



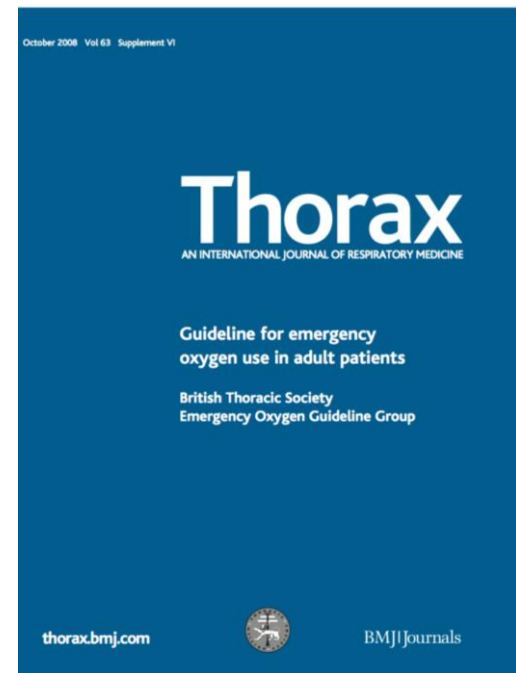
Oxygen and ABG

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Oxygen and ABGs... Simply in 10 cases

- Recap of:
 - ABG interpretation
 - Oxygen management
- Some common concerns
 - A-a gradient
 - Base Excess
 - Anion Gap
 - COPD patients
 - CPAP/BiPAP



First Case...

- 68yo man walks into A&E with mild breathlessness and productive cough. He has no PMH.

What would be your management?

- ABCDE
- Ex- talking to you, no signs of distress, creps in left base

BP 118/70 HR 105 RR 20 Sats 91%



Oxygen Therapy

Step 1 HOW IS THE PATIENT?

68yo. No PMH. Mild SOB/cough. RR 20 Sats 91% OA

Is the patient critically ill or O_2 Sats <85% ?

NO

Is patient at risk of hypercapnia?

Target Sats

Starting Device

NO →

94-98%

Nasal Cannula (2-6L/m)
or Face Mask (5-10L/m)

... and do an Arterial Blood Gas



Face Mask
Variable O_2 of 35-60%.
Flow 5-10 L/min

Nasal Cannulae
Variable O_2 of 24-50%
Flow 2-6L/min



Case 1: Arterial Blood Gas

pH	7.43	<i>Normal values</i> (7.35 – 7.45)
pCO ₂	4.0 kPa	(4.7 – 6.0 kPa)
pO ₂	11.1 kPa	(>10kPa)
HCO ₃	24 mmol/L	(22-26 mmol/l)
BE	0 mmol/L	(+/-2.0 mmol/l)



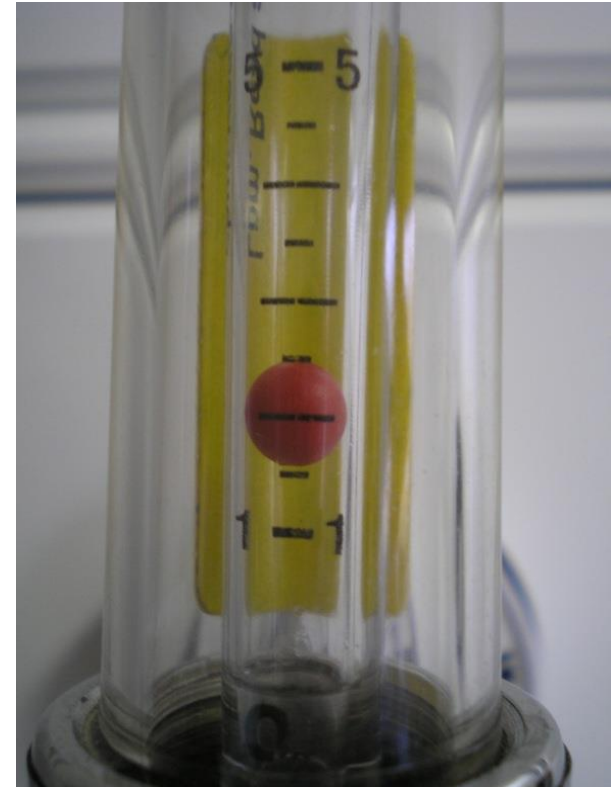
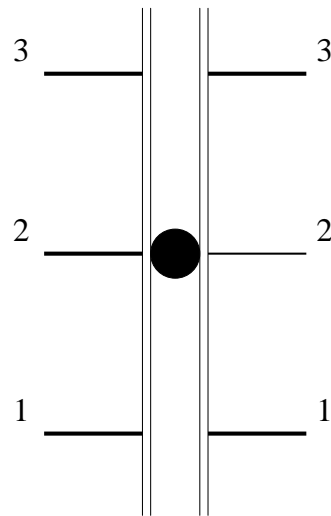
CO₂ low and not acidotic

