

***New i-Phone and i-Pad Acid-base Data Interpretation
Apps in Clinical Assessment of Critically Ill Patients:***

Is that a Problem or a Step into the Future?

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RADIOMETER®

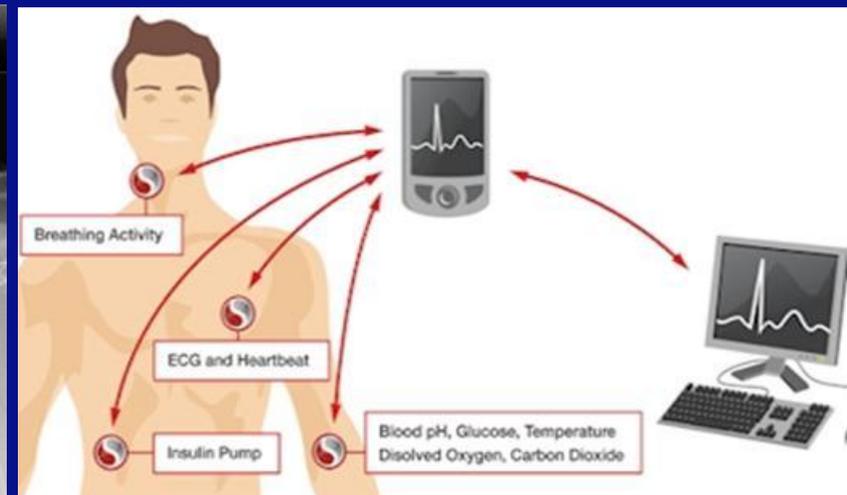
More than eighty percent of doctors now use smartphones and tablets and different clinical Apps at work



