RADIOMETER

High Five for safe arterial blood gas sampling

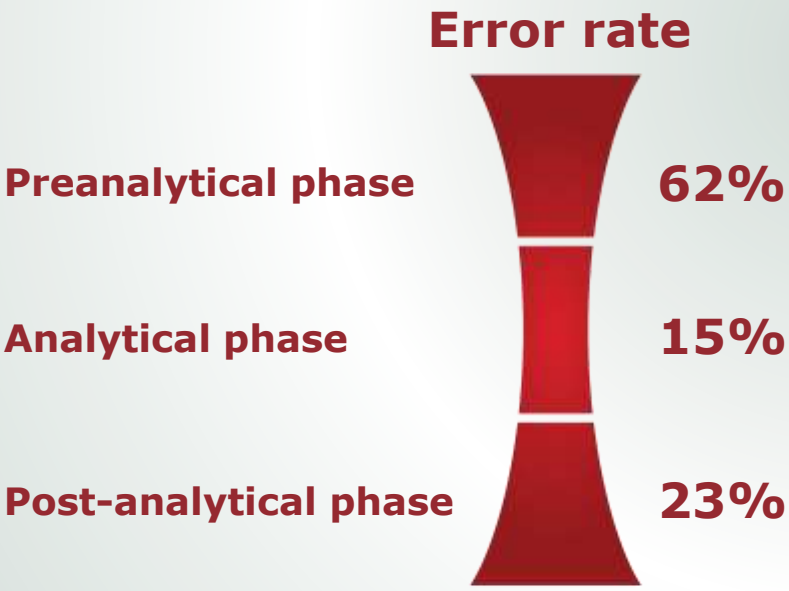
1. Carraro P *et al*. Errors in a stat laboratory: Types and frequencies 10 years later. Clin Chem 2007; 53,7: 1338-42.

Agenda

- Introduction
- Why the preanalytical phase is important
- High Five for safe arterial blood gas sampling
- Additional educational resources

The preanalytical phase of arterial blood gas sampling

Preanalytical errors are said to be the reason for up to 62% of all errors in laboratory medicine [1].



"Several aspects of blood pH and gas analysis are unique among clinical and laboratory determinations, and, at the same time, no other test results have more immediate impact on patient care" [2]

CLSI

1. Carraro P *et al*. Errors in a stat laboratory: Types and frequencies 10 years later. Clin Chem 2007; 53,7: 1338-42.
2. CLSI. Blood Gas and pH Analysis and Related Measurements; Approved Guideline – Second Edition. CLSI Document C46-A2. Wayne, PA: Clinical and Laboratory Standards Institute: 2009.
3. www.clsi.org.

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Safe arterial blood gas sampling:

Path of workflow [1,2]:

1. Patient preparation –
FOCUS ON: patient safety

2. Blood collection device
FOCUS ON: sample integrity and operator safety

3. Sample collection
FOCUS ON: safety for patient and operator

4. Sample handling
FOCUS ON: sample integrity

5. Sample transport
FOCUS ON: time to patient results

1. Clinical and Laboratory Standards Institute (CLSI). Procedures for the Collection of Arterial Blood Specimens; Approved Standard-Fourth Edition. H11-A4. Vol. 24 No. 28 [ISBN 1-56238-427-9]. Clinical and Laboratory Standards Institute, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898, USA. 2009.
2. Clinical and Laboratory Standards Institute (CLSI). Blood Gas and pH Analysis and Related Measurements; Approved Guidelines. NCCLS Document C46-A2. Vol. 29 No. 8 [ISBN 1-56238-694-4]. Clinical and Laboratory Standards Institute, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898, USA. 2009.

1. Patient preparation

Maximize patient safety

Specimen labeling errors have significant consequences for patient care, for healthcare management and for increasing costs that are often unaccounted for [1]

Errors can be caused by:

- Lack of patient identification and/or sample labeling
- Transcription errors due to manual data entry
- Lack of a dedicated procedure for identifying patient and samples

Errors can lead to:

- Non-compliance
- Misdiagnosis
- Incorrect treatment
- Resampling
- Lost billing opportunities

1. Kahn S. Specimen mislabeling: A significant and costly cause of potentially serious medical errors. www.acutecaretesting.org Apr 2005.

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Maximize patient safety

Accurate **patient identification** is fundamental for patient safety

- Use at least two patient identifiers [1]
- Always enter a patient ID into the analyzer before analysis

Proper sample labeling ensures the right result for the right patient

- Attach patient ID label to the syringe before leaving the patient
- Add additional patient characteristics and other relevant information

Tips!

Use **pre-barcoded** syringe

Use a barcode reader to **register at bedside**

Establish a **dedicated procedure** for identifying patient and sample

1. Joint commission on accreditation of healthcare organization. National patient goals. www.jointcommission.org. 2008. Accessed May 2013.

2. Blood collection device

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Greater sample integrity and operator safety

Heparin amount and type is important:

Too much heparin can bias electrolyte results - too little heparin may not be sufficient to prevent clotting

Non-compensated heparin may interfere with electrolyte results

Facts:

At some point in their career 48% of nurses had sustained an injury by a needle or sharp and 10% had been stuck in the last year [1]

The risk of infection by a contaminated needle is 1 in 3 for Hepatitis B, 1 in 30 for Hepatitis C, 1 in 300 for HIV [2]

1. Ball J *et al*. Needlestick injury in 2008. Results from a survey of RCN members. Royal College of Nursing 2008.
2. Sharps safety. RCN guidance to support implementation of the EU Directive 2010/32/EU on the prevention of sharps injuries in the health care sector. Royal College of Nursing 2011.

Greater sample integrity and operator safety

Heparin-induced bias can be caused by:

- Use of heparin that is not formulated to reduce bias on electrolytes
- The use of liquid heparin

This can lead to:

- Erroneous electrolytes and metabolites results
- Clots in the sample that may interfere with the analyzer and produce inaccurate value [1]
- Incorrect patient treatment [2]

Sharps injury can be caused by:

- Unavailability of sampling safety devices for operators
- Lack of a dedicated procedure for operator safety
- Dedicated procedures for operator safety are not followed

This can lead to:

- Operator concern over own safety
- Needlestick injury
- Infection by blood-borne pathogens

1. Higgins C. The use of heparin in preparing samples for blood gas analysis. www.acutecaretesting.org Apr 2007.
2. Siggaard-Andersen O *et al*. The concentration of free calcium ions in the blood plasma "ionized calcium". AS-79. Radiometer Medical ApS publication 1980: 163-90. Code no. 918-193.

