Arterial Blood Gas

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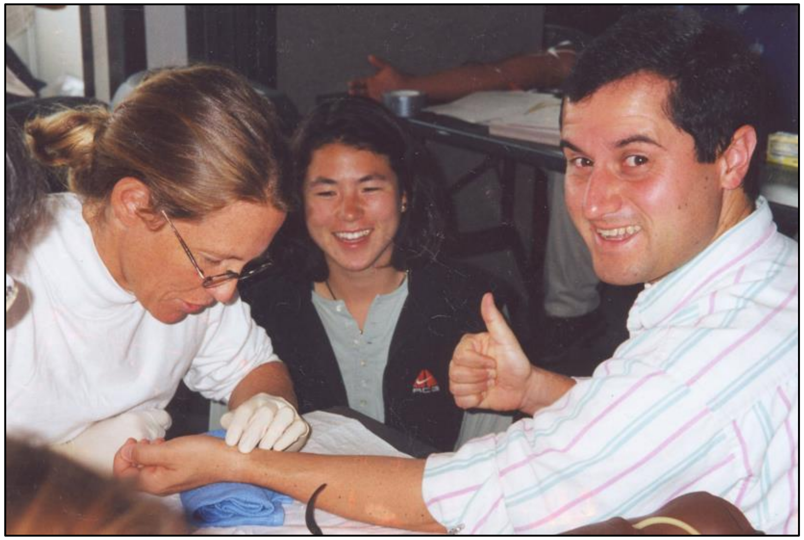
SIMPLY
FINALS

Plan

- 5-step approach for interpretation
- Case scenarios
- Some common concerns
  - A-a gradient
  - Base Excess
  - Anion Gap



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

5 step approach

Treat the patient and not the numbers…

1. **HOW IS THE PATIENT?**
2. Assess Oxygenation
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5 step approach

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

5 step approach

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

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Step 2: Assess Oxygenation

ON AIR: PaO_2 should be >10 kPa (75mmHg)

OR

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

e.g. 15 L/min delivers approx. 50-60% O_2 so should have PaO2 of ~40

Respiratory Failure

- **Type 1** ONE Problem PaO_2 <10kPa
- **Type 2** TWO Problems PaO_2 <10kPa, $PaCO_2$ >6.0kPa

5 step approach

1. HOW IS THE PATIENT?
2. Assess Oxygenation
3. pH- acidosis vs alkalosis
4. Respiratory component
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5 step approach

1. HOW IS THE PATIENT?
2. Assess Oxygenation
3. **pH- acidosis vs alkalosis**
4. Respiratory component
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Step 3: pH

Normal = 7.35-7.45

- Acidaemic pH<7.35
- Alkalaemic pH>7.45

$$pH \propto \frac{HCO_3}{CO_2}$$

5 step approach

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

5 step approach

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

Step 4: Respiratory vs Metabolic Component

$$pH \propto \frac{bicarb}{CO_2}$$

Take your time

Analyse the 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 HCO3- but **SAME** information

- Changes in acute setting

The normal base excess is +/- 2 mmol/l

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

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

Case 1

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

ABGs on 15l/min are:

- pH 7.01
- PaC02 2.9KPa
- Pa02 36.6KPa
- HC03 7mmol/l
- BE -21.9mmol/l
- Sats 100%

