6th EEMEA Acute Care Experts Meeting
October 15-16, 2025 • Vilnius

# The Hidden Impact of Preanalytics on Point-of-Care Testing Accuracy

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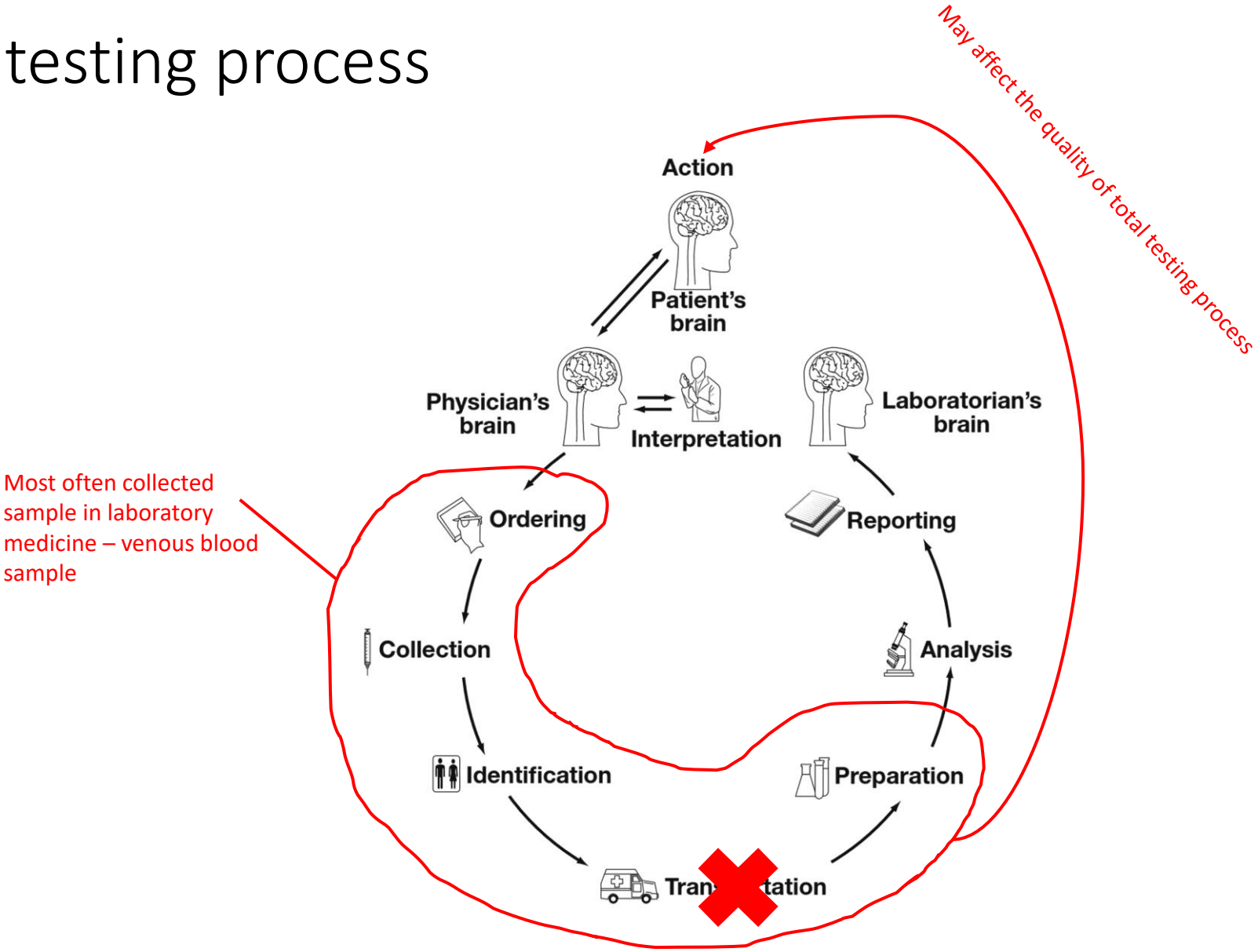
European Federation of Clinical Chemistry and Laboratory Medicine, Committee of Preanalytical Phase, Full Member – Young Scientist

# Disclosure

- I have received an honorarium from Werfen for this lecture.
- I have no other conflicts of interest related to the content of this presentation.

# Total testing process



# Importance of POCT in Patient Management

- **50–70 % of clinical decisions** are based on laboratory test results.
- **POCT (Point-of-Care Testing):** Provides rapid results at bedside, enabling immediate clinical action.
- **Impact on management:** Faster diagnosis, treatment initiation, and monitoring improve outcomes.

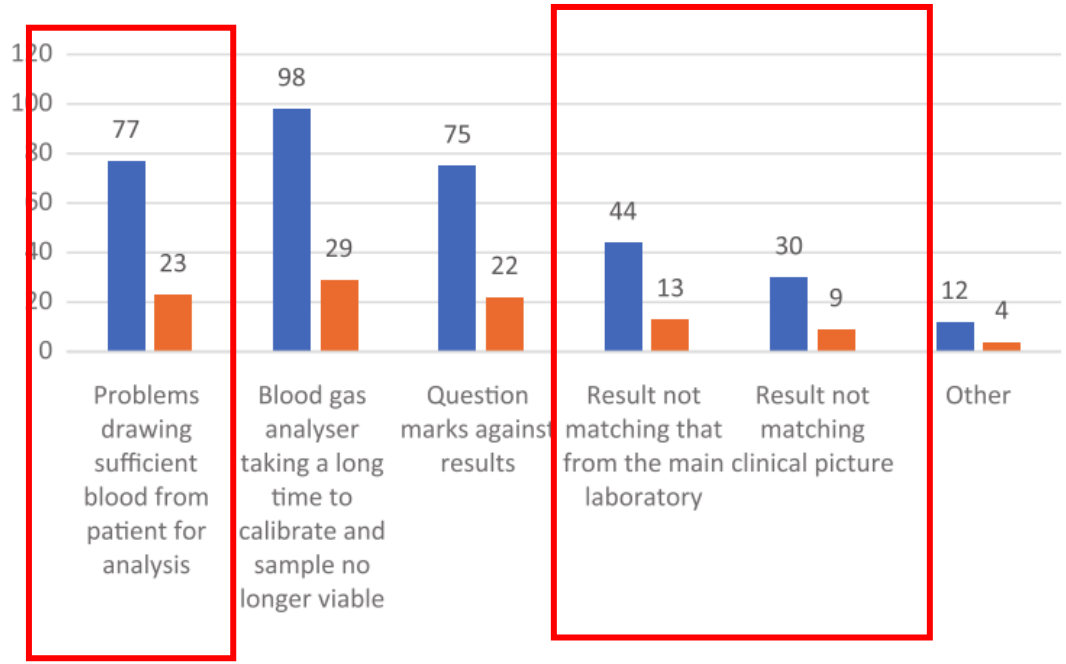
# Preanalytical Errors in POCT

- **~70 % of total laboratory errors** occur in the pre-analytical phase.
- Common issues:
  - Wrong patient identification
  - Inadequate or contaminated samples
  - Incorrect handling/storage
  - Operator-related mistakes (training, protocol deviation)
- These errors can **compromise patient safety** and lead to mismanagement.

POCT is a powerful tool for improving patient care, but **rigorous control of pre-analytical steps is critical** to ensure accuracy and safety.