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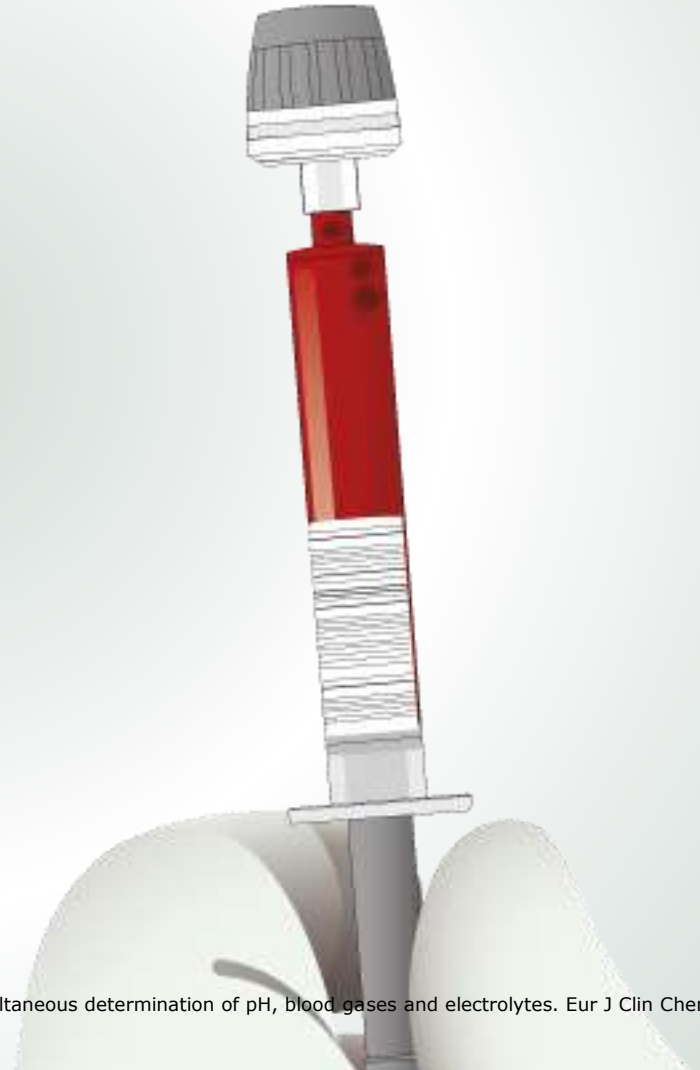
Heparin

3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors



1. Burnett RW *et al*. Approved IFCC recommendations on whole blood sampling, transport and storage for simultaneous determination of pH, blood gases and electrolytes. Eur J Clin Chem Biochem 1995; 33: 247-53.
2. Ordog GJ *et al*. Effect of heparin on arterial blood gases. Ann Emerg Med 1985; 14,3: 233-38.

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1. Heparin concentration

3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors

What is a sufficient concentration of heparin?

- The higher heparin concentration, the better anticoagulation
- Exact concentration for anticoagulation?
  - "10 IU/mL may not eliminate clotting and 150 IU/mL may also not be enough" [1]
  - "When below 200 IU/mL there is no effect on the blood gases but on electrolytes" [2]
- In 1960 the conventional heparin concentration adopted was 40 IU/mL [3]

1. NCCLS. Blood Gas and pH Analysis and Related Measurements; Approved Guideline. NCCLS document C46-A [ISBN 1-56238-444-9]. NCCLS, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898, USA 2001. Summary of Comments and Working Group Responses. C46-P: Blood Gas pH Analysis and Related Measurements; Proposed Guideline. Comment 8 to section 4.2.5.
2. Siggaard-Andersen O. Sampling and storing of blood for determination of acid-base status. Scand J Clin Lab Invest 1961; 13: 196-204.
3. Higgins C. The use of heparin in preparing samples for blood gas analysis. www.acutecaretesting.org Apr 2007.

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2. Heparin interference

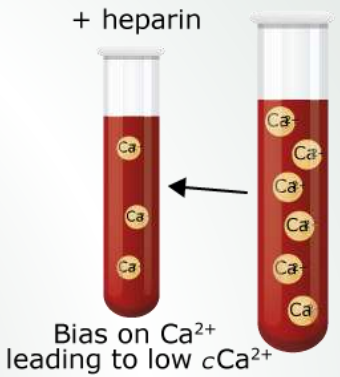
3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors

- Heparin binds positively charged ions
- Avoided by using electrolyte-balanced heparin



Bias on ionized calcium with the use of non-balanced heparin

IU/mL Heparin	Bias on cCa^{2+}[1,2]
15	-0.03
50	-0.15
100	-0.19

1. Toffaletti J. Use of novel preparations of heparin to eliminate interference in ionised calcium measurements: Have all the problems been solved? Clin Chem 1994; 40,4: 508-09.
2. Sachs C *et al*. Preanalytical errors in ionized calcium measurements induced by the use of liquid heparin. Ann Clin Biochem 1991; 28: 167-73.

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2. Heparin interference

3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors

According to international guidelines:

- **CLSI C46-A2**
  - **5.2.1** "..special preparations of heparin are available, which virtually eliminate the interference from heparin binding of these electrolytes."
  - **5.2.5** "Although a low concentration of ordinary heparin will reduce the error, it will not eliminate it, and the special heparin preparations discussed above (balanced or dispersed) are preferable"
  - **5.2.5** "Therapeutic heparin used for systemic anticoagulation should not be used....because of its very high concentration"

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The choice of device does make a difference

