

O<sub>2</sub>

# Oxygen and ABG

Dr William Dooley



# Plan

- Oxygen and ABG 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
- Hx- as above
- Ex- talking to you, no signs of distress, creps in left base

**BP 118/70 HR 105 RR 20 Sats 91%**

# Oxygen Therapy

68yo. No PMH. Mild SOB/cough. Wheeze. 118/70 RR20 HR105 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)

YES →

88-92%

Venturi 24%

... and do an Arterial Blood Gas



# Oxygen masks



- Variable O<sub>2</sub> of 35-60%.
- Flow 5-10 L/min
- **Comfortable**
- **Low cost**
- **Interfere with eating**
- **Easy displacement**
- **Increased aspiration by concealment of vomitus**

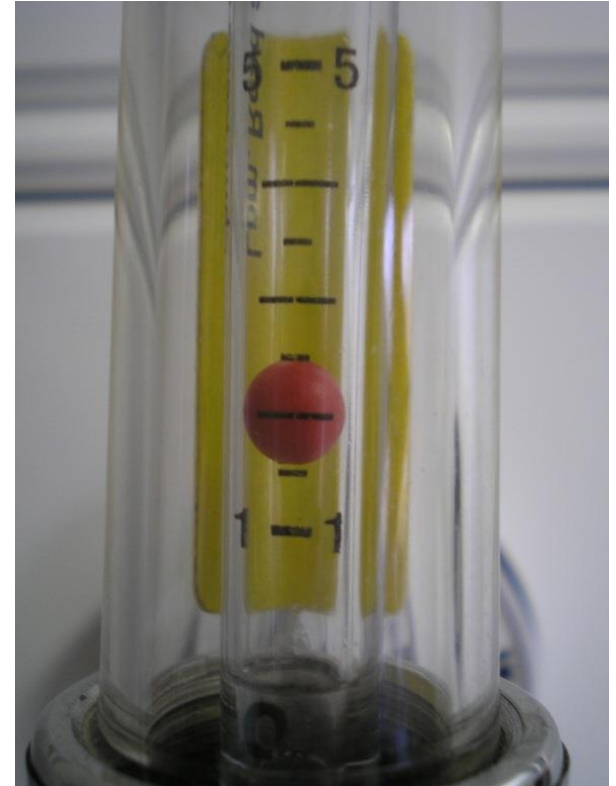
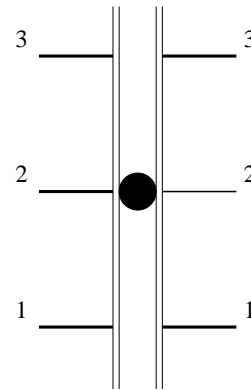
/

# Nasal cannula



- Variable O<sub>2</sub> of 24-50%
- Flow 2-6L/min
- **Convenient**
- **Patient preference**
- **Easily tolerated**
- **Nasal breathing**
- **Drying of mucosa and epistaxis**

# Oxygen Flow Meter



# Arterial Blood Gas


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

*CO<sub>2</sub> low and not acidotic*

Keep with target sats 94-98%

*(Treat as low risk hypercapnia)*

# Prescribe

| DRUG  |   | OXYGEN    |          |
|---|---|-----------|----------|
| (Refer To Trust Oxygen Policy)  |   |           |          |
| <i>Circle target oxygen saturation</i><br>88-92% <b>94-98%</b> Other ____         |   | STOP DATE |          |
| Starting device/flow rate <u>2-4 L/min, NRM</u><br><b>PRN /</b> Continuous        |   | PHARM     |          |
| (Saturation is indicated in almost all cases except for palliative terminal care) |   |           |          |
| SIGNATURE / PRINT NAME  |  | DATE      | 10/02/16 |



# 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
- Hx: as above
- Ex: distressed, widespread polyphonic wheeze
- Vital observations:



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 Re-breath  
Mask

15 L/min oxygen

Variable  $O_2$  of 60-80%  
Effective for short term  
Uncomfortable High Flow

Then do Arterial

Blood C

**HYPOXIA KILLS**

# ABG of our first 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 <sub>2</sub> | 10.9 KPa  | (4.7 – 6.0 kPa) |
| PaO <sub>2</sub>  | 7.6 KPa   | (>10kPa)        |
| HCO <sub>3</sub>  | 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: PaO<sub>2</sub> should be >10 kPa (75mmHg)