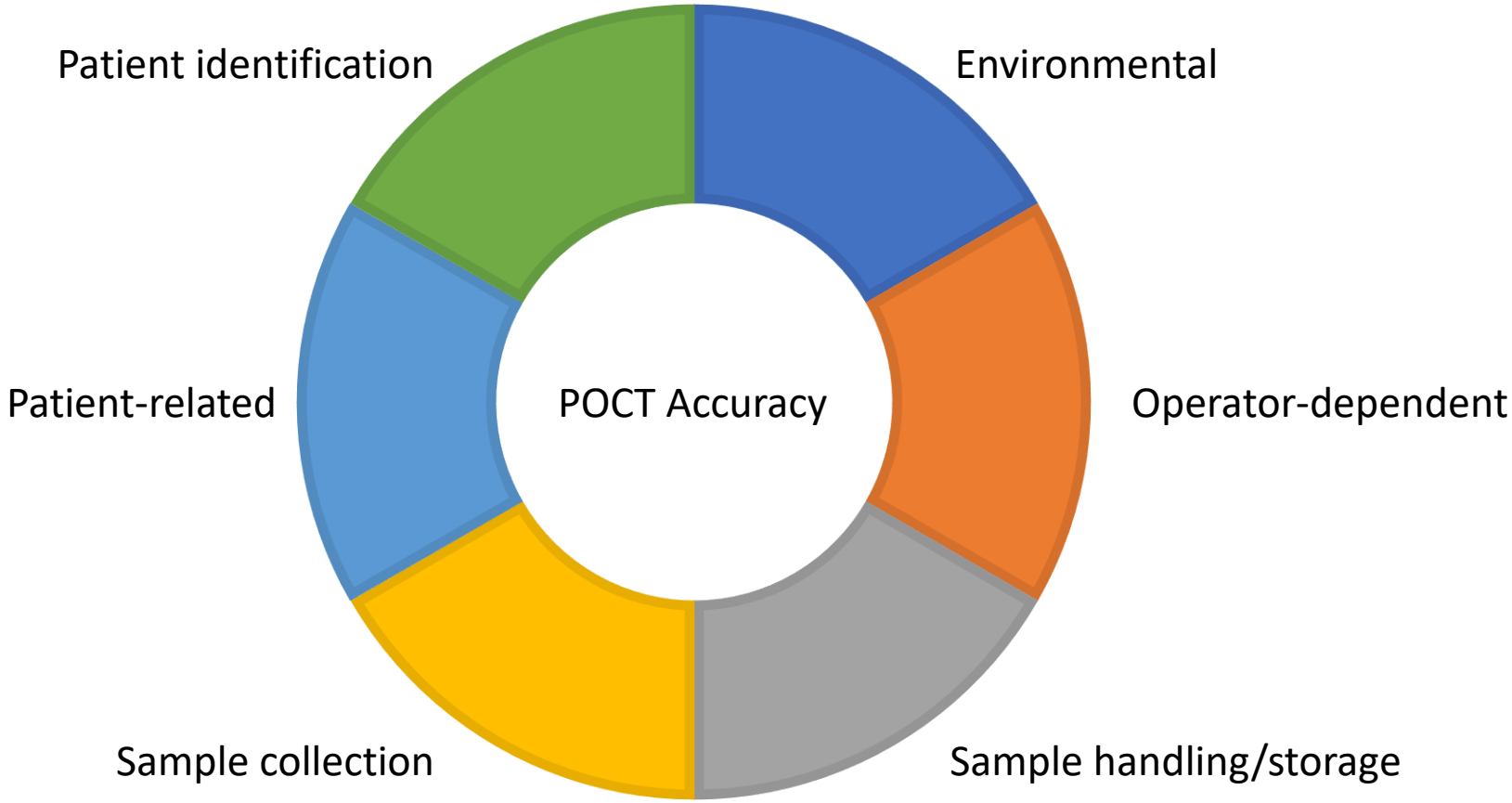
# POCT Challenges Reported by Critical Care Nurses

- Most common problems identified:
  - 23%: Difficulty drawing sufficient blood for testing
  - 13%: POCT results not matching laboratory results
  - 9%: POCT results not matching the clinical picture
- **Likely Causes** Preanalytical errors such as:
  - Improper sample collection or insufficient volume
  - Sample handling or labeling issues
  - Delays in processing or improper storage




Bench S. and Lennox S.DOI: [10.1111/nicc.12869](https://doi.org/10.1111/nicc.12869)

# Multiple Preanalytical Factors Shape POCT Accuracy



# Impact of Preanalytical Phase on POCT

- 37-bed ICU implemented **modified pre-analytical process** using a **multidisciplinary quality approach**.
- Aim: Assess effect on **POCT turnaround time** and **laboratory result accuracy**.

Auvet *et al. Ann. Intensive Care (2016) 6:57*
DOI 10.1186/s13613-016-0152-6

Annals of Intensive Care

RESEARCH Open Access

## Preanalytical conditions of point-of-care testing in the intensive care unit are decisive for analysis reliability

Adrien Auvet[1,2,3], Fabien Espitalier[2], Leslie Grammatico-Guillon[3,4], Mai-Anh Nay[1,2,3], Djilali Elaroussi[2], Marc Laffon[2,3], Christian R. Andres[3,5], Annick Legras[1], Stephan Ehrmann[1,3,6], Pierre-François Dequin[1,3,6], Chantal Gendrot[5] and Antoine Guillon[1,3,6*]

- **POCT became faster** after modifying preanalytical steps.
- **Hemoglobin measurement accuracy greatly improved**.
- No significant changes in potassium and sodium results.
- **Conclusion:** Proper preanalytical handling improves POCT speed and reliability.

# Patient Identification Errors in POCT

- **Why it matters:**
  - Wrong patient = wrong result applied
  - Can lead to misdiagnosis or inappropriate treatment
- **Common Scenarios:**
  - Emergency settings with multiple patients
  - Similar names or identifiers
  - Manual labeling at bedside
- **Best Practices:**
  - Use barcode/wristband scanning
  - Confirm patient verbally + cross-check ID
  - Label samples immediately, in presence of patient

