pH & pO_2 monitoring during mechanical ventilation: ABG, VBG, or etCO2?

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no conflicts of interest 💰

MINIMIZATION OF ARTERIAL BLOOD GAS SAMPLING IN MECHANICALLY VENTILATED PATIENTS VIA CONTINUOUS SPO2 AND END TIDAL CO2 MONITORING. A CHOOSING WISELY PROJECT.

The University of Vermont College of Medicine

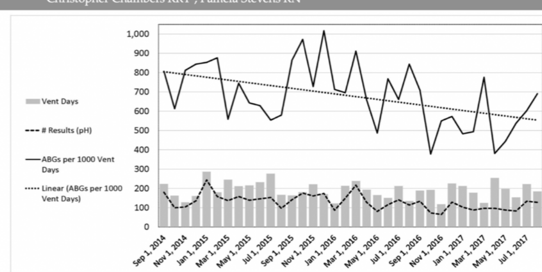
Ryan Clouser DO[1], Gilman Allen MD[1], Mark Hamlin MD, MS, FCCM[2], Emily Parent RRT[3], Christopher Chambers RRT[3], Pamela Stevens RN[4]

Introduction

❖ Routine (ABG) sampling in patients on mechanical ventilation (MV) rarely leads to dynamic changes in management. This practice contributes to increased cost, patient discomfort, and unneeded blood loss. In healthy patients, end tidal carbon dioxide (ETCO2) typically correlates with measured arterial PaCO2, but in critically ill patients, increased dead space creates a larger ETCO2-PaCO2 differential (Δ). We aimed to reduce ABG sampling by adjusting MV settings according to ETCO2 and the ΔETCO2-PaCO2.

Methods

❖ A policy was developed for respiratory therapists (RTs) to adjust MV by ETCO2 in our intensive care units. A baseline ABG was obtained upon initiation of MV to allow calculation of the ΔETCO2-PaCO2. Once this Δ was determined, RTs could adjust MV to maintain this Δ. ABGs were obtained at any time per the discretion of the treatment team. The option for routine serial ABGs was removed from all order sets. The number of ABGs, ventilator days and adverse events were tracked throughout the initiative via the electronic medical record (EMR).



Results

❖ ABG data were collected from the EMR from September 2014 to September 2017. Prior to our intervention (9/14 to 8/15), 1,752 ABGs were collected (mean: 146/month). Following implementation of universal ETCO2 monitoring, 1,686 ABGs were collected from 9/15 to 8/16 (mean: 140/month). Following initiation of our new ETCO2 protocol, 1,219 ABGs were collected from 9/16 to 8/17 (mean: 101/month). Total MV days declined over the period, but ABGs/1000 MV days still declined from 710 ('14-'15) and 777 ('15-'16) to 552 ('16-'17) following the intervention (ANOVA, $p<0.05$). There was a 30.8% reduction in testing and direct costs declined from $83,409 and $80,296 to $58,052; a total cost savings from 2014 to 2017 of $25,357.

Discussion

❖ MV guided by continuous ETCO2 monitoring and the ΔETCO2-PCO2, combined with removal of routine scheduled ABGs from EMR order sets, and education of ICU providers, was temporally associated with a reductio in ABGs in our MICU. Via these means, we project an estimated savings of ~$125,000 in direct medical center costs over the next five years without any anticipated increase in MV days or ICU length of stay, and reduced potential for unnecessary patient discomfort and ICU-acquired anemia.

Acknowlegements

[1] Division of Pulmonary and Critical Care Medicine, Larner College of Medicine at the University of Vermont, Burlington, VT, USA, [2] Department of Anesthesiology, Larner College of Medicine at the University of Vermont, Burlington, VT, USA, [3] Department of Respiratory Therapy, UVM Medical Center, Burlington VT, USA.
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The University of Vermont Medical Center

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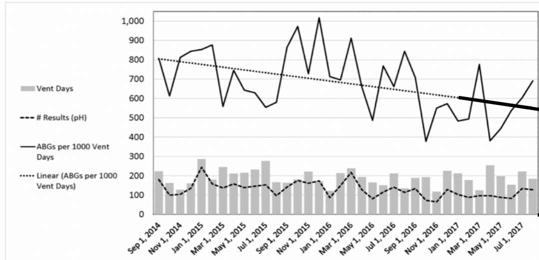

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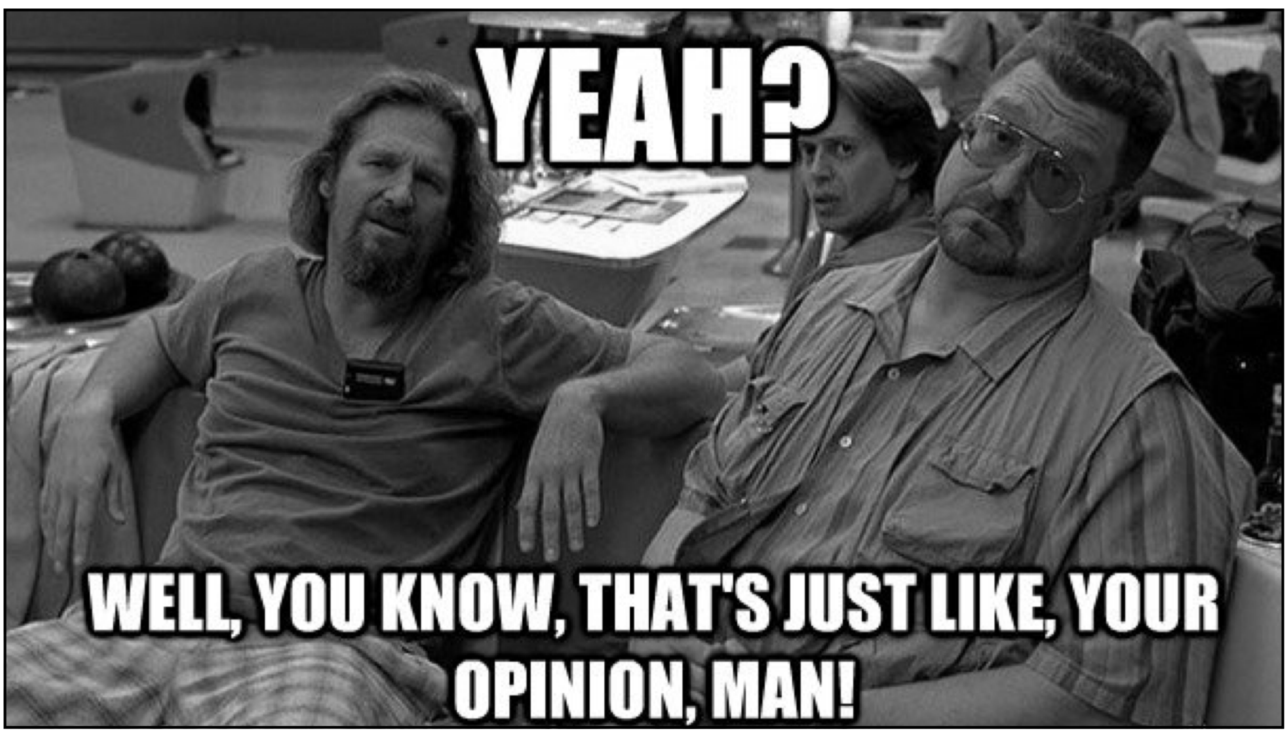

goals

- monitoring oxygenation: pO_2 vs. pulse oximetry?
- ventilation: what is our target pH?
- VBG vs. ABG?
- $etCO_2$ strengths & weaknesses
- putting it together: algorithm

