Capnography - The most vital of vital signs

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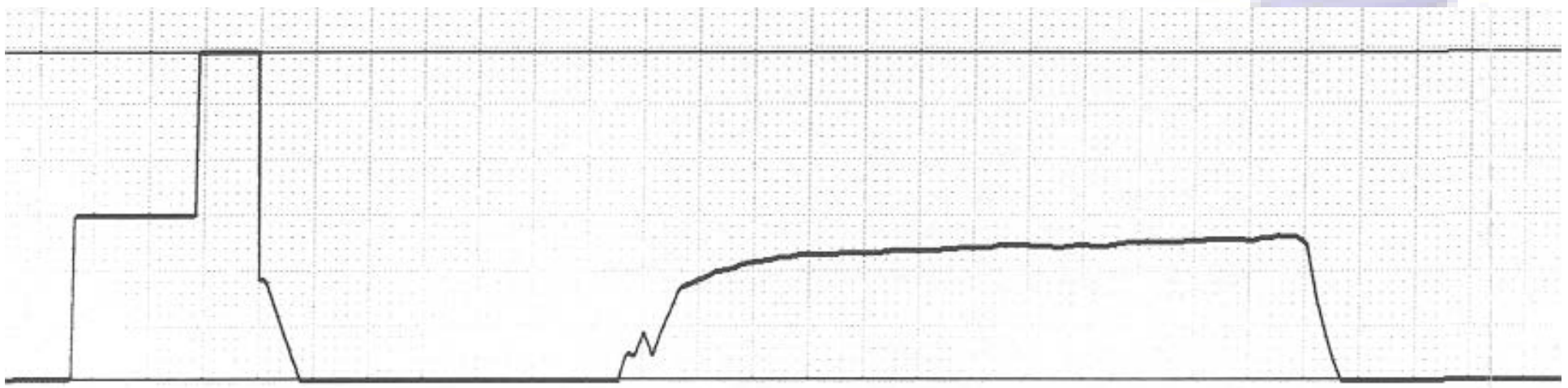
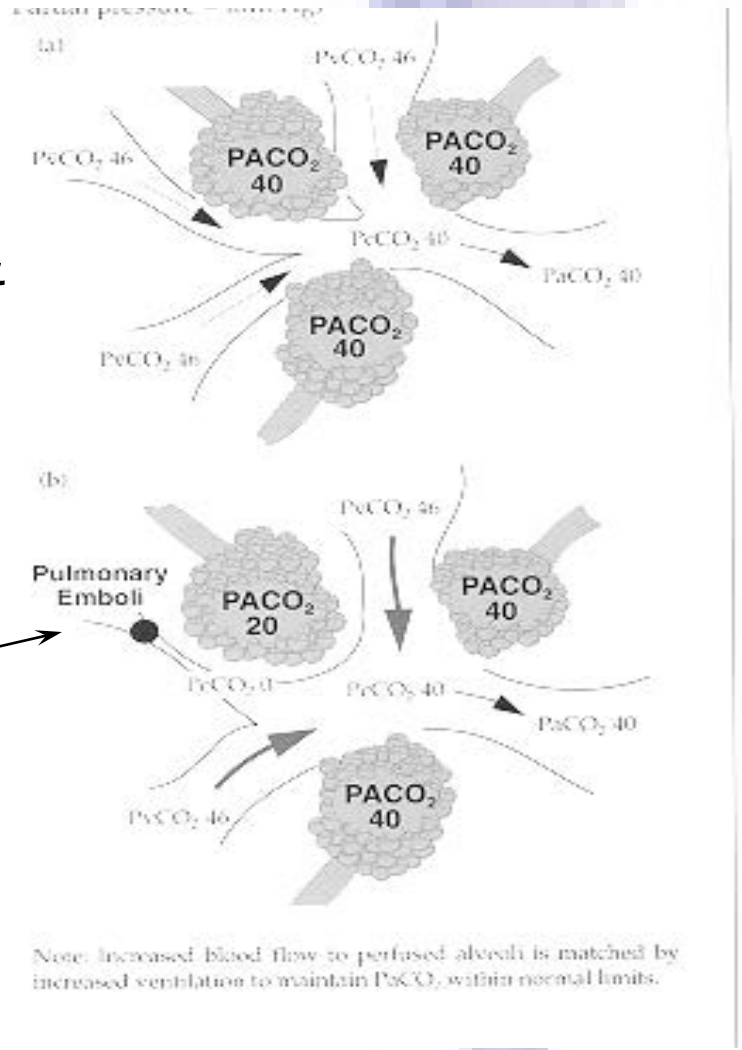
Capnography: The Newest Vital Sign