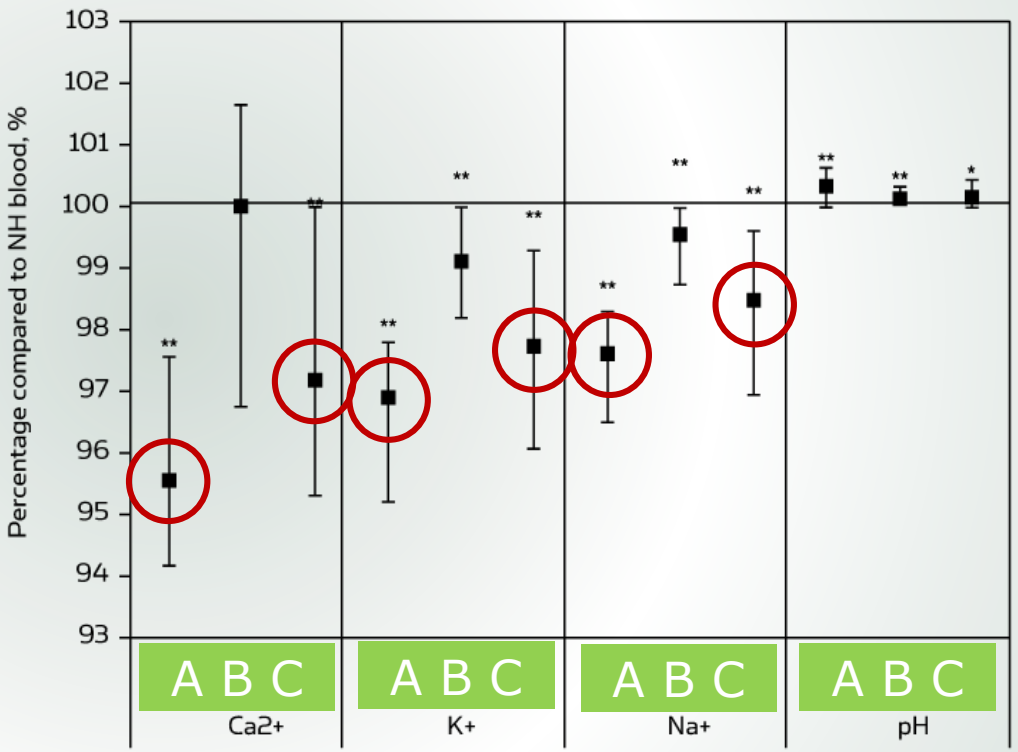
3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors

"Taken together, two out of the three syringes tested here introduced a clinically significant negative bias" [1]



1. van Berkel M *et al*. Electrolyte-balanced heparin in blood gas syringes can introduce a significant bias in the measurement of positively charged electrolytes. Clin Chem Lab Med 2011;49,2: 249-52.

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3. Heparin formulation

3 important points about heparin

- Sufficient concentration of heparin is needed
- Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}
- Heparin needs to be provided in a dry format to avoid dilution errors

"Excess liquid heparin statistically exaggerated or produced false results consistent with metabolic acidosis with respiratory compensation" [3]

"The danger from nonstandardized blood collection into syringe washed with liquid heparin should be carefully assessed. For preventing serious medical errors due to nonstandardized blood gas sampling, electrolyte balanced dry heparin may be recommended." [1]

1. Küme T *et al*. The effects of different syringe volume, needle size and sample volume on blood gas analysis in syringes washed with heparin. Biochem Med 2012; 22,2: 189-201
2. Ordog GJ *et al*. Effect of heparin on arterial blood gases. Ann Emerg Med 1985; 14,3: 233-38.

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3. Heparin formulation

3 important points about heparin

Sufficient concentration of heparin is needed

Electrolyte-balanced heparin minimizes bias on positive ions like Ca^{2+}, Na^{+} and K^{+}

Heparin needs to be provided in a dry format to avoid dilution errors

According to international guidelines:

- **IFCC [1]**:
  - "…a 5 % dilution may be acceptable for the blood gases, but not for the electrolytes"
- **CLSI [2]:**
  - 5.2.1 "The ideal collection device for arterial blood sampling is….containing a small amount of anticoagulant such as lyophilized heparin"

1. Burnett RW *et al*. Approved IFCC recommendations on whole blood sampling, transport and storage for simultaneous determination of pH, blood gases and electrolytes. Eur J Clin Chem Biochem 1995; 33: 247-53.
2. Clinical and Laboratory Standards Institute (CLSI). Blood Gas and pH Analysis and Related Measurements; Approved Guidelines. NCCLS Document C46-A2. Vol. 19 No. 8 [ISBN 1-56238-694-4]. Clinical and Laboratory Standards Institute, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898, USA. 2009.
3. Ordog GJ *et al*. Effect of heparin on arterial blood gases. Ann Emerg Med 1985; 14,3: 233-38.

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Greater sample integrity and operator safety

Tips!
Use a syringe with integrated needle shield device and tip cap

Dry electrolyte-balanced heparin is the foundation for a result you can trust

- Heparin is the only anti-coagulant recommended for blood gas analysis
- Use an anti-coagulant to reduce clotting of the sample
- Use an anti-coagulant which eliminates the interference from binding electrolytes
- Use dry anti-coagulant to prevent dilution effect

An ABG collection device with **sharps injury protection** prevents needlestick injuries

- Use one-hand operated sharps injury protection

1. Ball J *et al*. Needlestick injury in 2008. Results from a survey of RCN members. Royal College of Nursing 2008.
2. Sharps safety. RCN guidance to support implementation of the EU Directive 2010/32/EU on the prevention of sharps injuries in the health care sector. Royal College of Nursing 2011.

3. Sample collection

Sample contamination

When doing arterial punctures, there is a risk of accidentally puncturing a vein. Even a few drops of venous blood mixed with the arterial sample can cause bias on the patient results.

Example

Two samples are collected by arterial puncture. One is accidentally contaminated with a few drops of venous blood before the needle is correctly positioned in the artery. See below how this can affect patient results.

Pure arterial sample		Contaminated arterial sample	
Patient results		**Patient results**	
pO_2	100 mmHg (13.3 kPa)	pO_2	90 mmHg (12.0 kPa)
pCO_2	41 mmHg (5.5 kPa)	pCO_2	41.5 mmHg (5.5 kPa)
sO_2	98%	sO_2	97.4%

Maximum safety for patient

Sample contamination can be caused by:

- Mixing venous blood with arterial blood
- Diluting the sample with flush solution if an insufficient amount of flush solution has been removed

This can lead to:

- Contaminating the sample with either venous blood or flush solution will alter the values of the sample so that it no longer represents the patient status

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Maximum safety for patient and operator

A-puncture procedure

- Use of short-bevel needles eases the placement of needle in artery and minimizes the risk of puncturing opposite arterial wall
- Self-filling syringes fill readily indicating an artery has been punctured and rapid appearance of the blood flash indicates an artery has been punctures
- An ABG collection device with sharps injury protection prevents needle stick injuries
- Use one-hand operated sharps injury protection

4. Sample handling

- Two samples are collected from the same patient and measured after 5 minutes. One sample is mixed and air bubbles expelled, the other is not. This may alter patient results as shown below.