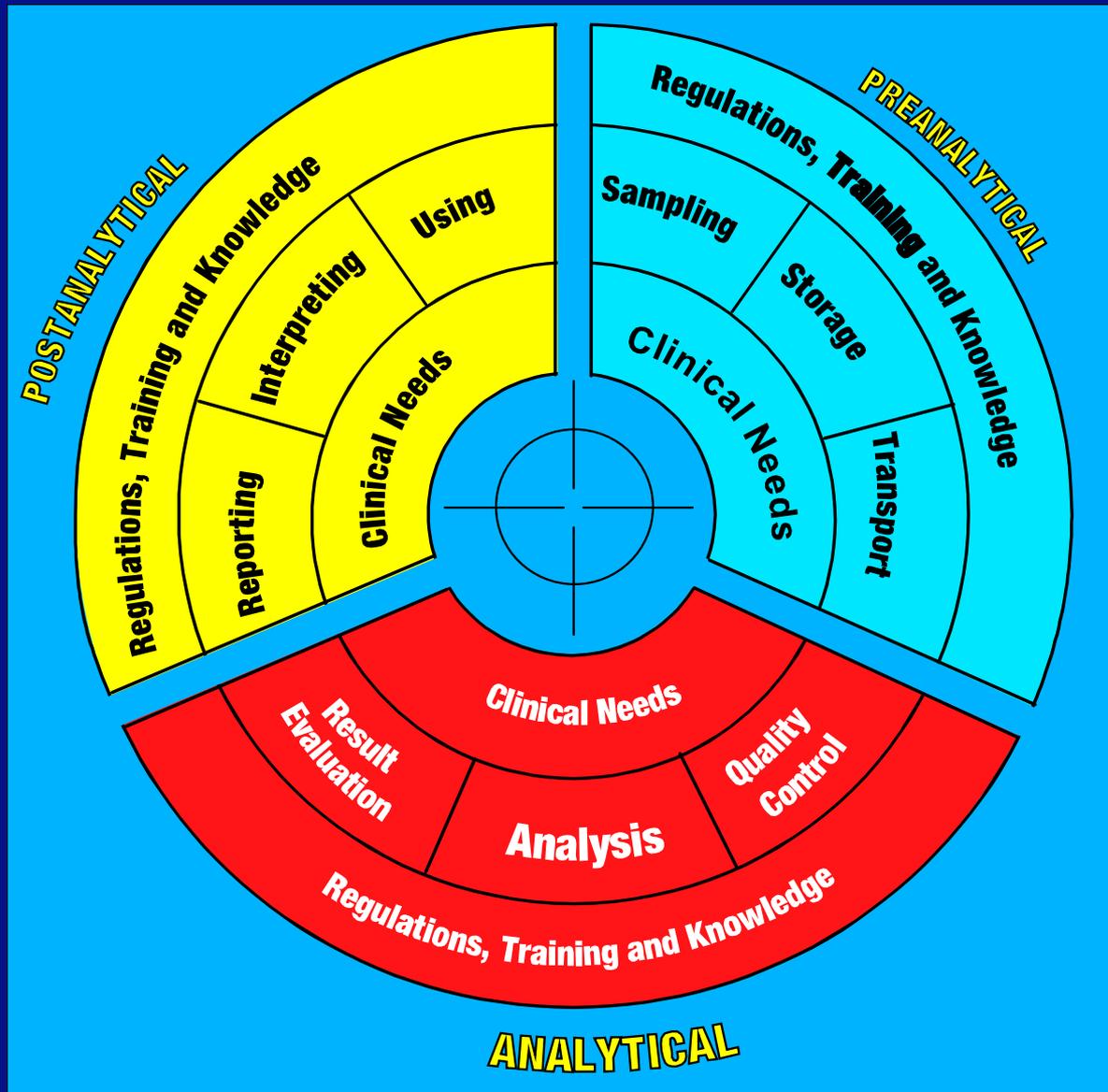
AirStrip Technologies

MIM Software™

Different Mobile Applications



Characteristics of Analytical ABG – Arterial Blood Gases



Interpretation of Acid-base Disorders in ICU

1. In a clinical survey 1982 conducted at a university teaching hospital, 70% of the participating physicians claimed that they were well versed in the diagnosis of acid-base disorders and that they needed no assistance in the interpretation of arterial blood gases (ABGs).

These same physicians were then given a series of ABG measurements to interpret, and they correctly interpreted only approx. 40% of the test samples.

Hingston DM. A computerized interpretation of arterial pH and blood gas data: do physicians need it? Respir Care 1982;27:809-815

2. A clinical survey at another teaching hospital 1984 revealed that incorrect acid-base interpretations led to errors in patient management in one-third (33%) of the ABG samples analyzed.

Broughton JO, Kennedy TC. Interpretation of arterial blood gases by computer. Chest 1984;85:148-149.

3. Another clinical survey 1998 reveals the same serious deficiencies and difficulties interpreting ABGs, correctly, as earlier.

