

Wrap up

and few Friday night cases

František Duška



Stewart's Textbook of Acid-Base

What is the role of bicarbonate (HCO_3^-) in acid-base balance? The answer is easy: none! If pH or $[\text{H}^+]$ is what we want to understand, the less said about $[\text{HCO}_3^-]$ the better.

What then determines pH or $[\text{H}^+]$ in body fluids? Understanding acid-base balance means having clear answers to this question, and the quantitative analysis in this book supplies them. They are astonishingly simple!

Over four decades ago, Peter A Stewart published his classic work on the quantitative approach to acid-base. Treasured by many, despised by some, this approach has now become the method of choice for those that truly want to understand the subject.

This is the fully revised third edition of the famous textbook, frequently referred to as the black bible of acid-base. Of course, this edition still contains Stewart's original writings in unabridged form. However, this is complemented by over 20 additional chapters written by an international team of world-renown clinicians and researchers in the field.

Edited by Paul WG Elbers, František Duška and John A Kellum, these discuss recent developments in acid-base medicine and physiology using the same clear and concise style as the original book. In particular, there is extensive focus on practical clinical application of the Stewart approach to acid-base in virtually every branch of medicine.

Key Features:

- Easy to read: simplifies acid-base medicine for better understanding
- Classic text: includes Stewart's "How to Understand Acid-Base"
- Updated content: covers the latest in quantitative acid-base medicine
- Clinical focus: highlights practical use in various specialties
- Clear visuals: includes many figures and tables to clarify key points

Recommended for:

everyone that seeks to understand, apply or practice acid-base medicine and physiology. This includes consultants, fellows and residents in critical care medicine, anesthesiology, internal medicine, emergency medicine and surgery; physicians in other branches of medicine; physiologists; veterinarians; bioscientists; and medical students.

Please visit acidbase.org
for additional copies, extras and updates



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Stewart's Textbook of Acid-Base - 3rd edition

Elbers • Duška • Kellum

Edited by
Paul WG Elbers
František Duška
John A Kellum

Stewart's textbook of Acid-Base

fully revised 3rd edition



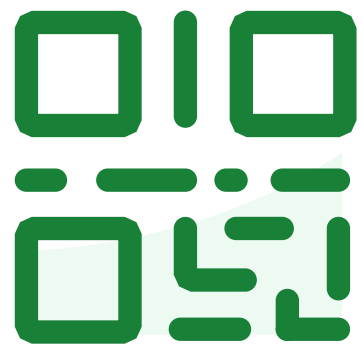
Chapter 29

Example cases

František Duška

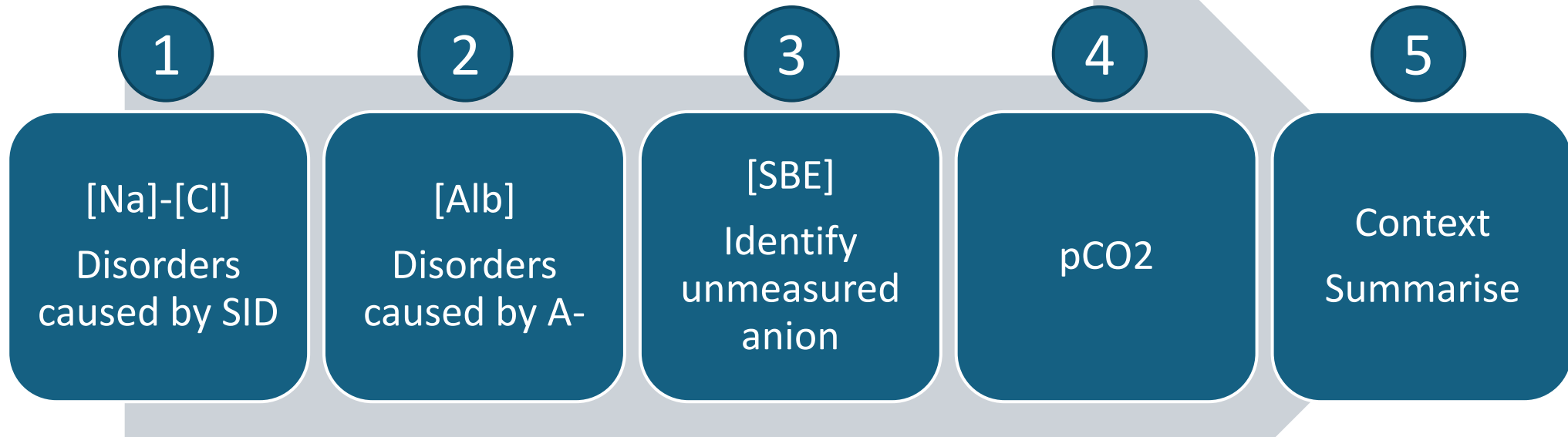
29.1 Introduction

Reading a blood gas printout is a daily routine for acute care clinicians, and in most cases, it is interpreted instantly through pattern recognition. However, some cases are more complex and require a deeper, more structured analysis. In this chapter, we will demonstrate the practical use of the simplified electroneutrality-based approach described in the previous chapter for solving complex acid-base cases. The approach, nicknamed "Stewart light" by Niels van Regenmortel, combines Stewartian physical-chemical principles [1] with the pathophysiological foundations laid by the pioneers of the classical approach [2], the empirical "Boston rules" [3] for detecting superimposed