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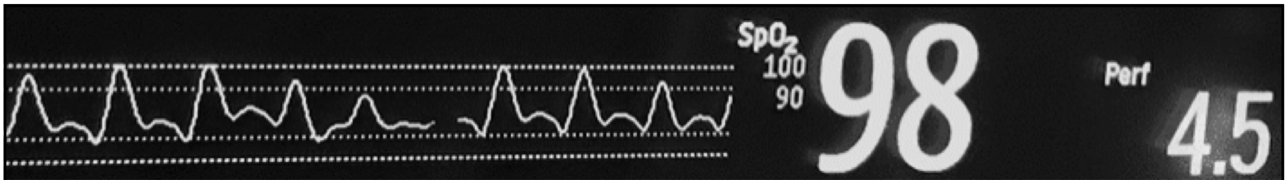
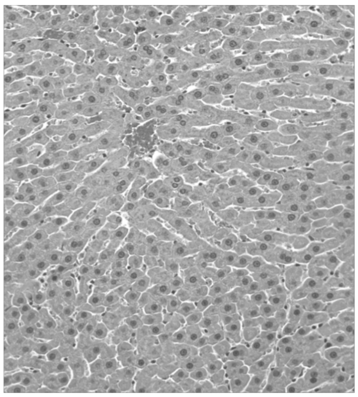
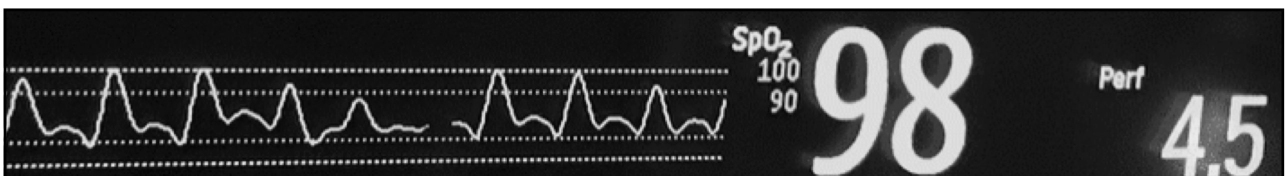


tissue oxygen delivery = 13.4 (cardiac output)(hemoglobin)(**oxygen saturation**)





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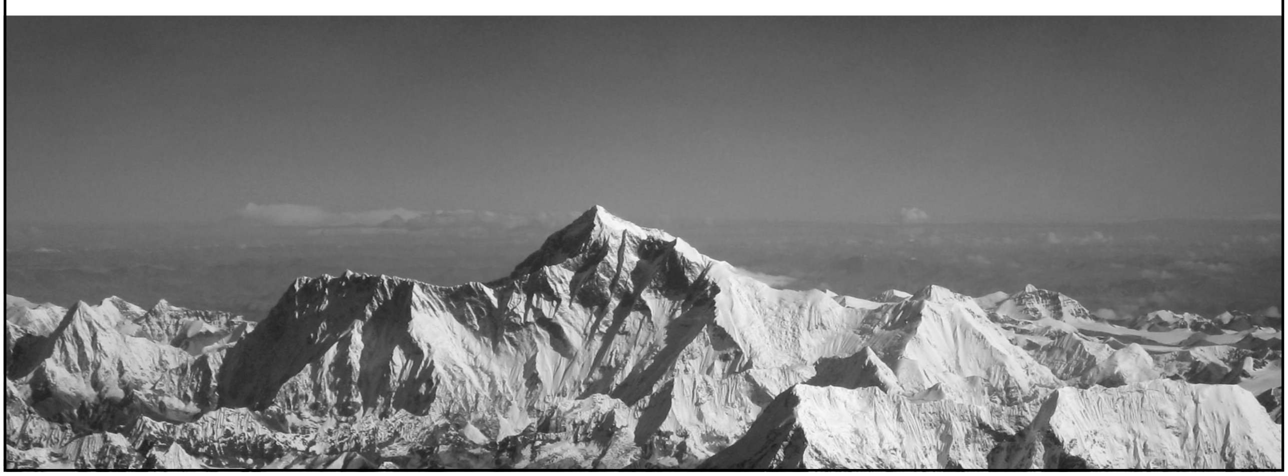

