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# Minimizing Pre-Analytical Error in Blood Gas Testing

## Recommended Patient Sample Collection, Handling, and Storage Procedures

Answers for life.

# Introduction

Siemens Healthcare Diagnostics is pleased to offer you this complimentary guide for the handling and storage of patient samples analyzed on all Siemens Blood Gas Systems. We have outlined the collection procedures, sample requirements, and handling techniques currently recommended for pH and blood gas analysis. These guidelines are also suitable for CO-ox analysis, and other analytes such as electrolytes and metabolites on Siemens analyzers.[1]

We hope that you will find this material useful and informative as a quick reference guide during your day-to-day activities. Your Siemens representative is always ready to help you with the latest educational materials and product information relating to critical care testing.

## Follow Established Policies and Procedures

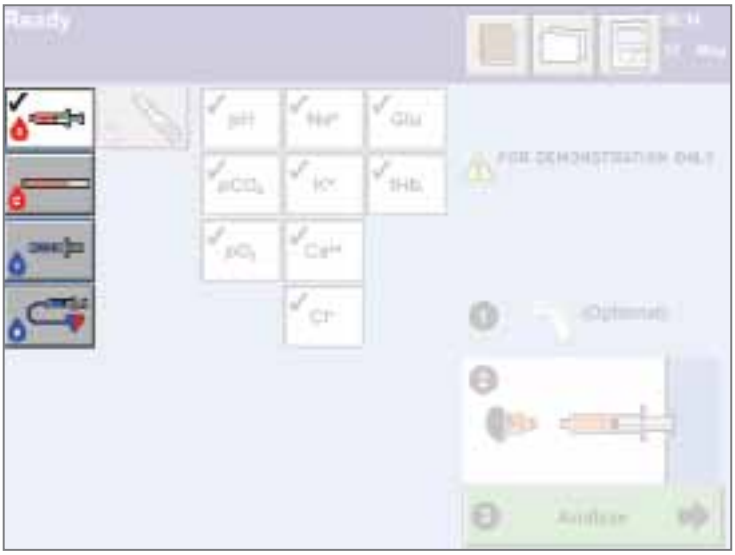
Whenever possible, all personnel involved with the collection, processing, and analysis of blood gas samples should follow a set of documented policies and procedures.

- Following your institution's polices and written protocols should help to maintain positive patient identification, maximize sample integrity, and help ensure accurate results

## Use the Correct Sample Type

Arterial and venous blood

Figure A. Siemens blood gas analyzer screen-capture showing sample type




Arterial syringe sample


Arterial capillary sample


Venous blood sample


Mixed venous blood sample

When determining $PO_2$ and $PCO_2$ for the purpose of evaluating the gas exchange function of the lungs, collect arterial blood only. Arterial blood may also be used for the assessment of metabolic acid-base disorders and electrolyte concentrations.

- In most instances, the ideal sampling device for arterial blood is a 1–3 mL self-filling disposable syringe containing an appropriate anticoagulant
- If arterial blood cannot be collected directly, use an arterialization technique to collect peripheral blood in an appropriately heparinized capillary tube

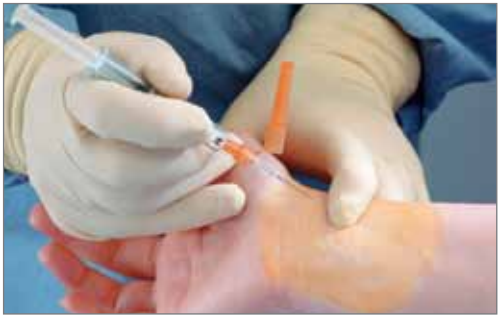
**Venous blood** is not a satisfactory substitute for arterial blood for routine blood gas analysis. However, when properly drawn[2], venous blood may be used to determine pH, electrolytes, and for the assessment of levels of dyshemoglobins including carboxyhemoglobin and methemoglobin (COHb and MetHb).

Note that inaccurate $K^+$ values may be reported when venous stasis is combined with forearm exercise (fist clenching) during sample collection.[3]

**Mixed venous blood** and arterial blood are required to evaluate $O_2$ uptake and cardiac output, and can be used to assess the degree of intrapulmonary shunting. True mixed venous blood is obtained from the pulmonary artery using a catheter.