- Has been called the 15 second triage tool
- The newest vital sign
- Its value lies in very simple application
  - Advanced use requires in depth understanding of ventilation and perfusion



How Capnography Reflects Ventilation and Perfusion

Normal Ventilation & Perfusion

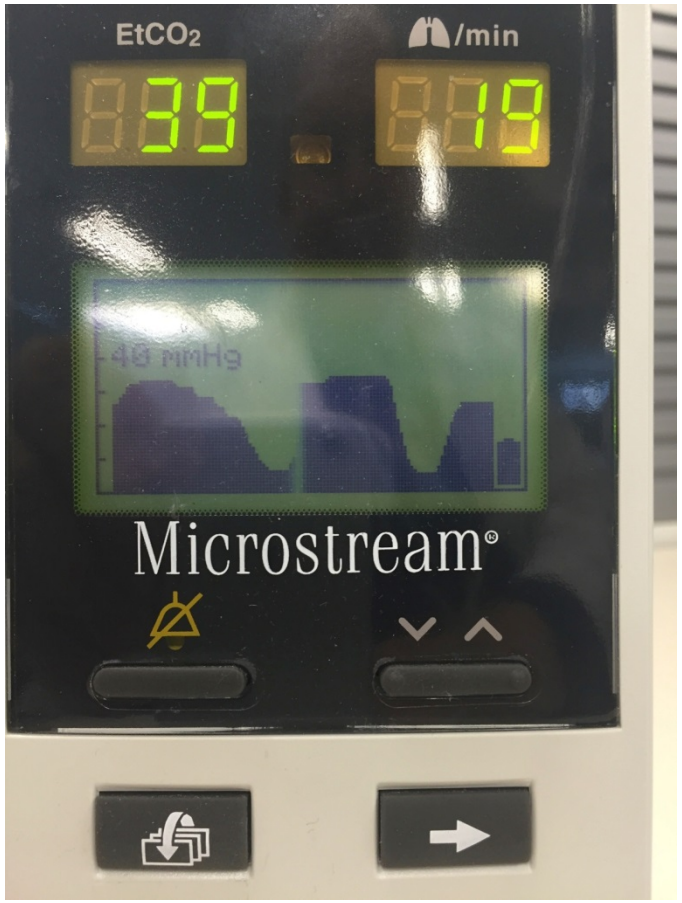


Reduced blood flow decreases alveolar CO2. This decrease is detected in the exhaled breath by capnography.

Key Uses of Capnography

- If PetCO2 increases, ventilation is threatened and airway protection may be needed.
- If PetCO2 suddenly falls to zero, airway is lost, breathing may have stopped, or the sensor is malpositioned.
- If PetCO2 suddenly falls (without a change in Ve), the loss of cardiac output is likely.