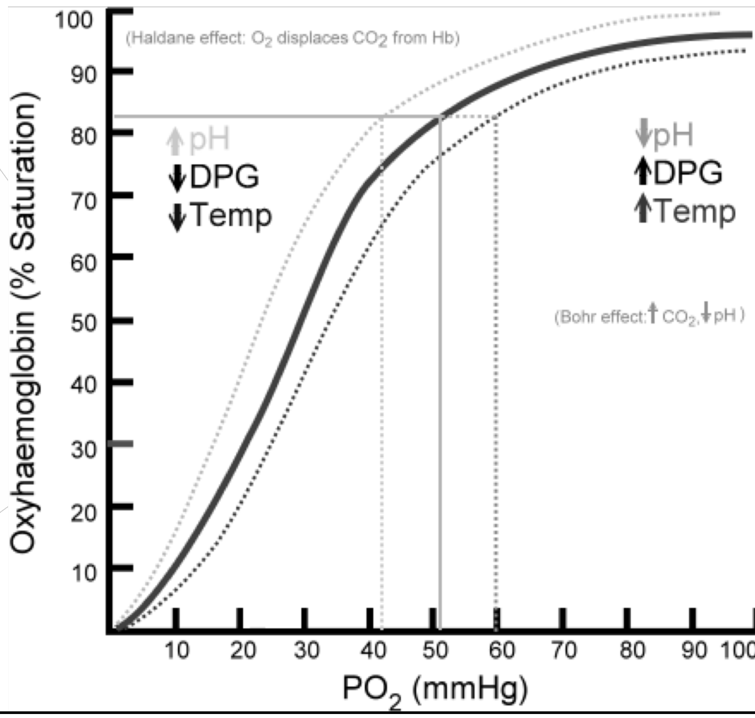

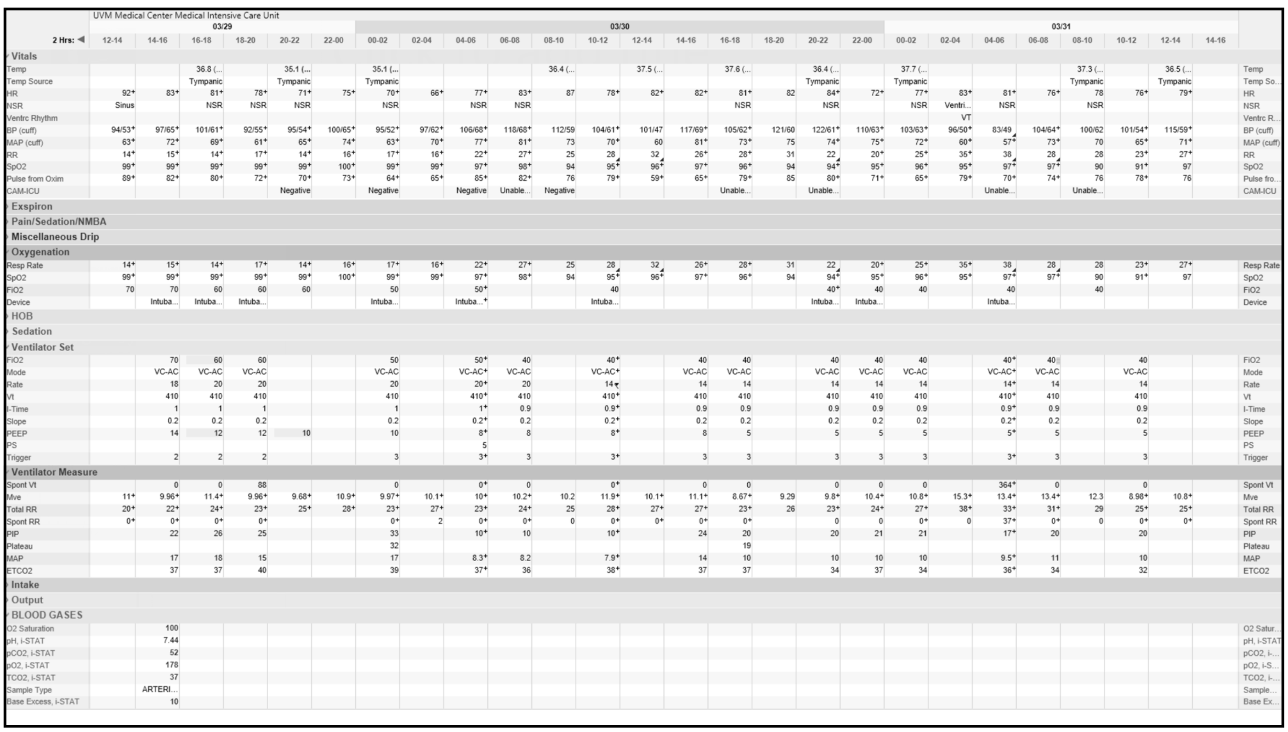

UVM Medical Center Medical Intensive Care Unit

2 Hrs: ◀	03/29 12-14	03/29 14-16	03/29 16-18	03/29 18-20	03/29 20-22	03/29 22-00	03/30 00-02	03/30 02-04	03/30 04-06	03/30 06-08	03/30 08-10	03/30 10-12
Vitals												
Temp			36.8 (...		35.1 (...		35.1 (...				36.4 (...	
Temp Source			Tympanic		Tympanic		Tympanic					
HR	92+	83+	81+	78+	71+	75+	70+	66+	77+	83+	87	78+
NSR	Sinus		NSR	NSR	NSR		NSR		NSR	NSR		
Ventrc Rhythm												
BP (cuff)	94/53+	97/65+	101/61+	92/55+	95/54+	100/65+	95/52+	97/62+	106/68+	118/68+	112/59	104/61+
MAP (cuff)	63+	72+	69+	61+	65+	74+	63+	70+	77+	81+	73	70+
RR	14+	15+	14+	17+	14+	16+	17+	16+	22+	27+	25	28
SpO2	99+	99+	99+	99+	99+	100+	99+	99+	97+	98+	94	95+
Pulse from Oxim	89+	82+	80+	72+	70+	73+	64+	65+	85+	82+	76	79+
CAM-ICU					Negative		Negative		Negative	Unable...	Negative	
Exspiron												
Pain/Sedation/NMBA												
Miscellaneous Drip												
Oxygenation												
Resp Rate	14+	15+	14+	17+	14+	16+	17+	16+	22+	27+	25	28
SpO2	99+	99+	99+	99+	99+	100+	99+	99+	97+	98+	94	95+
FiO2	70	70	60	60	60		50		50+			40
Device		Intuba...	Intuba...	Intuba...			Intuba...		Intuba...+			Intuba...
HOB												
Sedation												
Ventilator Set												
FiO2		70	60	60			50		50+	40		40+
Mode		VC-AC	VC-AC	VC-AC			VC-AC		VC-AC+	VC-AC		VC-AC+
Rate		18	20	20			20		20+	20		14+
Vt		410	410	410			410		410+	410		410+
I-Time		1	1	1			1		1+	0.9		0.9+
Slope		0.2	0.2	0.2			0.2		0.2+	0.2		0.2+
PEEP		14	12	12	10		10		8+	8		8+
PS									5			
Trigger		2	2	2			3		3+	3		3+
Ventilator Measure												
Spont Vt		0	0	88			0		0+	0		0+
Mve	11+	9.96+	11.4+	9.96+	9.68+	10.9+	9.97+	10.1+	10+	10.2+	10.2	11.9+
Total RR	20+	22+	24+	23+	25+	28+	23+	27+	23+	24+	25	28+
Spont RR	0+	0+	0+	0+			0+	2	0+	0+	0	0+
PIP		22	26	25			33		10+	10		10+
Plateau							32					
MAP		17	18	15			17		8.3+	8.2		7.9+
ETCO2		37	37	40			39		37+	36		38+
Intake												
Output												
BLOOD GASES												
O2 Saturation		100										
pH, i-STAT		7.44										
pCO2, i-STAT		52										
pO2, i-STAT		178										
TCO2, i-STAT		37										
Sample Type		ARTERI...										
Base Excess, i-STAT		10										

2 Hrs: ◀	03/30 12-14	03/30 14-16	03/30 16-18	03/30 18-20	03/30 20-22	03/30 22-00	03/31 00-02	03/31 02-04	03/31 04-06	03/31 06-08	03/31 08-10	03/31 10-12	03/31 12-14	03/31 14-16	
Vitals															
Temp	37.5 (...		37.6 (...		36.4 (...		37.7 (...				37.3 (...		36.5 (...		Temp
Temp Source					Tympanic		Tympanic				Tympanic		Tympanic		Temp So...
HR	82+	82+	81+	82	84+	72+	77+	83+	81+	76+	78	76+	79+		HR
NSR			NSR		NSR		NSR	Ventri...	NSR		NSR				NSR
Ventrc Rhythm								VT							Ventrc R...
BP (cuff)	101/47	117/69+	105/62+	121/60	122/61+	110/63+	103/63+	96/50+	83/49	104/64+	100/62	101/54+	115/59+		BP (cuff)
MAP (cuff)	60	81+	73+	75	74+	75+	72+	60+	57+	73+	70	65+	71+		MAP (cuff)
RR	32	26+	28+	31	22	20+	25+	35+	38	28	28	23+	27+		RR
SpO2	96+	97+	96+	94	94+	95+	96+	95+	97+	97+	90	91+	97		SpO2
Pulse from Oxim	59+	65+	79+	85	80+	71+	65+	79+	70+	74+	76	78+	76		Pulse fro...
CAM-ICU			Unable...		Unable...				Unable...		Unable...				CAM-ICU
Exspiron															
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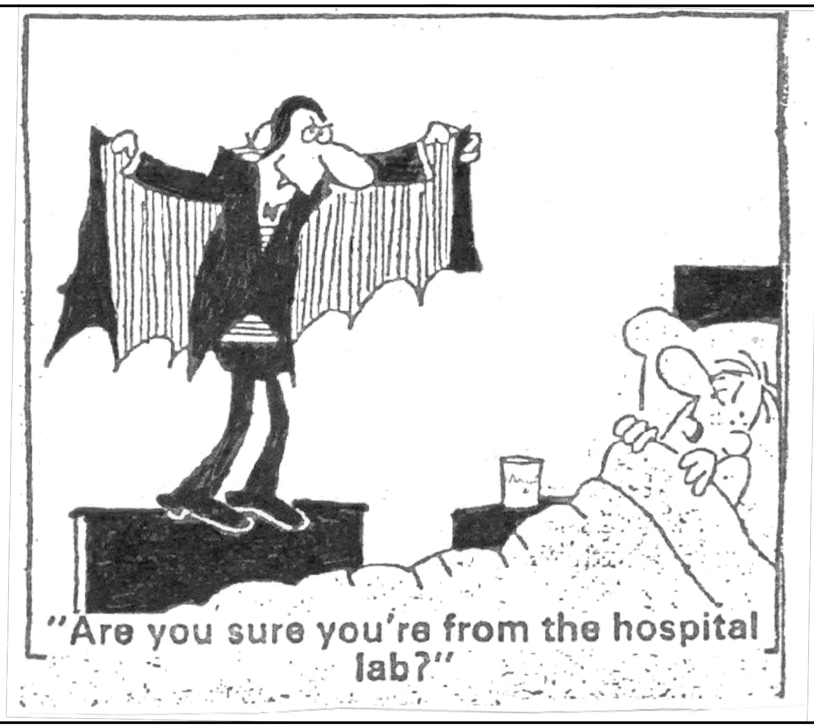
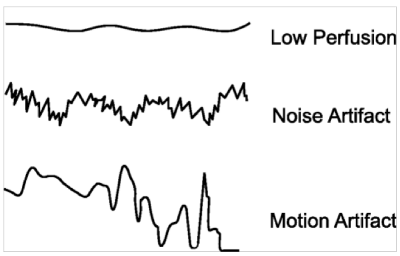
Miscellaneous Drip															
Oxygenation															
Resp Rate	32	26+	28+	31	22	20+	25+	35+	38	28	28	23+	27+		Resp Rate
SpO2	96+	97+	96+	94	94+	95+	96+	95+	97+	97+	90	91+	97		SpO2
FiO2					40+	40	40		40		40				FiO2
Device					Intuba...	Intuba...			Intuba...						Device
HOB															
Sedation															
Ventilator Set															
FiO2		40	40		40	40	40		40+	40		40			FiO2
Mode		VC-AC	VC-AC		VC-AC	VC-AC	VC-AC		VC-AC+	VC-AC		VC-AC			Mode
Rate		14	14		14	14	14		14+	14		14			Rate
Vt		410	410		410	410	410		410+	410		410			Vt
I-Time		0.9	0.9		0.9	0.9	0.9		0.9+	0.9		0.9			I-Time
Slope		0.2	0.2		0.2	0.2	0.2		0.2+	0.2		0.2			Slope
PEEP		8	5		5	5	5		5+	5		5			PEEP
PS															PS
Trigger		3	3		3	3	3		3+	3		3			Trigger
Ventilator Measure															
Spont Vt		0	0		0	0	0		364+	0		0			Spont Vt
Mve	10.1+	11.1+	8.67+	9.29	9.8+	10.4+	10.8+	15.3+	13.4+	13.4+	12.3	8.98+	10.8+		Mve
Total RR	27+	27+	23+	26	23+	24+	27+	38+	33+	31+	29	25+	25+		Total RR
Spont RR	0+	0+	0+		0	0	0+	0	37+	0+	0	0+	0+		Spont RR
PIP		24	20		20	21	21		17+	20		20			PIP
Plateau			19												Plateau
MAP		14	10		10	10	10		9.5+	11		10			MAP
ETCO2		37	37		34	37	34		36+	34		32			ETCO2
Intake															
Output															
BLOOD GASES															
O2 Saturation															O2 Satur...
pH, i-STAT															pH, i-STAT
pCO2, i-STAT															pCO2, i-...
pO2, i-STAT															pO2, i-S...
TCO2, i-STAT															TCO2, i-...
Sample Type															Sample...
Base Excess, i-STAT															Base Ex...


