Blood Gas Assays, GEM 7000

Purpose

This procedure provides instructions for performing Blood Gas Assays on GEM 7000 analyzers. The GEM Premier 7000 with iQM3 is a portable critical care system for use by health care professionals to rapidly analyze lithium heparinized whole blood samples at the point of health care delivery in a clinical setting and in a central laboratory.

The instrument provides quantitative measurements of pH, pCO2, pO2, sodium, potassium, chloride, ionized calcium, glucose, lactate, hematocrit, total bilirubin, and CO-Oximetry (tHb, O2Hb, COHb, MetHb, HHb, sO2) parameters from arterial, venous, or capillary lithium heparinized whole blood. These parameters, along with derived parameters, aid in the diagnosis of a patient's acid/base status, electrolyte and metabolite balance and oxygen delivery capacity.[1]

Policy Statements

This procedure applies to all personnel responsible for operating the GEM 7000 at Children's Minnesota Laboratory.

Principle

Electrochemical (EC) Card: The GEM Premier 7000 system makes use of potentiometric sensors to measure pCO2, pH, Na+, K+, Cl-, and Ca++. It uses amperometric sensors to measure pO2, glucose, and lactate concentrations. Blood conductivity is the method used to measure Hct.

Optical Card (COOX): CO-Oximetry and tBili measurements involve chemically lysing the whole blood sample and then utilizing a broad-spectrum spectrophotometer to evaluate the sample at a variety of wavelengths.

Hemolysis detection is performed simultaneous to the measurement process of patient samples, through the isolation of plasma and optical measurement of plasma free hemoglobin.[1]

Clinical Significance

Clinical management of respiratory and metabolic disorders often depends on rapid, accurate measurements of O2 and CO2 in blood. Vigorous measures to support life in patients with cardiopulmonary impairment depend largely on assisted ventilation using mixtures of gases that are tailored in response to laboratory blood gas results. Determination of blood gases also plays an important part in the detection of acid-base imbalances.[2]

Materials

- All material listed in procedure CH5.107 GEM 7000 General Operating Procedure
- Absorbent pads or gauze
- PPE

Special Safety Precautions

Follow all laboratory guidance and SOP related to handling patient whole blood samples. Consider all patient material as potentially infectious.

Sample

Sample volume, anticoagulant, and collection device: Samples may be collected in Lithium Heparin syringe or Lithium Heparin capillary tubes (65uL) depending on the test or panel ordered:

Measured Analytes	*Minimum Sample Volume (µL)*
pH, pCO2, pO2, Na+, K+, Cl-, Ca++, Glu, Lac, Hct, tHb, O2Hb, COHb, MetHb, HHb, sO2 or any combination of	150 uL minimum volume required for orders containing tests from both the EC and COOX cards.
tHb, O2Hb, COHb, MetHb, HHb, sO2	100 uL minimum volume required for orders containing tests from only the COOX card.
pH, pCO2, pO2, Na+, K+, Cl-, Ca++, Glu, Lac, Hct	65 uL (Capillary only) minimum volume required for orders containing tests from only the EC card.

NOTE: *Never run materials other than Lithium Heparinized whole blood, manufacturer designed quality materials, or proficiency testing materials through the analyzer. EDTA will damage sensors.*

Sample type and stability:

Analyte/Assay	*Sample Type*	*Stability Time*
pH	Arterial, Venous, Capillary	15m at RT
pCO2	Arterial, Venous, Capillary	15m at RT
pO2	Arterial, Venous	15m at RT
Na^+, K^+, Cl^-, Ca^{++}	Arterial, Venous, Capillary	2h at RT
Lactate	Arterial preferred, Venous accepted without use of tourniquet. Capillary accepted but strongly discouraged. Deliver on ice, append ICE comment for samples not on ice.	15m
tHb, O2Hb, COHb, MetHb, HHb, sO2	Arterial, Venous	15m at RT

Rejection Criteria: Unlabeled, clotted, exceed stability time, air bubbles, or wrong anticoagulant.

Preparation: Mix samples well by gentle vertical inversion, or by rolling >30 seconds or >20 rolls. For syringes, expel a small amount to check for clots prior to analysis. For capillary tubes, be sure to remove caps at both ends before sampling.

Test Codes

Assay/Parameter	*Type (Measured, Entered, Calculated)*	*SQ Test Codes*	*Additional Information*

Temperature	Entered	TEMP	
Specimen Type	Entered	ST, VST	
O2 Administered	Entered	O2AD	Fraction Inspired O2 (FIO2)
pH	Measured	PH, VPH, CBGPH	
pCO2	Measured	PCO2, VCO2, CPCO2	
pO2	Measured	PO2, VPO2	
O2 Saturation	Measured	O2S, VO2S	
Hemoglobin	Measured	HGB	
Carboxy Hemoglobin	Measured	COHB	
Methemoglobin	Measured	MHGB	
Sodium	Measured	NA, NAP	
Potassium	Measured	K, KP	
Chloride	Measured	CL	
Ionized Calcium	Measured	ICA, PICA	
Glucose	Measured	GLUC	
Lactate	Measured	LACT, LACTP	
Base Excess	Calculated	BE	
Bicarbonate	Calculated	HCO3	
Hematocrit	Calculated	HCT	
Total CO2	Calculated	TCO2	
Anion Gap	Calculated	AGAP	
Oxyhemoglobin	Measured	Not Reported	
Deoxyhemoglobin	Measured	Not Reported	

