ABG INTERPRETATION FOR THE FACEM WRITTEN EXAM

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SOME GENERAL COMMENTS ABOUT ABG QUESTIONS

Candidates become flustered on the blood gas analysis questions administered as part of the ACEM Fellowship exam. In my opinion ABG questions offer an excellent opportunity to score an 8+. They are all quite similar, without the subjective vagaries of the "describe and interpret a picture" type questions and this lends itself to a systematic, repeatable approach. The idea is that you write essentially the same answer every time, and just "plug in" the numbers from the question. Lots of people who get flustered by ABG questions do so because of a lack of understanding about the questions themselves, or by lacking the discipline to develop a comprehensive, simple, reproducible approach to the questions in their preparation.

There are two questions to think about when preparing for these VAQs.

1) Why is there an ABG question on the VAQ paper?

This is a question not to be under-estimated. The context of this question is not theoretical in nature ("why do FACEMs need to know about blood gases?"), it's practical.

The answer is – because the question *illustrates a disturbance of acid-base metabolism that the examiners would like you to identify and describe*. There are two conclusions to draw:

i) There *will be* an acid base disturbance present in the question
ii) To pass, you need to describe it. Everything else is window dressing/bonus marks.

Within this context then, there are very few things you need to be able to talk about to answer the question properly:

- metabolic acidosis
  - raised anion gap
  - normal anion gap/a mixed picture
- metabolic alkalosis
- respiratory acidosis
- respiratory alkalosis

That's it: 4 things. Having a reproducible and customizable list to explain all of these things is the key to answering the ABG question well.

The second thought to consider about why there is an ABG question on the exam pertains to ease of marking. In general there are a large number of calculations which can be performed by candidates and therefore marked objectively by examiners. This is an advantage for both. For examiners the question is standardized and easy to mark. For candidates the question is

standardized and easy to milk. This is the key to a high mark on ABG questions. Common calculations are:

- anion gap
- delta ratio
- A-a gradient
- Osmolar gap
- Corrected CO2/HCO3- values
- Electrolyte corrections, particularly Na and K
- Urea:creatinine ratios

You should anticipate that examiners will be looking for these calculations with pen poised as they read your answer.

2) How do I answer to maximize my mark.?

i) Address the central acid/base imbalance

Put it into context – ensure the stem is read. This often gives you the diagnosis, and sets up your interpretation, yet most people ignore it, except to think "oh shit, here comes the ABG question" Two examples from real exams follow with comments:

"A 59 year old obese man receives 5 mg of intravenous morphine for analgesia for abdominal pain. Thirty minutes later, his GCS has fallen to 12 and investigations are performed."

Straight away (before I even look at the numbers) I'm thinking:

- *obese – likely sleep apnoea, probably chronic CO2 retention*
- *IV morphine, decreased GCS – acute hypoventilation, acute on chronic respiratory acidosis. I'll need to correct HCO3 for both acute and chronic CO2 retention .*
- *It's probably morphine induced – I should mention reversal (and possibly quality assurance if I have time) in my interpretation section*
  - *Unsurprisingly this is exactly what the question showed*

"A 45 year old man with type 1 diabetes mellitus is brought in by ambulance with an altered conscious state"

Straight away:

- *The diagnosis will be DKA – ie RAGMA, Delta Ratio 1, hyperglycaemia*
- *I am looking for a concurrent lactic acidosis: shock/sepsis etc*
- *He will be hyponatraemic. I should correct his Na for his glucose*
- *I should mention the need for resuscitation, insulin infusion and possibly cerebral oedema given his decreased GCS*
  - *Again this is the correct answer on perusal of the college's examination report.*

ii) Put on some window dressing:

Comment on minor issues as the Q progresses. Don't leave it all to the end, because it becomes overwhelming. If it's in the question as you go you pick up the marks there and then, and are free to concentrate on

the acid base disturbance in your interpretation. Things to comment on include:

- Aa gradient
- Electrolytes
    - correct Na (for glucose)
    - correct K (for pH)
    - comment on the chloride if it's low. My standard comment is *"electrical equilibration for RAGMA"*
    - calculate U:C ratio → usually it suggests pre-renal failure

iii) Work through in a systematic/stepwise fashion

The examiners have to mark 50+ of these things. If your answer is illegible, a dog's breakfast or otherwise poorly structured you are likely to be the victim of a negative free-floating bias. If I need to tell you to write legibly you should not be sitting this exam ..

iv) Show perspective.

Use adjectives. pH of 7.26 and 6.9 are both "acidaemias". One is a "mild" acidaemia, one is "life threatening". You want to be a consultant. Prove it.

v) **MUDPILES** is for **MEDICAL STUDENTS**

Have something a bit more sophisticated. MUDPILES (causes of RAGMA) almost all present as a lactic acidosis. In my opinion it's like writing "I got some money from the ATM machine".