"Are you sure you're from the hospital lab?"

limitations of pulse oximetry



goals

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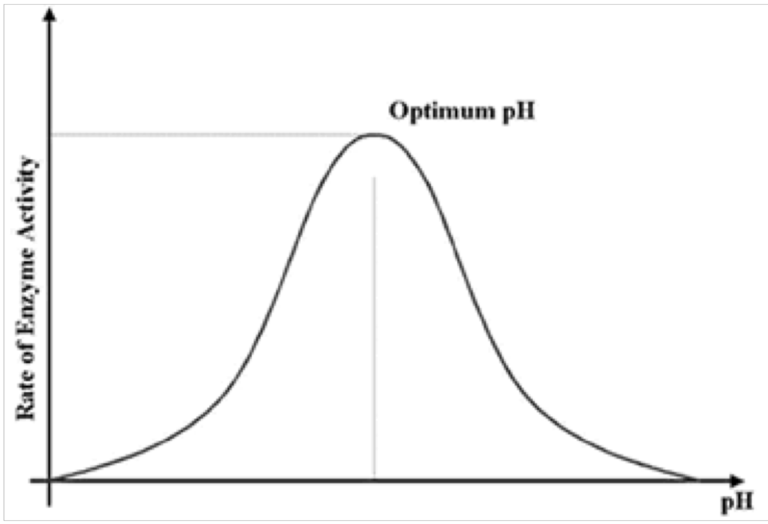
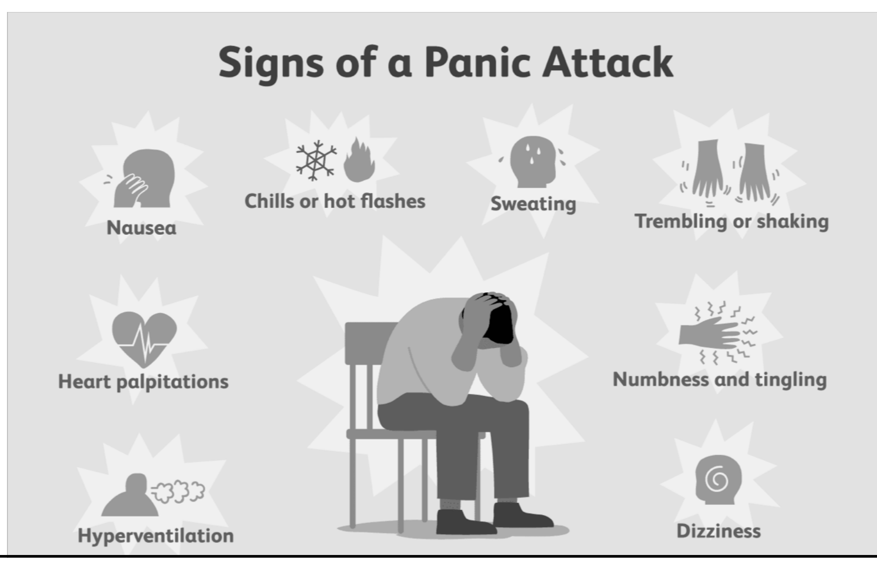
pH vs. pCO2



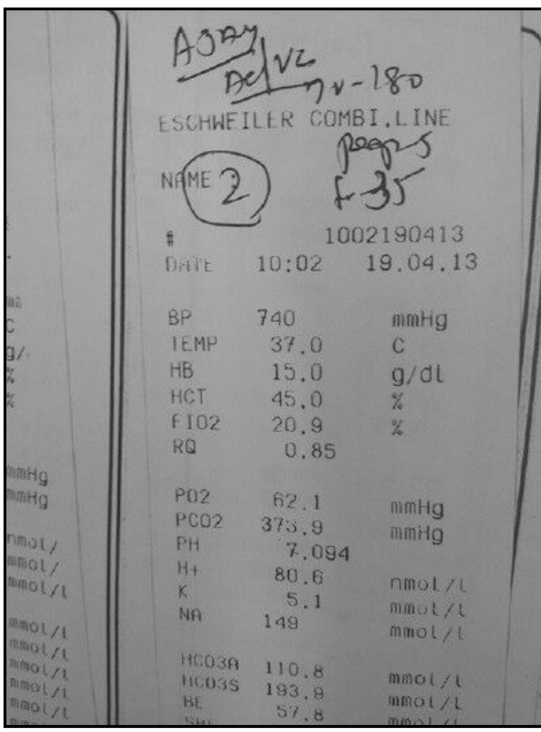
respiratory alkalosis



respiratory acidosis

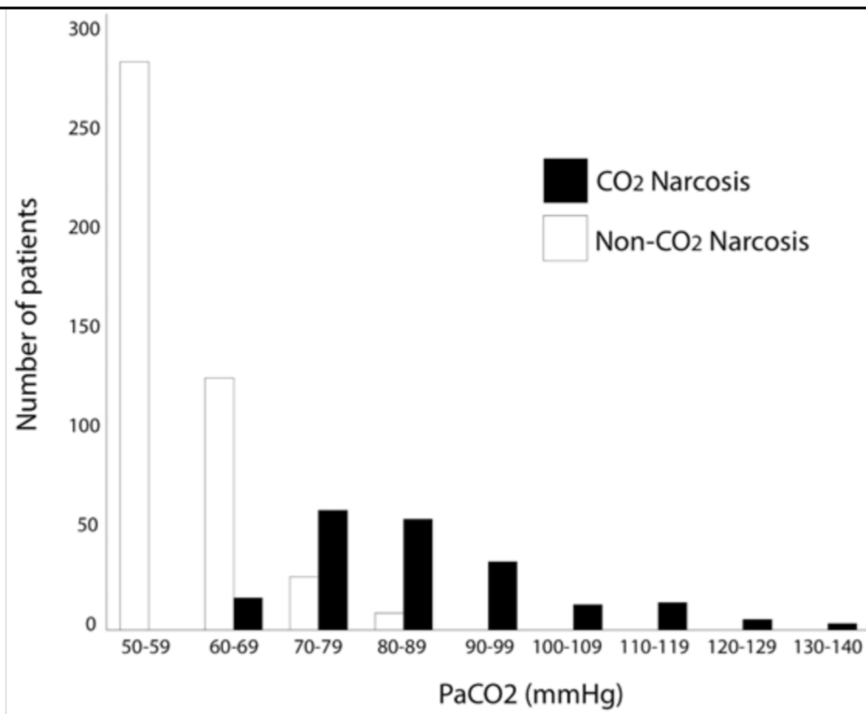
Apneic oxygenation in man, Anesthesiology 1959, Nov/dec;789-798

