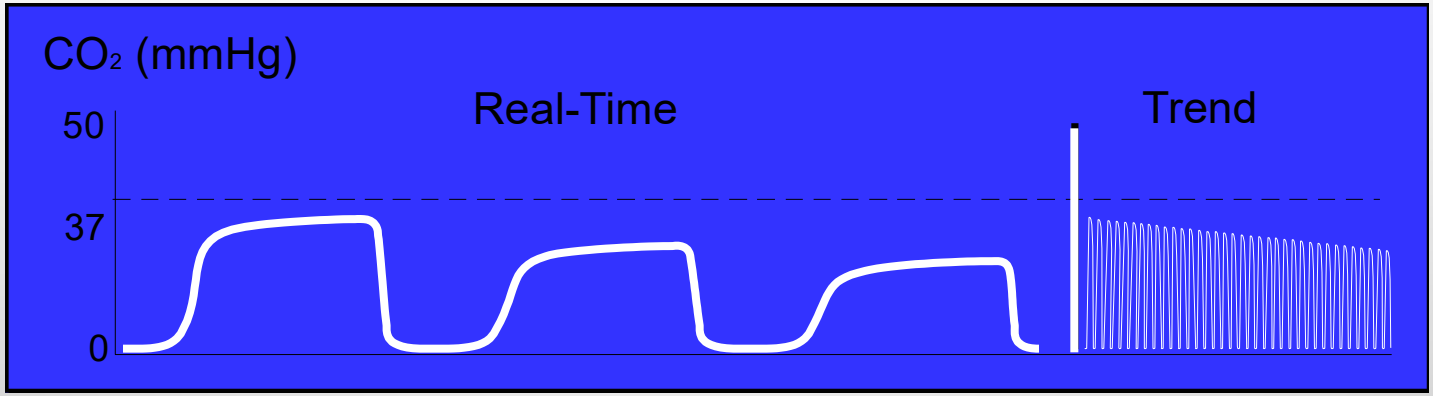
COMMON EXAMPLE: HYPOVENTILATION



- PT. RECEIVES 5MG MS FOR PAIN
- ETCO2 CLIMBS FROM 37 MMHG TO 45 MMHG

ABNORMAL CAPNOGRAPH WAVES

HYPERVENTILATION - DECREASE IN $ETCO_2$



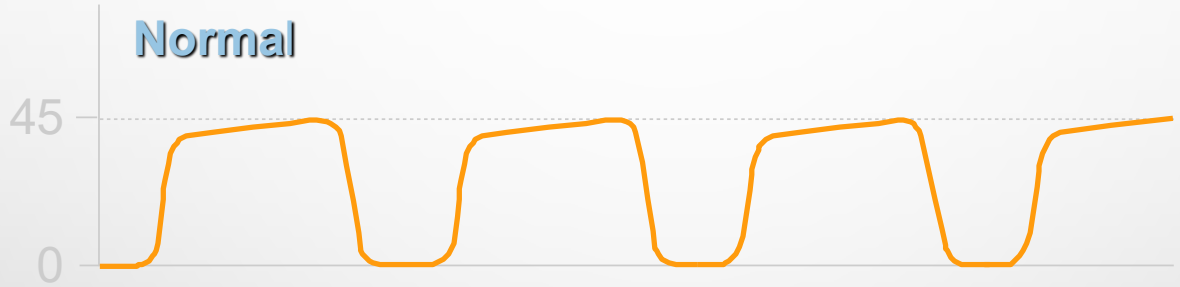
Possible Causes:

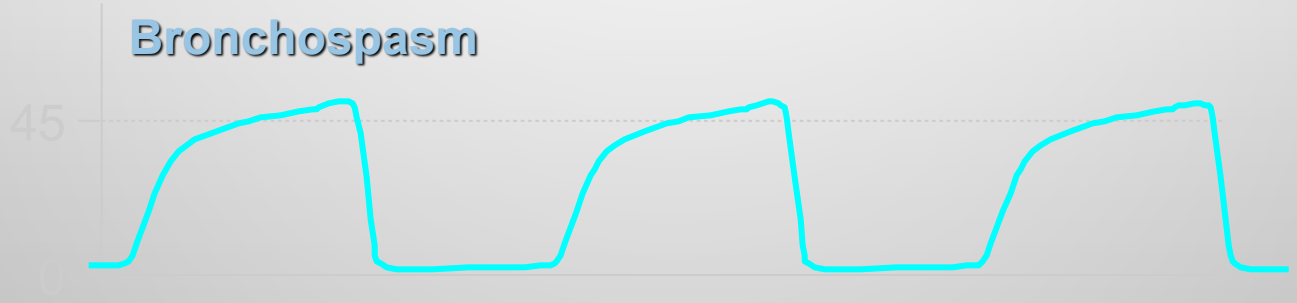
- Increase in respiratory rate
- Increase in tidal volume
- Decrease in metabolic rate
- Fall in body temperature

BRONCHOSPASM WAVEFORM PATTERN

- BRONCHOSPASM HAMPERS VENTILATION
  - ALVEOLI UNEVENLY FILLED ON INSPIRATION
  - EMPTY ASYNCHRONOUSLY DURING EXPIRATION
  - ASYNCHRONOUS AIR FLOW ON EXHALATION DILUTES EXHALED CO_2
- ALTERS THE ASCENDING PHASE AND PLATEAU
  - SLOWER RISE IN CO_2 CONCENTRATION
  - CHARACTERISTIC PATTERN FOR BRONCHOSPASM
  - “SHARK FIN” SHAPE TO WAVEFORM

CAPNOGRAPHY WAVEFORM PATTERNS





CAUSES OF AN ELEVATED ETCO2

- **METABOLISM**
  - MALIGNANT HYPERTHERMIA
- **CIRCULATORY SYSTEM**
  - INCREASED CARDIAC OUTPUT - WITH CONSTANT VENTILATION
- **RESPIRATORY SYSTEM**
  - RESPIRATORY FAILURE
  - RESPIRATORY DEPRESSION
  - OVERDOSE / SEDATION
  - OBSTRUCTIVE LUNG DISEASE
- **EQUIPMENT**
  - DEFECTIVE EXHALATION VALVE

CAUSES OF A DECREASED $ETCO_2$

- **METABOLISM**
  - PAIN
  - ANXIETY
- **CIRCULATORY SYSTEM**
  - CARDIAC ARREST
  - EMBOLISM
  - SUDDEN HYPOVOLEMIA OR HYPOTENSION
- **RESPIRATORY SYSTEM**
  - ALVEOLAR HYPERVENTILATION

EQUIPMENT

- LEAK IN AIRWAY SYSTEM
- PARTIAL AIRWAY OBSTRUCTION
- ETT IN HYPOPHARYNX

SUMMARY

- CAPNOGRAPHY CAN BE A USEFUL ASSESSMENT TOOL
- UNDERSTAND THAT IT IS A RELATIVELY STRAIGHT FORWARD, BUT VALUABLE TOOL—A LITTLE KNOWLEDGE CAN GO A LONG WAY!!!
- KNOW THE INDICATIONS & LIMITATIONS
- RECOGNIZE NORMAL WAVE FORMS/VALUES, THE ABNORMALS AND HOW TO RECTIFY THEM
- KNOW WHERE THERE ARE ADD'L RESOURCES

SELECTED REFERENCES

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