RADIOMETER

Avoiding preanalytical errors

– in blood gas testing

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CE
IVD *In vitro* diagnostic medical device.

How to avoid preanalytical errors in blood gas testing

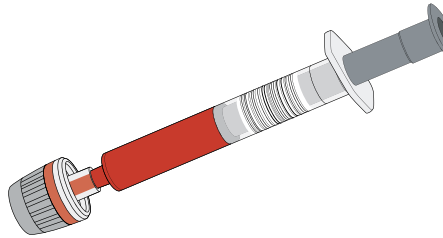
Up to 60 % of all errors in blood gas testing occur in the preanalytical phase. Luckily, many of them can be prevented.

This booklet offers you quick and straightforward information on the most common errors in the pre-analytical phase and, most importantly, how you can prevent them.

The pocket-size format allows you to always have the booklet with you, making it a valuable tool in your daily work.

For more information on how to avoid preanalytical errors in blood gas testing, contact your local Radiometer representative.

Patient identification



Missing or wrong identification of a patient sample is probably the most frequent preanalytical error.

Examples of consequences

Missing or wrong patient ID is one of the most critical errors in the preanalytical phase of blood gas testing.

This and all of the following critical errors in the preanalytical phase of blood gas testing can cause:

- Misdiagnosis
- Incorrect treatment
- Resampling

How to avoid these errors

Radiometer recommends:

- Use at least two patient identifiers whenever collecting arterial samples
- Ensure that the sampler has an ID label attached
- Always enter patient ID into the analyzer
- Prebarcoded arterial blood gas samplers are available

Your local guidelines:

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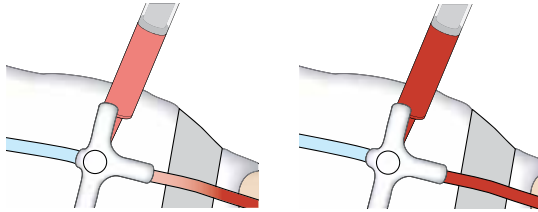
Dilution



During sampling from arterial catheters, there is a risk of diluting the sample with flush solution.

Dilution also occurs if liquid heparin has been added to the sampler.

Effect

↑pO_2	↓pCO_2	↓cK^+	↑cNa^+	↓cCa^{2+}
↑cCl^-	↓cGlu	↓cLac	↓ctHb	

Examples of consequences

The example shows a dilution with NaCl flush solution. The operators remove 1 and 6 times the dead space volume of the catheter.

Removal of 6 times the dead space

Patient Report		
cK^+	4.1 mmol/L	[3.5–5.0]
cNa^+	141 mmol/L	[136–146]
cCl^-	100 mmol/L	[98–106]

Removal of 1 time the dead space

Patient Report		
cK^+	3.4 mmol/L	[3.5–5.0]
cNa^+	147 mmol/L	[136–146]
cCl^-	110 mmol/L	[98–106]

Consequence of removing insufficient flush solution:

NaCl solution will cause positive bias to cNa^+ and cCl^-. The bias affecting pO_2 will depend on the actual patient pO_2. All other parameters will be negatively biased. Liquid heparin causes negative bias to all parameters by dilution and by binding the positive electrolytes.

How to avoid these errors

Radiometer recommends:

- Discard at least 3 times the dead space when you are sampling from catheters
- Check the specific catheter package for the exact volume of dead space
- Draw the blood gas sample with a dedicated blood gas sampler containing dry electrolyte-balanced heparin
- If in doubt of the quality of the sample, consider resampling

Your local guidelines:

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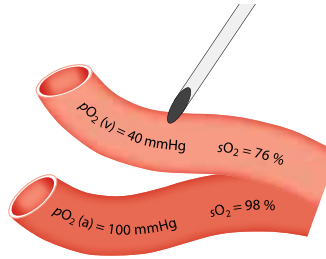
Positioning the needle



During arterial puncture, there is a risk of accidentally puncturing a vein.

Even a few drops of venous blood mixed with the arterial sample will cause bias on the results.

Effect

$\downarrow pO_2$ $\uparrow pCO_2$ $\downarrow sO_2$

Examples of consequences

Two samples are drawn by arterial puncture.
One of them was accidentally contaminated by a few drops of venous blood before the needle was correctly positioned in the artery.