Subject	*Apnea duration (Minutes)*	*Lowest arterial saturation*	Lowest pH	Highest PaCO2
1	***30***	***100***	-	-
2	***45***	***100***	-	-
3	***55***	***100***	-	-
4	***45***	***100***	6.88	160
5	***18***	***99***	6.97	130
6	***45***	***98***	6.87	160
7	***53***	***98***	6.72	250
8	***38***	***100***	6.96	130



Garg SM 2014 PMID 25249747

permissive hypercapnia



Yang C et al. Emergency Medicine 2018

Eastwood *et al. Critical Care* (2017) 21:196
DOI 10.1186/s13054-017-1770-6

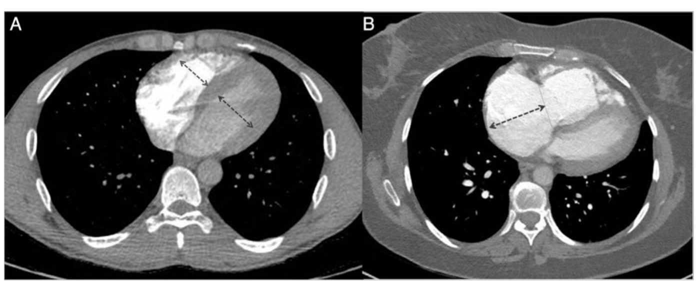
Critical Care

LETTER Open Access

Targeted therapeutic mild hypercapnia after cardiac arrest

Glenn M. Eastwood[1,2*], Alistair Nichol[2,3,4] and Matt P. Wise[5]

contraindications to permissive hypercapnia



~7.2?

7.5

~7.2?

$$pH = 6.1 + \log_{10}\left(\frac{[HCO_3^-]}{0.03 \times pCO_2}\right)$$

7.5

Mediquations App

~7.2?

$$pH = 6.1 + \log_{10}\left(\frac{[HCO_3^-]}{0.03 \times pCO_2}\right)$$

7.5

Bicarbonate 24 mEq/L

pCO2 **64** mm?

pCO2 **32** mm

~7.2

$$pH = 6.1 + \log_{10}\left(\frac{[HCO_3^-]}{0.03 \times pCO_2}\right)$$

7.5

Bicarbonate 35 mEq/L

pCO2 **93** mm?

pCO2 **46** mm

josh farkas
@PulmCrit

goose-chase principle: if there is no solid evidence regarding a therapeutic goal (e.g. pH in ARDS), don't go crazy trying to chase it with high accuracy.

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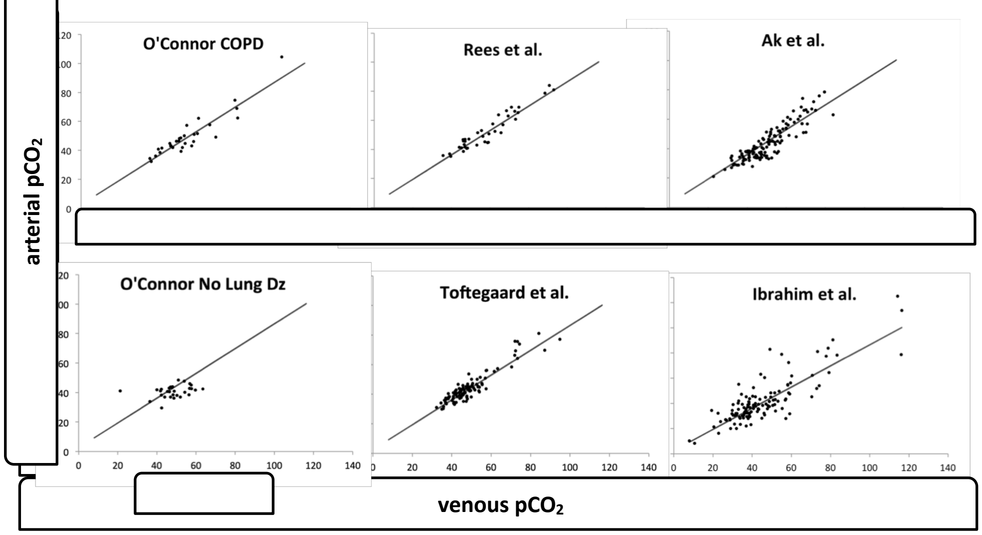
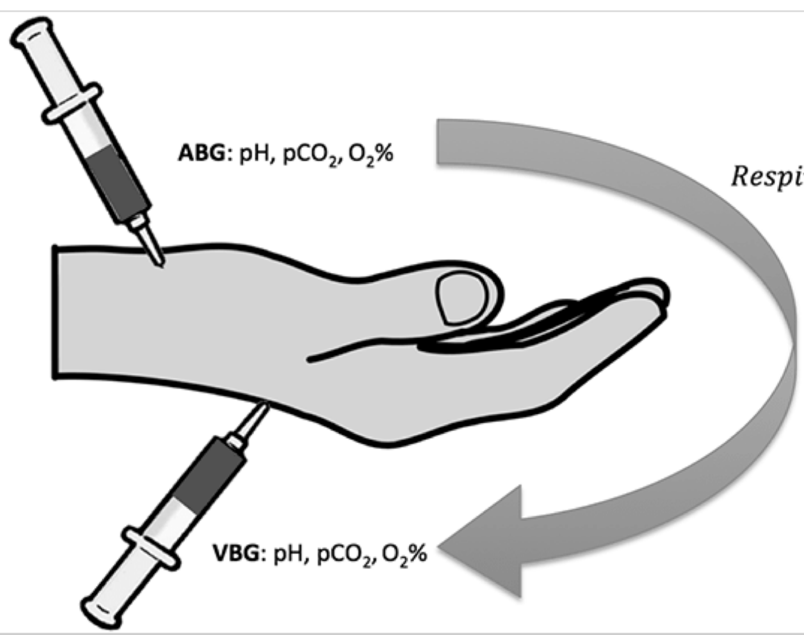
CO_2: direct comparisons