Methods for Measuring Exhaled CO2 - Capnography

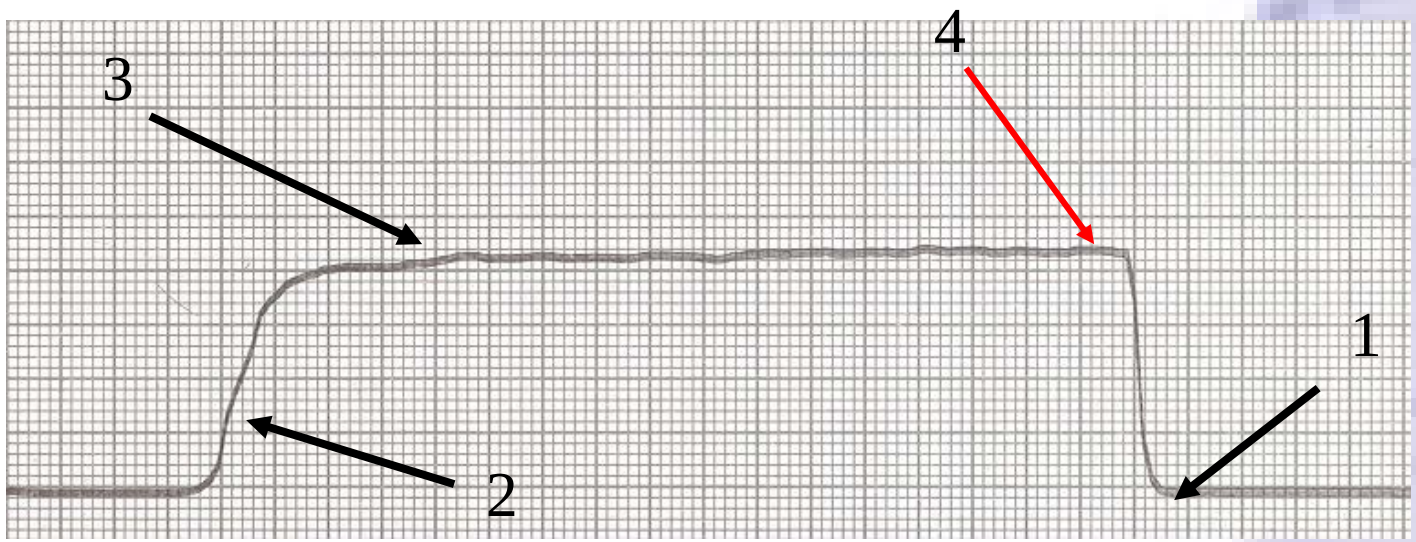


Hand held side stream capnogram

Bedside monitor mainstream capnogram

Handheld, Nasal Cannula

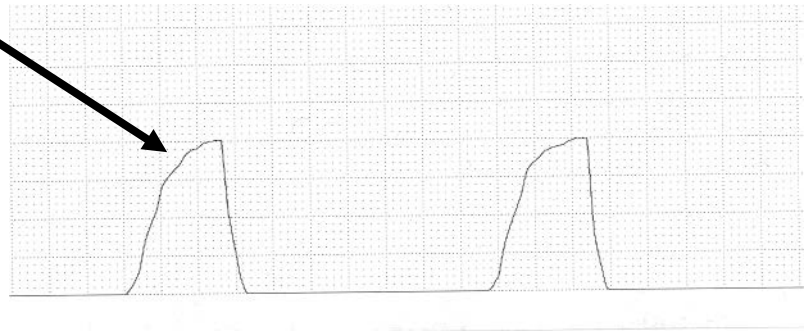
Capnography reflects CO2 when exhaled from the lungs



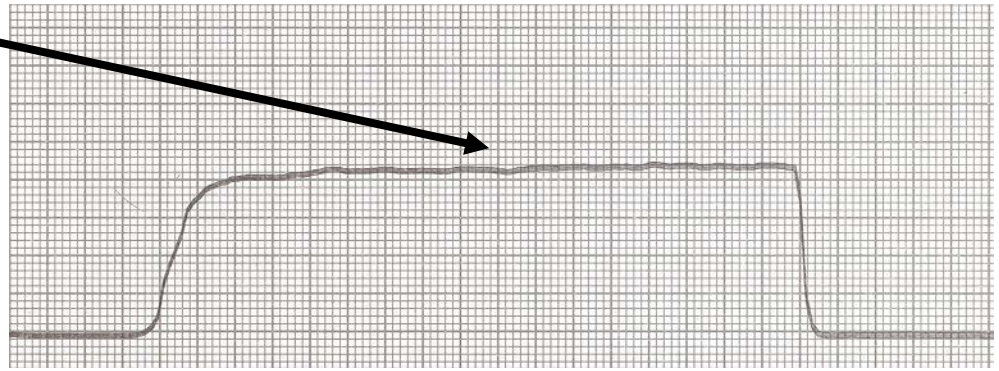
- At the end of exhalation, called the end tidal CO2 or PetCO2 for pressure of CO2 at end tidal breathing, the exhaled CO2 is reflecting alveolar CO2. Normally, the PetCO2 value is 1-5 mm Hg below the arterial (or alveolar) CO2 level.

Identifying Adequate CO2 Emptying Pattern

Incomplete exhaled CO2 pattern



Adequate plateau phase indicating good alveolar emptying



Clinical Application Assessing Adequacy of Ventilation

If PetCO2 increases, ventilation is threatened and airway protection may be needed.

A rise in the PetCO2 of > 5 mm Hg is abnormal. Action may be needed.

A rise in the PetCO2 of > 10 mm Hg needs support of breathing and/or reversal of analgesia/sedation.