Pure arterial sample

Patient Report

pO_2	100 mmHg	[83 – 108]
pCO_2	41 mmHg	[35 – 48]
sO_2	98 %	[95 – 99]

Contaminated sample

Patient Report

pO_2	90 mmHg	[83 – 108]
pCO_2	41.5 mmHg	[35 – 48]
sO_2	97.4 %	[95 – 99]

Consequence of venous contamination:
The admixture of venous and arterial blood causes bias on O_2- and CO_2-related parameters.

How to avoid these errors

Radiometer recommends:

- Use self-filling syringes – they fill readily when puncturing an artery but not when hitting a vein
- Use short-bevelled needles – they are easier to position inside the artery without puncturing the opposite artery wall
- Make the puncture at an angle of 45° for better positioning

Your local guidelines:

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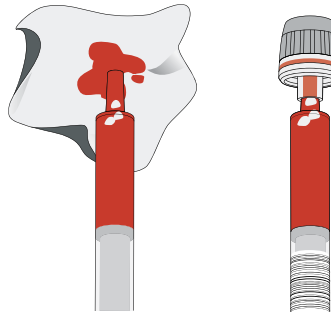
Air bubbles



Air bubbles may seriously affect the arterial sample. Especially the parameters related to pO_2 will be biased.

Effect

↑pH ↑pO_2 ↓pCO_2 ↑sO_2

Examples of consequences

Two samples are taken from the same patient and measured after 5 minutes. One sample is mixed before expelling the air.

Without air

Patient Report		
pO_2	70 mmHg	[83–108]
pCO_2	45.6 mmHg	[35–48]
sO_2	94.0 %	[95–99]

With air

Patient Report		
pO_2	90 mmHg	[83–108]
pCO_2	45.4 mmHg	[35–48]
sO_2	96.9	[95–99]

Consequence of not expelling air:
The actual bias will depend on the original pO_2 of the sample, the size of the bubble, the extent of mixing and the duration of exposure.

How to avoid these errors

Radiometer recommends:

- Visually inspect the sample for air bubbles
- Dislodge any bubbles by gently tapping the sides of the sampler
- Expel air bubbles
  - right after sampling
  - before mixing
- Arterial blood gas samplers with vented tip caps that will allow you to expel air and seal the sampler without getting in contact with blood are available

Your local guidelines:

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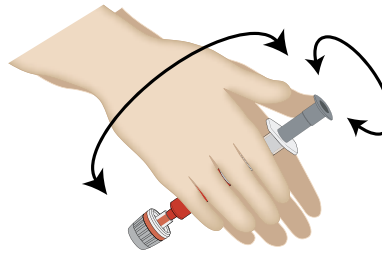
Clotting



Blood samples will coagulate unless mixed thoroughly with heparin right after sampling. A clotted sample is not homogeneous, and the results not reliable.

Effect

↑cK^+

Examples of consequences

Two samples are taken from the same patient. One is mixed with heparin immediately, the other is not mixed. 20 minutes later, the samples are mixed and analyzed.

Mixed

Patient Report
cK^+ 4.9 mmol/L [3.5–5.0]

Not mixed

Patient Report
cK^+ 5.1 mmol/L [3.5–5.0]

Consequence of clotting:
Clots may block the sample pathway of the blood gas analyzer and affect the current and future samples. The sample is unrepresentative of the patient status and should not be measured.
cK^+ increases because of release from cells.

How to avoid these errors

Radiometer recommends:

- Use samplers that are preheparinized with dry electrolyte-balanced heparin to avoid:
  - clotting
  - bias on electrolytes
- Avoid use of liquid heparin as it dilutes your sample
- Mix the sample in two dimensions by rolling it between the hands AND inverting it vertically
- Arterial blood gas samplers with a metal ball for the ease of mixing are available

Your local guidelines:

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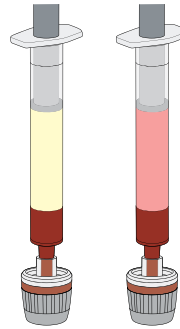
Hemolysis



No hemolysis

cK^+: 4 mmol/L

0.5 % hemolysis

cK^+: 4.5 mmol/L

There is a risk of blood cell rupture when samples are cooled directly on ice or when handled vigorously.