$$Respiratory\ Quotient\ (RQ) = \frac{\Delta CO_2}{\Delta O_2}$$

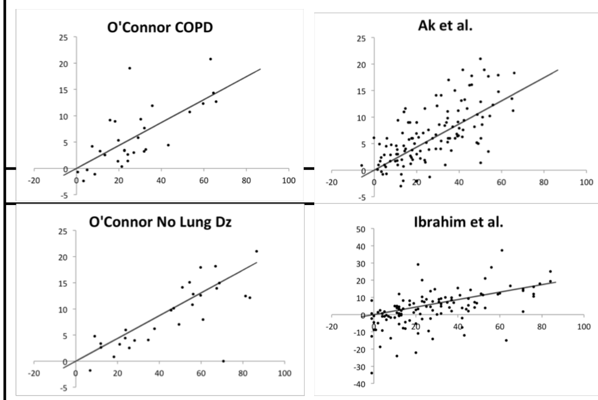
$$RQ \approx stable \approx 0.8$$

$$\therefore$$

$$\Delta CO_2 \propto \Delta O_2$$

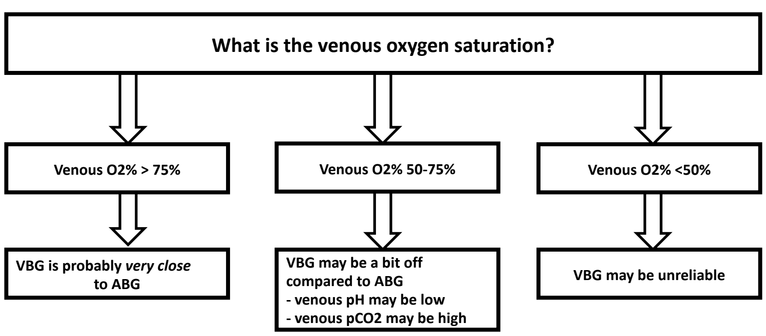
ΔpCO_2 vs. $\Delta O_2\%$

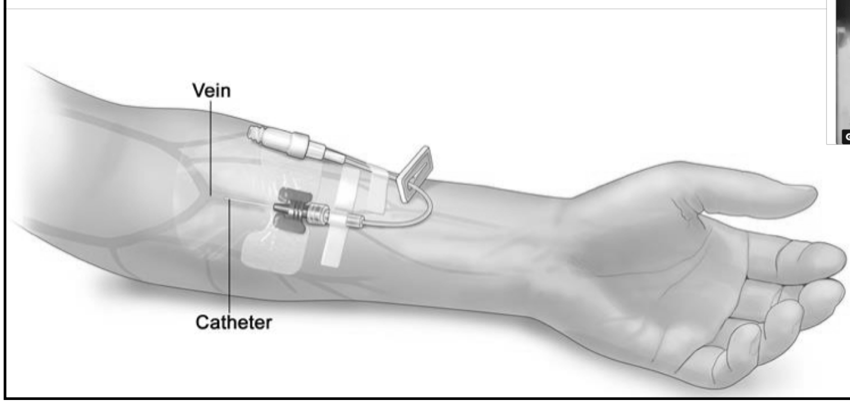
ΔpCO_2 = (venous pCO_2 – arterial pCO_2)



$\Delta O_2\%$ = (arterial $O_2\%$ - venous $O_2\%$)

Use of **venous oxygen saturation** to qualify reliability of VBGs





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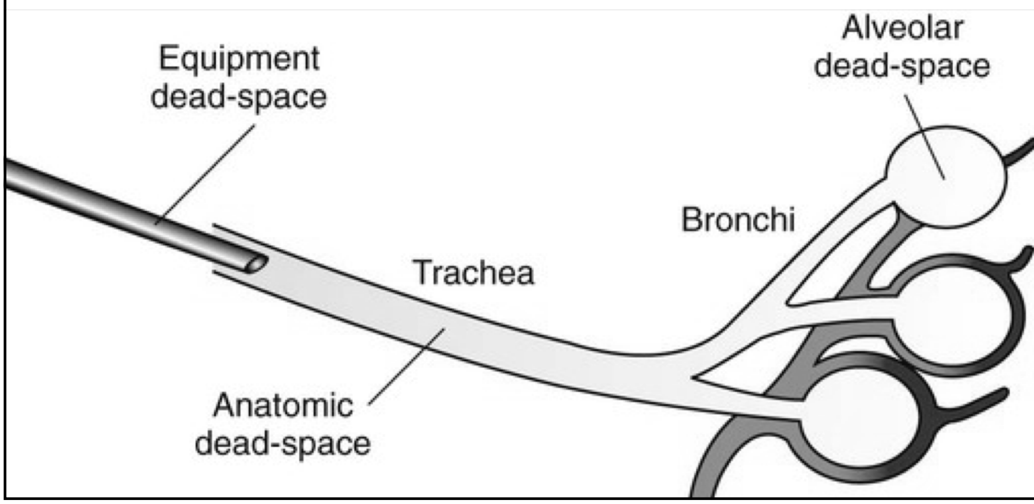
arterial pCO2 > etCO2
difference ~ dead space



arterial pCO2 > etCO2

- high etCO2 (60 mm)

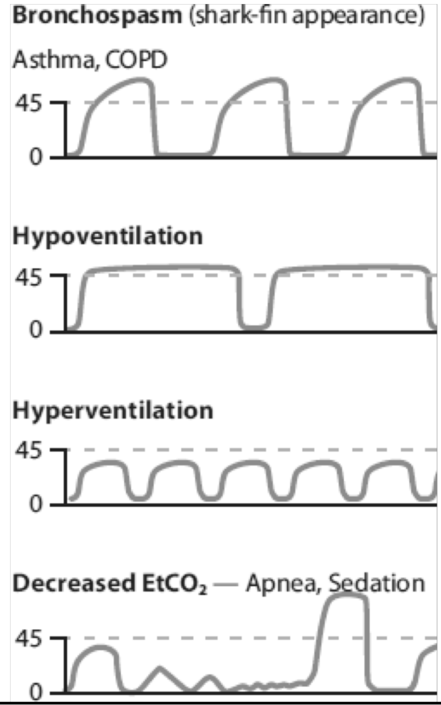
- low etCO2 (20 mm)


30
40
50
60
80

narrow-gap patient

- normal lungs
  - intubated for non-respiratory reason
  - no history of lung disease
  - normal chest x-ray
- good capnograph

(PaCO2-etCO2) < ~15 mm



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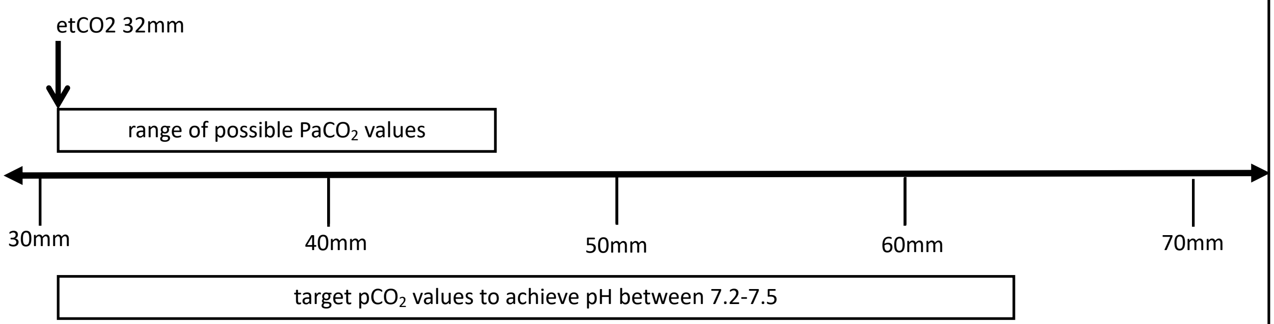
7.5

Bicarbonate 24 mEq/L

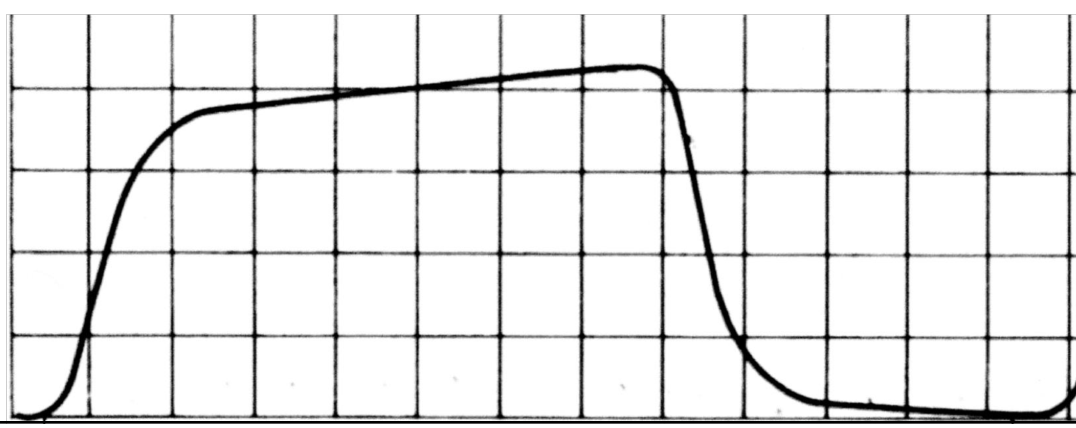
pCO2 **64** mm?