Deitch K, Miner J, Chudnofsky CR, Dominici P, Latta D. Does end tidal CO2 monitoring during emergency department procedural sedation and analgesia with propofol decrease the incidence of hypoxic events? A randomized, controlled trial. Ann Emerg Med. 2010 Mar;55(3):258-64.

Ventilation Assessment

- The main reason for a PetCO2 value to increase is reduced alveolar ventilation.
  - Obtaining a blood gas can confirm this possibility.
- During sedation, weaning from ventilation or managing reactive airway patients, the PetCO2 is the first indication of danger.
  - If the PetCO2 increases by 10 mm Hg, airway protection should be implemented .
  - If sedation or analgesia is being administered, stop the infusion until the PetCO2 returns to near baseline.
    - Monitoring patient simultaneously for comfort and awareness

Limited Role of Pulse Oximetry in Assessing Ventilation

- Normal SaO_2 determined by PaO_2
- If patient hypoventilates, $PaCO_2$ increases and will drive PaO_2 downward in direct proportion to $PaCO_2$ increase
  - If $PaCO_2$ increases by 10, PaO_2 will decrease by 10
  - If PaO_2 is 90, will decrease to 80 mm Hg
    - SaO_2 will decrease from 98 to 97.
- Oximeter is not sensitive to rises in $PaCO_2$
- When oxygen therapy is added or increased, rise in $PaCO_2$ is completely obscured

Case Example of Limited Role of Oximetry in Hypoventilation

PaO_2	95	80	99
SpO_2	.98	.96	.98
FIO_2	RA	RA	.30
$PetCO_2$	39	54	60
pH	7.38	7.25	7.23

Case 1

A 56 year old man admitted to the outpatient procedure area for a follow-up colonoscopy. The patient had a colonoscopy 3 years earlier where a pre cancerous polyp was removed. During the last colonoscopy, the patient required above normal amounts of sedation and had a prolonged post procedure recovery. During this procedure, the physician elects to use Propofol instead of Midazolam due to it's more rapid elimination and shorter recovery time. Since Propofol can suppress respiration as well, the physician elects to use capnography to monitor the patient. The capnography is to be measured by a nasal cannula, sidestream method. Twenty minutes into the procedure, you note the PetCO2 listed below. What would your actions be based on this information?

Admission	72	12	132/72	100	37
5 minutes into procedure	76	10	128/70	100	42
20 minutes into procedure	73	10	134/78	100	48

Case 2

A 76 year old female is being weaned from mechanical ventilation. He has a mainstream CO2 analyzer in his ventilator circuit. Fifteen minutes into the weaning attempt, the following information is available. Based on this information, what would you do?

	P	RR	BP	SpO2	PetCO2
0730 (weaning initiated)	71	15	130/86	98	35
0745	82	19	128/88	97	51

Case 3

A 73 year old man is on your unit with the diagnosis of CHF and COPD. He has been improving and is expected to be discharged tomorrow. He is on oxygen therapy at 4 LPM and is simultaneously be monitored by capnography via the nasal cannula, sidestream method. At 0300, you hear the CO2 alarm and go into investigate. He is difficult to arouse. The following information is available to you. What would your actions be based on this information?

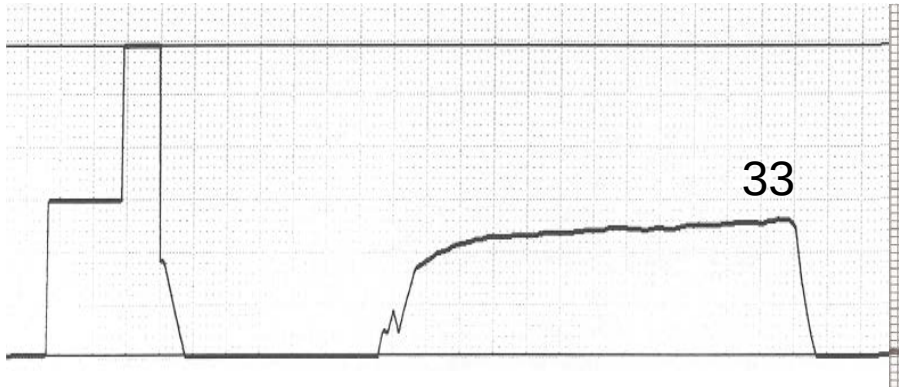
0100	87	14	138/82	95	31
0200	79	10	134/84	97	33
0300	83	10	138/78	95	59