*Even a perfect test result is meaningless if assigned to the wrong patient.*

# Managing Patient Identification Errors: Key Insights

Review

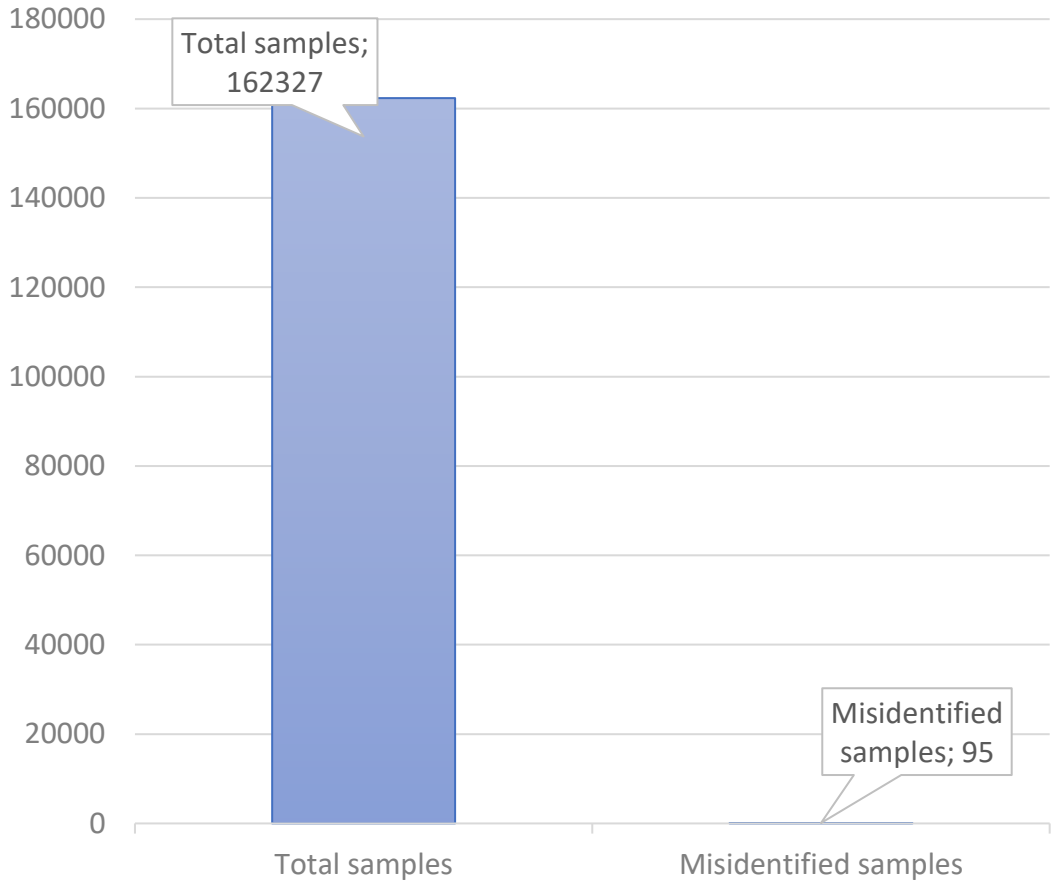
## Managing the patient identification crisis in healthcare and laboratory medicine

Giuseppe Lippi [a], Camilla Mattiuzzi [b], Chiara Bovo [c], Emmanuel J. Favaloro [d]

- Patient and sample identification is critical in health care.
- The frequency of misidentification in laboratory medicine is around 0.01–0.1%.
- Up to 10–20% of these errors translate into harm for patients.
- Use of > 2 unique patient identifiers and training are mainstays for prevention.
- Labeling blood collection tubes before venipuncture is safer.

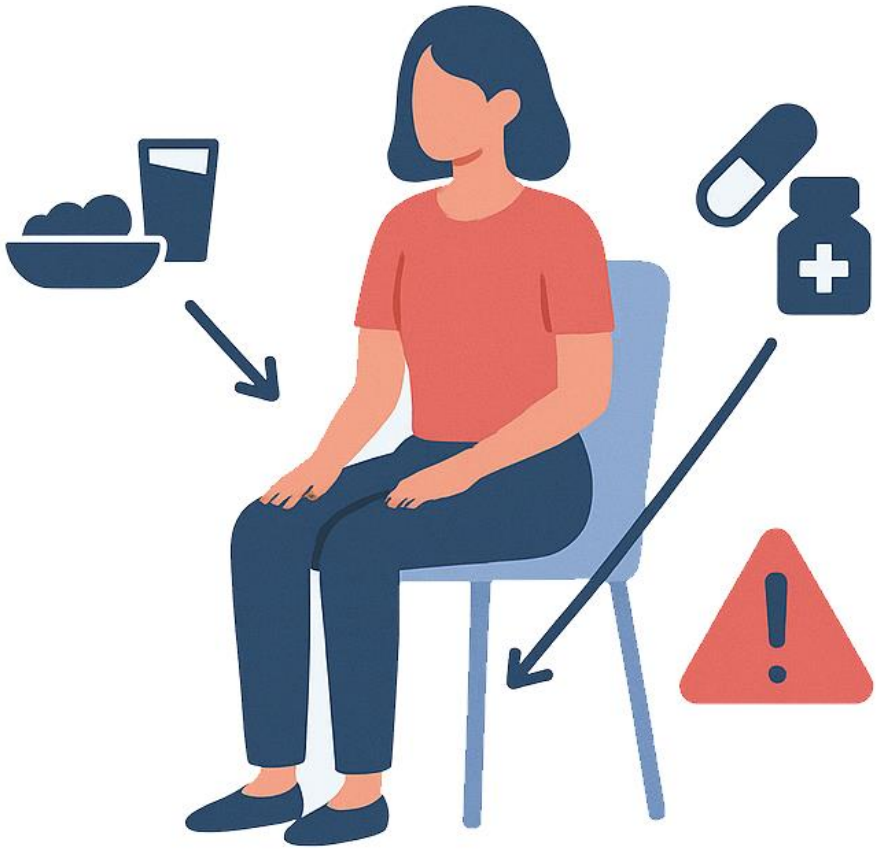
# Patient Identification Errors: Real Data from Our Institution

- **Total samples processed:** 162,327
- **Misidentified samples:** 95
- **Error rate:** 0.058% (~6 per 10,000 samples)
- **Impact:** Even a small number of errors can lead to serious patient safety risks



# Patient-Related Preanalytical Factors Affecting POCT Accuracy

- POCT accuracy is influenced not only by devices and operators but also by **patient-specific factors** before the sample is even collected.
- Common patient-related factors:
  - Fasting status or recent meals
  - Hydration level and posture
  - Medications or supplements
  - Body temperature, smoking, or alcohol intake
- These factors can **alter analyte levels**, leading to misleading results if not controlled.



# Preanalytical Interference in Point-of-Care Troponin T Testing

- A case series of 5 patients with suspected ACS using Roche Troponin T Card Test (POCT).
- Despite following correct sample collection & test protocol → no valid result obtained in these cases.
- Key patient-related abnormalities observed:
  - Extreme haematocrit (anaemia or polycythaemia)
  - Leucocytosis (very high white cell count)
  - Thrombocytopenia
  - Hepatic and renal dysfunction (biochemical derangements)
- After stabilization of those parameters, repeat POCT yielded valid troponin results.