pCO2 **32** mm

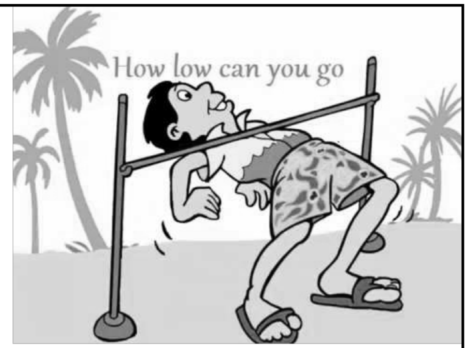


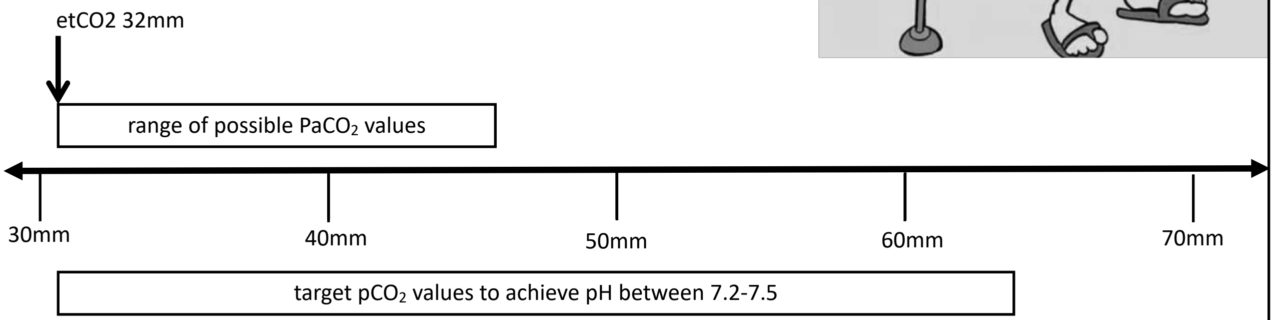
limitations of etCO2

- APRV 😰
- rapidly evolving lung disease



saving grace of etCO2





ideal monitoring: etCO2 & minute ventilation

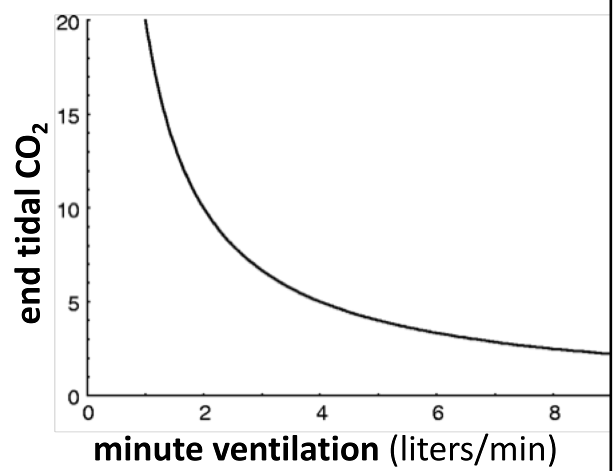
⇩ etCO2 ⇧ minute ventilation

⇩ etCO2 ⇔ minute ventilation

ideal monitoring: etCO2 & minute ventilation

↓ etCO2 ↑ minute ventilation

↓ etCO2 ⇔ minute ventilation



UVM Medical Center Medical Intensive Care Unit

	03/29						03/30												03/31								
2 Hrs: ◀	12-14	14-16	16-18	18-20	20-22	22-00	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-00	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	
Vitals																											
Temp			36.8 (...		35.1 (...		35.1 (...				36.4 (...		37.5 (...		37.6 (...		36.4 (...		37.7 (...				37.3 (...		36.5 (...		Temp
Temp Source			Tympanic		Tympanic		Tympanic										Tympanic		Tympanic				Tympanic		Tympanic		Temp So...
HR	92+	83+	81+	78+	71+	75+	70+	66+	77+	83+	87	78+	82+	82+	81+	82	84+	72+	77+	83+	81+	76+	78	76+	79+		HR
NSR	Sinus		NSR	NSR	NSR		NSR		NSR	NSR					NSR		NSR		NSR	Ventri...	NSR		NSR				NSR
Ventrc Rhythm																				VT							Ventrc R...
BP (cuff)	94/53+	97/65+	101/61+	92/55+	95/54+	100/65+	95/52+	97/62+	106/68+	118/68+	112/59	104/61+	101/47	117/69+	105/62+	121/60	122/61+	110/63+	103/63+	96/50+	83/49	104/64+	100/62	101/54+	115/59+		BP (cuff)
MAP (cuff)	63+	72+	69+	61+	65+	74+	63+	70+	77+	81+	73	70+	60	81+	73+	75	74+	75+	72+	60+	57+	73+	70	65+	71+		MAP (cuff)
RR	14+	15+	14+	17+	14+	16+	17+	16+	22+	27+	25	28	32	26+	28+	31	22	20+	25+	35+	38	28	28	23+	27+		RR
SpO2	99+	99+	99+	99+	99+	100+	99+	99+	97+	98+	94	95+	96+	97+	96+	94	94+	95+	96+	95+	97+	97+	90	91+	97		SpO2
Pulse from Oxim	89+	82+	80+	72+	70+	73+	64+	65+	85+	82+	76	79+	59+	65+	79+	85	80+	71+	65+	79+	70+	74+	76	78+	76		Pulse fro...
CAM-ICU					Negative		Negative		Negative	Unable...	Negative				Unable...		Unable...				Unable...		Unable...				CAM-ICU
Exspiron																											
Pain/Sedation/NMBA																											
Miscellaneous Drip																											
Oxygenation																											
Resp Rate	14+	15+	14+	17+	14+	16+	17+	16+	22+	27+	25	28	32	26+	28+	31	22	20+	25+	35+	38	28	28	23+	27+		Resp Rate
SpO2	99+	99+	99+	99+	99+	100+	99+	99+	97+	98+	94	95+	96+	97+	96+	94	94+	95+	96+	95+	97+	97+	90	91+	97		SpO2
FiO2	70	70	60	60	60		50		50+			40					40+	40	40		40		40				FiO2
Device		Intuba...	Intuba...	Intuba...			Intuba...		Intuba...+			Intuba...					Intuba...	Intuba...			Intuba...						Device
HOB																											
Sedation																											
Ventilator Set																											
FiO2		70	60	60			50		50+	40		40+		40	40		40	40	40		40+	40		40			FiO2
Mode		VC-AC	VC-AC	VC-AC			VC-AC		VC-AC+	VC-AC		VC-AC+		VC-AC	VC-AC		VC-AC	VC-AC	VC-AC		VC-AC+	VC-AC		VC-AC			Mode
Rate		18	20	20			20		20+	20		14		14	14		14	14	14		14+	14		14			Rate
Vt		410	410	410			410		410+	410		410+		410	410		410	410	410		410+	410		410			Vt
I-Time		1	1	1			1		1+	0.9		0.9+		0.9	0.9		0.9	0.9	0.9		0.9+	0.9		0.9			I-Time
Slope		0.2	0.2	0.2			0.2		0.2+	0.2		0.2+		0.2	0.2		0.2	0.2	0.2		0.2+	0.2		0.2			Slope
PEEP		14	12	12	10		10		8+	8		8+		8	5		5	5	5		5+	5		5			PEEP
PS									5																		PS
Trigger		2	2	2			3		3+	3		3+		3	3		3	3	3		3+	3		3			Trigger
Ventilator Measure																											
Spont Vt		0	0	88			0		0+	0		0+		0	0		0	0	0		364+	0		0			Spont Vt
Mve	11+	9.96+	11.4+	9.96+	9.68+	10.9+	9.97+	10.1+	10+	10.2+	10.2	11.9+	10.1+	11.1+	8.67+	9.29	9.8+	10.4+	10.8+	15.3+	13.4+	13.4+	12.3	8.98+	10.8+		Mve
Total RR	20+	22+	24+	23+	25+	28+	23+	27+	23+	24+	25	28+	27+	27+	23+	26	23+	24+	27+	38+	33+	31+	29	25+	25+		Total RR
Spont RR	0+	0+	0+	0+			0+	2	0+	0+	0	0+	0+	0+	0+		0	0	0+	0	37+	0+	0	0+	0+		Spont RR
PIP		22	26	25			33		10+	10		10+		24	20		20	21	21		17+	20		20			PIP
Plateau							32								19												Plateau
MAP		17	18	15			17		8.3+	8.2		7.9+		14	10		10	10	10		9.5+	11		10			MAP
ETCO2		37	37	40			39		37+	36		38+		37	37		34	37	34		36+	34		32			ETCO2
Intake																											
Output																											
BLOOD GASES																											
O2 Saturation		100																									O2 Satur...
pH, i-STAT		7.44																									pH, i-STAT
pCO2, i-STAT		52																									pCO2, i-...
pO2, i-STAT		178																									pO2, i-S...
TCO2, i-STAT		37																									TCO2, i-...
Sample Type		ARTERI...																									Sample...
Base Excess, i-STAT		10																									Base Ex...