Keep with target sats 94-98%


(continue to treat as low risk hypercapnia)



Oxygen Flow Meter



Prescribe

DRUG		OXYGEN (Refer To Trust Oxygen Policy)	
<i>Circle target oxygen saturation</i> 88-92% 94-98% Other ____		STOP DATE	
Starting device/flow rate <u>2-4 L/min, NRM</u> PRN / Continuous		PHARM	
(Saturation is indicated in almost all cases except for palliative terminal care)			
SIGNATURE / PRINT NAME 		DATE 01/03/17	



Case number 2...

A 68yo man comes by ambulance to A&E. Wife called ambulance as concerned that husband very unwell and breathless.

Has known COPD (states similar to previous exacerbation)

What would be your management?

- ABCDE
- Ex: distressed, widespread polyphonic wheeze

BP 125/85 HR 120 RR 29 Sats 78%



Oxygen Therapy

Step 1 HOW IS THE PATIENT?

68yo COPD. SOB. Wheeze. RR 29 HR 120 Sats 78% OA.

Is the patient critically ill or O_2 sats <85% ?

YES

High Flow/Non Rebreath Mask
15 L/min oxygen

Then do Arterial Blood Gas



Variable O_2 of 60-80%
ALWAYS at 15 L/min flow
Effective for short term
Uncomfortable High Flow

HYPOXIA KILLS

ABG of our unwell case...

68yo, acute exacerbation of his known COPD, following this ABG.

What does this ABG show?

pH	7.20	(7.35 – 7.45)
PaCO ₂	10.9 KPa	(4.7 – 6.0 kPa)
PaO ₂	7.6 KPa	(>10kPa)
HCO ₃	30 mmol/l	(22-26 mmol/l)
BE	3.0	(+/-2.0 mmol/l)

(on 15L/min)



*Type 2 respiratory failure
Acidosis- Respiratory
Compensating- Metabolic*

Step 2: Assess Oxygenation

ON AIR: PaO₂ should be >10 kPa (75mmHg)

OR

ON OXYGEN: <10kPa less than the % inspired concentration

e.g. 15 L/min delivers approx. 50-60% O₂ so should have PaO₂ of ~40

Respiratory Failure

- **Type 1** ONE Problem PaO₂ <10kPa
- **Type 2** TWO Problems PaO₂ <10kPa
PaCO₂ >6.0kPa



Case 3

70yo man walks into A&E with breathlessness and productive cough. She has known COPD and has had previous ITU admissions with *“problems with the gases in my blood”*

What would be your management?

- ABCDE
- Ex- talking to you, no signs of distress, widespread polyphonic wheeze

BP 145/90 HR 105 RR 20 Sats 87%



Case 3: Oxygen Therapy

70yo COPD. Mild SOB/cough. Wheeze. RR20 HR105 Sats 87% OA

Is the patient critically ill or O_2 sats <85% ?

NO

Is patient at risk of hypercapnia?