*OR*

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

e.g. 15 L/min delivers approx. 50-60% O<sub>2</sub> so should have PaO<sub>2</sub> of ~40

## Respiratory Failure

- **Type 1**      ONE Problem      PaO<sub>2</sub> <10kPa
- **Type 2**      TWO Problems      PaO<sub>2</sub> <10kPa  
PaCO<sub>2</sub> >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
- Hx- as above
- Ex- talking to you, no signs of distress, widespread polyphonic wheeze

**BP 145/90 HR 105 RR 20 Sats 87%**



# 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                                  |
|------|-------------|--|
| NO → | 94-98%      | Nasal Cannula (2-6L/m)<br>or Face Mask (5-10L/m) |

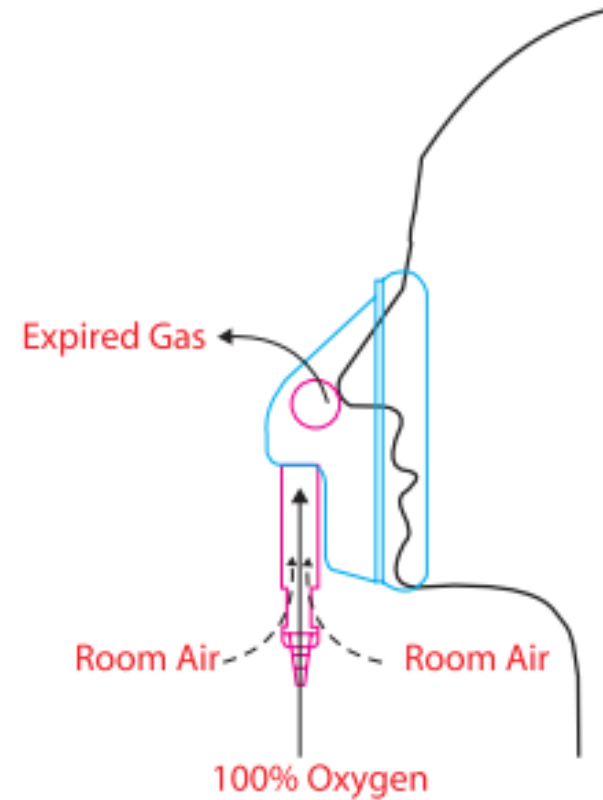
YES → 88-92% Venturi 24%

... and do an Arterial Blood Gas

# Venturi Masks

Deliver constant/Fixed O<sub>2</sub> of 24-40%  
Increasing flow does not increase oxygen  
Concentration

Fixed delivery of Oxygen




# 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                |



# Prescribe

| DRUG   |  | OXYGEN           |  |
|--|--|------------------|--|
| (Refer To Trust Oxygen Policy)   |  |                  |  |
| <i>Circle target oxygen saturation</i><br><b>88-92%</b> <b>94-98%</b> Other ____                           |  | STOP<br>DATE     |  |
| Starting device/flow rate <u>24% Venturi</u><br>PRN <b>Continuous</b> 2L/min                               |  |                  |  |
|  |  | PHARM            |  |
| (Saturation is indicated in almost all cases except for palliative terminal care)                          |  |                  |  |
| SIGNATURE / PRINT NAME  |  | DATE<br>11/02/15 |  |

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

... Arterial blood gas

|                  |      |
|------------------|------|
| pH               | 7.42 |
| pCO <sub>2</sub> | 7.1  |
| pO <sub>2</sub>  | 14.3 |
| HCO <sub>3</sub> | 27   |

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

*CO<sub>2</sub> elevated (>6.0kPa) and pH normal*  
Continue with target sats 88-92%

|                  |      |
|------------------|------|
| pH               | 7.38 |
| pCO <sub>2</sub> | 5.9  |
| pO <sub>2</sub>  | 15.1 |
| HCO <sub>3</sub> | 24   |