goals

- monitoring oxygenation: pO_2 vs. pulse oximetry?
- ventilation: what is our target pH?
- VBG vs. ABG?
- $etCO_2$ strengths & weaknesses
- **putting it together: algorithm**

Approach to: **intubated patient**

↓

Need ABG to monitor oxygenation?
- Unreliable pulse oximetry waveform
- Methemoglobinemia/carboxyhemoglobinemia

Yes →

Vampire pathway

ABG, repeat PRN.

(Also follow $etCO_2$)

↓ **No**

Approach to: **intubated patient**

Need ABG to monitor oxygenation?
- Unreliable pulse oximetry waveform
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Yes →

Vampire pathway

ABG, repeat PRN.

(Also follow $etCO_2$)

No ↓

Criteria for etCO2-only monitoring

[1] Precise CO2 control unnecessary
- No ICP elevation
- Not hemodynamically unstable with pulmonary HTN
- Not pregnant

[2] etCO2 expected to be reliable
- Good waveform
- No chronic lung disease
- No acute lung disease (intubated for non-pulmonary reason)
- Chest X-ray shows normal-appearing lungs

Yes →

Anesthesiologist pathway (No ABG/VBG!)

- Use oxygen saturation to monitor O_2
- Use etCO2 to monitor CO_2
- Follow minute ventilation

No ↓

Approach to: **intubated patient**

need ABG to monitor oxygenation?
- Unreliable pulse oximetry waveform
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Yes →

vampire pathway

ABG, repeat PRN.

(Also follow $etCO_2$)

No ↓

criteria for etCO2-only monitoring

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- chest X-ray shows normal-appearing lungs

Yes →

anesthesiologist pathway (no ABG/VBG!)

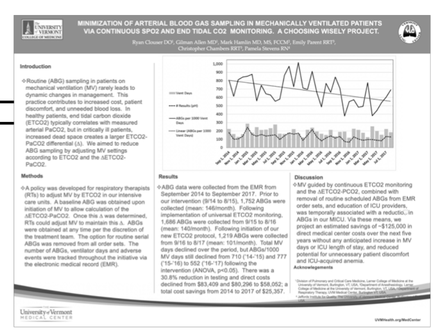
- use oxygen saturation to monitor O_2
- use etCO2 to monitor CO_2
- follow minute ventilation

No ↓

VBG pathway

- oxygen saturation to monitor O_2
- initial VBG to correlate & confirm the accuracy of etCO2.
- subsequently monitor CO_2 using minute ventilation & $etCO_2$
- repeat VBG if substantial change or data not making sense (avoid lots of VBGs)

←



MINIMIZATION OF ARTERIAL BLOOD GAS SAMPLING IN MECHANICALLY VENTILATED PATIENTS VIA CONTINUOUS SPO2 AND END TIDAL CO2 MONITORING. A CHOOSING WISELY PROJECT.

Ryan Clouser DO[1], Gilman Allen MD[1], Mark Hamlin MD, MS, FCCM[2], Emily Parent RRT[3], Christopher Chambers RRT[3], Pamela Stevens RN[4]

Introduction

- Routine (ABG) sampling in patients on mechanical ventilation (MV) rarely leads to dynamic changes in management. This practice contributes to increased cost, patient discomfort, and unneeded blood loss. In healthy patients, end tidal carbon dioxide (ETCO2) typically correlates with measured arterial PaCO2, but in critically ill patients, increased dead space creates a larger ETCO2-PaCO2 differential (Δ). We aimed to reduce ABG sampling by adjusting MV settings according to ETCO2 and the ΔETCO2-PaCO2.

Methods

- A policy was developed for respiratory therapists (RTs) to adjust MV by ETCO2 in our intensive care units. A baseline ABG was obtained upon initiation of MV to allow calculation of the ΔETCO2-PaCO2. Once this Δ was determined, RTs could adjust MV to maintain this Δ. ABGs were obtained at any time per the discretion of the treatment team. The option for routine serial ABGs was removed from all order sets. The number of ABGs, ventilator days and adverse events were tracked throughout the initiative via the electronic medical record (EMR).

Results

- ABG data were collected from the EMR from September 2014 to September 2017. Prior to our intervention (9/14 to 8/15), 1,752 ABGs were collected (mean: 146/month). Following implementation of universal ETCO2 monitoring, 1,686 ABGs were collected from 9/15 to 8/16 (mean: 140/month). Following initiation of our new ETCO2 protocol, 1,219 ABGs were collected from 9/16 to 8/17 (mean: 101/month). Total MV days declined over the period, but ABGs/1000 MV days still declined from 710 ('14-'15) and 777 ('15-'16) to 552 ('16-'17) following the intervention (ANOVA, $p<0.05$). There was a 30.8% reduction in testing and direct costs declined from $83,409 and $80,296 to $58,052; a total cost savings from 2014 to 2017 of $25,357.

Discussion

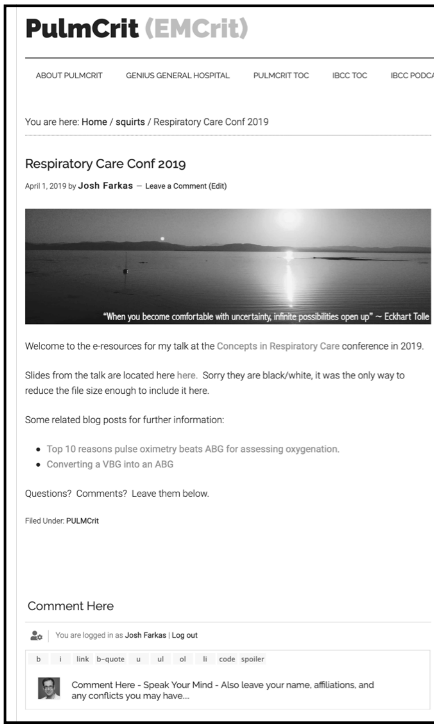
- MV guided by continuous ETCO2 monitoring and the ΔETCO2-PCO2, combined with removal of routine scheduled ABGs from EMR order sets, and education of ICU providers, was temporally associated with a reduction in ABGs in our MICU. Via these means, we project an estimated savings of ~$125,000 in direct medical center costs over the next five years without any anticipated increase in MV days or ICU length of stay, and reduced potential for unnecessary patient discomfort and ICU-acquired anemia.

Acknowlegements

[1] Division of Pulmonary and Critical Care Medicine, Larner College of Medicine at the University of Vermont, Burlington, VT, USA, [2] Department of Anesthesiology, Larner College of Medicine at the University of Vermont, Burlington, VT, USA, [3] Department of Respiratory Therapy, UVM Medical Center, Burlington VT, USA.

The University of Vermont Medical Center

UVMHealth.org/MedCenter



electronic handout

- https://emcrit.org/squirt/**resp2019/**

- link will be posted on **@PulmCrit**