Target Sats

Starting Device

YES →

88-92%

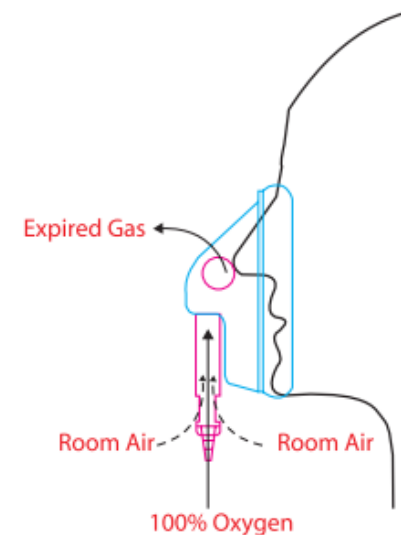
Venturi 24%

... and do an Arterial Blood Gas



Venturi Mask

Deliver fixed oxygen
24-40%



Colour Coded Venturi Masks

Colour of Mask attachment	Oxygen (%)	Rate of Oxygen L/Min
Blue	24	2-4
White	28	4-6
Yellow	35	8-10
Red	40	10-12
Green	60	12-15

70yo COPD. Mild SOB/cough. Wheeze. RR20 HR105 Sats 87% OA

... Arterial blood gas

1

pH	7.42
pCO ₂	7.1
pO ₂	14.3
HCO ₃	27

DO NOT STOP THEIR OXYGEN due to hypercapnia
HYPOXIA KILLS! HYPOXIA KILLS!

CO₂ elevated (>6.0kPa) and pH normal
Continue with target sats 88-92%

2

pH	7.38
pCO ₂	5.9
pO ₂	15.1
HCO ₃	24

CO₂ normal and not acidotic
Change to target sats 94-98%
(Treat as low risk hypercapnia)

3

pH	7.21
pCO ₂	8.0
pO ₂	7.8
HCO ₃	30

CO₂ elevated (>6.0kPa) and acidotic
Consider NIV ... i.e. Get help!

Normal values
(7.35 – 7.45)
(4.7 – 6.0 kPa)
(>10kPa)
(22-26 mmol/l)
(+/-2.0 mmol/l)

Repeat ABG in 30-60mins



Alert Card

OXYGEN ALERT CARD

Name: _____

I am at risk of type II respiratory failure with a raised CO₂ level.

Please use my ____% Venturi mask to achieve an oxygen saturation of ____% to ____% during exacerbations.

Use compressed air to drive nebulizers (with nasal oxygen at 2 L/min).

If compressed air not available, limit oxygen-driven nebulizers to 6 minutes.

Tracheostomy masks








Case 4

An 18-year-old insulin dependent diabetic is admitted to the emergency department. He has been vomiting for 48h and because he was unable to eat, he has taken no insulin.

Breathing spontaneously RR 35 /min SpO2 98% P 130 /min, BP 90/65 mmHg
GCS 12 (E3, M5, V4)

What would you expect the ABG to reveal?

ABGs on 15l/min are:

-  pH 7.01
-  pCO2 2.9KPa
-  pO2 36.6KPa
-  HCO3 7mmol/l
-  BE -21.9mmol/l
- Sats 100%

**METABOLIC
ACIDOSIS
WITH PARTIAL
RESPIRATORY
COMPENSATION**

pH 7.35 – 7.45
pO2 >10 kPa on air
PCo2 4.7-6.0 kPa
HCO3 22 – 26 mmol/l
BE +/- 2 mmol/l

BM 30 mmol/l Urine ketones +++ in the urine



Step 3: pH

Step 4: Respiratory Component

Step 5: Metabolic Component



Normal pH = 7.35-7.45

$$\text{pH} \propto \frac{\text{bicarb}}{\text{CO}_2}$$

Take your time

Analyse pCO_2 and HCO_3 separately related to the pH

pCO_2 opposite way as pH

(high CO_2 = Acidosis)

HCO_3 same way as pH

(high HCO_3 = Alkalosis)

Beware of mixed and compensatory change



Base Excess

Alternative to HCO_3^- but **SAME** information
Changes more acutely than bicarbonate

The normal base excess is ± 2 mmol/l

- Base excess $> +2$ = metabolic alkalosis
- Base excess < -2 = metabolic acidosis



Case 5... Same hx as Case 4: DKA patient

18-year-old T1 DM unwell with DKA

Biochemistry on admission:

Na⁺ 136 K⁺ 4.8 Cl⁻ 101 urea 8.1

Reminder of the ABG:

pH 7.01 pCO₂ 2.9 pO₂ 36.6 HCO₃⁻ 7 BE -21.9

What's the anion gap?

