The 13th EFLM Continuous Postgraduate Course in Clinical Chemistry and Laboratory Medicine
New Trends in Diagnosis and Monitoring using POC Instruments
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POCT Blood Gases

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Agenda

- **What is “Blood gases” ?**
- **Why the POCT Blood gases ?**
- **Some clinical cases**
- **POCT Blood gases: the future**
- **Conclusion**

What is “Blood gases” ?

Arterial blood gases

Definition.

ABG's is a collective term applied to three separate measurements

pH, PCO_2, PO_2 generally made together to evaluate acid-base status,

ventilation, and arterial oxygenation.

Some calculated or derived variables may be reported with the ABG's .

The bicarbonate concentration, which can be calculated from

the pH and PCO_2 , is the most useful of these

E.P. Trulock

What is ABG's

With the arrival of more recent ABG's analyzers and the evolution of the concept of point of care testing (POCT), what we meant for BG analysis has been redefined and extended also to meet the needs of critical care e and emergency medicine

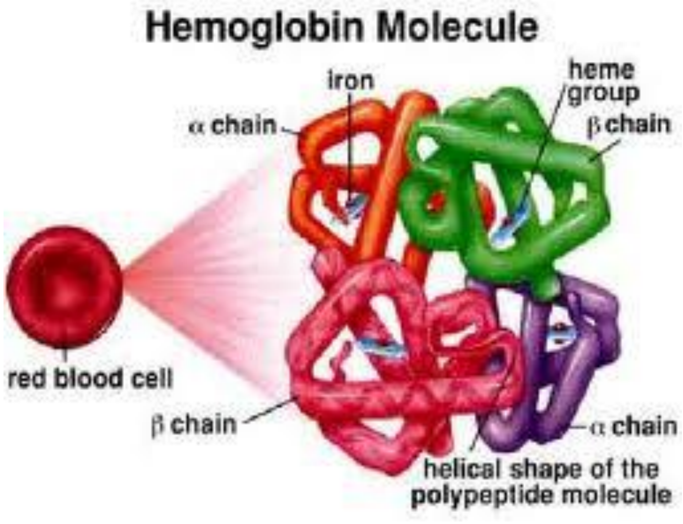
What is ABG's

In particular, alongside the traditional parameters measured the cations (sodium, potassium, calcium and chlorine) and lactate were added.

This allowed us to address more detailed issues related to the acid-base disorders and that those related to electrolyte disorders

What is ABG's

In the field of oxygenation same measured parameters have been introduced such as hemoglobin and his fractions (FO_2Hb, FHHb, FCOHb, FMetHb) and saturation of hemoglobin with oxygen (SaO_2)



BG analysis: parameters

pH

pCO_2 mmHg

HCO_3 mmol/L

ABE mmol/L

Lattato mmol/L

Na^+ mEq/L

K^+ mEq/L

Ca^{++} mEq/L

Cl^- mEq/L

A G mEq/L

Hb g/dl

Ht %

PO_2 mmHg

sO_2 %

FO_2Hb %

FCOHb %

FHHb %

FMetHb %

P50 mmHg

ct O_2

How can we understand the importance of ABG's in clinical practice ?

The four most important equations in clinical practice

Four equations are necessary for both understanding and interpreting arterial blood gases

These equations are clinically useful (particularly in the acute and critical patients) not so much for the number they generate, as for their qualitative relationship.

Adapded from L.Martin

The four most important equations in clinical practice

The PCO_2 equation

$$PaCO_2 = \frac{VCO_2 \times 0.863}{VA}$$

Ventilation

The four most important equations in clinical practice

Alveolar gas equation

$$PAO_2 = FiO_2\,(P_B - 47) - 1.2\,(PaCO_2)$$

↓

$$\Delta O_2\,(A\text{-}a)$$

Pulmonary shunt

The four most important equations in clinical practice

The Kassirer – Bleich equation

$$[\,H^+] = k \times \frac{PaCO_2}{[\,HCO_3]}$$

Acid - base balance

The four most important equations in clinical practice

Oxygen content equation

$$CaO_2 = (SaO_2 \times Hb \times 1.34) + 0.003\ (PaO_2)$$

Oxygenation

Why POCT Blood gases ?

Is it useful in the management of the patients?

When to take the BG analysis ?

Indications for arterial blood gas analysis

Patients arriving to the ED with symptoms or signs such as:

Dyspnea

Chest pain

Altered state of consciousness

Poor tissue perfusion

Acute hemorrhage

Intoxication

Hypovolemia or dehydration

When to take the BG analysis ?