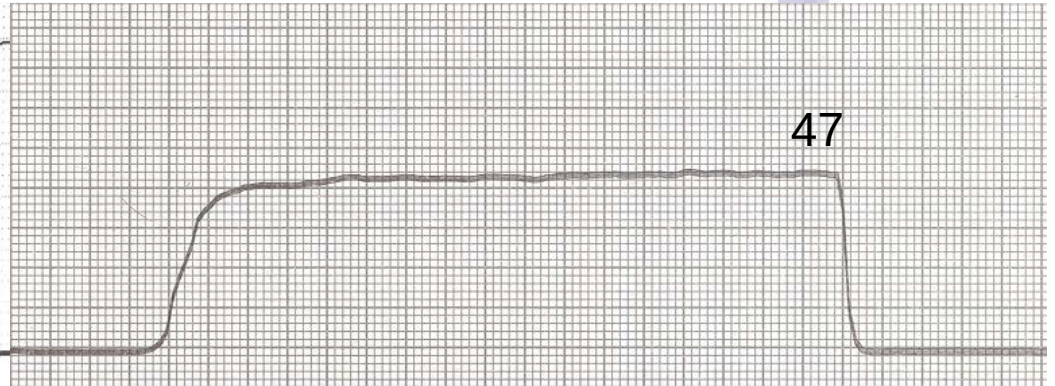
Case 4

A 44 yr old male admitted to MICU with unknown fever, SOB, hypoxemia. pH 7.34, PaCO2 38, PaO2 44, SpO2 .78. He is intubated, IMV 12/44. Extubates himself, is reintubated. Sedation is increased. RR decreases to 12.

.What is the effect of sedation on ventilation?

	Pulse	RR	NIBP	SpO2	PetCO2	Meds
Pre extubation	114	44	132/64	98	34	2 mg Midazolam, 50 mcg/Fentanyl
Extubated	102	38	138/60	97	33	5 mg bolus Gtt to 4 mg Midazolam, Gtt to 100 mcg/Fentanyl
Post reintubation and sedation	76	12	128/88	99	47	