Does it fit with our diagnosis?



Anion Gap

ONLY DO IN METABOLIC ACIDOSIS

- Calculates level of unmeasured anions

$$\begin{aligned}\text{Anion Gap} &= \text{MEASURED Positive ions} - \text{MEASURED Negative ions} \\ &= \text{Na}^+ - (\text{Cl}^- + \text{HCO}_3^-)\end{aligned}$$

Normal = 6-12

High anion gap

- Lactic / Keto- / Urate- acidosis

Normal anion gap

- Diarrhoea, Renal tubal acidosis



Case 5 continued

Biochemistry on admission:

Na⁺ 136 K⁺ 4.8 Cl⁻ 101 urea 8.1

Reminder of the ABG:

pH 7.01 pCO₂ 2.9 pO₂ 36.6 HCO₃ 7 BE -21.9

What's the anion gap?

$$\text{Anion Gap} = \text{Na} - (\text{Cl} + \text{HCO}_3)$$

Does it fit with our diagnosis?

$$\begin{aligned}\text{Anion Gap} &= \text{Na} - (\text{Cl} + \text{HCO}_3) \\ &= 136 - (101 + 7) \\ &= 28\end{aligned}$$






HIGH ANION GAP



Case 6

A 64yo lifelong smoker is seen in outpatients clinic with a 2 year history of worsening cough and exertional dyspnoea. Walks into clinic room.

ABGs on room air show:

 pH 7.37
 PaCO₂ 6.9KPa
 PaO₂ 7.1KPa
 HCO₃ 33mmol/l
 Base excess + 8.9mmol/l
Sats 89%