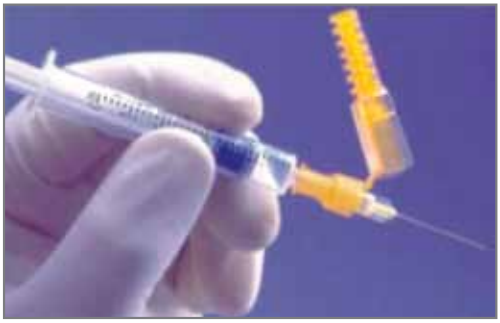
## Use the Correct Sampling Device and Anticoagulant

Figure B



- When collecting samples for the analysis of pH/blood gases and other electrolytes or metabolites, it is very important to use specialized, auto-venting sampling devices containing the appropriate type and concentration of anticoagulant.[4] (Figure B)

Figure C



- Collect blood in heparinized syringes that satisfy requirements for blood gas analysis (Figure C)
- Analyze the sample within 30 minutes of collection
- Never use syringes containing mineral oil or mercury—these substances may alter sample values and damage the analyzer

Figure D

- Collect blood in capillary tubes that contain electrolyte-balanced heparin (Figure D)
- Never use capillary tubes containing mixing bars—these devices may cause hemolysis (which affects $K^+$ results) and impact sample integrity

**Optimal analyzer performance** requires the use of properly heparinized samples. The use of blood samples without anticoagulant will result in clots and fluidic errors, and has also been shown to impact sensor performance.

**Choice of anticoagulant** will vary according to the analytes being determined and the method of analysis. The type of anticoagulant used must have little or no effect on all the analytes measured and all varieties of anticoagulants require gentle mixing of the sample by rolling the sample device between the hands and by inverting the sample device in a vertical motion (see Table 1).

Table 1: Types of Anticoagulants

| Anticoagulant | Effect |
|---|---|
| Dry, Electrolyte-balanced Heparin | Preferred anticoagulant, no effect on critical care parameters, requires adequate mixing |
| Liquid Heparin | Dilution effect:<br>–May cause increase in $pO_2$, $Na^+$, $Cl^-$ results<br>–May cause decrease in $pCO_2$, $K^+$, $Ca^{++}$, Glucose, Lactate and THb results |
| Sodium Heparin | Unacceptable for sodium measurement |
| Lithium Heparin | Unacceptable for lithium measurement |

## Collecting the Patient Sample

**Perform the collection procedure (Figure E, Figure F) under proper medical supervision. Use sterile technique at all times to avoid infecting the sample site.**

- When the sample is to be drawn from the radial artery, an "Allen's Test" should be performed to ensure sufficiency of collateral circulation[5]
- Immediately expel any air in syringes after sample collection, and cap to avoid room air contamination (Figure G)
- When collecting venous blood, the tourniquet should be left on until the blood starts to flow (tourniquet pressure may adversely affect venous lactate levels)
- When mixed venous blood is taken, blood should be slowly withdrawn from the pulmonary artery catheter to avoid obtaining retrograde blood that may be partially arterialized
- When collecting a capillary sample, collect blood from the center of the blood droplet
- Never use strong repetitive pressure (milking) when collecting a capillary sample, as this may cause hemolysis (which affects $K^+$ results) and/or sample contamination with tissue fluid
- Fill capillary tubes completely, then cap securely to avoid room air contamination
- Mix all samples well by rolling and repeatedly inverting the collection device using a consistent technique (Figure H)
- Never shake samples, as the resulting hemolysis will significantly impact $K^+$ results
- Position labels toward the top of syringe barrels (near the plunger) to facilitate easy insertion into the analyzer and prevent syringes from falling off after insertion into the sample port

**Minimize sample exposure to air to help ensure accurate results. Room air contamination can markedly affect pH, $PO_2$, $PCO_2$, and ionized calcium results.**

Exposure of blood to the atmosphere generally increases sample $PO_2$, except when the patient is on supplemental oxygen. pH also increases, while $PCO_2$ and ionized calcium levels are lowered.