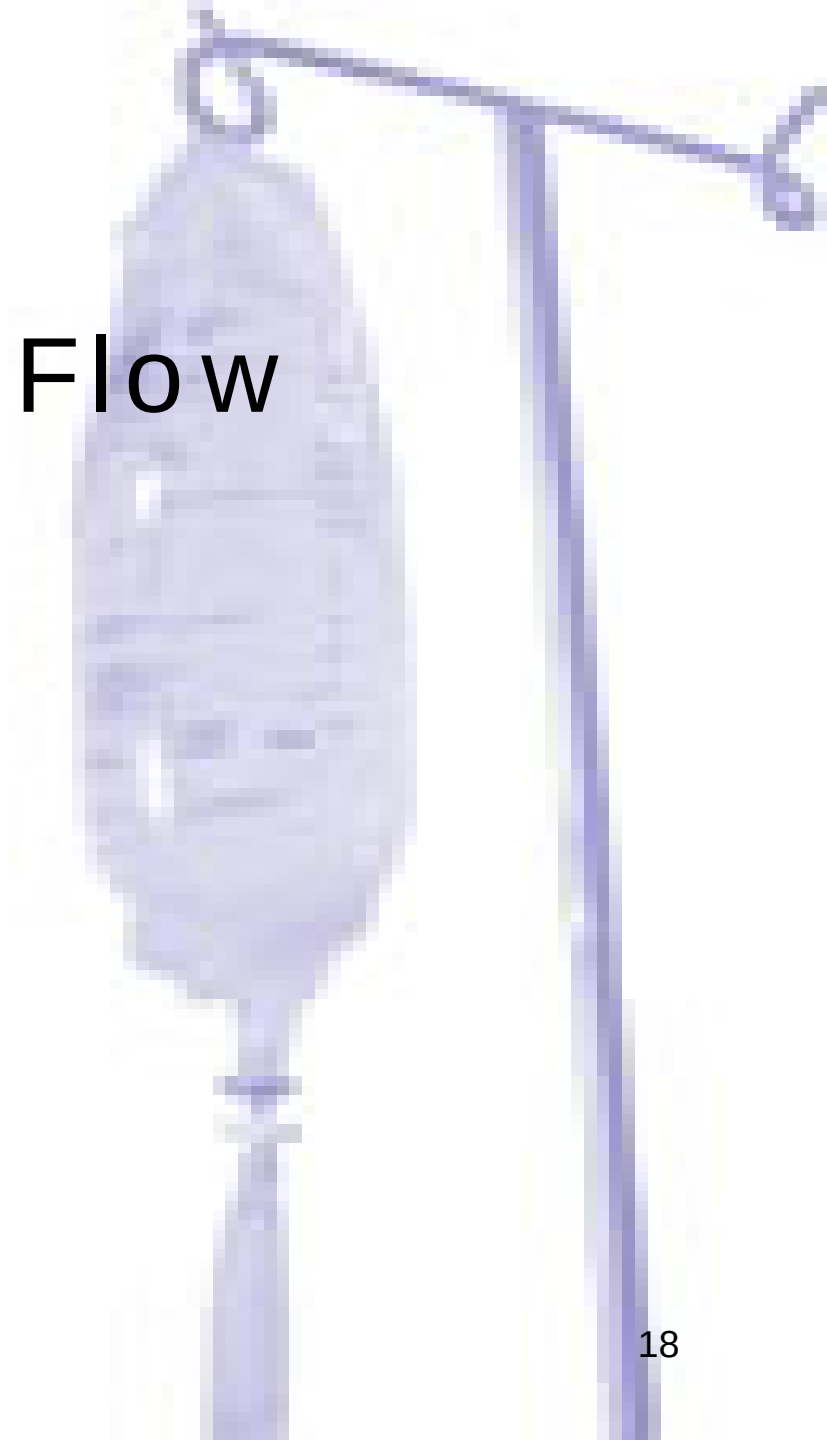


STANDARDS FOR BASIC ANESTHETIC MONITORING

- **Committee of Origin: Standards and Practice Parameters (Approved by the ASA House of Delegates on October 21, 1986, and last amended on October 20, 2010 with an effective date of July 1, 2011)**

- In October 2010, the ASA House of Delegates approved a change to the ASA "Standards for Basic Anesthetic Monitoring". Specifically, Standard 3.2.4 under VENTILATION, METHODS was changed to read: "During regional anesthesia (with no sedation) or local anesthesia (with no sedation), the adequacy of ventilation shall be evaluated by continual observation of qualitative clinical signs. During moderate or deep sedation the adequacy of ventilation shall be evaluated by continual observation of qualitative clinical signs and monitoring for the presence of exhaled carbon dioxide unless precluded or invalidated by the nature of the patient, procedure, or equipment." **The intent is that during moderate or deep sedation (regardless of location), the adequacy of ventilation be evaluated by both continual observation of qualitative clinical signs and by monitoring for the presence of exhaled carbon dioxide.** The House of Delegates recognized that there might be rare circumstances when it was not possible to accomplish this and added the following qualifier "unless precluded or invalidated by the nature of the patient, procedure, or equipment."

