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Letter to Editor

Biochemistry Section

How to Avoid Pre-analytical Errors in Arterial Blood Collection for Blood Gas Analysis

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Dear Editor,

Arterial Blood Gas (ABG) analysis is a necessary test in patients admitted in Intensive Care Unit (ICU)/Intensive Coronary Care Unit (ICCU) for diagnostic and therapeutic purposes. However, many times the results of ABG analysis are not satisfactory and this is mostly due to errors at pre-analytical level. The pre-analytical phase includes identification of the patient, blood collection, labelling, storage and transportation of the blood samples. Though some articles on this topic have been published [1-9], this letter tries to make it simple and stepwise so that a quick glance of it would refresh the pre-analytical issues associated with arterial blood collection. Here are a few tips to avoid/minimise pre-analytical errors in arterial blood collection for blood gas analysis based on clinically-approved guidelines:

1. **Identification of the patient:** Identity the patient by name, age and bed number and match with the requisition form to ensure the blood collection of the desired patient [1-8].
2. **Prepare the patient [1-8]:**
   - Explain the patient about the test to make the patient comfortable mentally and physically as the pain and anxiety may induce hyperventilation resulting in spuriously reduced pCO_2.
   - Let the patient relax and rest for about 3-5 minutes, if he/she is without any pulmonary disease.
   - Let the patient relax and rest for 20-30 minutes, if he/she has Chronic Obstructive Pulmonary Disease (COPD) or there have any ventilatory changes been done (administration of oxygen and mechanical ventilation may affect measured values).
3. **Blood collection [1,2]:**

   a. From Radial Artery
   - Perform the modified Allen test to ensure adequate collateral circulation from ulnar artery (to ensure the patency of the radial artery, ulnar artery and palmer arches in case of any damage to the artery during the procedure).
   - Use of short-beveled needle helps to position the needle correctly and to avoid the risk of puncturing the opposite arterial wall.
   - Use of pre-heparinised syringe reduces the chance of blood clots (blood clots affect the measured parameters as well as damage the analyser).
   - Use of dry electrolyte-balanced heparinised syringe reduces the risk of electrolyte bias and sample dilution (the calcium binding property of heparin reduces the ionised calcium concentration and hence, may give falsely low-ionised calcium).
   - Use of self-filling syringe avoids hitting a vein (The Gold Standard sample for blood gas testing is arterial blood).
   - Puncture the artery at 45° with bevel facing up to minimise trauma to the blood vessel.
   - Insert the needle slowly to minimise arterial spasm.
   - Avoid the redirection of the needle to prevent nerve damage.
   - If the artery is punctured correctly, a blood flash appears and then, allow the syringe to fill to appropriate level without pulling the piston. Alternatively, preset the syringe plunger to the desired volume before the arterial puncture and allow the syringe to fill to the desired level.
   - Filling the syringe with correct amount of blood is important [1-9]
     - In pre-filled liquid heparinised or 'in-house' heparinised syringe (prepared from therapeutic heparin, though not recommended) the blood volume should be 20 times the dead space of the syringe (a 2 mL syringe has a dead space of about 0.1 mL so, 2 mL blood will be required. Likewise, the 1 mL syringe would require 1 mL blood). The dead space of syringe is the volume of liquid remaining in the hub and the needle after completely emptying the syringe. It varies with the size of syringe and the needle.
     - Underfilling the heparinised syringe may give erroneous results due to dilution and chemical effects (the dilution of blood with heparin may result in spuriously low pCO_2 and bicarbonate whereas use of concentrated heparin may cause an increase in pCO_2 and reduction in pH).
     - The dry electrolyte-balanced heparinised syringe also requires correct amount of blood as underfilling may give erroneous results.
   - Expel the air bubble quickly, if any, by taping the sides of the syringe to allow them to go to the top of the syringe for expulsion and it is better to use syringe with a tip cap that is vented for safe removal of air bubbles (air bubble, if not expelled, may result in spurious elevation or drop of *in vitro* pO_2 depending on the initial arterial pO_2 of the sample and that of the ambient air in a time-dependent manner) [1-9].
   - Cap the syringe with syringe cap (not the needle cap) properly to prevent the leakage of gases and mix the blood by gentle inversions and rolling between the palms of hands to ensure the proper mixing of blood with the heparin (mixing is important to prevent microclots which may block the analyser and prevent analysis. However, vigorous mixing may result in haemolysis causing false elevation of potassium results).
   - If syringe cap is not available then, after removing the air bubbles insert the tip of the needle in a bung to prevent the leakage of gas and blood during transport (do not bend the needle, which is a common practice, because it doesn't prevent the leakage completely and it may cause needle stick).

   b. From Indwelling Catheter
   - To prevent the contamination of the blood sample with flush solution, at least three times the dead volume of

the catheter (as given on catheter package) should be drawn and discarded before drawing the sample for ABG using a new syringe as the dilution of blood sample with flush solution may affect the blood gas and electrolyte parameters giving erroneous results [4,5]. (Dead volume of catheter is the volume of residual fluid between the sampling point and the blood stream).

4. **Label the syringe with patient's identification details, date and time of blood collection using a waterproof marker pen** (writing patient's identification details with waterproof marker pen is important when the blood sample syringe is to be kept in ice-water slurry).
5. **Transport the sample to the laboratory immediately as it should be analysed within 15-20 minutes [1-9]:**
    - If it is not possible to send the sample immediately then, keep the sample in a container with ice water slurry (not with ice alone which may result in haemolysis) to reduce cellular metabolism (the *in vitro* blood cells metabolism may consume oxygen and generate carbon dioxide resulting in spurious pO_2, pCO_2 and pH values) but it should be analysed within an hour because plastic syringes are partially permeable to gases and the permeability increases at lower temperature.
    - Samples with high leukocyte or platelet counts and for shunt analysis need to be analysed within five minutes (to avoid the effect of *in vitro* cellular metabolism on blood gas parameters).

Common Sources of Pre-analytical Errors

- **Incorrect identification** of the patient
- **Patient not stabilised and relaxed** before the procedure
- **Haemolysis**- Due to use of too fine needle and vigorous shaking of the blood sample
- **Clotting**- Due to incorrect amount of heparin and inadequate mixing
- **Sample dilution**- Due to under-filling of syringe
- **Air bubbles**- If not expelled before capping the syringe
- **Venous blood contamination**- Due to use of long bevel needle and piercing the artery with an incorrect angle.
- **Leakage from syringe**- Due to improper sealing of the syringe
- **Delayed measurement**

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