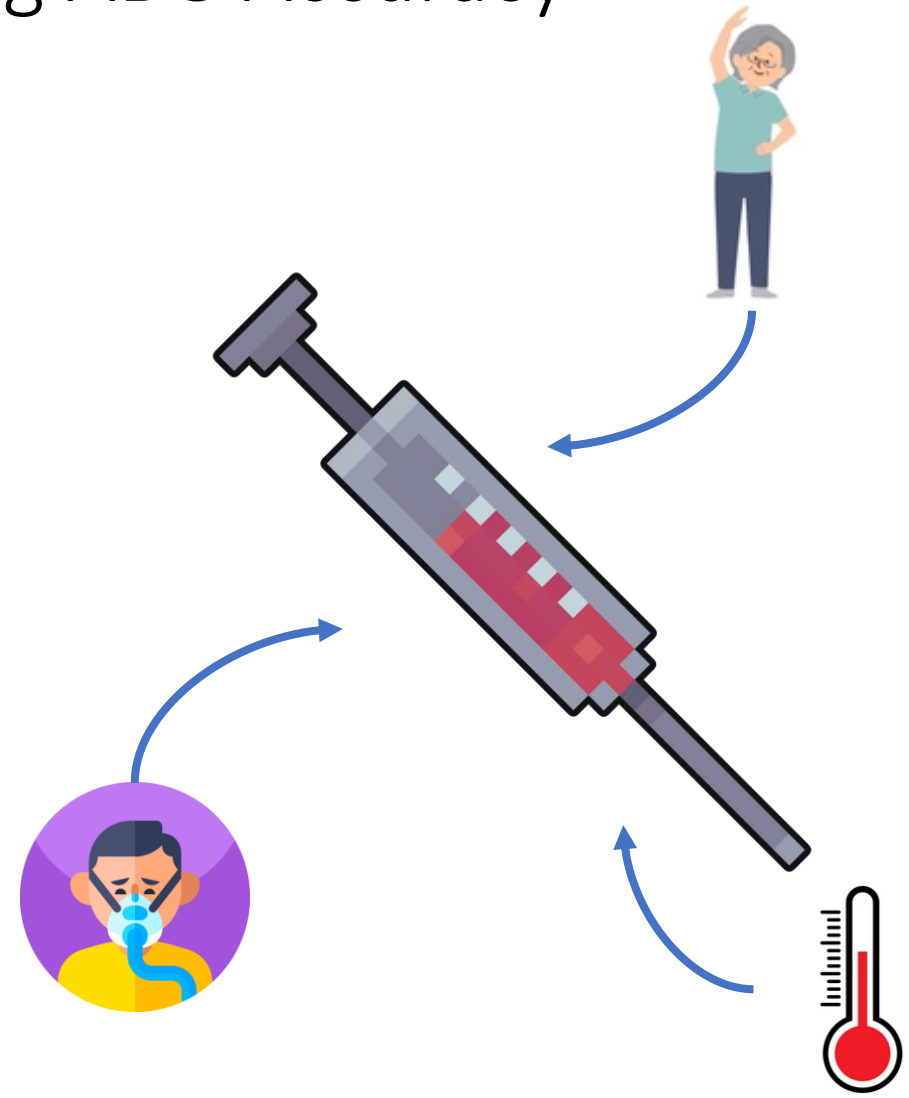
**Table 1:** Haematological and biochemical profiles of patients with aborted troponin T (POCT) during acute episode of illness.

| Parameter | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Normal range |
|---|---|---|---|---|---|---|
| Haemoglobin, g/L | 73 | 177 | 91 | 163 | 112 | Male: 13.5–17.5 Female: 12.0–15.5 |
| WBC, $\times 10^3$/μL | 23.48 | 8.2 | 50.2 | 35.6 | 13.9 | 4–11 |
| Platelets, $\times 10^3$/μL | 130 | 230 | 100 | 280 | 175 | 150–450 |
| RBC, $\times 10^6$/μL | 2.9 | 7.69 | 3.2 | 6.96 | 4.6 | Male: 4.7–6.1; Female: 4.2–5.4 |
| PCV, % | 22.1 | 64.5 | 26.3 | 56.8 | 35.2 | Male: 40–54; Female: 36–48 |
| ALT, U/L | 104 | 58 | 112 | 92 | 88 | 10–28 |
| Bilirubin, μmol/L | 20.5 | 32.5 | 25.7 | 27.4 | 37.6 | 3.4–20.5 |
| Urea, mmol/L | 13.6 | 23.6 | 15.7 | 26.8 | 14.3 | 3.6–8.3 |
| Creatinine, μmol/L | 185.6 | 159.1 | 132.6 | 212.2 | 106.1 | 53–115 |
| Troponin I, ng/mL | 176 | – | – | 0.025 | 76.9 | <0.034 |

Kamarajan L. *et al.* DOI: 10.1515/DX-2025-0104

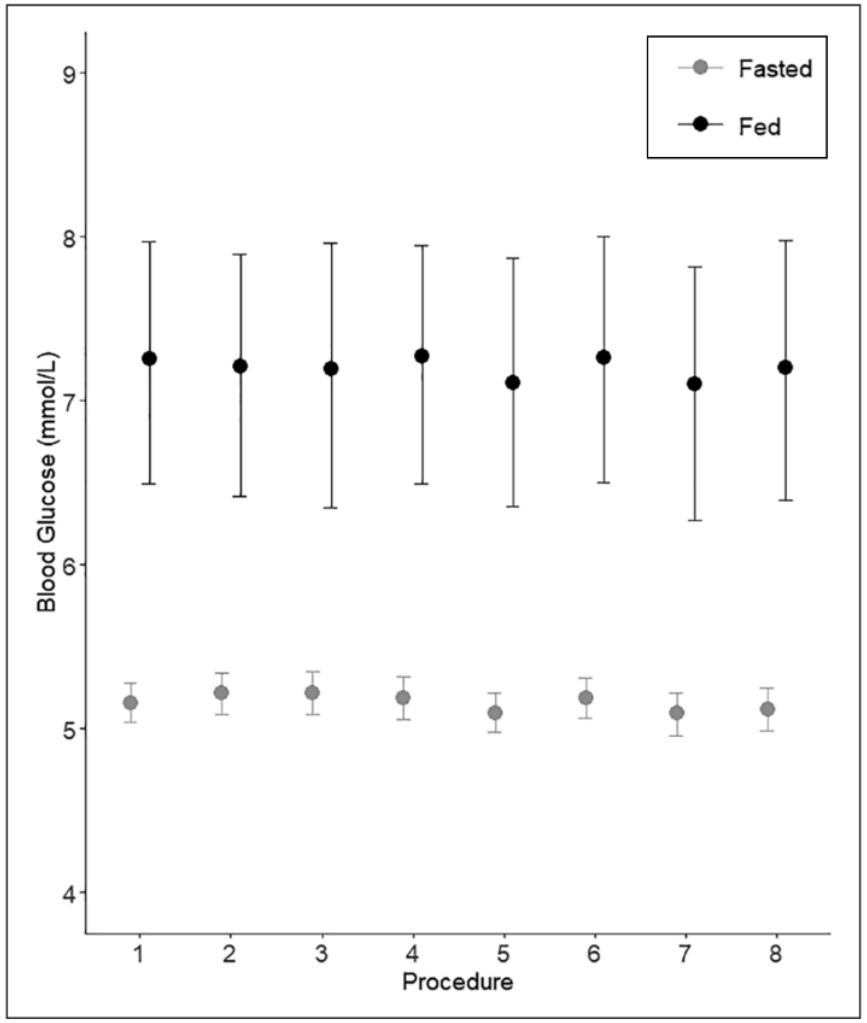
# Patient-Related Variables Affecting ABG Accuracy

- **Stable Patient Condition:**
  - Blood should be drawn when patient is **resting and stable**.
  - Exact **time of collection** must be recorded.
  - Deviations from steady state (exercise, crying, anxiety) must **be noted on report**.
- **Key Patient Variables at Time of Collection:**
  - **Patient status:** resting, exercising, crying, anxious
  - **Ventilatory setting:** spontaneous or assisted mechanical ventilation
  - **Oxygen delivery mode:** FiO2 via nasal cannula, Venturi mask, etc.
  - **Respiratory rate**: hyperventilation, hypoventilation
  - **Body temperature:** affects pH, pCO2, ionized calcium
- **Stabilization Period:**
  - Without pulmonary disease: 3–5 minutes after change
  - With pulmonary disease: 20–30 minutes (CLSI C46-A2)



# Impact of Patient-Related Preanalytical Factors on POCT Glucose Accuracy

- Study design:
  - **30 non-diabetic participants**
  - Compared 8 procedures:
    - Hand washing vs none
    - Alcohol wipe vs none
    - First drop vs second drop
  - Conditions: **fasted vs fed** (75 g glucose load)
- Key findings:
  - **Blood glucose rose by +2.07 mmol/L** after carbohydrate ingestion (as expected).
  - **No significant differences** in readings between procedures (hand washing, alcohol, drop number).
  - **Greater variability** observed in fed condition (possible clinical impact).
  - Results apply to *nondiabetic* individuals → not generalizable to hypoglycemia or diabetes patients.