Panel	*SQ Test Code*	*Reported Parameters*
Arterial Blood Gas	ABG	ST, TEMP, O2AD, PH, CO2, PO2, BE, HCO3, O2S
Venous Blood Gas	VBG	ST, TEMP, O2AD, VPH, VCO2, VPO2, BE, HCO3, VO2S
Capillary Blood Gas	CBG	ST, TEMP, CGBPH, CPCO2, BE, HCO3
Electrolyte Panel	LYTE	NA, K, CL, TCO2, AGAP
OR ABG (OR use only)	ABGOR	ST, TEMP, O2AD, PH, CO2, PO2, BE, HCO3, O2S, LACT, ICA, GLUC, NA, K, CL, HGB, HCT
OR VBG (OR use only)	VBGOR	VST, TEMP, O2AD, VPH, VCO2, VPO2, BE, HCO3, VO2S, LACT, ICA, GLUC, NA, K, CL, HGB, HCT
Pump ABG	ABGP	ST, TEMP, O2AD, PH, CO2, PO2, BE, HCO3, O2S
Pump VBG	VBGP	ST, TEMP, O2AD, VPH, VCO2, VPO2, BE, HCO3, VO2S

Calibration

See CH 5.107 GEM 7000 General Operating Procedure for calibration and calibration verification information.

Quality Control

See CH 5.107 GEM 7000 General Operating Procedure for quality control information.

Sampling Procedure

See CH 5.107 GEM 7000 General Operating Procedure

Calculations

Assay/Parameter	*Associated Calculations*
Base Excess	Calculated within the analyzer. BE(B) = (1 - 0.014 x tHb) x [HCO_3^- - 24.8 + (1.43 x tHb + 7.7) x (pH - 7.4)]
Bicarbonate	Calculated within the analyzer. Standard Bicarbonate = 25 + 0.78 x BE(B) + 0.002 x tHb x (O2Hb - 100) mmol/L
Hematocrit	Calculated within the analyzer. Derived Hct is calculated from the measured tHb, and is determined by using the following equation: Hct(c) % = 3.0 x tHb Where: tHb = tHb measured for the current sample, in g/dL
Total CO2	Calculated within the analyzer. TCO2 = HCO_3^- + 0.0307 x pCO2
Anion Gap	Anion Gap (AGAP) will be calculated in SQ and within the analyzer for LYTE orders. AGAP = NA - (CL + TCO2)
Temperature Correction	The following equations are used to calculate the temperature corrected parameters pH, pCO2 and pO2 within the analyzer. pH(T) = pH + (T - 37) x [-0.0147 + 0.0065 x (7.4 – pH)] pCO2(T) = pCO2 x 10[0.019 x (T - 37)] pO2(T) = pO2 x 10 [K x (T – 37)] Where: T = Temperature entered by the operator for the sample

Interpretation and Resulting

For values exceeding the reportable range report as < Low reportable value or as > High reportable value, see Reference Intervals table (below).

For each assay, use reportable digits as expressed in the Reference Intervals table (below).

Hemolysis flags: the GEM 7000 hemolysis detection system will characterize each sample's hemolysis level. If hemolysis is detected, the instrument will flag the potassium result and note hemolysis as either mild, moderate, or gross hemolysis. For potassium results with mild or moderate hemolysis, append the comment Hemolysis Present (HP) to the result. The analyzer will not generate results for potassium if gross hemolysis is detected, in this case cancel the order and request a redraw.

Incalculable flags: For any parameter that generates an incalculable flag, use the code Unable to Calculate (UNCAL).

Suspected line contamination: If line contamination is suspected, cancel and credit the order, and request redraw. Use the code Questionable Results (QR) to credit the order.

Disabled tests: When the analyzer detects errors with sensors, the associated test(s) will be disabled. Use your best judgement regarding if the GEM PAK is still useful with disabled tests(s). Generally, tests such as pH, pO2, pCO2, or tHb being disabled will require replacement and credit. If the GEM PAK has few tests remaining or is near expiration and at lower use test such as electrolytes or glucose is disabled, you may continue to use the PAK until all tests are consumed. Consult CH 5.107 GEM 7000 General Operating Procedure for GEM PAK replacement and credit.