Sample without air bubbles		Sample containing air bubbles	
Patient results		**Patient results**	
pO_2	70 mmHg (9.3 kPa)	pO_2	90 mmHg (12.0 kPa)
pCO_2	45.6 mmHg (6.1 kPa)	pCO_2	45.4 mmHg (5.5 kPa)
sO_2	94.0%	sO_2	96.9%

- 0.2 mL of air is added to a blood gas sample and transported via pneumatic tube. The initial pO_2 value is 105 mmHg. After the pneumatic tube transport the pO_2 increases to 150 mmHg [2].

Key steps for **greater sample integrity**

Exposure to room air can lead to:

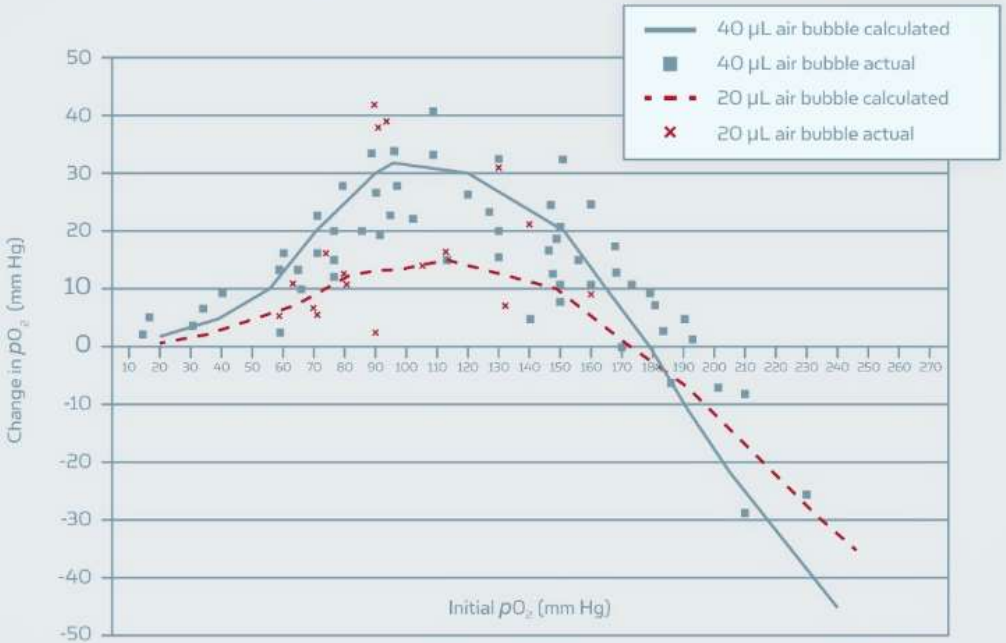
- Sample values no longer representative of patient status
- pO_2 will be most impacted – there will be minor effects on pCO_2 and pH [1]

An inhomogeneous sample can lead to:

- Erroneous hemoglobin and Hct values and bias on calculated parameters derived from *c*tHb

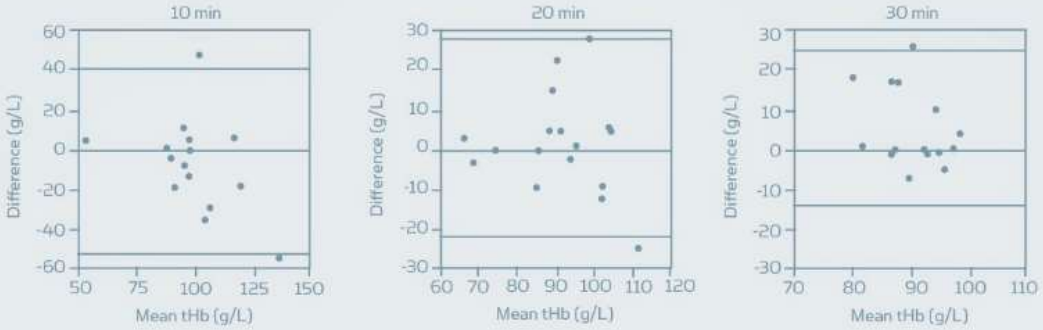
1. Toffaletti J. Effect of small air bubbles on changes in blood *p*O2 and blood gas parameters: Calculated vs. measured effects. www.acutecaretesting.org July 2012.

Calculated and measured changes in blood pO_2 when 20 or 40 µL air (atmospheric pO_2) was added to blood. Data points are based on changes in pO_2 as measured on 19 blood specimens as air was sequentially introduced and equilibrated with the blood in a syringe.

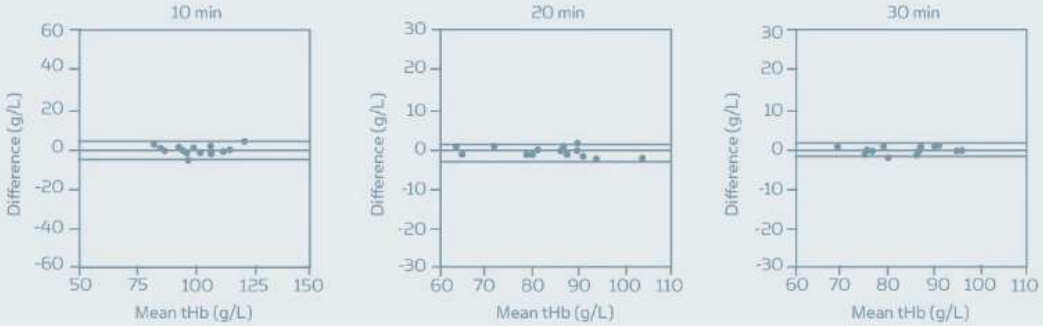


Toffaletti J. Effect of small air bubbles on changes in blood pO_2 and blood gas parameters: Calculated vs. measured effects. Acutecaretesting.org Jul 2012.

Manual mixing (ABL700)



Automatic mixing (ABL800 FLEX)



Grenache DG *et al*. Integrated and automatic mixing of whole blood: an evaluation of a novel blood gas analyzer. Clin Chim Acta 2007; 375: 153-57.

1. Grenache DG *et al*. Integrated and automatic mixing of whole blood: an evaluation of a novel blood gas analyzer. Clin Chim Acta 2007; 375: 153-57.