Laming B. *et al*. DOI: 10.1177/19322968251361163/FORMAT/EPUB

# Anticoagulants in ABG Testing

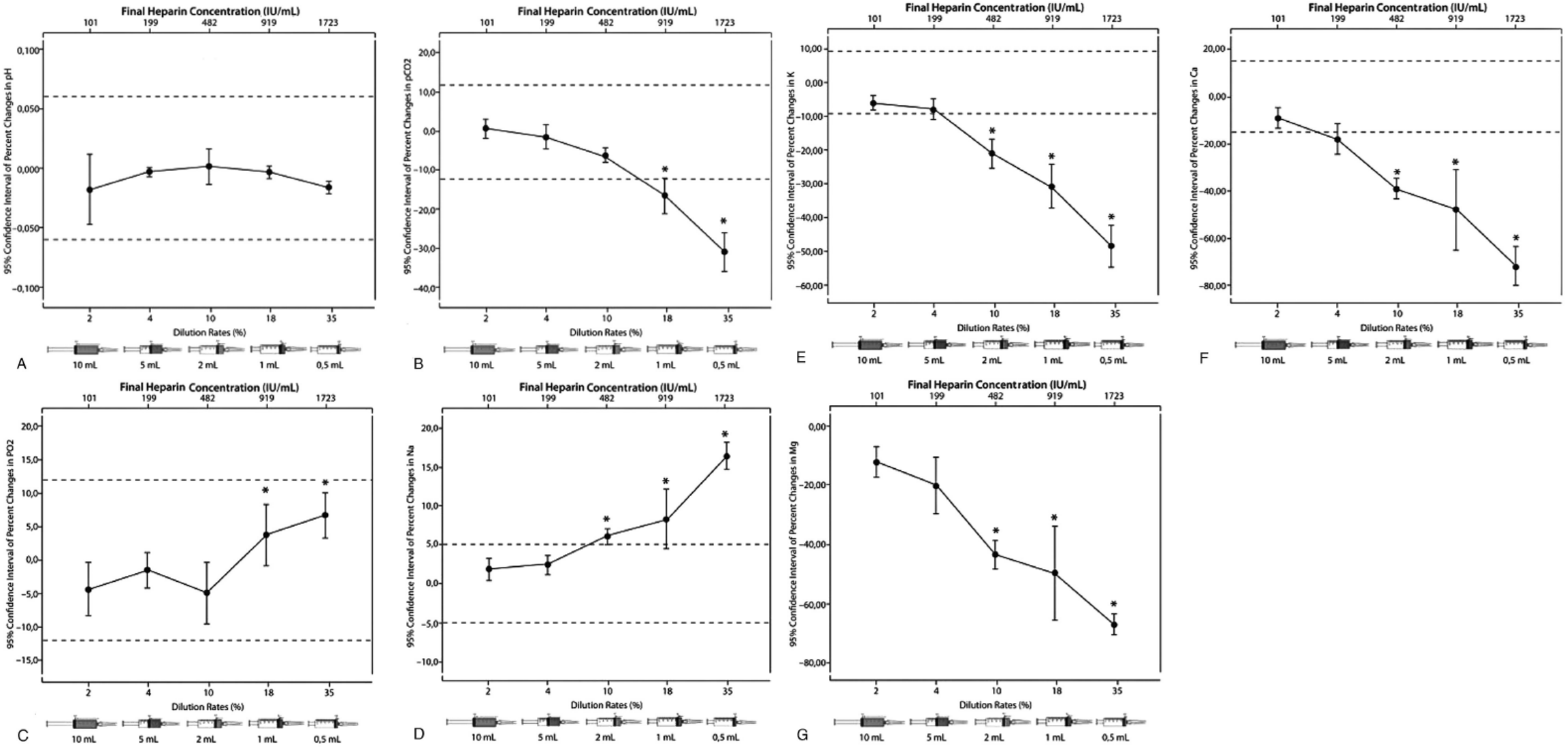
## Pitfalls & Best Practice

- CLSI C46-A2: **Lyophilized balanced lithium-heparin**
- Final concentration: **20 IU/mL blood**
- Excess heparin **alters pH, $pO_2$, $pCO_2$**

- ❌ Ordinary syringes flushed with liquid heparin → contamination & dilution errors
- ✅ Use pre-heparinized syringes with lyophilized balanced heparin

## Why Balanced & Lyophilized?

- **Balanced heparin:** prevents cation binding ($Ca^{2+}$, $Na^{+}$, $K^{+}$) → avoids electrolyte underestimation
- **Lyophilized heparin:** spray-dried coating, stable, prevents dilution
- **Liquid heparin:** risk of dilution if underfilled




pH changes (A), pCO2 changes (B), pO2 changes (C), Na+ changes (D), K+ changes (E), iCa+2 changes (F), iMg+2 changes (G)

Kume T. *et al*. DOI: 10.11613/BM.2012.022

# Transport Mode as a Preanalytical Factor in ABG Testing

- Study: 50 paired ABG samples (pneumatic tube vs human courier)
- **Strong agreement** for pH, $PaCO_2$, $HCO_3^-$, $O_2$ saturation
- **$PaO_2$ variability:** wide limits of agreement (–40.8 to +39.0 mmHg)
- Tendency:
  - $PaO_2$ < 160 mmHg → PTS gave **higher** values
  - $PaO_2$ > 160 mmHg → PTS gave **lower** values
- **Risk:** Clinically unacceptable errors in oxygen measurement
- **Recommendation:** Use courier transport when precise $PaO_2$ is critical

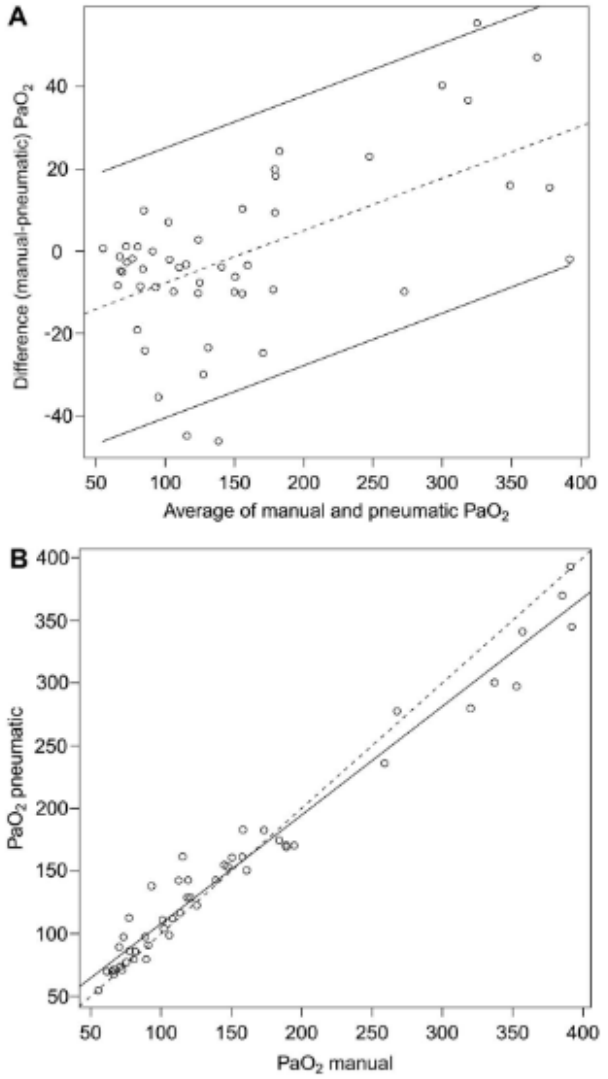



**Figure 3** Relationship between manual and pneumatic arterial blood gas samples analysed for oxygen (mm Hg).
(A) Regression based 95% LOA (solid lines) for the difference in $PaO_2$ levels vs. the average (dashed line) by manual and pneumatic transport systems (in mm Hg). (B) Concordance for pneumatic and manual arterial blood gas samples. Solid line shows the linear relationship with the dashed line indicating perfect concordance.