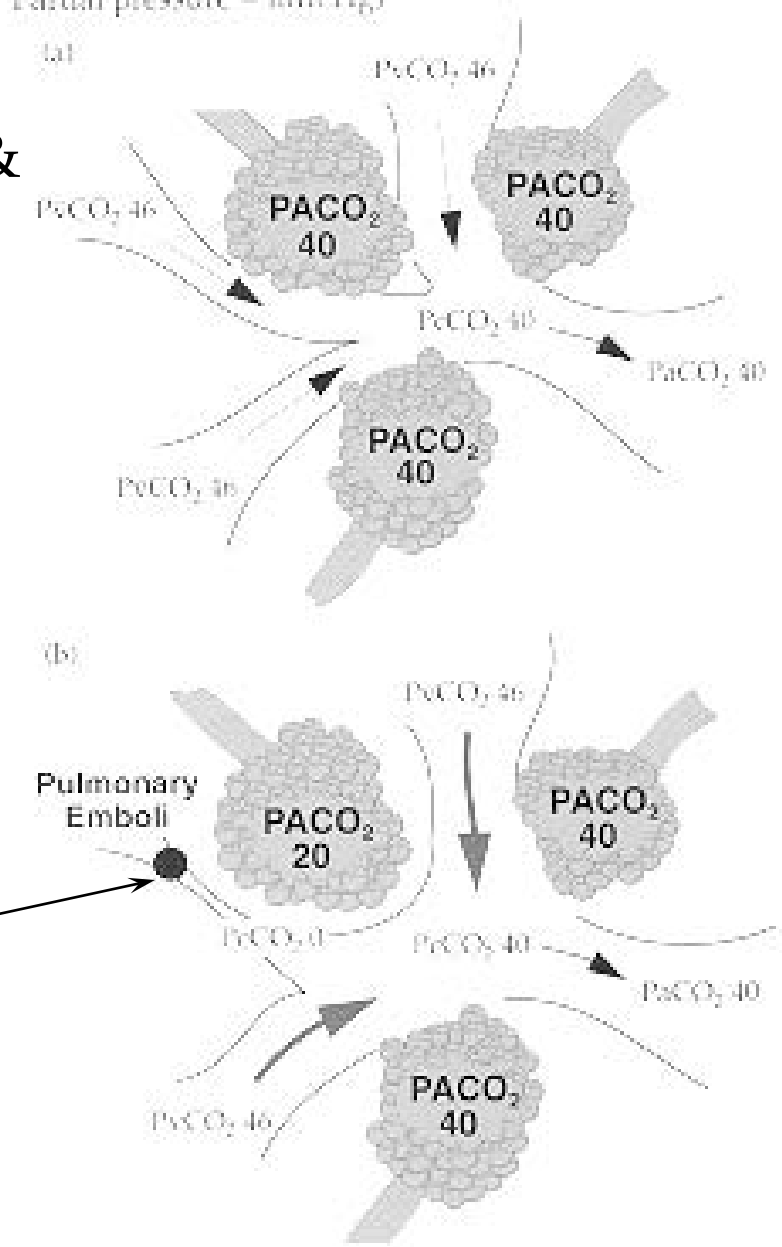
Application #3 Capnography and Assessment of Blood Flow



Use in Critical Care

Normal Ventilation & Perfusion

Illustration of the Formation of Deadspace in the Lungs



Note: Increased blood flow to perfused alveoli is matched by increased ventilation to maintain P_ACO_2 within normal limits.

Reduced blood flow decreases alveolar CO2 - this decrease is detected in the exhaled breath by capnography

Capnography and Deadspace

- Normally, the end portion of the capnography wave (end tidal PCO_2 or $PetCO_2$) is slightly lower than the arterial PCO_2 level
- The normal $PaCO_2$ -$PetCO_2$ gradient is 1-5 mm Hg.
- The primary reason for the gradient to widen is an increase in physiologic deadspace (such as occurs with a change in perfusion)
- Sudden change in $PetCO_2$ and the $PaCO_2$-$PetCO_2$ gradient is usually due to sudden drop in pulmonary blood flow

Capnography and Resuscitation

Application Capnography and Assessment of Blood Flow

Case Study

A 69 year old male with esophageal variceal bleeding. Varicies have been ligated via endoscopy and no active bleeding at this time. Does the patient show evidence of hypovolemia? Is treatment needed?

	P	RR	BP	SpO2	PetCO2
Prior to leg raise	102	21	110/70	100	27
1 minute after leg raise	98	19	114/72	100	38

Case Study

A 71 year old female with a history of acute cardiac dysfunction . She is admitted to an extended care facility in preparation for discharge to home. She has no symptoms of discomfort at this time, lung sounds unchanged from yesterday. Does she show signs of worsening cardiac function?

	P	**RR**	**BP**	**SpO2**	**PetCO2**
Yesterday	88	18	132/83	97	30
Today	87	20	138/85	97	25

Case Study

A 40 year old male is admitted to the ED from home with a change in behavior and LOC. He has a penetrating wound on his left foot, where his wife states he stepped on a broken board and had part of the board penetrate his foot. At this point, does he show signs of hypovolemia?

	P	RR	BP	SpO2	PetCO2
Prior to leg raise	110	23	104/66	95	29
1 minute after leg raise	102	20	118/70	96	37

Case Study

A 57 year old male is in cardiac rehab following a STEMI. He is able to perform well, 2 weeks into his rehab process. Current medications include ticagrelor, ASA, metoprolol, captopril and rosuvastatin.

	P	**RR**	**BP**	**SpO2**	**PetCO2**
Prior exercise session – ending measurements	74	22	135/85	95	33
Today's session	78	24	140/86	97	24

Summary

- Capnography is an indicator of cardiac output.
  - Increases in the PetCO2 indicates hypovolemia (with passive leg raise)
  - Decreases in PetCO2 in patients with heart failure can be an early warning sign of cardiac decompensation