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Key steps for **greater sample integrity**

Thorough **removal of air bubbles** minimizes room air contamination of the sample

- Visually inspect the sample for air bubbles
- Expel any air bubbles before mixing

Proper **mixing of the sample** immediately post sample collection for a clot-free sample

- Mix immediately after air bubbles have been expelled
- Mix to dissolve the heparin to prevent clots to form

Mixing – again – prior to analysis to obtain a homogeneous sample

- Thoroughly mix the sample by inverting the syringe several times and rolling it between the palms of your hands
- Use automated mixing

Tips!

Use syringes with **vented tip caps** that seal the sample and remove air without getting in contact with blood

Establish a **dedicated mixing procedure** in your facility

Gentle mixing of the sample is required to avoid the risk of hemolysis

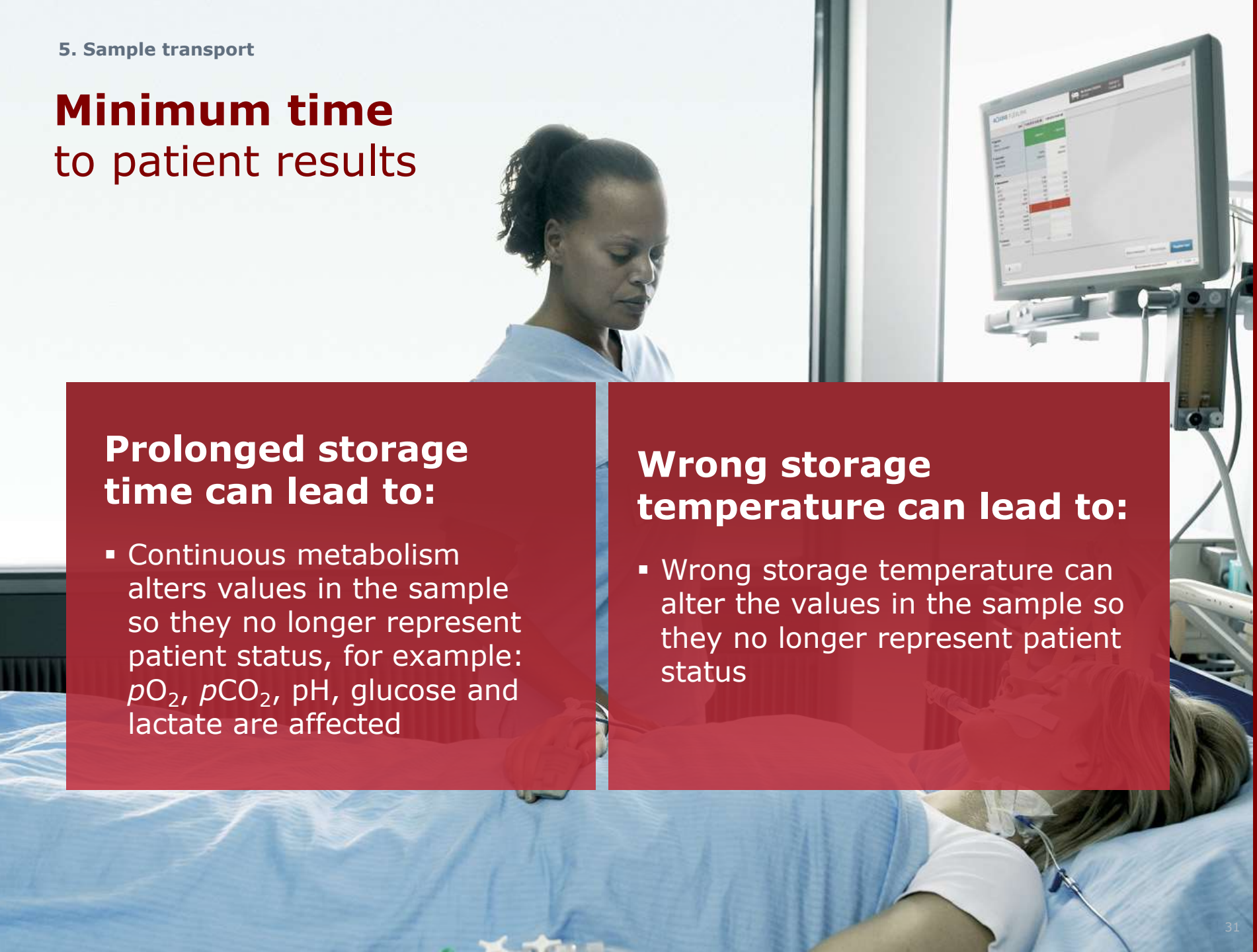
1. Grenache D *et al*. Integrated and automatic mixing of whole blood: An evaluation of a novel blood gas analyzer. Clin Chim acta 2007; 375: 153-57.
2. Benoit M *et al*. Evaluation and advantages of an automatic magnetic mixing of syringes integrated to a whole blood gas analyser. Scand J Clin Lab Invest 2009; 69,5: 628-32.

5. Sample transport

Biochemistry predicts the following changes caused by continued metabolism of heparinized arterial blood gas samples obtained anaerobically and stored at room temperature [1]:

Parameter	Change	Because...
pO_2	↓	The cells that utilize oxygen continue to do so
pCO_2	↑	CO_2 is a product of the metabolism
pH	↓	Combined effect: 1) Increase in CO_2 causes a decrease in pH 2) Increase in hydrogen-ion concentration due to continued glycolysis
Glucose	↓	Due to continued glycolysis
Lactate	↑	Due to continued glycolysis

Minimum time to patient results



Prolonged storage time can lead to:

- Continuous metabolism alters values in the sample so they no longer represent patient status, for example: pO_2, pCO_2, pH, glucose and lactate are affected

Wrong storage temperature can lead to:

- Wrong storage temperature can alter the values in the sample so they no longer represent patient status

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Minimum time to patient results

Immediate analysis of sample for greater sample integrity and short TAT

- If storage is unavoidable, store the sample for maximum 30 minutes
- Glass syringes should be used if analysis will be delayed (more than 30 minutes after collection)

NB!
Analyze special samples within 5 minutes: high pO_2, high leucocyte count, shunt studies

Store plastic sampling devices at **room temperature** to minimize any effect on sample values

- Glass sampling devices can be stored in ice slurry water or at room temperature

Tips!
Use a blood gas analyzer that can keep track of sample age

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Minimum time
to patient results