*CO<sub>2</sub> normal and not acidotic*  
Change to target sats 94-98%  
(Treat as low risk hypercapnia)

|                  |      |
|------------------|------|
| pH               | 7.21 |
| pCO <sub>2</sub> | 8.0  |
| pO <sub>2</sub>  | 7.8  |
| HCO <sub>3</sub> | 30   |

*CO<sub>2</sub> 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 CO<sub>2</sub> 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, oxygen 4 l/min via Hudson mask, SpO<sub>2</sub> 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  
↓ PaCO<sub>2</sub> 2.9KPa  
↔ PaO<sub>2</sub> 36.6KPa  
↓ HCO<sub>3</sub> 7mmol/l  
↓ BE -21.9mmol/l  
↓ Sats 100%

**METABOLIC  
ACIDOSIS  
WITH PARTIAL  
RESPIRATORY  
COMPENSATION**

## *NORMAL VALUES*

*pH* 7.35 – 7.45  
*paO<sub>2</sub>* >10 kPa on air  
*PaCo<sub>2</sub>* 4.7-6.0 kPa  
*Bicarb* 22 – 26 mmol/l  
*BE* +/- 2 mmol/l

BM 30 mmol/l      Urine ketones +++ in the urine  
DDx / Ix / Mx



# Step 3: pH

Normal = 7.35-7.45

Acidaemic pH < 7.35

Alkalaemic pH > 7.45

$$\text{pH} \propto \frac{\text{HCO}_3}{\text{CO}_2}$$



# Step 4: Respiratory Component

# Step 5: Metabolic Component

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

Take your time

Analyse the  $\text{pCO}_2$  and  $\text{HCO}_3$  separately related to the pH

$\text{pCO}_2$  opposite way as pH      (*high  $\text{CO}_2$  = Acidosis*)

$\text{HCO}_3$  same way as pH      (*high  $\text{HCO}_3$  = Alkalosis*)