There are only three (or four depending on your opinion of the theory of salycilate poisoning) causes of a RAGMA:

- ketoacids
    - starvation
    - diabetes
    - profound dehydration (hyperemesis gravidarum, children)
- lactic acid
    - type A – tissue hypoperfusion (shock, anaemia, haemorrhage, SMA occlusion etc)
    - type B1 – liver failure, sepsis
    - type B2 – drugs (all the MUDPILES ones)
    - type B3 – inborn errors of metabolism. (Thankfully it's not a PICU fellowship exam)
- uraemic renal failure

Examiners hate MUDPILES. Something with clarity and sophistication looks much better.

SPECIFIC ABG STRUCTURE: ACTUALLY WRITING THE ANSWER

This is the way I actually set out my answer. All calculations are included *in vitro* and the answer progresses logically. I actually write the numeric headers to guide the examiners through my answer.

1. Acid base balance
    - Comment on the pH – *acidaemia, alkalaemia*
    - Comment on the CO2 – *hyper/hypocarbia, respiratory acidosis/alkalosis*
    - Comment on the bicarbonate – *high/low, metabolic acidosis/alkalosis*
    - Decide on the major disturbance. *This always is in the same direction as the pH.*
    - Correct the dependent variable for the major disturbance. *If the primary disturbance is metabolic, correct the CO2 for the HCO3. If the primary disturbance is respiratory, correct the HCO3 for the CO2. A great site describing the Boston Bedside Rules can be found here.*
    - If there is a metabolic acidosis calculate an anion gap and delta ratio[1]
    - Summary statement of the above, for example:
        a. *"Isolated RAGMA, appropriate resp compensation"*
2. Oxygen
    - Calculate Aa gradient[2]
    - Make a comment, this can be standardized across papers[3]

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[1] Delta ratio is defined as (change in AG)/(change in HCO_3^-). A delta ratio is interpreted as follows:

- < 0.4 (large drop in HCO_3^- without change in AG) = NAGMA
- 0.4 – 0.8 (intermittent drop in AG compared to HCO_3^-) = NAGMA + RAGMA
- 1.0 (equal drop in HCO_3^- and AG) = RAGMA
- 2.0^+ (lower drop HCO_3^- in than expected for AG) = there is a previously existing or concurrent metabolic alkalosis occurring. Mathematically this ratio occurs *because the resting HCO_3^- for the patient is greater than 24mmol/L*

[2] A-a gradient = [(760-vapour pressure) x FiO_2 – 1.25x$PaCO_2$) – PaO_2. One of the hardest things in the exam is trying to calculate the first part (the P_AO_2) for an FiO_2 that's not room air. My suggestion is to estimate:

- If FiO2 = 21% (room air) then the first number in the equation (760-VP x FiO_2) is 150mmHg.
- By dead reckoning, FiO_2 40% then the first number is doubled: 300mmHg
- Similarly on 28% O_2 (somewhere in the ballpark of 1.5 x 21…) I use P_AO_2 = 225mmHg

[3] My standard comment in the event of an elevated A-a gradient is *"A-a gradient elevated. .: V/Q mismatch:*

- *APO*
- *ARDS*
- *PE*
- *LRTI*
- *Other respiratory membrane disease*

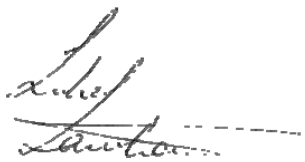
3. Electrolytes/other
    - Comment on all minor abnormalities
    - Don't forget:
        a. Correct Na+ for glucose[4]
        b. Correct K+ for pH[5]
        c. Calculate U:C ratio[6]
        d. Calculate osmolality[7]
4. Synthesize
    - This is where the major list for the acid base disturbance comes into play.

"Interpret" can be a pretty nebulous term. The college has its own definition, but I think the key is to relate your answer back to the stem:

- What is the diagnosis/differential?
    - (ie write the appropriate list and identify the most likely Dx)
- What other tests do you need to sort this out?
    - Eg glucose for RAGMA if not given (?DKA)
    - CT brain for obtundation
    - Septic workup if sepsis is suspected
    - Drug levels if OD
    - Etc. Essentially ask yourself "what would I want the intern to have ordered?"
- What are the implications of your findings?
    - Likely prognosis
    - Need for emergent management
        - Antidotes, O2, intubation etc

And that should take you a little under 10 minutes, if you practice hard and prepare well.

Good luck!



[4] Corrected $Na^+ = Na^+ + (Glucose - 5)/3$. This is very important for DKA cases

[5] For each pH fall below 7.4 K^+ should rise by 0.5mmol above 5.0mmol/L. Therefore my comment would be along the lines of:

K^+ 4.0mmol/L = normal. Expect K^+ for pH 7.2 = 5.0 + 2 x 0.5 = 6.0mmol/L. Pt .: relatively hypokalaemic. Watch/replace K^+ as pH corrected.

[6] This is almost always ~100. I usually comment that this suggests pre-renal failure.

[7] The only reason to give you a measured osmolality in the stem is so you can calculate an osmolar gap. Calculated osmolality = 2 x Na^+ + urea + glucose, and osmolar gap = OSM_m - OSM_c. <u>If there is a measured osmolality in the stem you would be a fool not to perform these calculations.</u>