Peter V. J. *et al*. DOI: 10.1515/CCLM.2011.611

# Hemolysis: An Underestimated Preanalytical Risk

- Up to **4-12 % of arterial blood gas samples** are hemolyzed
- **Difficult to detect** in ABG samples → hidden risk
- Effects of hemolysis:
  - ↓ $pO_2$
  - ↑ $pCO_2$
  - False electrolyte changes (↑ $K^+$, altered $Ca^{2+}$)
- Occurs during:
  - Sampling
  - Transport
  - Storage

# Predicting Falsely Elevated POC Potassium from Hemolysis

## Detection of Falsely Elevated Point-of-Care Potassium Results Due to Hemolysis Using Predictive Analytics

*Robert C. Benirschke, PhD,*[1,2] *and Thomas J. Gniadek, MD, PhD*[1]

From the [1]Department of Pathology, NorthShore University HealthSystem, Evanston, IL; and [2]Department of Pathology, University of Chicago Pritzker School of Medicine, Chicago, IL.

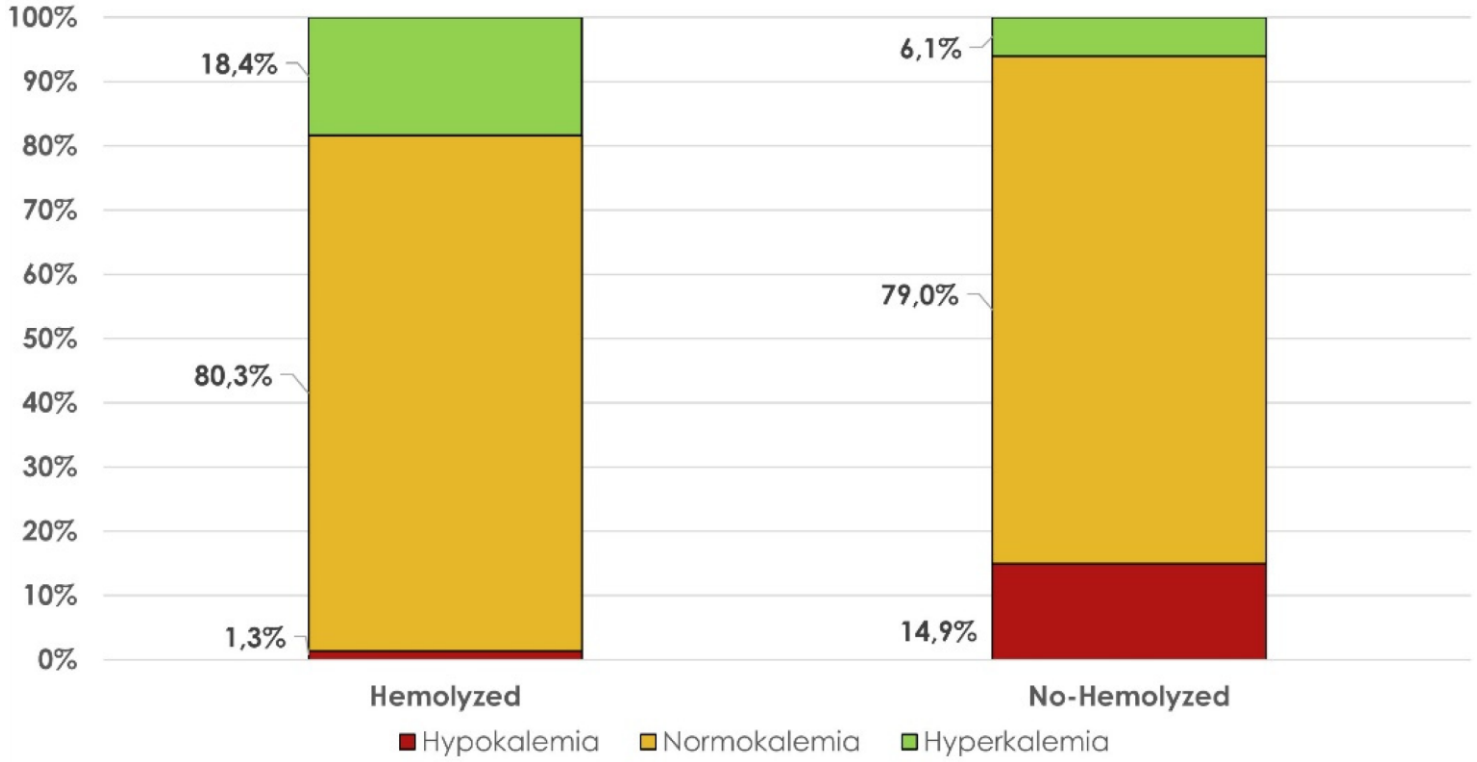
**Key Words:** Pseudohyperkalemia; Potassium; Machine learning; Logistic regression; Computational pathology; Clinical decision support

*Am J Clin Pathol* August 2020;154:242-247

DOI: 10.1093/AJCP/AQAA039

- Study compared point-of-care (POC) potassium results vs core laboratory values to identify false elevations due to hemolysis.
- Used a **machine learning model** (logistic regression) to predict when a high POC potassium value is likely spurious.

# Potassium Misinterpretation in Hemolyzed vs Non-Hemolyzed Arterial Samples




Distribution of hypo-, normo-, and hyperkalemia among hemolyzed and non-hemolyzed samples.

Nigro M. *et al*. DOI: **10.3390/medicina59010066**

# What Leads to Hemolysis?

- Vigorous sample mixing
- Sample turbulence (e.g. shaking, rough handling)
- **Pneumatic tube transport**
- Excessive aspiration force during sampling
- Improper cooling: ice cubes vs recommended **ice slurry**

# Capillary Blood Collection – Special Risk

- “Milking” finger/heel → causes hemolysis & tissue fluid contamination
- **Leads to false results** for multiple parameters
- **Best practice:** avoid milking, allow free blood flow
- Document and report any difficulties during sampling to aid correct interpretation