Reference Intervals

Assay	*Reference Interval*	*Critical Values*	*Reportable Range*
pH	Arterial: 7.35-7.45 Venous: 7.31-7.41 Capillary: 7.35-7.45	<7.20 or >7.60	7.00 - 7.92
pCO2 (mmHg)	Arterial: 35-48 (Male), 32-45 (Female) Venous: 40-52 Capillary: 35-48 (Male), 32-45 (Female)	<15 or >70	6 - 125
PO2 (mmHg)	Arterial: 80-105 Venous: 30-50	Arterial: <40	6 - 690
O2 Sat. (%)	Arterial: 95-99	None defined	0.7 - 100.0
Ionized Calcium (mEq/L)	0-7 days: 2.10-2.96 8 days-17 years: 2.40-2.76 >18 years: 2.32-2.64	<1.50	0.22 - 8.50
Carboxy Hgb (%)	0.0-1.5	None defined	0.3 - 75.0
Methemoglobin (%)	0.0-1.5	None defined	0.7 - 30.0
Glucose (mg/dL)	<1 d: 40-60 1 d- <1 yr: 50-80 1-18 yr: 60-100 >18 yr: 74-100	<50 or >300	4 - 685
Lactate (mg/dL)	5-20	>45	3 - 153
Sodium (mEq/L)	0-28 d: 133-146 29 d- <1 yr: 139-146 1-17 yr: 138-145 >17 yr: 136-145	<124 or >156	100 - 180
Potassium (mEq/L)	0-28 d: 3.7-5.9 29 d- <1 yr: 4.1-5.3 1-17 yr: 3.4-4.7 >17 yr: 3.4-5.1	<2.5 or >6.5	1.0 - 19.0
Chloride (mEq/L)	0-30 d: 98-113 >30 d: 98-107	None defined	40 - 158
Base Excess (mmol/L)	None defined	None defined	-20 - 20
HCO3 (mmol/L)	22-27	None defined	
Total CO2 (mEq/L)	0-14 d: 5-20 15 d- 1 yr: 10-24 1 yr- 4 yr: 14-24 5 yr- 14 yr: 17-26 15-18 yr: 18-28 (Male), 17-26 (Female)	<10 or >40	

	19 yr-59 yr: 22-29 >59 yr: 23-31		
Anion Gap	7-16	None defined	
Hemoglobin (g/dL)	0-7 d: 14.5-22.5 7-14 d: 13.5-19.5 15 d-1 m: 12.5-20.5 1 m-2 m: 10.0-18.0 2 m-3 m: 9.0-14.0 3 m-6 m: 9.5-13.5 6 m-2 yr: 10.5-13.5 2 yr-12 yr: 11.5-15.5 12 yr – 18 yr: 13.0-16.0 (Male), 12.0-16.0 (Female) >18 yr: 13.5-17.5 (Male), 12.0-16.0 (Female)	<7.0 HemOnc: <5.0	
Hematocrit (%)	0-7 d: 45-67 7-14 d: 42-66 15 d-1 m: 39-63 1 m-2 m: 31-55 2 m-3 m: 28-42 3 m-6 m: 29-41 6 m-2 yr: 33-49 2 yr-6 yr: 34-40 6 yr – 12 yr: 35-45 12 yr – 18 yr: 36-51 (Male), 33-51 (Female) >18 yr: 37-53 (Male), 33-51 (Female)	<21 or >65 HemOnc: None	

Limitations

See section 11.2 of the GEM Premier 7000 with iQM3 Operator's Manual for limitations and interferences.

See section 4.5.1 of the GEM Premier 7000 with IQM3 Operator's Manual for associated flags.

Hemolysis flags: the GEM 7000 hemolysis detection system will characterize each sample's hemolysis level. If hemolysis is detected, the instrument will flag the potassium result and note hemolysis as either mild, moderate, or gross hemolysis. For potassium results with mild or moderate hemolysis, append the comment Hemolysis Present (HP) to the result. The analyzer will not generate results for potassium if gross hemolysis is detected, in this case cancel the order and request a redraw.

Incalculable flags: For any parameter that generates an incalculable flag, cancel using the code Unable to Calculate (UNCAL).

Disabled tests: When the analyzer detects errors with sensors, the associated test(s) will be disabled. Use your best judgement regarding if the GEM PAK is still useful with disabled test(s). Generally, tests such as pH, pO2, pCO2, or tHb being disabled will require replacement and credit. If the GEM PAK has few tests remaining or is near expiration and a lower use test such as electrolytes or glucose is disabled, you may continue to use the PAK until remaining tests have been consumed. Always call the service

hotline and consult CH 5.107 GEM 7000 General Operating Procedure for GEM PAK replacement and credit.

Method Performance Specifications

See section 11.1 of the GEM Premier 7000 with iQM3 Operator's Manual for method performance characteristics.

References

1. GEM Premier 7000 with IQM3 Operator's Manual, PN 00000026407 Rev. 00 Aug 2023
2. Tietz Textbook of Clinical Chemistry and Molecular Diagnostics. 6th Ed. Edited by Carl A. Burtis, David E. Bruns, Nader Rifai. St. Lous, MO: Elsevier; 2022

Appendices

None

Training Plan/Competency Assessment

Use CH 1.20.T1 GEM 7000 Training for initial employee training. StaffReady will be used to perform Competency Assessments after initial training on the GEM 7000 instrumentation.

Historical Record

Version	Author	Effective Date	Summary
1	Matt Johnson	10/24/2025	Initial Version