*Beware of mixed and compensatory change*



# Base Excess

Alternative to  $\text{HCO}_3^-$  but **SAME** information

- Changes in acute setting

The normal base excess is  $\pm 2$  mmol/l

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





# Compensation

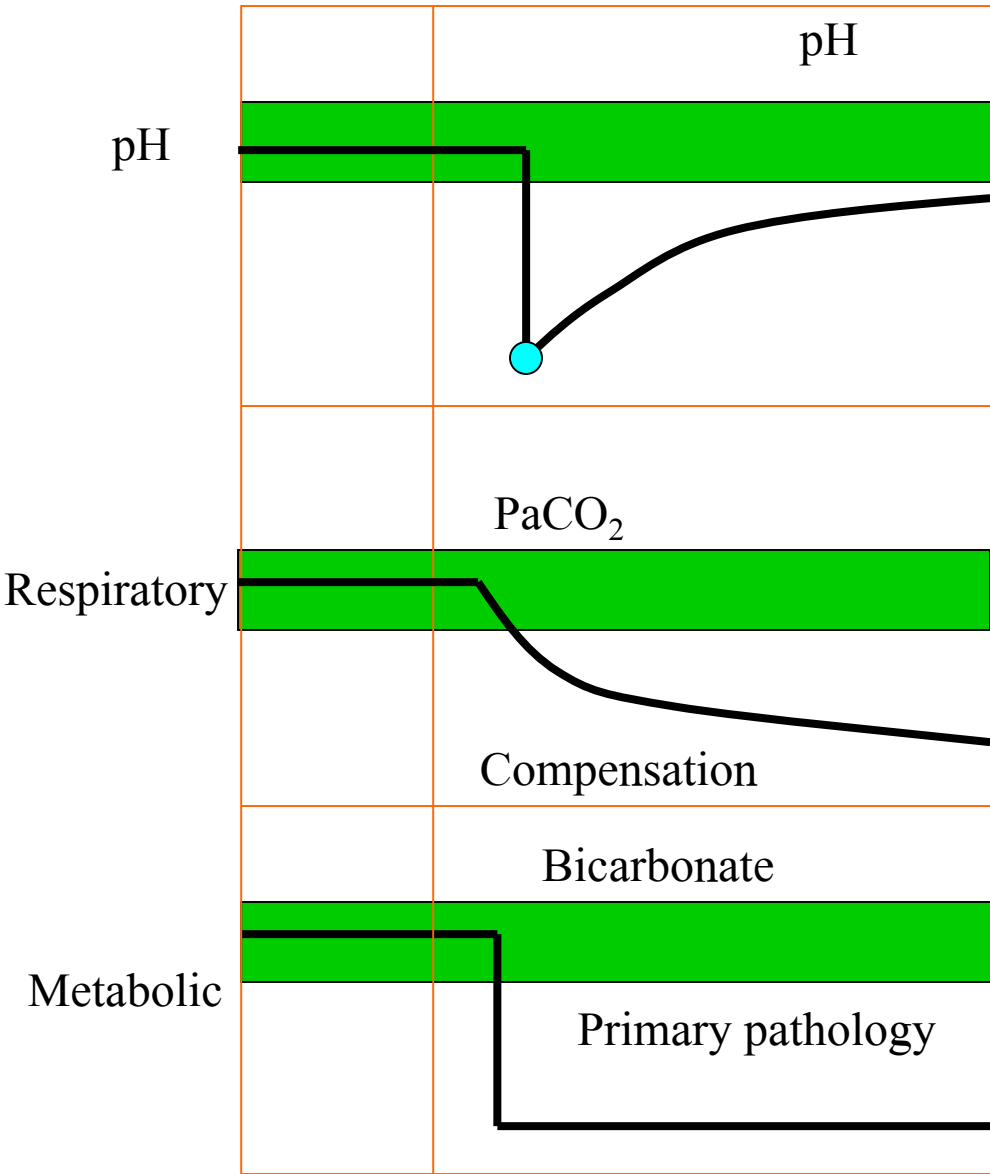
Response to correct initial problem

*Will not “over” compensate*

*Respiratory = quick*

*Metabolic = slow*





HYPER VENTILATION



METABOLIC ACIDOSIS



# Case 4 again

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, oxygen 4 l/min via Hudson mask, SpO<sub>2</sub> 98% P 130 /min, BP 90/65 mmHg, GCS 12 (E3, M5, V4)

ABGs on 15l/min are:

pH 7.01

PaCO<sub>2</sub> 2.9KPa

PaO<sub>2</sub> 36.6KPa

HCO<sub>3</sub> 7mmol/l

BE -21.9mmol/l

Sats 100%

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

DDx / Ix / Mx

**METABOLIC ACIDOSIS  
WITH PARTIAL RESPIRATORY  
COMPENSATION**



# Case 4 continued

Biochemistry on admission:

Na<sup>+</sup> 136 K<sup>+</sup> 4.8 Cl<sup>-</sup> 101 urea 8.1

Reminder of the ABG:

pH 7.01 pCO<sub>2</sub> 2.9 pO<sub>2</sub> 36.6 HCO<sub>3</sub> 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

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

Normal = 6-12

### High anion gap

- Lactic / Keto- / Urate-acidosis

### Normal anion gap

- Diarrhoea, Renal tubal acidosis

# Case 4 continued

Biochemistry on admission:

Na<sup>+</sup> 136 K<sup>+</sup> 4.8 Cl<sup>-</sup> 101 urea 8.1

Reminder of the ABG:

pH 7.01 pCO<sub>2</sub> 2.9 pO<sub>2</sub> 36.6 HCO<sub>3</sub> 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 5

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  
↑ PaCO<sub>2</sub> 6.9KPa  
↓ PaO<sub>2</sub> 7.1KPa  
↑ HCO<sub>3</sub> 33mmol/l  
↑ Base excess + 8.9mmol/l  
Sats 89%

## *NORMAL VALUES*

*pH* 7.35 – 7.45

*paO<sub>2</sub>* >10 kPa on air

*PaCo<sub>2</sub>* 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)

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 FiO<sub>2</sub> (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 = PaO<sub>2</sub> – FiO<sub>2</sub> x (760-47) – (PaCO<sub>2</sub>/0.8)*





# Case 6

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.