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Stewart light approach



Compare Na-Cl
with 34 mM

(apply correction
to 34 if pH is
extreme: +1.5 for
pH < 7.35, -0.1)

Add 3mM to
predicted SBE for
each 10g/L below
40 g/L

Compare SBE
on BG strip
with SBE
predicted.
Look at lactate

Use „Bostron
rules“, eg.
Winters formula



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Case 1: The “black bible” case

Presentation

Man, 34 years old, known history of alcohol abuse, presented with three days of inability to walk and vomiting. He was confused, tachycardic, and had a blood alcohol level of 0 g/L. Author's own case.

pH	7.432	Na ⁺	132 mmol/L	Hb	7.45 mmol/L (12 g/dL)
PCO ₂	4.81 kPa (36.1 mmHg)	K ⁺	4.6 mmol/L	Glucose	8.0 mmol/L (144 mg/dL)
HCO ₃ ⁻	24.0 mmol/L	Cl ⁻	70 mmol/L	Lactate	20 mmol/L
SBE	-0.3 mmol/L			Albumin	22 g/L

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- STEP 1: Calculate Na-Cl, compare with 35 , predict SBE based on this (lower = acidosis)
- STEP 2: Look at Albumin, predict SBE based on this (3 mM for each 10g/L below 40)
- STEP 3: Compare predicted SBE from step 1 and 2 and compare with SBE on blood gas.
Difference = lactate + unmeasured ions
- STEP 4: Assess pCO₂
- STEP 5: Summarise

Write down all disorders you have identified



What acid base disorders are present?

Stewart light dissection

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- Na-Cl = 62 (should be 35) = this predicts BE +27
- Alb = 20g/L = this predicts BE + 6
- I expect BE +33, but it is 0, that means there are 33 mM of negative charge unaccounted for
 - 20 is explained by lactate
 - 13 remains unaccounted for = another GOLDMARK anion

Stewart light dissection

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- BE +27 High SIDa (“hypochloridemic”) alkalosis
- BE + 6 Hypoalbuminemic acidosis
- BE - 20 lactic acidosis
- BE -13 another ion acidosis (Ethylenglycol metabolites? Ketones?)

Case 2: Acid base at osmolarity disorders

Presentation

Man, 42 years old with known schizophrenia, was found at home unconscious, intubated at scene. Author's own case. On site, paramedics measured blood glucose of 3.7 mM (67 mg/dL) and administered an intravenous bolus of 40% glucose.

pH	7.170	Na ⁺	106 mmol/L	Hb	-
PCO ₂	5.34 kPa (40.1 mmHg)	K ⁺	2.3 mmol/L	Glucose	11.5 mmol/L (202)
HCO ₃ ⁻	15.8 mmol/L	Cl ⁻	68 mmol/L	Lactate	1.0 mmol/L
SBE	-10.0 mmol/L			Albumin	40.6 g/L

Q1: Is there any SID disorder (e.g. hypochloremic alkalosis or hyperchloridemic acidosis)?



Is there any SID disorder?

Explanation

- Correct answer: No SID disorder is present
- $\text{Na-Cl} = 106 - 68 = 38$
 - In normal pH, this would compare with 35, meaning SBE +3
 - BUT with acidosis, Na-Cl normally widens by 1.5 mM for each 0.1 pH drop below 7.4 (this is due to Hamburgers effect/intracellular buffering)
 - Therefore, in our patient with pH 7.15, Na-Cl should be $35 + 3 = 38$, exactly as measured. No SID disorder is present.
- Take home message: For SID diagnostic at extremes of pH, apply pH correction of Na-Cl reference of 35

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Q2: Assess pCO₂.



What respiratory disorder is present?

Explanation

- Correct answer: Respiratory acidosis
- Explanation:
 - Although $p\text{CO}_2$ is in normal range, during metabolic acidosis, $p\text{CO}_2$ is expected to be lower



What is the expected level of pCO₂ in patient with HCO₃=15mM?

Explanation

- Correct answer = 4.0 kPa
- Winters formula **$p\text{CO}_2 = \text{HCO}_3^-/5 + 1 \text{ kPa}$** ($\pm 0.3 \text{ kPa}$)
- Take home message: Superimposed respiratory disorders can be diagnosed in patients with metabolic acid base disorders
 - Too little compensation can mean impending respiratory failure or inappropriate ventilator setting
 - Too much compensation = respiratory alkalosis needs explanation

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Q3: Use Stewart light to quantify non-lactic anion that is present.



How much non-lactic anion is present?

Explanation

- STEP 1: Na-Cl = 38 mM, with pH 7.15, it should be $35+3 = 38$, i.e. no SID disorder present (predicted SBE =0)
- STEP 2: Albumin is normal (predicted SBE =0)
- STEP 3: SBE predicted from steps 1 and 2 is 0, but ABG reads SBE= -10 mM. This means 10 mM of anions, and this is not lactate. Hence, unmeasured anions are 10 mM

Further investigations revealed starvation ketosis and hypoosmolarity due to polydipsia. Patient recovered.

Do you have more questions?

- What is exactly the cause of hyponatremia and how do I find out?
- What will 2 L of 0.9 NaCl i.v. do with acid base status of this patient?
- How do I interpret the blood gas and set the ventilator if patient temperature turns out to be 32 C?
- And many more?

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M. Bestle, P. Caironi, PWG Elbers, T. Langer, M. Malbrain, N. van Regenmortel et al.



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