Vergara F. Evaluating the Accuracy of and Time Spent in Analysis of Acid-Base Reports by Three Methods: Is a Computer-Aided Method Best? Proc. AMIA Symp. 1998, 1092

Conclusion:

The impact of this ABG-interpreting inadequacy may cause trouble in the ICU, where 9 of every 10 patients may have an acid-base disorder.

Is Clinical Acid-base Interpretation Still a Problem?

In a study in Australia from 2010 29% of ABGs were incorrectly interpreted by EM doctors.

Austin K et al. Accuracy of interpretation of arterial blood gases by emergency medicine doctors. Emergency Medicine Australasia 2010;22:159-165

31% were incorrectly interpreted by critical care nurses in a study 2011 from Utah, USA. However, using graphical tools improved the result to approx. only 17% incorrectly interpreted.

Doig AK et al. Graphical Arterial Blood Gas Visualization Tool Supports Rapid and Accurate Data Interpretation. Computers Informatics Nursing 2011;29:204-211

Acid-Base-Disorders

Henderson-Hasselbalch

$$\text{pH} = \text{pK}_1 + \log \frac{c\text{HCO}_3^-}{a \times p\text{CO}_2}$$

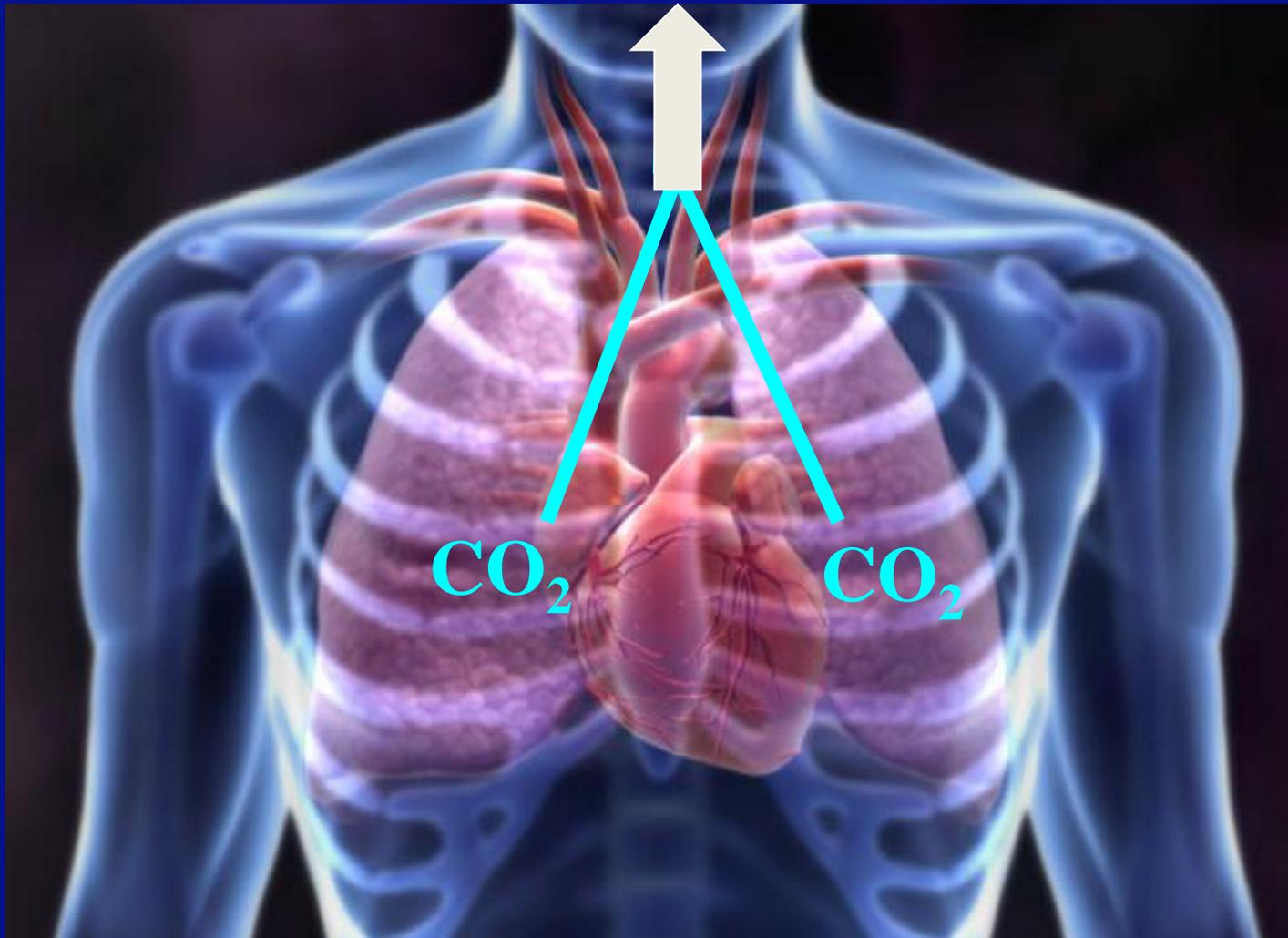
Kidney regulation (24-48 hours)