Immediate analysis of sample for greater sample integrity and short TAT

- If stora idable sample for ma um 3 nut
- Glass s ges ld used if a sis be dela than minutes er collect

NB!
Analyze special samples within 5 minutes: high pO_2, high leucocyte s

POCT

Tips!
- e a blood g alyzer that can keep track of sample age

Store plastic sampling devices at **room temperature** to minimize any effect on sample values

- Glass sampling devices can be stored in ice slurry water or at room temperature

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High Five for **safe arterial blood gas sampling:**

Path of workflow:

1. **Patient preparation** – *patient assessment and correct data registration to maximize patient safety*
2. **Blood collection device** – *greater sample integrity and operator safety*
3. **Sample collection** – *maximum safety for patient and operator*
4. **Sample handling** – *key steps for greater sample integrity*
5. **Sample transport** – *minimum time to patient results*

More educational resources
Blood gas preanalytics app:

- Handbook with video demonstrations
- Skill test
- Interactive troubleshooting guide

Available for
iPhone, Android, Windows Phone

Appendix

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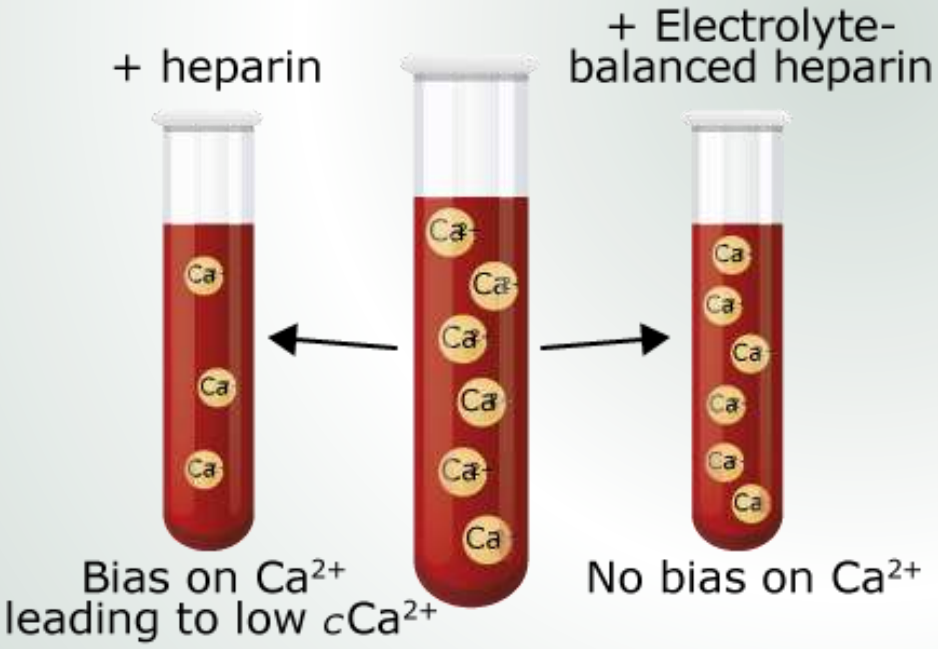
Radiometer's solution

First and only to market **with fully balanced heparin**

Dry electrolyte-balanced heparin



Radiometer facts:

First to market with high sensitive calcium measurement

First to market with balanced heparin

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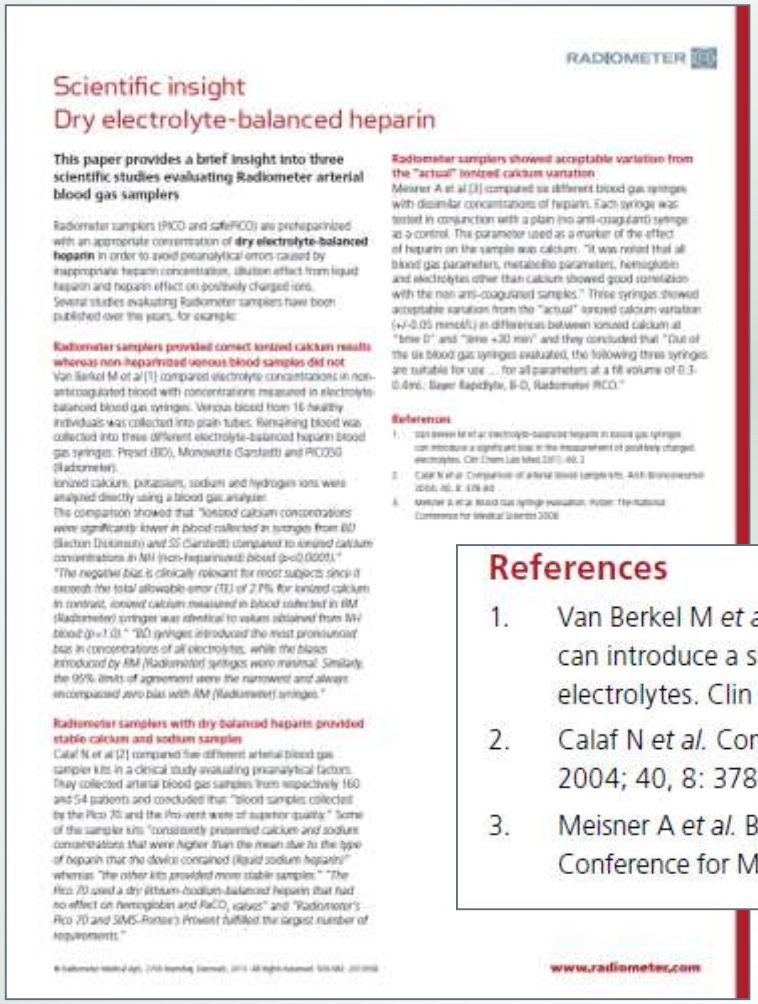
Radiometer's dry electrolyte-balanced heparin – **superiority confirmed by additional studies**



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Scientific insight
Dry electrolyte-balanced heparin

This paper provides a brief insight into three scientific studies evaluating Radiometer arterial blood gas samplers

Radiometer samplers (PICO and safePICO) are preheparinized with an appropriate concentration of **dry electrolyte-balanced heparin** in order to avoid preanalytical errors caused by inappropriate heparin concentration, dilution effect from liquid heparin and heparin effect on positively charged ions. Several studies evaluating Radiometer samplers have been published over the years, for example:

Radiometer samplers provided correct ionized calcium results whereas non-heparinized venous blood samples did not

Van Berkel M *et al* [1] compared electrolyte concentrations in non-anticoagulated blood with concentrations measured in electrolyte-balanced blood gas syringes. Venous blood from 16 healthy individuals was collected into plain tubes. Remaining blood was collected into three different electrolyte-balanced heparin blood gas syringes: Preset (BD), Monovette (Sarstedt) and PICO50 (Radiometer).
Ionized calcium, potassium, sodium and hydrogen ions were analyzed directly using a blood gas analyzer.
This comparison showed that *"ionized calcium concentrations were significantly lower in blood collected in syringes from BD (Becton Dickinson) and SS (Sarstedt) compared to ionized calcium concentrations in NH (non-heparinized) blood (p<0.0005)."*
"The negative bias is clinically relevant for most subjects since it exceeds the total allowable error (TE) of 2.1% for ionized calcium. In contrast, ionized calcium measured in blood collected in RM (Radiometer) syringes was identical to values obtained from NH blood (p=1.0)." *"BD syringes introduced the most pronounced bias in concentrations of all electrolytes, while the biases introduced by RM (Radiometer) syringes were minimal. Similarly, the 95% limits of agreement were the narrowest and always encompassed zero bias with RM (Radiometer) syringes."*

Radiometer samplers with dry balanced heparin provided stable calcium and sodium samples

Calaf N *et al* [2] compared five different arterial blood gas sampler kits in a clinical study evaluating preanalytical factors. They collected arterial blood gas samples from respectively 160 and 54 patients and concluded that: "blood samples collected by the Pico 70 and the Pro-vent were of superior quality." Some of the sampler kits *"consistently presented calcium and sodium concentrations that were higher than the mean due to the type of heparin that the device contained (liquid sodium heparin)"* whereas *"the other kits provided more stable samples."* *"The Pico 70 used a dry lithium-/sodium-balanced heparin that had no effect on hemoglobin and $PaCO_2$ values"* and *"Radiometer's Pico 70 and SIMS-Portex's Prevent fulfilled the largest number of requirements."*

Radiometer samplers showed acceptable variation from the "actual" ionized calcium variation

Meisner A *et al* [3] compared six different blood gas syringes with dissimilar concentrations of heparin. Each syringe was tested in conjunction with a plain (no anti-coagulant) syringe as a control. The parameter used as a marker of the effect of heparin on the sample was calcium. "It was noted that all blood gas parameters, metabolite parameters, hemoglobin and electrolytes other than calcium showed good correlation with the non anti-coagulated samples." Three syringes showed acceptable variation from the "actual" ionized calcium variation (+/-0.05 mmol/L) in differences between ionized calcium at "time 0" and "time +30 min" and they concluded that "Out of the six blood gas syringes evaluated, the following three syringes are suitable for use ... for all parameters at a fill volume of 0.3-0.6mL: Bayer Rapidlyte, B-D, Radiometer PICO."

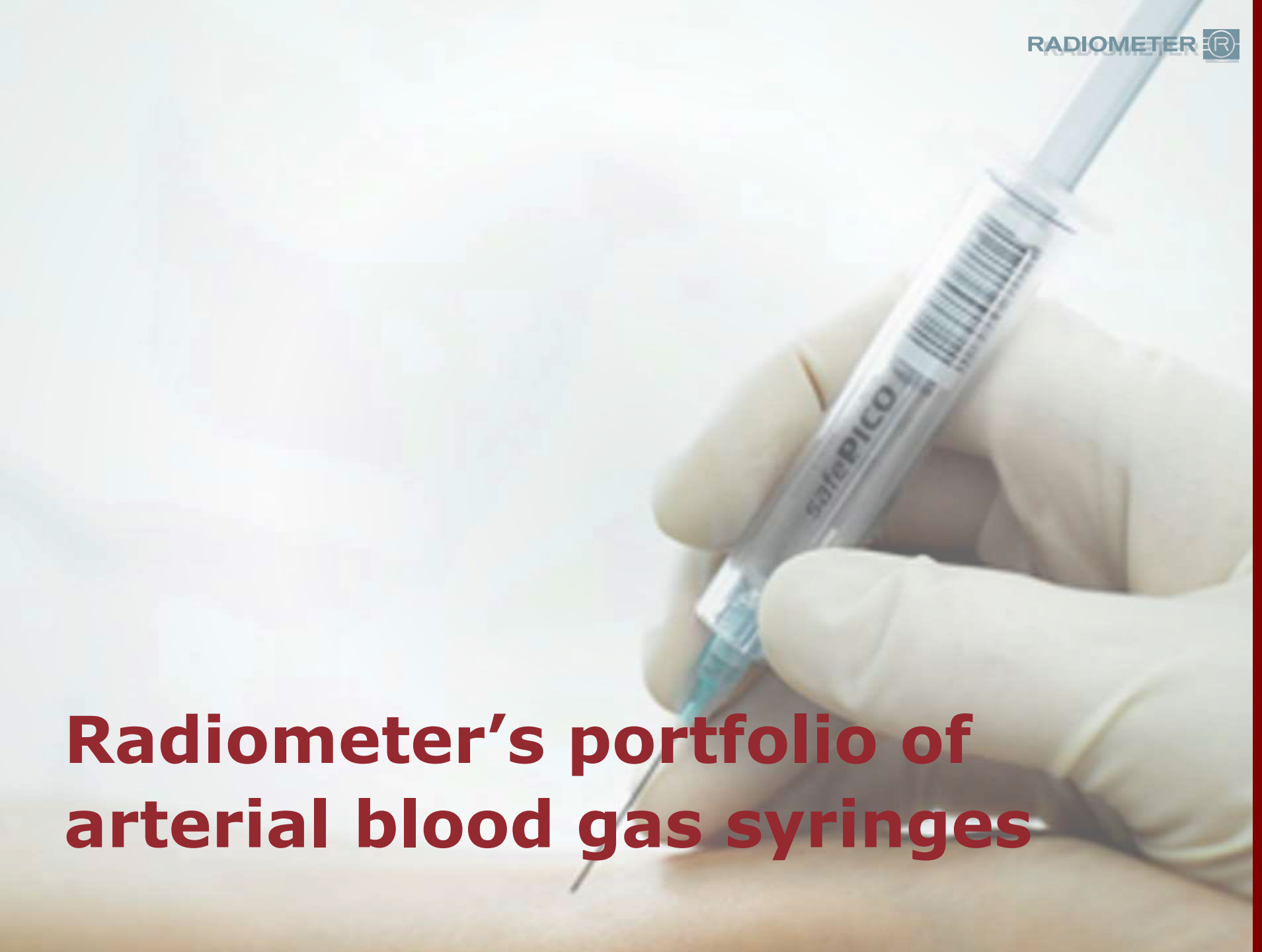
References

1. Van Berkel M *et al.* Electrolyte-balanced heparin in blood gas syringes can introduce a significant bias in the measurement of positively charged electrolytes. Clin Chem Lab Med 2011; 49, 2
2. Calaf N *et al.* Comparison of arterial blood sample kits. Arch Bronconeumol 2004; 40, 8: 378-80
3. Meisner A *et al.* Blood Gas Syringe evaluation. Poster: The National Conference for Medical Scientist 2008

