

Blood gas interpretation in the neonate - what do you need to know now?

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Many authors contend that drawing of umbilical ABGs is a simple method to evaluate the condition of the neonate and ideally would be routinely done for all newborns [13].

Other authors disagree. Appropriate general principles guide clinicians when drawing and interpreting ABGs for all patients. The special needs of the neonate require that the respiratory therapist (RT) or nurse who is charged with obtaining the sample understand the results.

Blood gases are the most common tests done on neonates [1]. And while the results are important drivers of clinical care, there are questions about whether arterial blood gas (ABG) testing is always necessary or desirable in this patient population.

As well, if you are a nurse or respiratory therapist (RT) drawing the ABG, how can you know if the results are worth the effort and pain to the patient? A review of the literature yields mixed answers.

There is little question that when any patient, including a neonate, is critically ill, the ABG results give clinicians essential

information, i.e. analysis of the acid-base status of the patient. Knowing how to interpret the ABG results allows RTs, nurses and other clinicians who draw ABGs to anticipate and prepare for treatment courses and clinical outcomes.

Importantly, the ABG values may be a reflection of preanalytical issues if the results don't make sense given the patient's clinical presentation. Therefore, those who draw ABGs must employ good technique and use the correct modality (point-of-care vs. lab) while remaining sensitive to the special needs of neonates under their care.

To get a handle on how neonates as patients, along with technique, results and treatment are currently intersecting with regard to ABG interpretation, I searched Medline, Ovid and CINAHL databases for the terms "neonates and blood gases", "neonates and ABG interpretation" and "cord blood gas".

What I found was a somewhat mixed bag, in terms of current opinions regarding whether routine ABGs are appropriate in healthy neonates. Even with neonates who are in distress, there are some cautionary tales about where, when and how to draw ABGs.

When is ABG testing needed?

DiIulio [1] explains that with regard to an ABG blood draw in a neonate, there are a number of considerations that don't come into play when dealing with adults.

For example, these small patients don't have the blood volume to tolerate multiple draws, so the justification for the testing needs to be very solid. One of those situations could be when a newborn displays a low Apgar score [2].

Wong and MacLennan [2] assert that cord gases should be utilized to help determine the cause of a baby's low Apgar scores. They explain that the information gained from a blood gas assessment of the umbilical cord (done in conjunction with other testing such as placental histology) will not only assist clinicians with diagnosis and counselling of the parents, it can also provide a defence in case of a lawsuit.

Their retrospective study of 12,887 deliveries (babies who demonstrated an Apgar score of ≤ 6 at 5 minutes) in a hospital in Australia focused on the issues surrounding acute intrapartum hypoxia (AIP) and its relationship to cerebral palsy (CP).

In order for AIP to be a viable causative factor in CP, Wong and MacLennan say that several criteria must be met. These include the presence of severe metabolic acidosis (pH < 7.0 and base deficit ≥ 12 mmol/L) in the arterial cord blood without evidence of chronic fetal pathology [2].

They emphasize that a normal pH "excludes a causal relationship between an acute hypoxic intrapartum event and subsequent neurological disability" [2]. They also note that if their protocol were to be instituted, it would only represent approximately 2 % of all deliveries, and "should not be a drain on clinical resources" [2].

So it appears that getting ABG and acid-base data on high-risk babies is entirely appropriate. Wong and MacLennan acknowledge that while some experts advise getting cord gases on all babies, they realize that this may not be practical.

The advice here seems to be clear cut. However, Malin *et al* [3] say that while the criteria listed above are widely accepted, they are not evidence-based.

They are instead derived through consensus, and "existing observational studies of the association between cord pH and outcomes have drawn inconsistent inferences. Therefore substantial uncertainty remains about the value clinicians may attach to acidosis in the clinical management of neonates and the long term implications of a low arterial cord pH" [3].

With that said, Malin and colleagues [3] acknowledge that cord pH is widely used to validate and defend clinical actions and to report research trial results. "It is therefore imperative that the validity of [the cord pH] association is supported with high-quality evidence" [3], they say.

To that end, they did an extensive review of the literature to discern the relationship between acidosis at birth and neonatal morbidity and mortality. They found that low cord pH did indicate a "strong, consistent, and temporal" association with outcomes that are "biologically plausible" [3].

Given that their meta-analysis included 51 articles covering more than 400,000 infants, it is safe to say that their conclusions are valid.