Lung regulation (10-15 minutes)

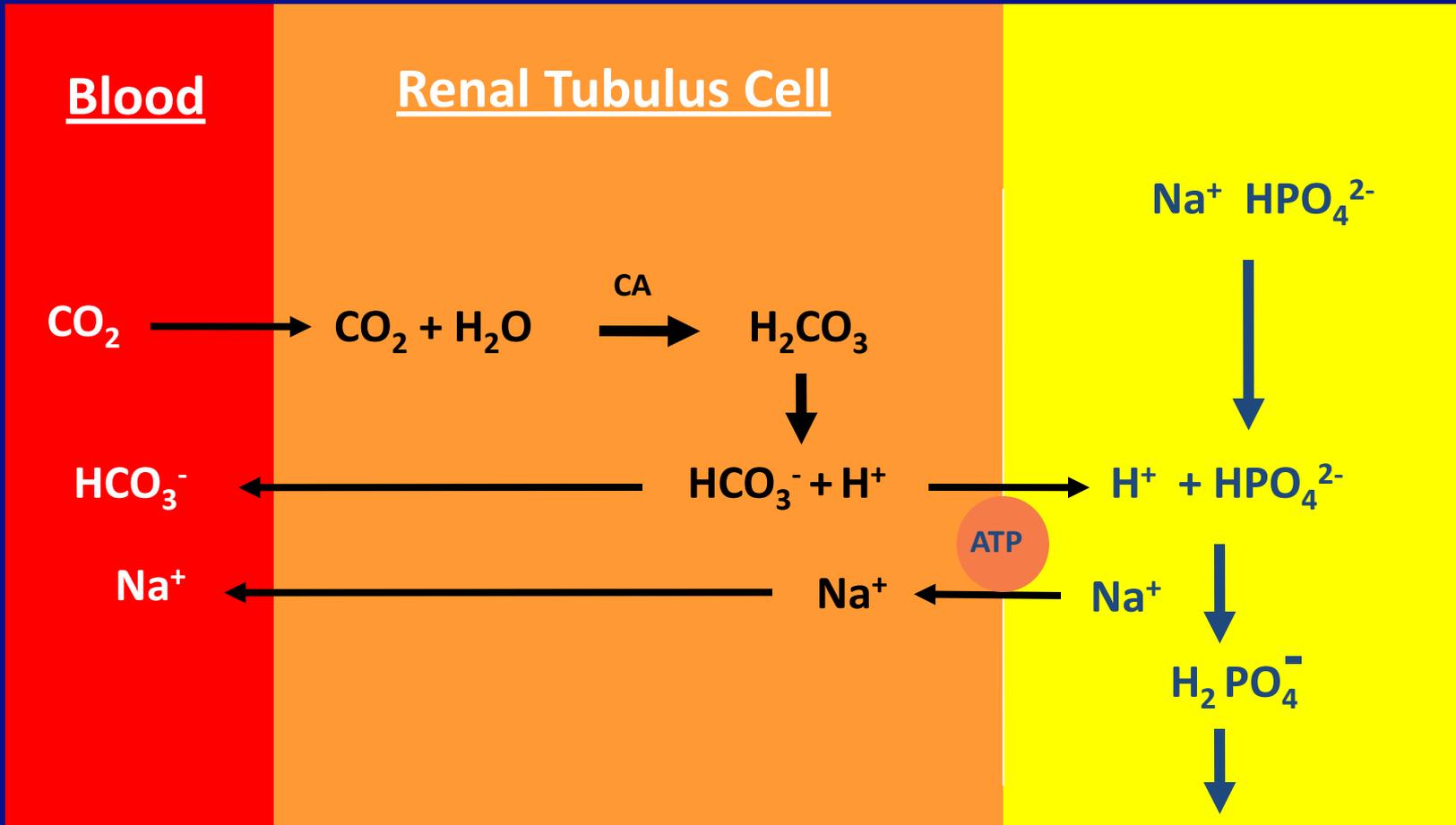
$$\text{pK}_1 = 6,12$$

$$a = 0,0307 \text{ mmol} \times \text{L}^{-1} \times \text{mmHg}^{-1}$$

Lung-Regulation - CO₂ Excretion

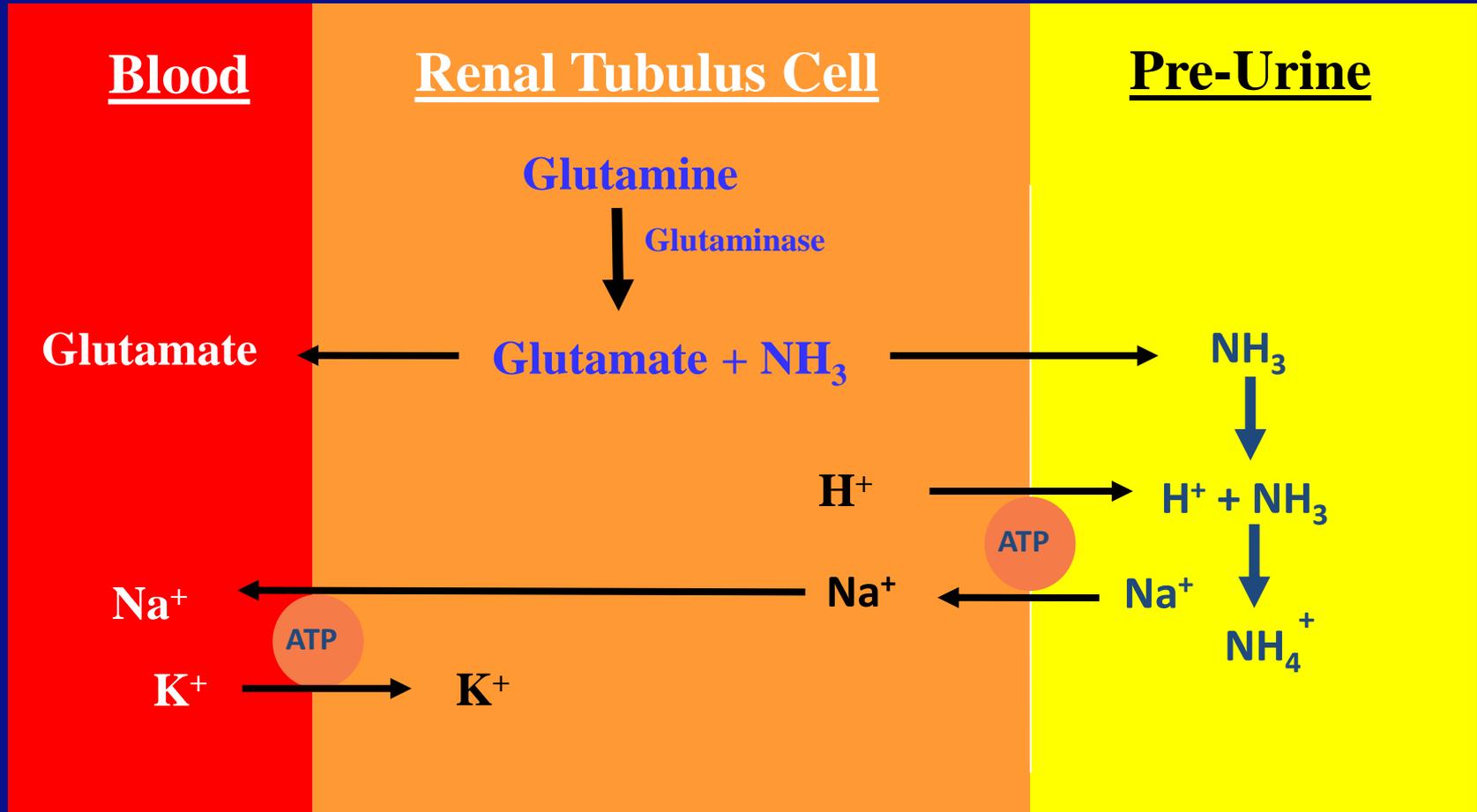


Kidney Hydrogen Ion Excretion Bicarbonate Reabsorption



Dihydrogen phosphate in urine max. 70 mmol H^+ /day

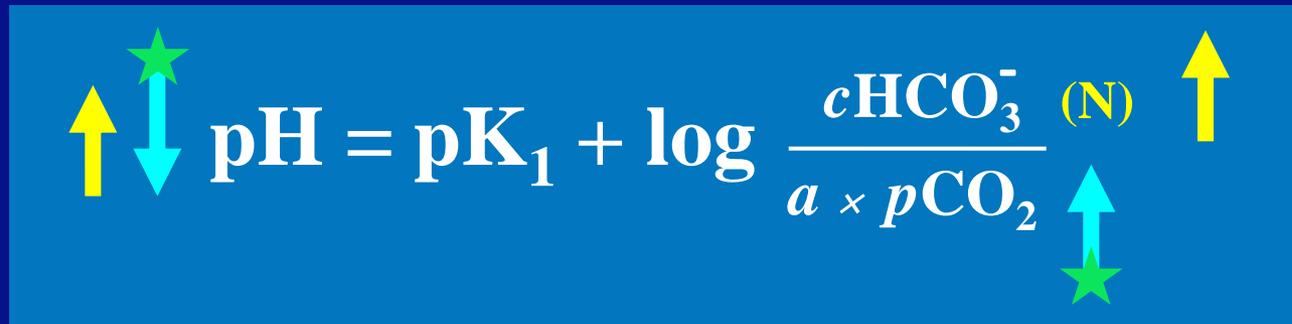
Kidney Hydrogen Ion Excretion



Ammonium in urine max.
400 mmol H⁺/day

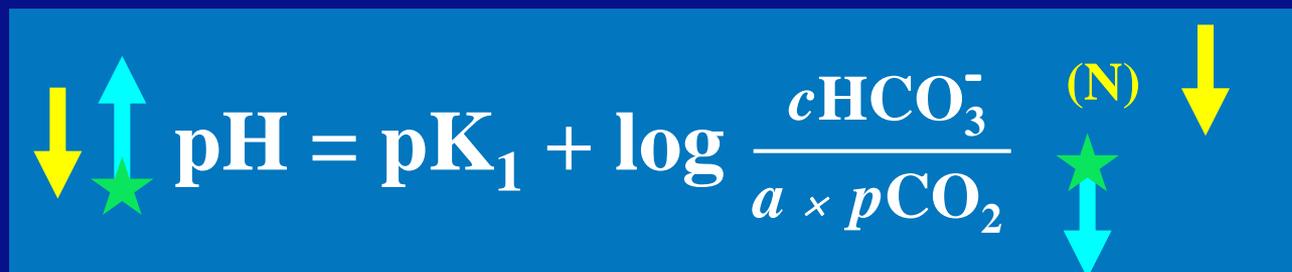
Physiologic Compensation of Respiratory Acidosis and Alkalosis

Clinical ex. of respiratory acidosis: Airway obstruction, overdose of morphine



Compensation Kidney: Reabsorption of $c\text{HCO}_3^-$

Clinical ex. of respiratory alkalosis : Fever, hyperventilation



Compensation Kidney: Excretion of $c\text{HCO}_3^-$

Physiologic Compensation of Metabolic Acidosis and Alkalosis