www.radiometer.com

References

1. Van Berkel M *et al.* Electrolyte-balanced heparin in blood gas syringes can introduce a significant bias in the measurement of positively charged electrolytes. Clin Chem Lab Med 2011; 49, 2
2. Calaf N *et al.* Comparison of arterial blood sample kits. Arch Bronconeumol 2004; 40, 8: 378-80
3. Meisner A *et al.* Blood Gas Syringe evaluation. Poster: The National Conference for Medical Scientist 2008



Radiometer's portfolio of arterial blood gas syringes

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Arterial blood gas syringes

PICO

Arterial puncture and arterial line sampling

PICO70

PICO50

*safe*PICO70

Arterial puncture sampling with integrated needle shield device

*safe*PICO70

*safe*PICO

Premium solution for arterial blood gas sampling

*safe*PICO self-fill

*safe*PICO aspirator

RADIOMETER

Radiometer's **PICO line** – features

PICO syringe

- Available as **aspirator for arterial line** procedures and **vented for arterial puncture** procedure
- Pre-heparinized with **dry** electrolyte-balanced heparin coated on fiber disc
- TipCap to seal sample during transport
- Fill volume: PICO70 0.3-1.5 mL, PICO50 0.5-2 mL

PICO50
Aspirator for arterial line draw

PICO70
Vented syringe for arterial puncture draw

*safe*PICO70 syringe

- Arterial puncture draw
- Same features as PICO line
- Integrated needle shield device – single handed activation and audible "click" when activated correctly
- Fill volume: 0.3-1.5 mL

***safe*PICO70**
Vented syringe for arterial puncture draw

Needle assortment
For self-filling syringes:
Broad assortment of needles to suit puncture site and patient characteristics

Length \ Outer diameter	25G Orange	23G Blue	22G Clear
16 mm	x	x	
25 mm		x	x
32 mm		x	x

Preferably short-bevel 20-25 gauge needles with a length of 16-38 mm are acceptable for arterial puncture [1]

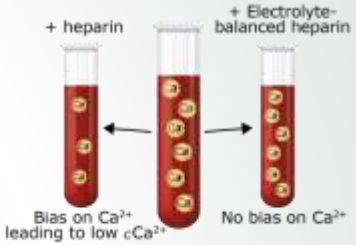
1. Clinical and Laboratory Standards Institute (CLSI). Procedures for the Collection of Arterial Blood Specimens; Approved Standard-Fourth Edition. H11-A4. Vol. 24 No. 28 [ISBN 1-56238-427-9]. Clinical and Laboratory Standards Institute, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087-1898, USA. 2009.

RADIOMETER

Radiometer's **PICO line** – benefits

Dry electrolyte-balanced heparin

- Specially prepared heparin that minimizes bias on all electrolytes, Na^+, K^+, Ca^{2+} as recommended by CLSI guidelines
- Minimal bias on electrolytes even at smaller sample volumes
- Heparin superiority proven by independent study



Vented plunger system on self-filling syringe

- Vented plunger designed to minimize bubbles in sample

Needles with short bevel

- Easy placement of needle in artery; prevent puncture of opposite arterial wall
- Minimize the risk of mixing venous blood with arterial blood

Needles with super-thin needle wall

- Larger inner diameter compared to regular needles
- Faster filling and reduced patient discomfort

TipCap

- Minimize room air: The special design of the Radiometer TipCap leaves no room for air in the luer tip
- Anaerobe sample: The TipCap is designed to expell air from the sample before sealing

RADIOMETER

Radiometer's **needle safety mechanism**

***safe*PICO70 syringe**

Maximum operator safety

- Onboard safety mechanism → always where needed
- Single handed activation → allows operator to take care of patient while disposing of needle
- Audible "click" signals correct activation → ensure correct usage every time
- Full encapsulation of needle → safe disposal of needle and optimal prevention of stick injury
- Robust and irreversible once activated → maximum user safety

***safe*PICO70**
Features onboard needle shield device for maximum safety

RADIOMETER

Radiometer's **premium *safe*PICO line** – features

*safe*PICO syringe

Maximum safety and sample integrity

- *safe*PICO aspirator for arterial line draw
- *safe*PICO self-fill for arterial puncture draw
- Pre-heparinized with dry electrolyte-balanced heparin coated on fiber disc
- *safe*TIPCAP for safe and easy removal of air bubbles; seals the sample during transport
- Integrated mixing ball for easy and efficient mixing of sample
- Pre-barcoded to enable automatic match of patient ID and sample ID
- *safe*PICO self-fill available with integrated needle shield device
- Fill volume: *safe*PICO self-fill 0.7-1.5 mL, *safe*PICO aspirator 0.7-1.7 mL

Needle assortment – for self-filling syringes

Broad assortment of needles to suit puncture site and patient characteristics

Length	Outer diameter: 25G Orange	23G Blue	22G Clear
16 mm	x	x	
25 mm		x	x
32 mm		x	x

RADIOMETER

Radiometer's **premium *safe*PICO line** – benefits

***safe*TIPCAP**

Greater sample integrity and operator safety

- Allows for easy expelling of air while preventing exposure to blood
- Seals the sample during transport
- Stays on during measurement; forms a closed system once attached

Mixing ball

Greater sample integrity

- Gold plated metal mixing ball ensures easy, quick and efficient mixing
- Dissolves heparin to prevent clotting
- Ensures homogenous sample for correct hemoglobin results

Pre-barcoded

Maximum data accuracy

- Pre-attached barcode on syringe for automatic match of patient ID and sample ID