Figure E

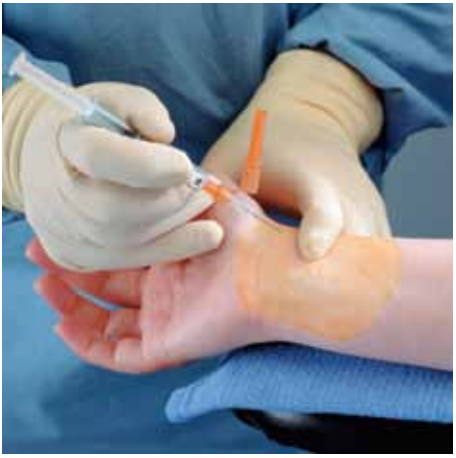


Figure F

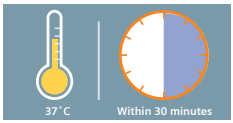
Figure G

Figure H

# Storing, Handling, and Analyzing the Patient Sample

**Patient samples must be handled and stored correctly, and analyzed promptly, to minimize erroneous results. Use the following procedures after collection of human whole blood samples:[6]**

- Hand carry samples without any vigorous movement whenever possible
- Re-check for air bubbles if pneumatic transport is used—even the smallest bubble may impact $PO_2$ results, especially, as well as pH and $PCO_2$ results
- Analyze the sample as soon as possible to minimize the effects of metabolic changes and oxygen consumption
- Immediately before analysis, re-mix all samples by rolling and repeatedly inverting the collection device using a consistent technique




- Keep syringes at room temperature, and analyze the sample within 30 minutes of collection


- If a delay in testing of greater than 30 minutes of collection is anticipated, consider storage of syringe in ice


- If samples are chilled, or have been stored for more than 10 minutes, increase mixing time to ensure thorough mixing


- Blood collected for special studies, such as A-a $O_2$ gradients or shunt studies, should be analyzed within five minutes of collection

**Always analyze a sample as soon as possible after collection.** This is particularly important when determining $PO_2$, glucose, and lactate values because the sample consumes oxygen and glucose, and lactate forms rapidly during storage.

Oxygen consumption by the sample is affected by storage temperature, white blood cell count, and reticulocyte count.

At room temperature the rate of change in lactate levels has been shown to be approximately 0.6 mmol/L/h if you use a normal range of 0.5-1.6 mmol/L with a mean of 1.1 mmol/L - this is about a 57% change. At 4°C, the change has been shown to be approximately +0.006 mmol/L/h.[7]

**$PO_2$ and $PCO_2$** in blood kept at room temperature for 30 minutes or less in syringes or capillaries are minimally affected, except in the presence of an elevated leukocyte or platelet count.

**pH and $PCO_2$** in blood collected in syringes stored in ice are minimally affected for up to two hours. Samples with elevated white blood cell or reticulocyte counts should be analyzed immediately.

**Electrolyte determinations** should not be made on samples collected in or syringes stored in ice for a prolonged period. Electrolyte transport between the cells and plasma affects $K^+$ results in particular.

**Blood cells settle during storage.** If samples are not mixed well prior to analysis, total hemoglobin results can be falsely decreased or increased.

## Summary

In summary, collecting, handling, and storing patient samples correctly will help to ensure quality patient results.


1. For more information about collecting and handling patient samples, refer to Clinical and Laboratory Standards Institute. Blood Gas and pH Analysis and Related Measurements; Approved Guideline — Second Edition. CLSI Document C46-A2. Vol. 29, No. 8.
2. Procedures for the Collection of Diagnostic Blood Specimens by Venipuncture; Approved Standard — Sixth Edition. CLSI Document H3-A6, Vol. 27, No. 26.
3. Don, B.R. et al. N Engl J Med 1990; 322:1290-1292.
4. Other anticoagulants such as EDTA, citrate, oxalate, and fluoride significantly affect blood pH, sodium, potassium, chloride, ionized calcium, and CO-oximetry results.
5. Refer to Procedures for the Collection of Arterial Blood Specimens; Approved Standard - Fourth Edition; H11-A4, Vol. 24, No. 28
6. Wandrup. Clin Chem, 1989; 35(8):1741.
7. Andersen O, Haugaard SB, Jørgensen LT et al. Preanalytical handling of samples for measurement of plasma lactate in HIV patients. Scand J Clin Lab Invest 2003; 63, 449-54