Clinical ex. of metabolic acidosis: Acute kidney failure, diabetes coma



Compensation Lungs: Hyperventilation

Clinical ex. of metabolic alkalosis: Vomiting, therapy with loop diuretics



Compensation Lungs: Hypoventilation

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ABL90 PATIENT REPORT -R- Default Copy Preview

Identifications

Patient ID 999
 Patient last name Last name
 Patient first name First name
 Sample type Arterial
 T 37.0 °C

Blood gas values

pH 7.400 [-]
 pCO₂ 41.5 mmHg [-]
 pO₂ 95.5 mmHg [-]

Electrolyte values

cK⁺ 4.3 mmol/L [-]
 cNa⁺ 141 mmol/L [-]
 cCa²⁺ 1.22 mmol/L [-]
 cCl⁻ 102 mmol/L [-]

Temperature-corrected values

pH(T) 7.400
 pCO₂(T) 41.5 mmHg

Acid-base status

cBase(B)_C 0.8 mmol/L
 cBase(Ecf)_C 0.9 mmol/L
 cHCO₃⁻(P)_C 25.7 mmol/L
 cHCO₃⁻(P,st)_C 25.1 mmol/L

Calculated values

Anion Gap_C 13.3 mmol/L
 AnionGap.K⁺_C 17.6 mmol/L
 ctCO₂(B)_C 50.4 Vol%
 ctCO₂(P)_C 60.4 Vol%