NORMAL VALUES

pH 7.35 – 7.45

paO₂ >10 kPa on air

PaCo₂ 4.7-6.0 kPa

Bicarb 22 – 26 mmol/l

BE +/- 2 mmol/l

- 1. TYPE 2 RF**
- 2. RESPIRATORY ACIDOSIS
WITH METABOLIC COMPENSATION
(CHRONIC)**

Compensation

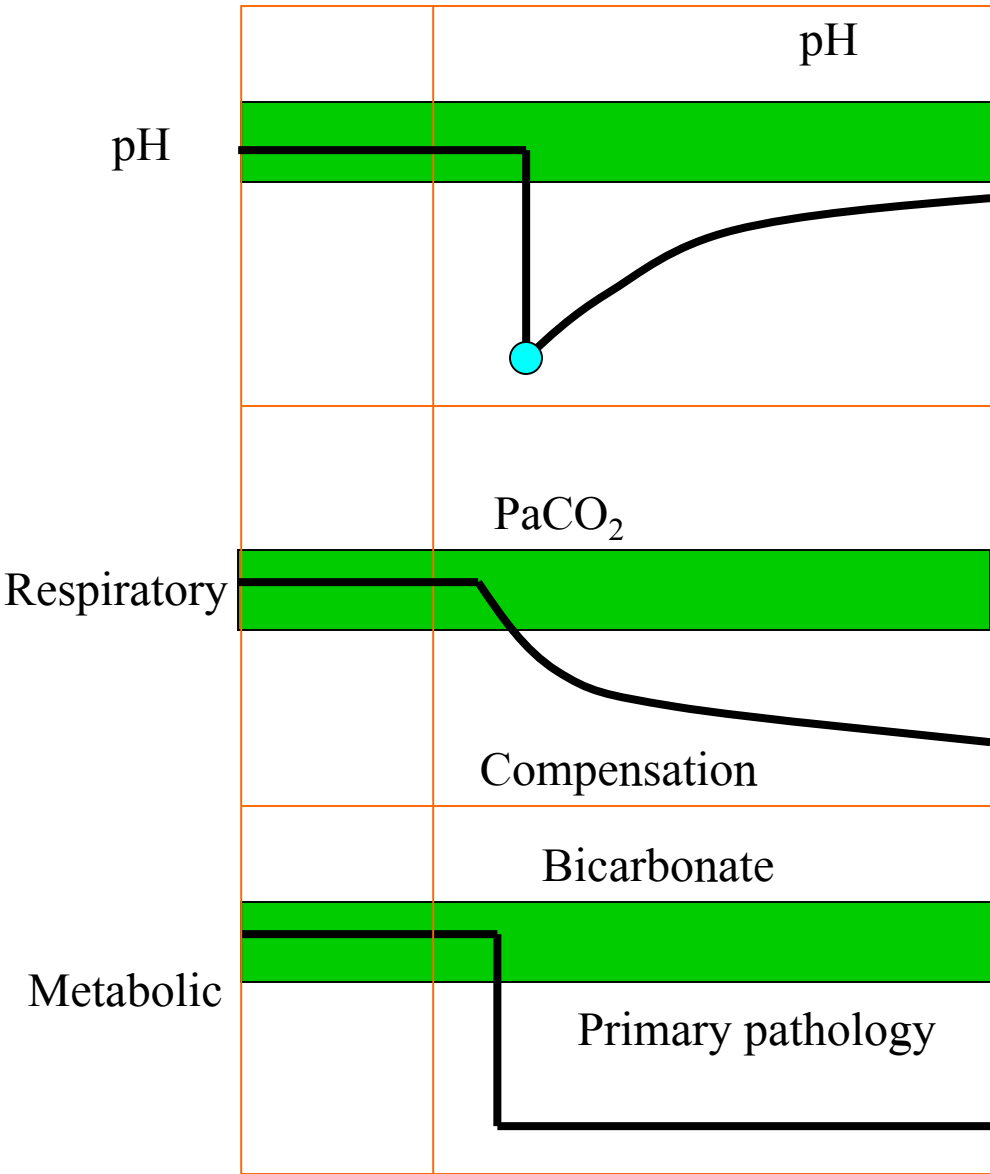
Response to correct initial problem

Will not “over” compensate

Respiratory = quick

Metabolic = slow





HYPER VENTILATION

↑

METABOLIC ACIDOSIS



Case 7 : Same hx as Case 6

A 64yo lifelong smoker is seen in outpatients clinic with a 2 year history of worsening cough and exertional dyspnoea. Walks into clinic room.

1. **TYPE 2 RF**
2. **RESPIRATORY ACIDOSIS WITH METABOLIC COMPENSATION (CHRONIC)**

Would you expect this patient to have high / low / normal Aa gradient?



A-a Gradient






- Evaluates the CAUSE of **hypoxaemia**
- Measure of the difference between **A**lveolar oxygenation and **a**rterial oxygenation
- **Normal Aa = extra-pulmonary problem, for example:**
 - Hypoventilation (Neuromuscular disorders / CNS disease / sedation)
 - Low inspired FiO2 (high altitude)
- **Raised Aa = intra-pulmonary problem, for example:**
 - R to L shunt (CCF / ARDS)
 - V/Q mismatch (PE / COPD / pneumonia / pneumothorax / asthma / atelectasis)
 - Alveolar hypoventilation (interstitial lung disease)
- Normal = 5-10
- *A-a gradient = PaO2 – FiO2 x (760-47) – (PaCO2/0.8)*



Case 8

A 78yo man attends A&E with a 3 month history of weight loss and a sensation of 'early fullness' on eating. This is now associated with a four day history of worsening 'projectile' vomiting.

ABG on room air

 pH 7.62
 PaCO₂ 4.8KPa
 PaO₂ 12.6KPa
 HCO₃ 54.8mmol/l
 Base excess + 20.9mmol/l
Sats 96%

NORMAL VALUES

pH 7.35 – 7.45
paO₂ >10 kPa on air
PaCo₂ 4.7-6.0 kPa
Bicarb 22 – 26 mmol/l
BE +/- 2 mmol/l

METABOLIC ALKALOSIS

WHAT COULD THE CAUSE BE?