Indication for arterial blood gas analysis

Pathological conditions such as:

Sepsis

Acute renal failure

Deep venous thrombosis or pulmonary embolism

Transient loss of consciousness

Pneumonia

Acute cardiac failure

Diabetic ketoacidosis

Acute abdominal pain

(intestinal ischemia or infarction)

Which Diagnostics ?

Acid-base and electrolyte disorders

pH PCO$_2$ HCO3

Na K Cl

Lactate

Which diagnostics ?

Oxygenation disorders

PaO_2 HbCO MetHb

Acute anemia (particularly in the trauma setting)

Hb or Ht determination (CBC)

Acid-base and electrolyte disorders

The standard turnaround time for acute care laboratory testing in tertiary care institution **is typically less than 15 minutes for blood gas or electrolyte values**.

From a clinical perspective, however, the desirable turnaround time is more on **the order of 5 minutes**, and this is technically achievable.

To achieve a turnaround time of 5 minutes, is **necessary** to move the “laboratory” closer to the patient and to have more than one instrument available

Cox CJ. Clin Lab Med 2001;21:321-35

POCT in trauma management

Value of point-of-care blood testing in emergent trauma management

Conclusion: Na, CL,K and blood urea nitrogen levels do not influence the initial management of major trauma patients. In patients with severe blunt injury, **hemoglobin, glucose, blood gas and lactate measurements** occasionally result in morbidity-reducing or resource-conserving management changes

Asimos AW et al. J Trauma 2000;48:1101-8

Why POCT Blood gases?

- **Does it reduce the turnaround time (TAT) ?**
- **Does it reduce the therapeutic turnaround time (T-TAT) ?**
- **Does it reduce the length of stay (LOS) in the ER ?**

Why POCT Blood gases?

- **Significant decrease in time to medical decision making but no change in ED LOS**

  Kendall J et al. Br Med J 1998.

- **Decrease in T-TAT but no data on patient LOS in the ED**

  Kilgore M et al. Clin Chem 1998.

- **Significant decrease in TAT, a decrease in patient LOS in the ED. Physicians were satisfied with TAT and test accuracy**

  Lee-Lewandrowsky E et al. Arch Pathol Lab Med 2003

Some clinical cases

Case 1

72 year old female

History

Hypertension, type 2 diabetes, previous stroke

Medication : Acetylsalicylic acid 100 mg /die, metformin1 g/die, amlodipine 10 mg

Found in a coma by the firefighters in a room (kitchen) smoke-filled.

Examination

- GCS 3
- BP 150/90 mmHg, HR 79 /min, T 36,8°C

SO_2 100 %, IOT

Case 1

- **ABG**

pH = 7,37
PaO_2 = 567 mmHg
$PaCO_2$ = 28, 5 mmHg
HCO_3 = 16,3 mEq/l
CO = 20,7 %

- **Electrolyte**

Na^+ = 138 mEq/l
Cl^- = 108 mEq/l
K^+ = 3,8 mEq/l

Lactic acid 10,6 mmol/L, creatinine 1,2 mg/dL, glycemia 200 mg/dL

Anion gap: Na^+ - (Cl^- + HCO_3) = 13,7 (n.v. 8-16)

Case 1

FO_2HB	74,3	%
FHHB	4	%
FCOHB	20,7	%
FMETHB	2	%

Lactic acid 10.6 mmol/L

Case 1

Therapy

- Cianokit 5g (Hydroxocobalamin)

Hydroxocobalamin chelates cyanid to form cyanocobalamin

- Hyperbaric oxigen

HCN 1690 ng/dL

CASE 2

	Patient 1	Patient 2	Patient 3
	F, 61 yo	F, 35 yo	F, 28 yo
	Sorbitol breath test because of food intolerance		
After a few minutes	Vomiting and circulatory shock	Seizure and circulatory shock	CPA
	Trasferred to ER	Trasferreed to ER	ALS on site
	Severe cyanosis, A F	Severe cyanosis, AF	Dead
	MetHB 71%	**MetHb 71.9%**	
	Methylene blu 2 mg/Kg GI decontamination	Methylene blu 2 mg/Kg GI decontamination	
After 30 min	MetHb 4%	MetHb 2,7%	
	Amiodarone	AF spontaneous rsolution	
On 45th day	Asthenia	Irritability	

CASO 1

donna muore dopo test di intolleranza, è caccia al sorbitolo assassino

Sorbitolo. Balduzzi: "Nessun allarme sanitario. Ma non utilizzate quello acquistato su internet"

Donna morta , non era sorbitolo ma nitrito di sodio

LA TRAGEDIA

stroncata dal nitrito di sodio

L'autopsia: ingerito in grande quantità

La sostanza era in concentrazione altissima (il 70%)