Notes

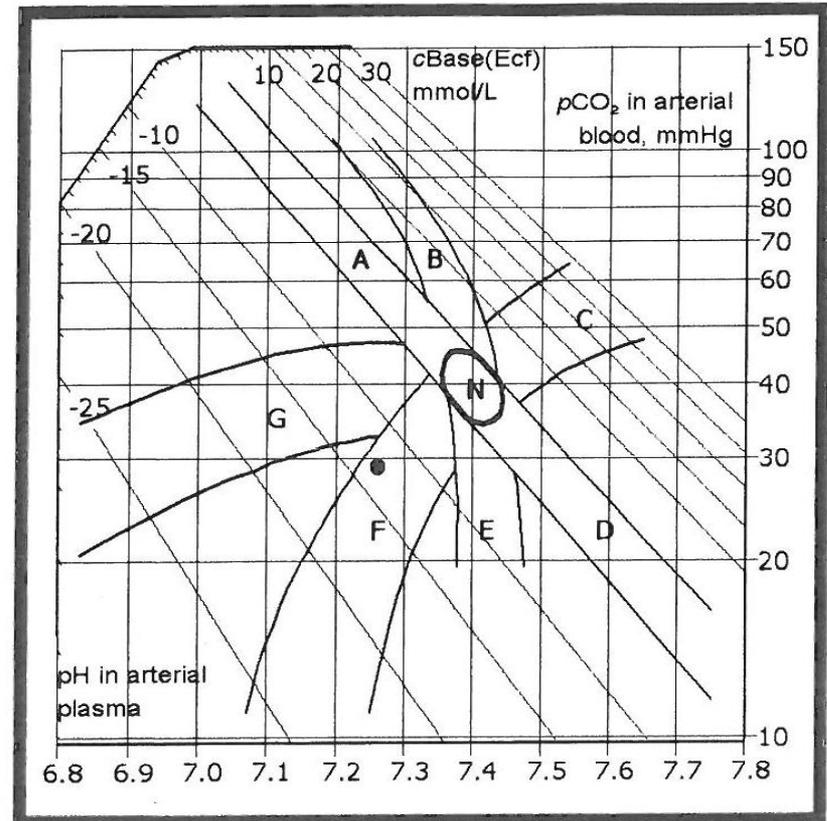
c Calculated value(s)

RADIOMETER ABL90 SERIES

ABL90 PATIENT REPORT Syringe - S 65uL 03:28 PM 7/27/2012
 Sample # 5

Acid-Base Chart

Patient ID:



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- | | |
|-------------------------------|------------------------------|
| A acute hypercapnia | E chronic hypocapnia |
| B chronic hypercapnia | F chronic metabolic acidosis |
| C chronic metabolic alkalosis | G acute metabolic acidosis |
| D acute hypocapnia | N normal area |

How does the new mobile technology gadgets represented by different Apps fit into the picture of supporting intensive doctors and nurses in interpreting ABG?

ABG Stat App



Icon

\$1.99

Category: Medical

Updated: Jan 24, 2012

Version: 1.6

Size: 2.5 MB

Languages: English, Spanish

Seller: Shane Garst

© 2012 Impact RN, Guaranteed to Increase your score on the NCLEX and CCRN.

Requirements: Compatible with iPhone, iPod touch, and iPad. Requires iOS 4.0 or later.

Description

All ABG calculations accurate according to the American Association of Critical-Care Nurses “Blood Gas Analysis”

ABG STAT is an aid for interpretation of ABGs, Anion Gap, A-a Gradient, Oxygen Content, along with detailed notes on possible causes and potential corrections.

Features

- Easy to use

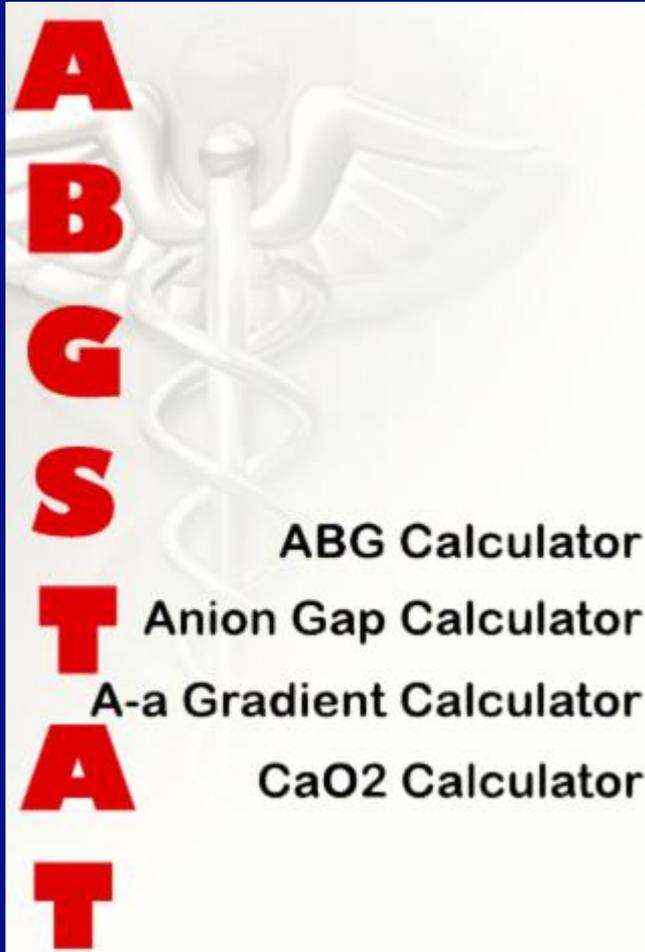
- Fast, accurate input using slot roller