The American College of Obstetricians and Gynecologists (ACOG) has also weighed in on the matter. In their committee opinion #348 on umbilical cord analysis [4], they state that clinicians should try to get venous and arterial cord blood in these situations: cesarean delivery related to fetal compromise; low 5-minute Apgar scores, severe growth restriction, abnormal fetal heart-rate tracing, maternal thyroid disease, intrapartum fever, or multi-fetal gestation [4].

And while ACOG states that asphyxia (mild to severe) in the full-term infant is 25 per 1,000 live births [4], most will not sustain any appreciable injury. If the asphyxia leads to a significant metabolic acidosis, then treatment would be warranted. The diagnosis of what is known

as intrapartum fetal asphyxia justifies a blood gas and acid-base assessment.

But as ACOG and others have asked: "What is the threshold of metabolic acidosis beyond which fetal morbidity or mortality may occur?" [4] There are a number of proposed definitions, which are beyond the scope of this article.

Suffice it to say that for the purposes of the nurse or RT who is responsible for drawing an ABG, the previous discussion provides context for these key questions:

How do I interpret ABG results and what can I anticipate will be the clinical course and interventions?

Preanalytical ABG technique

As the likely drawers of the ABG, it is important for the nurse or RT to refresh his or her memory about proper technique.

What does the literature say about current recommendations regarding

- What blood to draw
- When to draw it
- Why to draw it
- Where to draw it
- Where to analyze it?

The ACOG committee paper [4] suggests that immediately after an infant is delivered, a segment of cord should be double-clamped, divided, and placed on the delivery table pending the outcome of the 5-minute Apgar score [4].

The committee also states that "values from the umbilical cord artery provide the most accurate information regarding fetal and newborn acid-base status. If the neonate has a normal 5-minute Apgar score and appears otherwise healthy, the cord can be discarded" [4].

It is reasonable to assume that the RT or nurse will not be drawing an ABG unless there is some question of the

neonate's viability. Even in their meta-analysis, Malin *et al* [3] did not find any evidence that studies have shown that there is a solid prognostic value to the use of cord pH.

Therefore, it is very likely that when you are asked to draw an ABG, your neonate patient is very ill indeed.

DiIulio [1] explored the outcomes and issues with drawing ABGs for point-of-care (POC) bedside testing vs. sending the ABG sample to the lab.

One obvious advantage of POC testing is turnaround. POC testing also allows the clinician to draw a smaller volume of blood for a sample, thus sparing the neonate from having their blood volume unnecessarily depleted. However, the cost of POC testing can compare unfavorably with that of sending blood to the lab to be analyzed.

On the matter of blood volume preservation, one important question raised by DiIulio [1] is this: "If you use POC testing, will other laboratory draws be eliminated?" [1] And just as important, will you preserve the neonate's blood volume?

The article notes that one study found that up to 40 % of POC tests were standing orders [1]. This raises the specter of cost-effectiveness in care. POC testing can cost up to 10 times as much as comparable laboratory testing [1].

If the test is a regularly ordered test, why not have it pulled with the scheduled blood draws? Another issue beyond cost is that of patient comfort and safety.

A neonate only has so much blood, and as DiIulio notes, arterial sticks are not usually done on neonates [1]. The usual technique involves capillary sticks or draws from indwelling catheters.

However, these techniques have issues with clots and contamination. If the RT draws an ABG and the results do not make sense given the patient's clinical presentation, then error in technique should be suspected. If there is an issue there, a serious discussion needs to occur regarding whether another draw is really necessary.

Belliemi and Buonocore [5] wrote about guidelines for research in children and neonates, but their points apply here.

They note that even routine heel pricks can harm a baby, by flooding their system with free radicals [5], such as advanced oxidation protein products (AOPP) and total hydroperoxide (TH) [6].

Also, when you consider, as in their example [5], that a 600-g baby only has 50-60 mL of blood [5], one should consider carefully drawing say, 1 mL of blood, even in the sickest babies. That 1 mL is “about 2% of the total amount [of the baby’s blood volume]” [5].

Acid-base-acid-base?

Now that you’ve drawn the ABG and the results are back, what have you got? As with so many things, it depends. Your institution’s POC calibration values may not exactly match the lab’s values.

DiIulio [1] suggest that if your institution reports results from both areas in the electronic medical record, they should be separate line items and labelled as such. This also makes it imperative to know which lab and POC analyzers your organization employs, as well as the testing and reporting parameters of every system used in house.

Additionally, your recall of normal ABG lab values will help you to interpret results. With a firm grasp of this knowledge, you can assist your colleagues in formulating appropriate clinical plans for the neonate. If you think that your input would not be valuable here, consider this.