Effect

$\uparrow cK^+$ $\downarrow cNa^+$ $\downarrow cCa^{2+}$

Examples of consequences

Two samples are taken from the same patient.
One is analyzed immediately, the other stored for 25 minutes on ice cubes, resulting in 5 % hemolysis.

Immediately

Patient Report

cK^+	4.0 mmol/L	[3.5–5.0]
cNa^+	140 mmol/L	[136–146]
cCa^{2+}	1.21 mmol/L	[1.15–1.29]

After 25 minutes

Patient Report

cK^+	7.0 mmol/L	[3.5–5.0]
cNa^+	136 mmol/L	[136–146]
cCa^{2+}	1.11 mmol/L	[1.15–1.29]

Consequence of hemolysis:
5 % hemolysis, as described above, seriously affects cK^+ and other electrolytes; however, even 0.5 % hemolysis will give a critical positive bias to cK^+.

How to avoid these errors

Radiometer recommends:

- Do not store the sample directly on ice cubes
- Do not mix vigorously
- Avoid turbulence in sample caused by
  - too narrow needle diameter
  - obstruction in sample pathway
  - too fast manual aspiration
  - old pneumatic tube systems

Your local guidelines:

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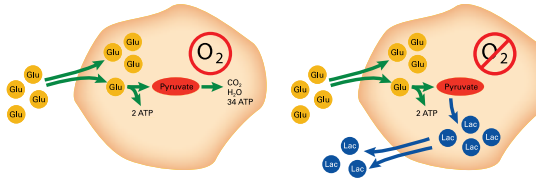
Prolonged storage



Cellular metabolism continues even after blood has been collected in the sampler.

Effect

↓pH ↓pO_2 ↑pCO_2 ↑cCa^{2+}
↓cGlu ↑cLac

Examples of consequences

Two samples are taken from the same patient. One is analyzed immediately, the other after 60 minutes storage at room temperature.

Immediately

Patient Report

pH	7.41	[7.35–7.45]
*c*Glu	5.4 mmol/L	[3.9–5.8]
*c*Lac	1.5 mmol/L	[0.5–1.6]

After 60 minutes

Patient Report

pH	7.39	[7.35–7.45]
*c*Glu	4.9 mmol/L	[3.9–5.8]
*c*Lac	2.0 mmol/L	[0.5–1.6]

Consequence of prolonged storage:
Delayed analysis increases the risk that the result no longer represents the actual patient status.

How to avoid these errors

Radiometer recommends:

- Measure sample immediately

If storage is unavoidable:

- Analyze within 30 minutes
- Analyze special samples within 5 minutes
  - high pO_2, high leukocyte or platelet count or for special studies, e.g. shunt
- Storage longer than 30 minutes
  - use a glass syringe and store in an ice slurry
- Blood gas analyzers that can keep track of sample age are available

Your local guidelines:

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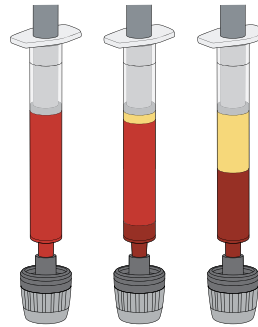
Mixing



Blood samples separate when stored, i.e. the red blood cells sediment.

The sample must be mixed thoroughly before analysis to ensure homogeneity.

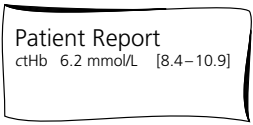
Effect

↓↑ctHb

Examples of consequences

Two samples are stored for 10 minutes before analysis. Red cell sedimentation is visible. One is mixed thoroughly, the other just long enough to make it appear homogeneous.

Thorough mixing



Brief mixing

Consequence of insufficient mixing prior to analysis:

Hemoglobin, *c*tHb will be biased, but the actual bias will depend on which portion of the sample is measured, i.e. whether it is the sedimented portion or the plasma portion. Calculated parameters derived from *c*tHb will be biased.

How to avoid these errors

Radiometer recommends:

- Mix the sample in two dimensions by rolling it between the hands AND inverting it vertically
- If the sample is visibly sedimented it needs mixing for several minutes
- Blood gas analyzers with effective automatic mixing prior to measurement are available
- Arterial blood gas samplers with a metal ball for the ease of mixing are available

Your local guidelines:

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ACUTE CARE TESTING