- Detailed views listing possible causes of the acid-base disorder

iPhone/iPad Screenshots



ABG Stat App



ABG Acid-Base Eval Support



Icon

- Free
- Category: Medical
- Updated: May 25, 2011
- Size: 0.3 MB
- Language: English
- Seller: Joshua D. steinberg
- © 2011 Joshua Steinberg MD and Laleh Jafarian

Requirements: Compatible with iPhone, iPod touch, and iPad. Requires iOS 3.1.2 or later

Description

ABG Acid-Base eval walks a clinician through a stepwise approach to analyse ABG's and electrolytes in order to arrive at acid-base disorders and diagnostic ideas about ill patients.

Features

The app addresses such common questions as:

- What are common causes of metabolic acidosis?
- How do I calculate predicted $p\text{CO}_2$?
- What is the primary acid-base disorder?
- Are additional acid-base disorders present, and if so, what are they?

This app is written and intended for practicing clinicians like internists, family physicians, ER docs, cardiologists, pulmonologists, intensivists, and for resident physician trainees.

iPhone/iPad Screenshots



ABG Acid-Base Eval Support

Step 1

Gather Data. Enter blood test values, preferably from simultaneous blood draw(s)

reset to normals

pH	pCO2	Na+	HCO3-	Cl-
7.17	34	147	13	97
7.18	35	148	14	98
7.19	36	149	15	99
7.20	37	150	16	100
7.21	38	151	17	101

go to Step 2

ABG eval Read This! About References

Step 3 Step 4

Look for respiratory compensation
Compare actual vs. predicted pCO2.

$$\text{Pred pCO}_2 = (1.5 \times \text{HCO}_3^-) + 8$$
$$30 = 1.5 \times 15 + 8$$

calculate clear Actual pCO2: 36

If actual pCO2 within +/-2 of predicted, then there is proper resp compensation; if actual pCO2 too low, then there is additional resp alkalosis; if actual pCO2 too high, then additional resp acidosis.

Actual pCO2 is... rationale

too high additional resp acidosis

too low additional resp alkalosis

appropriate proper, no disorder

ABG eval Read This! About References

Acid Plus - The ABG Calculator



Icon

Homepage: [Free Radical Software, LLC](#)

Rating: (74)

Version: 2.5

Size: 0.5 MB

Price: \$3.99

Requirements:

Compatible with iPhone, iPod touch, and iPad. Requires iPhone OS 2.2.1 or later.

Description:

Designed, programmed, and used by two internal medicine docs, Acid Plus is an essential tool for healthcare professionals who need quick, powerful, and easy-to-interpret acid-base results from ABGs and metabolic panels.

Audience:

Ideal for MDs, PAs, RNs, RTs, EMTs, and med students, everything you need for acid-base calculations is put right in the palm of your hand. No more ABG cards or guesswork.

With an intuitive design and easy-to-read display, Acid Plus makes it a breeze to answer even the most complex acid-base problems in seconds. Just turn the device to landscape view to get a colorful graph with an arrow highlighting the disorder.

iPhone/iPad Screenshots

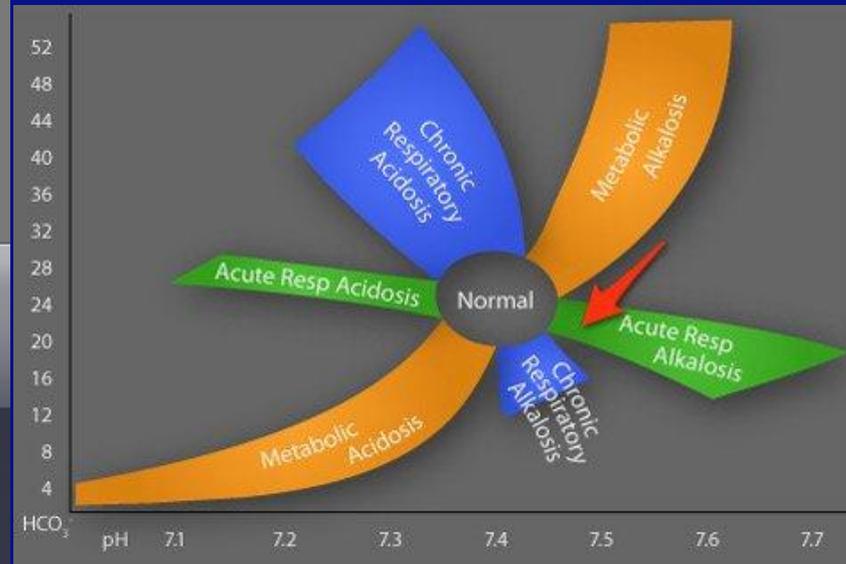


Acid Plus - The ABG Calculator

1° Anion Gap Metabolic Acidosis, which is partially compensated
 Anion Gap = 15 Delta Delta = 0.3
 Base Excess = -8