An informal study [7] done in Bristol, United Kingdom, found that when presented with the results of ABGs, 54 % of the physicians surveyed correctly identified the normal range of values.

And while 71 % correctly described the abnormality (metabolic vs. respiratory cause), only 27 % could offer two appropriate differential diagnoses. The authors suggest that this indicates the need for ongoing education regarding practical clinical use of ABGs. It also

suggests that an understanding of what the numbers mean would benefit everyone involved.

While it is unlikely you would personally be asked to offer a differential diagnosis, solid knowledge of the ABG—in theory and in practice—will help you distinguish between outcomes and plans that make sense, versus those that don’t. What specifically do you need to know?

Lekhwani et al [8] studied acid-base imbalances in critically ill neonates. They studied 50 critically ill newborns presenting in an emergency room setting in India. The babies required blood gas analysis (BGA) as part of their care.

The clinicians treated 41 males and 9 females, and took pains to point out that while the sex ratio may be skewed, there was no correlation between age or sex and severity of acid-base disturbances [8]. Therefore they determined that their data can be generalized to sick neonates elsewhere.

They found significant correlation between poor outcomes and critical values. Just as important, though, was the understanding that certain conditions have their own markers. For example, birth asphyxia was associated with the highest plasma lactate levels and the lowest base excess (BE).

This even though plasma lactate and BE were generally higher in the neonates who died. What this shows is the importance of other information from the ABG. The authors point out that changes in arterial pH and $p\text{CO}_2$ —but not BE—can help predict the clinical outcome [8].

What their results really tell us is that an understanding of why acid-base results come back the way they do is the key to treatment. To that end, a brief review of the ABG and the interpretation of the results would be helpful.

ABG interpretation: step-by-step

Most of the following should be review for RTs and nurses who regularly draw and interpret ABGs.

The first thing to look at is the pH. Is it trending basic or acidic? If it is less than or equal to 7.4, it will tend to be acidic [8]. Conversely, anything over a pH of 7.4 is alkaline [9].

Then look at the $p\text{CO}_2(\text{a})$; is it increased (>40) or decreased (<40)? If the former, it is a respiratory acidic situation; the latter, a respiratory alkalotic situation [9, 10].

If, however, the bicarbonate (HCO_3^-) explains the change in pH, then it is a metabolic disorder [8]. Normal range for bicarbonate is 22-26 [11]. In general, if there are alterations in the bicarbonate, that indicates a metabolic disorder [10].

In short, $p\text{CO}_2$ is mediated by the respiratory system, and the HCO_3^- is mediated by the renal system [10].

The foregoing is a very simplified algorithm. Therefore, to engage in accurate ABG interpretation, it may be useful to heed a bit more advice from the literature.

Sood et al [9] advise clinicians (physicians in particular) to refrain from interpretation of an ABG without knowing a history of the patient

In that vein, Beaudet Jones [10] lists some diagnoses for children that can be gleaned from various ABG results. For example, metabolic acidosis, defined as pH of less than 7.35 without an elevated $p\text{CO}_2(\text{a})$, is most commonly caused in children by insufficient tissue perfusion [10].

The interpretation of the cause of a metabolic acidosis is further refined by calculation of the anion gap ($\text{Na}^+ - [\text{Cl}^- + \text{HCO}_3^-]$) [10].

Sood et al [9] summarize ABG interpretation in this manner: In a normal ABG, pH and $p\text{CO}_2(\text{a})$ move in opposite directions; when they go in the same direction, the issue is metabolic. As well, in a normal ABG, the HCO_3^- and $p\text{CO}_2(\text{a})$ move in the same direction; if they move in opposing directions, you have a mixed disorder.

They also suggest checking the percent difference between the $p\text{CO}_2(\text{a})$ and the HCO_3^- ; whichever is

further (percentage wise) from the normal value, will be the dominant (respiratory vs. metabolic) disorder [9].

Graham [12] also gives a very elegant step-by-step approach to ABG interpretation. It is similar to other authors' advice: first, you must know the patient's clinical story. Clearly, an ABG in isolation is just a bunch of numbers.

Second, they suggest that you look at the pH. Third, tease out where you are seeing compensation (for the initial disorder). Then make a determination of the type of disorder.

Finally Graham [12] also then advises determining chronic vs. acute. If the disorder is a metabolic acidosis, expect to see importance placed on the anion gap [10, 12].

Conclusion

Many authors contend that drawing of umbilical ABGs is a simple method to evaluate the condition of the neonate and ideally would be routinely done for all newborns [13].

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