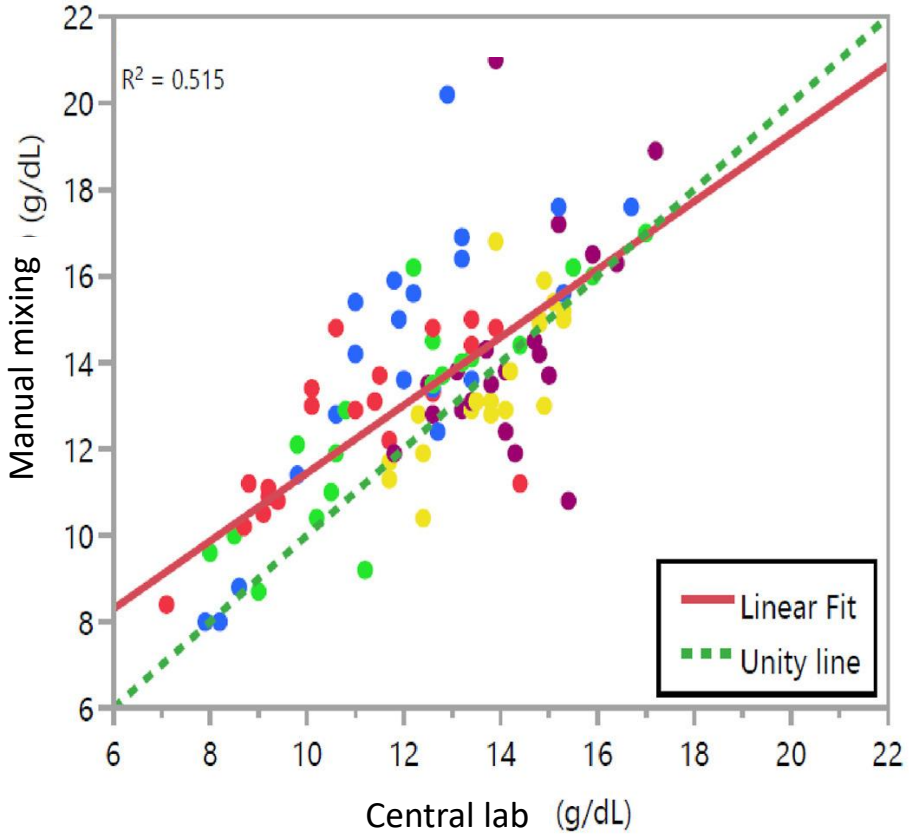
| Without milking | | Milking applied | |
|---|---|---|---|
| ELECTROLYTES | | ELECTROLYTES | |
| $Na^+$ | 140.1 | $Na^+$ | 137.1 |
| $K^+$ | 3.76 | $K^+$ | 4.12 |
| $Ca^{++}$ | 0.97 ↓ | $Ca^{++}$ | 0.70 ↓ |
| $Ca^{++}$ (7.4) | 0.99 | $Ca^{++}$ (7.4) | 0.71 |
| $Cl^-$ | 104 | $Cl^-$ | 101 |

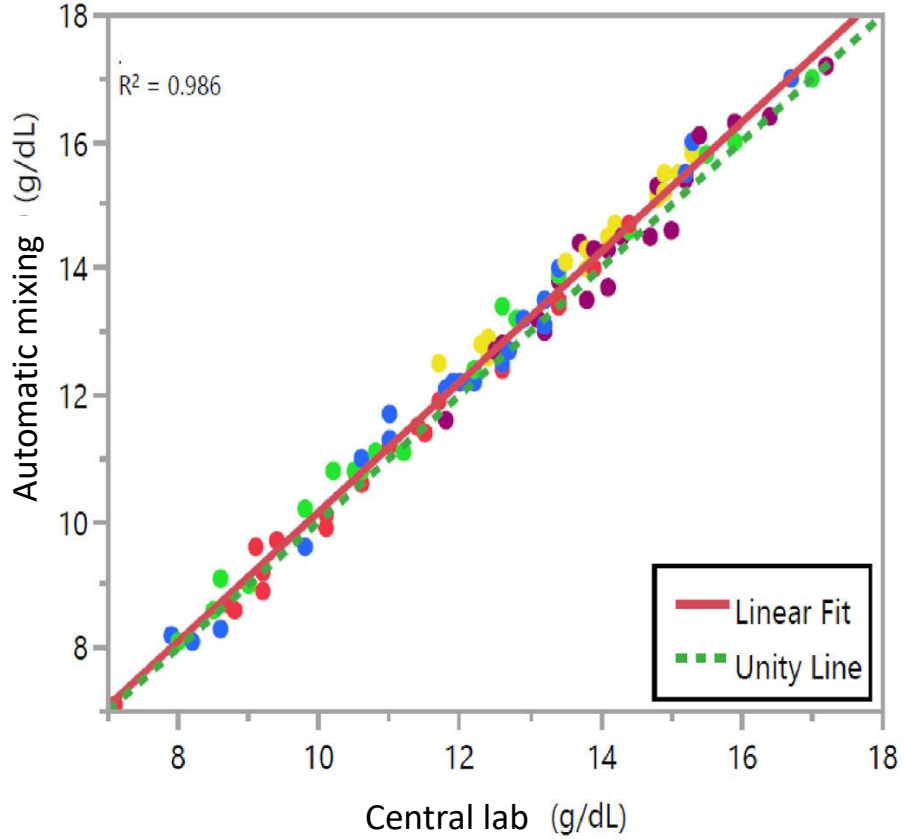
Tietz Textbook of Laboratory Medicine

# Proper Sample Mixing in Blood Gas Testing

- **Purpose of mixing:**
  - Prevent clot formation
  - Dissolve heparin
  - Ensure uniform suspension of cells
- **Best practices:**
  - Mix **immediately after sampling**, only after removing air bubbles
  - **Gentle mixing** → invert & roll syringe (manual)
  - Automatic mixing uses **metal ball + magnet**
- **Risks of improper mixing:**
  - Hemolysis if mixing is too vigorous
  - Clotting → analyzer malfunction
  - False ↑ potassium due to platelet release
- **Transport & delays:**
  - Always re-mix before analysis
  - < 1 min mixing if analyzed quickly
  - ≥ 2 min mixing if > 20–30 min delay