2° Concomitant Non-Gap Metabolic Acidosis

pH	pCO ₂	Na ⁺	Cl ⁻	HCO ₃ ⁻
7.28	32	138	106	15
7.29	33	139	107	16
7.30	34	140	108	17
7.31	35	141	109	18
7.32	36	142	110	19



More Info

Metabolic Acidosis

Anion Gap and Delta-Delta

- Anion Gap = $[Na] - ([Cl] + [HCO_3])$
- The anion gap (AG), or difference of cations minus anions, is made up of unmeasured anions, typically serum proteins and sulfates.
- If the gap increases, this suggests the presence of other unmeasured anions such as organic acids or toxins (see "MUDPILES" below)
- A normal AG ranges from 12 to 20 based on the instruments used to measure serum ions (check with your institution's lab)
- The delta-delta (Δ/Δ), or delta ratio, is the ratio of the increase in anion gap to the decrease in bicarbonate.

Mobile Medical Applications

DRAFT GUIDANCE

This guidance document is being distributed for comment purposes only.

Document issued on: July 21, 2011

Definition of a Mobile Platform

For purposes of this guidance, “mobile platforms” are defined as commercial off-the-shelf (COTS) computing platforms, with or without wireless connectivity, that are handheld in nature. Examples of these mobile platforms include mobile computers such as the iPhone®, BlackBerry® phones, Android® phones, tablet computers, or other computers that are typically used as smart phones or personal digital assistants (PDAs).

Definition of a Mobile Medical Application (Mobile Medical App)

For purposes of this guidance, a “mobile medical app” is a mobile app that meets the definition of “device” in section 201(h) of the Federal Food, Drug, and Cosmetic Act (FD&C Act); and either:

- is used as an accessory to a regulated medical device; or
- transforms a mobile platform into a regulated medical device.

Mobile Medical Apps for which FDA will apply Regulatory Oversight

Mobile apps may take a number of forms, but it is important to note that the FDA will apply its regulatory oversight to only the subset of mobile medical apps as expressed in this guidance.

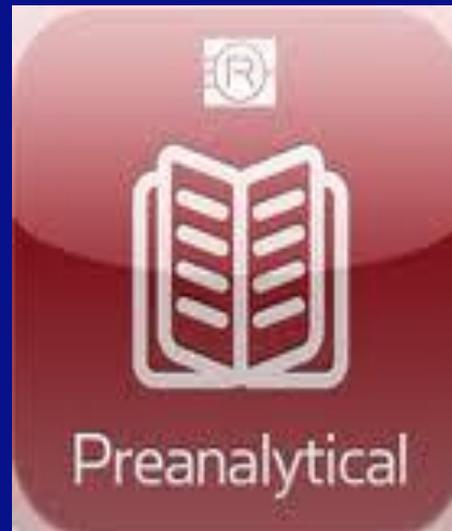
The following examples represent mobile apps FDA considers mobile medical apps and that will be subject to its regulatory oversight:

- Mobile apps that are an extension of one or more medical device(s) by connecting to such device(s) for purposes of controlling the device(s) or displaying, storing, analyzing, or transmitting patient-specific medical device data.
- Mobile apps that allow the user to input patient-specific information and - using formulae or processing algorithms - output a patient-specific result, diagnosis, or treatment recommendation to be used in clinical practice or to assist in making clinical decisions.

Mobile Medical Apps for which FDA will not Seek Regulatory Oversight

This FDA guidance is limited only to mobile medical apps. The following examples represent mobile apps that FDA does not consider to be mobile medical apps for purposes of this guidance:

Mobile apps that are electronic “copies” of medical textbooks, teaching aids or reference materials, or are solely used to provide clinicians with training or reinforce training previously received. These types of apps do not contain any patient-specific information, but could show examples for a specific medical specialty. Examples of such medical text books include the electronic Physician’s Desk Reference and similar reference materials.



Summary and Conclusion Regarding ABG-interpreting Apps

Possibilities and Benefits

- Potential to transform healthcare in both the developing and the developed world
- Mobiles are personal and available at the point of care where POCT data are needed
- Mobiles are permanently carried by most doctors or nurses
- Mobiles or tablets are always on (WIFI)
- Mobiles offers an extended possibility for supporting interpreting analytical transmitted data at the point of care, correctly.

Problems and Issues to be Solved

- How about security issues regarding sensitive patient data
- Issues regarding correct transmission of data and secure passwords for receiving the data
- Adequate documentation regarding the support of interpreting the data and possible limitations in interpreting guidance
- How will FDA secure design control and post-marked surveillance of ABG-interpreting Apps already on the market which at present ought to be classified as accessories to medical devices (blood gas analyzers)