METABOLIC ACIDOSIS WITH PARTIAL RESPIRATORY COMPENSATION

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*

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

DDx / Ix / Mx

Compensation

Response to correct initial problem

Will not "over" compensate

Respiratory = quick / Metabolic = slow

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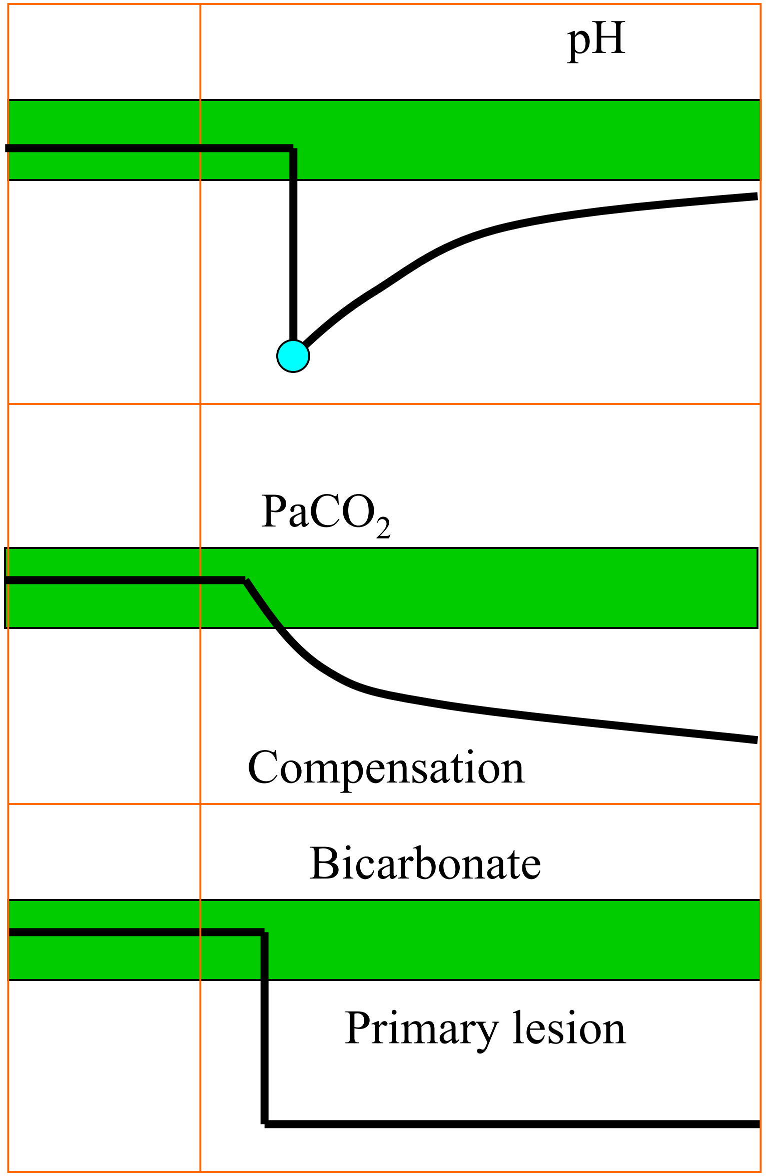

HYPER VENTILATION

↑

METABOLIC ACIDOSIS

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Case 1 (cont.)

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?

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Anion Gap

- **ONLY DO IN METABOLIC ACIDOSIS**
- Calculates level of unmeasured anions

Anion Gap = ***MEASURED*** Positive ions – ***MEASURED*** Negative ions
= Na^+ **-** (Cl^- + $HCO3^-$)

Normal = 6-12

High anion gap
- Lactic / Keto- / Urate- acidosis

Normal anion gap
- Diarrhoea, Renal tubal acidosis

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Case 1 (cont.)

Biochemistry on admission:

<u>Na^+ 136</u> K^+ 4.8 **<u>Cl^- 101</u>** urea 8.1

Reminder of the ABG:

pH 7.01 pCO2 2.9 pO2 36.6 **<u>HCO3 7</u>** BE -21.9

What's the anion gap?

Does it fit with our diagnosis?

$$\text{Anion Gap} = Na - (Cl + HCO3) = 136 - (101 + 7) = 28$$

HIGH ANION GAP

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Case 2

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

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*

ABGs on room air show:

- ↔ pH 7.37
- ↑ PaC02 6.9KPa
- ↓ Pa02 7.1KPa
- ↑ HCO3 33mmol/l
- ↑ Base excess + 8.9mmol/l
- Sats 89%

1. **TYPE 2 RF**
2. **RESPIRATORY ACIDOSIS**

WITH METABOLIC COMPENSATION (CHRONIC)

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

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A-a Gradient

- Measure of the difference between **A**lveolar oxygenation and **a**rterial oxygenation
- Evaluates the SOURCE of **hypoxaemia**

- **Normal Aa = extra-pulmonary problem e.g.**
  - R to L shunt (CCF / ARDS)
  - V/Q mismatch (PE / COPD / pneumonia / pneumothorax / asthma / atelectasis)
  - Alveolar hypoventilation (interstitial lung disease)
- **Raised Aa = intra-pulmonary problem e.g.**
  - Hypoventilation (Neuromuscular disorders / CNS disease / sedation)
  - Low inspired FiO_2 (high altitude)

- Normal = 5-10
- *A-a gradient = PaO_2 – FiO_2 x (760-47) – ($PaCO_2$/0.8)*

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Case 3

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 (↑)
- PaC02 4.8KPa (↔)
- Pa02 12.6KPa (↔)
- HC03 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

DDx / Ix / Mx

Case 3 (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
- PaC02 4.8KPa
- Pa02 12.6KPa
- HC03 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

DDx / Ix / Mx

SIMPLY FINALS

Case 4

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

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*

Type 2 Respiratory Failure

MIXED ACIDOSIS

Both Respiratory and Metabolic component

SIMPLY FINALS

Respiratory

Acidosis ($PaCO_2 > 6.0$kPa)

Hypoventilation

T2 RF-Impaired gas exchange

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

Alka ($PaCO_2 < 4.7$kPa)

$$pH \propto \frac{BICARB}{pCO_2}$$

Hyperventilation due to

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

Metabolic

Acidosis (HCO3 <22mmoll/l)

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

Alkalosis (HCO3 >26mmoll/l)

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

**Anion gap*

$$pH \propto \frac{BICARB}{pCO_2}$$

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Summary

- Make sure you look at the clinical scenario
- Be systematic and always use the 5 step approach
- Look out for compensation and mixed pictures

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