# Automatic vs Manual Mixing in ABG Samples – Effect on Hemoglobin Accuracy




Altawallbeh G. *et al.* DOI: 10.1016/j.plabm.2020.e00163

# Effects of Delay on ABG

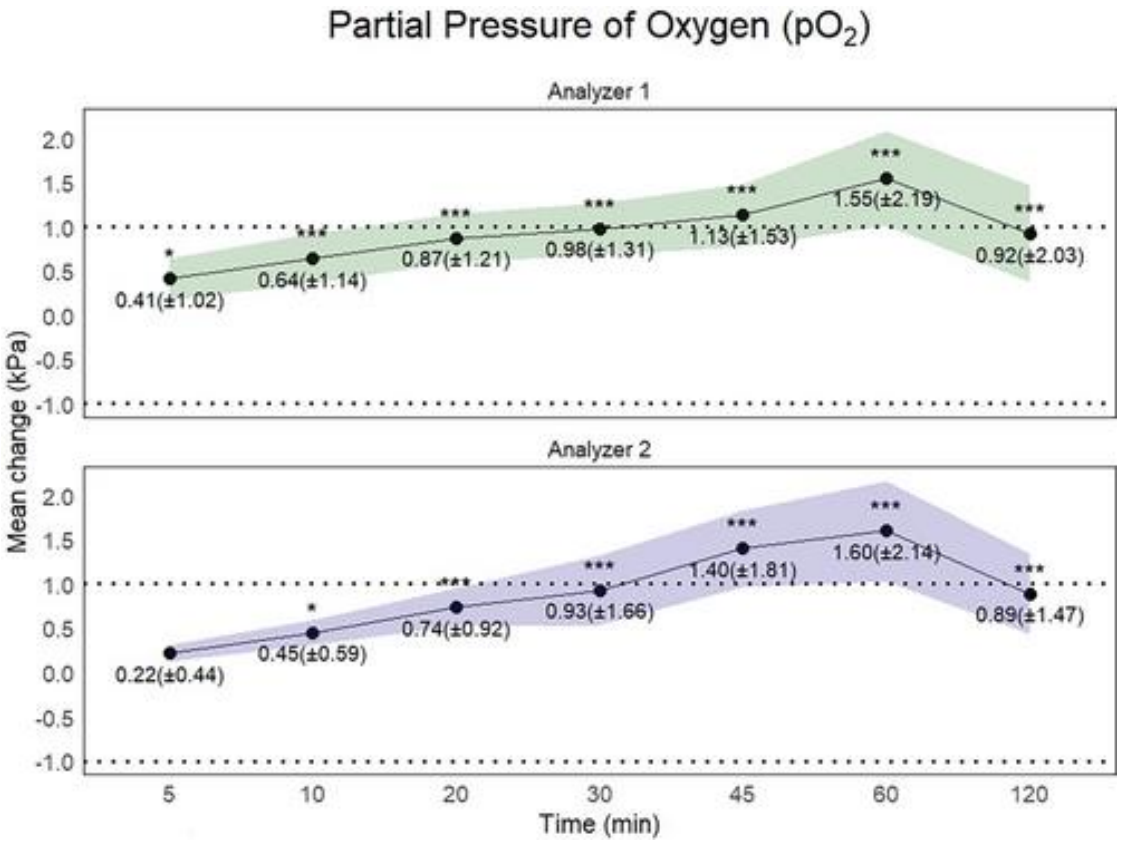
RESEARCH ARTICLE | Full Access

**Effects of Analysis Delay on pH, $pO_2$, $pCO_2$, Bicarbonate, Glucose, Lactate, Electrolytes, and Other Arterial Blood Gas Variables**

Eyrun Arna Kristinsdottir, Svajunas Statkevicius, Martin Ingi Sigurdsson, Fredrik Hansson, Marcus Ewert Broman

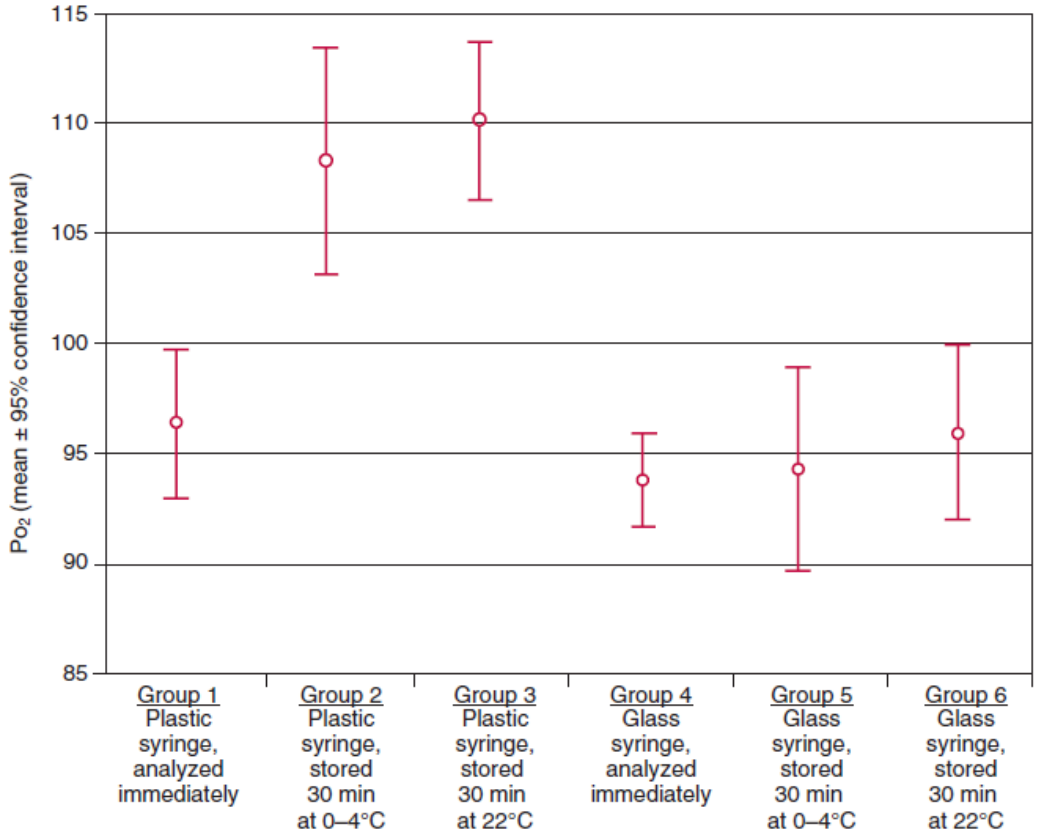
First published: 07 May 2025 | https://doi.org/10.1111/aas.70049

- Study with 80 patients, samples analyzed at multiple time points: 0, 5, 10, 20, 30, 45, 60, 120 min after collection.
- **Aim:** Determine when ABG variables deviate beyond clinically acceptable thresholds.
- **Key findings:**
  - Up to 30 minutes delay: no variable exceeded predefined clinically relevant change.
  - **At 45 minutes, $pO_2$ was the first variable** to exceed acceptable threshold.



# Effect of Plastic Syringes on ABG Transport & Storage

- **Transport Guidelines:**
  - Hand-deliver arterial samples, avoid vigorous movement
  - Analyze **as soon as possible** (≤30 min in plastic syringes)
  - Properly mix samples before analysis to avoid sedimentation
- **Plastic vs Glass Syringes:**
  - Plastic syringes → must be analyzed quickly
  - Should **not be cooled** (0–4 °C causes contraction, pores form → ↑ $O_2$ diffusion, $pO_2$ bias)
  - Glass syringes → preferred for delays >30 min; can be cooled on ice to slow metabolism
- **Key Deviation:**
  - Cooling plastic syringes mainly distorts **oxygen and $O_2$-related parameters**
  - $CO_2$ less affected (larger molecule, less diffusion through plastic)
- **Standard (CLSI C46-A2):**
  - Plastic syringe → room temp, ≤30 min to analysis
  - Glass syringe + ice → if >30 min transport expected




Knowles TP, *et al*. PMID: 16800906

# Summary & Take-Home Messages

- Preanalytical phase is critical in POCT
  - Covers all steps before analysis: patient preparation, sample collection, handling, mixing, transport, storage.
  - Errors here account for the largest share of inaccuracies in POCT results.
- Key factors highlighted
  - Anticoagulants & sample integrity (hemolysis, clotting, mixing).
  - Patient-related variables (temperature, perfusion, capillary vs venous sampling).
  - Transport & timing (plastic vs glass syringes, immediate analysis, avoiding delays).
  - Device-related aspects (manual vs automatic mixing, correction algorithms).
- Clinical impact
  - Even minor preanalytical errors can shift diagnosis categories (e.g., electrolyte imbalance, acid-base status).
  - May lead to inappropriate clinical decisions at the bedside.
- Final takeaway
  - Standardization and vigilance are essential for reliable POCT results.
  - Staff training and adherence to guidelines reduce risk of errors.
  - Research gap: Despite POCT being widely used, systematic studies on the preanalytical phase — both worldwide and especially in Lithuania — are still lacking.

Thank you for your attention!