CASO 1

ACIDO-BASE 37.0 °C		
pH	7.368	
pCO_2	43.8	mmHg
pO_2	195.9↑	mmHg
HCO_3^-act	24.7	mmol/L
HCO_3^-std	23.9	mmol/L
BE(B)	-0.8	mmol/L
BE(ecf)	-0.6	mmol/L
$ctCO_2$	26.0	mmol/L

CO-OSSIMETRIA		
Hct	44	%
tHb	14.8	g/dL
sO_2	98.9	%
FO_2Hb	27.8↓	%
FCOHb	0.0↓	%
FMetHb	71.9↑	%
FHHb	0.3	%

OSSIGENAZIONE 37.0 °C		
BO_2	5.8	mL/dL
pO_2/F_IO_2	5.60	mmHg/%
$ctO_2(a)$	6.3	mL/dL

Case 3

A 74 years- old woman suffering from Alzheimer's disease, in therapy with Donezepil and Escitalopram, comes to the emergency room for diarrhea and vomiting after accidental ingestion of a sip of sparkle lamp's liquid.

The patient had altered mental status (drowsiness) but vital signs were normal.

Sparkle lamp or glitter lamps are design objects very popular in the 70's that have recently been replicated by interior decorators

The ingestion of the lamp liquid contents may cause different toxic effects.

The acute clinical manifestations varies according to the specific liquid composition

BG analysis

	Time 0 (4 h from ingestion)	Time 1 (24 h later)
Ph	7.35	7.47
pO_2 mmHg	74.1	65.5
pCO_2 mmHg	33.9	30.0
Lactate mmol/l	2.6	1.8
HCO^{3-} mmol/l	18.4	22.4
BE mmol/l	-6.1	-0.8

	Time 0 (4 h from ingestion)	Time 1 (24 h later)
Hb g/dl	16.1	12.9
WBC/mcl	26.240	18.180
PLT/mcl	370.000	254.000
Na^+ mEq/l	142	138
K^+ mEq/l	4.2	3.7
Cl^- mEq/l	**142**	107
Ca^{++} mEq/l	**4.45**	2.62
Calcium mg/dl	**18.1**	10.8
Cr mg/dl	0.79	1.23

Hypercloremic metabolic acidosis ($CaCl_2$) and respiratory alkalosis

POCT: The future

POCT Interpretation

Diagnosis and management of acid-base disorders ranks high among the medical problems that intimidate many physicians. In practice, acid-base disorders can be approached very systematically as they can be easily diagnosed when certain rules are applied

Ghosh AK. JAPI 2006;54;720-724

POCT Interpretation

Since 2003 we have developed a software for the interpretation and for the differential diagnosis of acid-base disorders.

POCT Interpretation

The software is able to differentiate:

Seven single acid-base disorders:

- Respiratory alkalosis — acute, chronic
- Respiratory acidosis — acute, chronic
- Metabolic alkalosis
- Metabolic acidosis — high anion gap, hyperchloremic

POCT Interpretation

Ten mixed double acid-base disorders:

ADDITIVE COMBINATIONS

- Respiratory alkalosis + Metabolic alkalosis
- Respiratory acidosis + AG metabolic acidosis
- Respiratory acidosis + AG metabolic acidosis
- Mixed AG and hyperchloremic

COUNTERBALANCED COMBINATIONS

- Respiratory alkalosis + Hyperchloremic metabolic acidosis
- Respiratory alkalosis + AG metabolic acidosis
- Metabolic alkalosis + Hyperchloremic metabolic acidosis
- Metabolic alkalosis + AG metabolic acidosis
- Respiratory acidosis + Metabolic alkalosis

DOUBLE RESPIRATORY DISORDERS

- Acute respiratory acidosis superimposed on chronic respiratory acidosis

POCT Interpretation

Four mixed triple acid-base disorders:

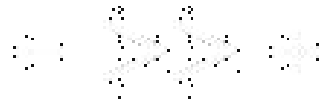
- AG metabolic acidosis + Metabolic alkalosis + Respiratory acidosis
- AG metabolic acidosis + Metabolic alkalosis + Respiratory alkalosis
- Mixed AG and hyperchloremic + respiratory acidosis
- Mixed AG and hyperchloremic + respiratory alkalosis

Software accuracy

The software is able to interpret correctly 95%

of acid – base disorders.