Case 8 (alternative history)

A 3 week old baby is brought to A&E with projectile vomiting and poor weight gain.

ABG on room air

pH 7.62

↑ PaCO₂ 4.8KPa

↔ PaO₂ 12.6KPa

↔ HCO₃ 54.8mmol/l

↑ Base excess + 20.9mmol/l

↑ Sats 96%

METABOLIC ALKALOSIS

WHAT IS THE MOST LIKELY CAUSE?

Case 9

pH	7.21
pCO ₂	7.3 kPa
pO ₂	5.9 kPa
HCO ₃	14.6 mmol/L
BE	-7.9 mmol/L
Sats	76%

NORMAL VALUES

<i>pH</i>	<i>7.35 – 7.45</i>
<i>paO₂</i>	<i>>10 kPa on air</i>
<i>PaCo₂</i>	<i>4.7-6.0 kPa</i>
<i>Bicarb</i>	<i>22 – 26 mmol/l</i>
<i>BE</i>	<i>+/- 2 mmol/l</i>

Type 2 Respiratory Failure

MIXED ACIDOSIS

Both Respiratory and Metabolic component

Cause?



Case 10: CPAP or BiPAP?

You are FY1 on August 2nd 2017

Nurse calls...

“68yo COPD patient becoming unwell and now very short of breath.

What would you like to do doctor, CPAP or BiPAP?”

What would you do??



Case 10: Management

- ABCDE
- Give high flow O2
- See the notes / involve the patient
- Hx / Ex
- Basic investigations – ABG, ECG, Bloods, CXR
- Institute initial management
- Get Help!



Non-Invasive Ventilation



Avoids intubation.
Can easily apply/remove.

Contraindications

- Patient declines- is v.uncomfortable
- Patient very confused
- High Aspiration Risk
- Facial Trauma

Should show ABG or clinical improvement
within 2 hours

Non-Invasive Ventilation

CPAP (Continuous)

Oxygenation

Type 1 RF

e.g. LVF/CCF

Chest wall trauma

Continuous pressures

“Breathing into wind tunnel”

BiPAP (Bi-Level)

Ventilation

Type 2 RF

e.g. COPD with Acidosis

Decompensated OSA

IPAP/EPAP pressures

“Senses inspiration”

Pushes O₂ in and CO₂ out



Long term Oxygen Therapy

- Indicated in Chronic hypoxaemia
 - pO_2 consistently <7.3 kPa or 7.3-8.0 with polycythaemia / peripheral oedema / nocturnal hypoxaemia / pulm HTN
 - Also indicated in nocturnal hypoventilation / palliative
- Background lung disease e.g. COPD/CF/bronchiectasis/CCF
- Need smoking cessation
- Use for >15 hrs / day
- Increases survival



ABG interpretation: 5 step approach

- Step 1 HOW IS THE PATIENT?
- Step 2 Assess Oxygenation
- Step 3 pH- acidosis vs alkalosis
- Step 4 Respiratory component
- Step 5 Metabolic component



Summary

- Make sure you look at the clinical scenario
- Be systematic and always use the a standardised approach, so don't miss whole picture
- Hypoxia kills



Respiratory

Acidosis ($\text{PaCO}_2 > 6.0 \text{ kPa}$)

Hypoventilation

T2 RF-Impaired gas exchange

- COPD
- Heroin OD
- Chest wall defect
- Resp. muscle weakness
e.g. G.Barre

Alkalosis ($\text{PaCO}_2 < 4.7 \text{ kPa}$)

Hyperventilation due to

- Anxiety
- Hypoxemia
- Metabolic acidosis
- Neurologic Lesions
- Trauma
- Infection

Metabolic

Acidosis ($\text{HCO}_3^- < 22 \text{ mmol/l}$)

- DM Ketoacidosis
- Urate acidosis (Renal failure)
- Lactic Acidosis
Decreased perfusion
Severe hypoxemia/sepsis
- Drugs (e.g. Salicylates)

***Anion gap**

Alkalosis ($\text{HCO}_3^- > 26 \text{ mmol/l}$)

- XS loss (e.g. Vomiting)
- Ingestion of alkali