ABGs on room air

↑ pH 7.62  
↔ PaCO<sub>2</sub> 4.8KPa  
↔ PaO<sub>2</sub> 12.6KPa  
↑ HCO<sub>3</sub> 54.8mmol/l  
↑ Base excess + 20.9mmol/l  
Sats 96%

DDx / Ix / Mx

## *NORMAL VALUES*

*pH* 7.35 – 7.45  
*paO<sub>2</sub>* >10 kPa on air  
*PaCo<sub>2</sub>* 4.7-6.0 kPa  
*Bicarb* 22 – 26 mmol/l  
*BE* +/- 2 mmol/l

## **METABOLIC ALKALOSIS**






*WHAT COULD THE CAUSE BE?*



# Case 6 (alternative)

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

ABGs on room air

 pH 7.62  
 PaCO<sub>2</sub> 4.8KPa  
 PaO<sub>2</sub> 12.6KPa  
 HCO<sub>3</sub> 54.8mmol/l  
 Base excess + 20.9mmol/l  
Sats 96%

## *NORMAL VALUES*

*pH* 7.35 – 7.45  
*paO<sub>2</sub>* >10 kPa on air  
*PaCo<sub>2</sub>* 4.7-6.0 kPa  
*Bicarb* 22 – 26 mmol/l  
*BE* +/- 2 mmol/l

## METABOLIC ALKALOSIS

DDx / Ix / Mx



# Case 7

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

## *NORMAL VALUES*

|                         |                          |
|-------------------------|--------------------------|
| <i>pH</i>               | <i>7.35 – 7.45</i>       |
| <i>paO<sub>2</sub></i>  | <i>&gt;10 kPa on air</i> |
| <i>PaCo<sub>2</sub></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?*



# 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



# Case 8: CPAP or BiPAP?

You are FY1 on August 5<sup>th</sup> 2015

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 8: Management

- ABCDE
- Give high flow O<sub>2</sub>
- See the notes / involve the patient
- Hx / Ex / Ix
- Basic investigations – ? CXR, ABGs, ECG, Bloods
- Institute initial management
- Get Help!



# Non-Invasive Ventilation



Avoids intubation.  
Can easily apply/remove.

## Indications

- Acute Type 1 or Type 2 RF
- Chronic T2 RF/ Sleep Apnoea
- Uncontrolled acidosis or hypercapnia

## 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 Positive Pressure Ventilation



## **CPAP**

Continuous Positive Airway  
pressure ventilation

## **BiPAP**

Bilevel Positive Airway  
Pressure ventilation device

*Both deliver oxygen above  
estimated Peak End  
Expiratory Pressure (PEEP)*



# NIV

## CPAP

Oxygenation

Type 1 RF

e.g. LVF/CCF

Chest wall trauma

Continuous pressures

“Breathing into wind tunnel”

## BiPAP

Ventilation

Type 2 RF

e.g. COPD with Acidosis

Decompensated OSA

IPAP/EPAP pressures

“Senses inspiration”

Pushes O<sub>2</sub> in and CO<sub>2</sub> out



# Cases 9 & 10

9. A 23yo Asthmatic with an acute asthma attack who has O<sub>2</sub> sats of 93% on room air. ABG: pH 7.40, pO<sub>2</sub> 8.8, pCO<sub>2</sub> 8.0, HCO<sub>3</sub> 25

*What is your management?*

10. A previously fit and well 61yo man who is immediately post hemi-colectomy, no specific complaints.

Sats 98%, HR 90, BP 120/80, RR 14

*Would you continue oxygen?*

*Other considerations?*



9. A 23yo Asthmatic with an acute asthma attack who has O<sub>2</sub> sats of 93% on room air. ABG=Type 2 Respiratory Failure

***What is your management?***

SENIOR HELP/ITU. High flow oxygen- 15L/min NRM.

Monitor all vital signs. Examine patient for possible reversible causes

10. A previously fit and well 61yo man who is immediately post hemi-colectomy, no specific complaints.

Sats 98%, HR 90, BP 120/80, RR 14

***Would you continue oxygen?***

?Nasal Specs, 2-4L/min

***Other considerations?***

Fluid balance, NBM/IV Fluids; regular obs. Analgesia/Anti-emetics.



# 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