HUMAN ALBUMIN



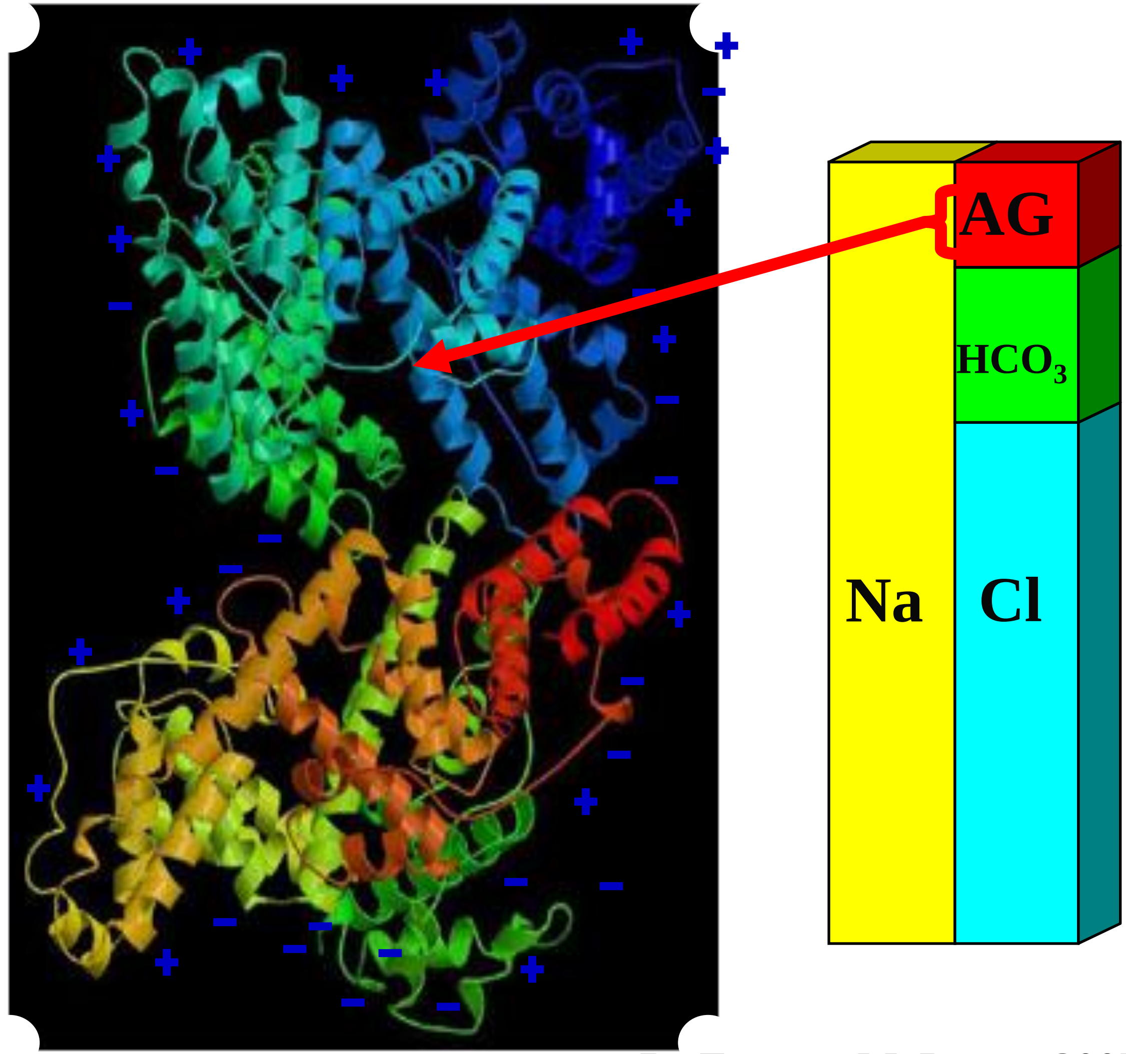
Net Na-Albumin

At pH = 7.4
about net 22 negative charges

MW = 66,500 mg/mm
1 gm% = 0.154 mm/l
= 3.3 mEq/l

For each 1 gm% fall in
albumin the AG falls
About 2.5 mEq/l

AG adjusted =
AG + 2.5 (4.5-observed Alb)



By Emmett M. Parma 2007

POCT interpretation

For the routine use of the computerized interpretation:

- The computer for interpretation acid-base disorders and the reporting system should be located in the machine (POCT)
- The laboratory instrumentation (POCT) should assay the serum albumin
- The insertion of clinical data could change this system to an expert one

Conclusions

Conclusions

POCT Blood gases is **essential** in the management of very acute patients or patient with life threatening symptoms .

POCT with POCI could be appreciated by many physicians and nurses, because of difficulties in the interpretation of acid-base disorders also in view of patient safety