Acidobazická rovnováha

František Duška

KAR 3. LF UK a FNKV, Praha

Conflict of interest.

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

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

What then determines pH or [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 Stewart published his classic work on the quantitative approach to acid-base. Treasured by many, despised by some, it has become the method of choice for those that want to truly understand acid-base.

This fully revised third edition, known as the "black bible" of acid–base, retains Stewart's original, unabridged writings and adds 20 chapters by world-renowned clinicians and researchers. These cover recent advances in acid–base medicine and physiology in the same clear, concise style, with extensive focus on practical clinical application of the Stewart approach across virtually every medical specialty, including a step-by-step bedside tutorial illustrated with many case examples.

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 with many example cases
- 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 Elbers
František Duška
John Kellum

Stewart's textbook of Acid-Base

fully revised **3rd** edition

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Buy at acidbase.org

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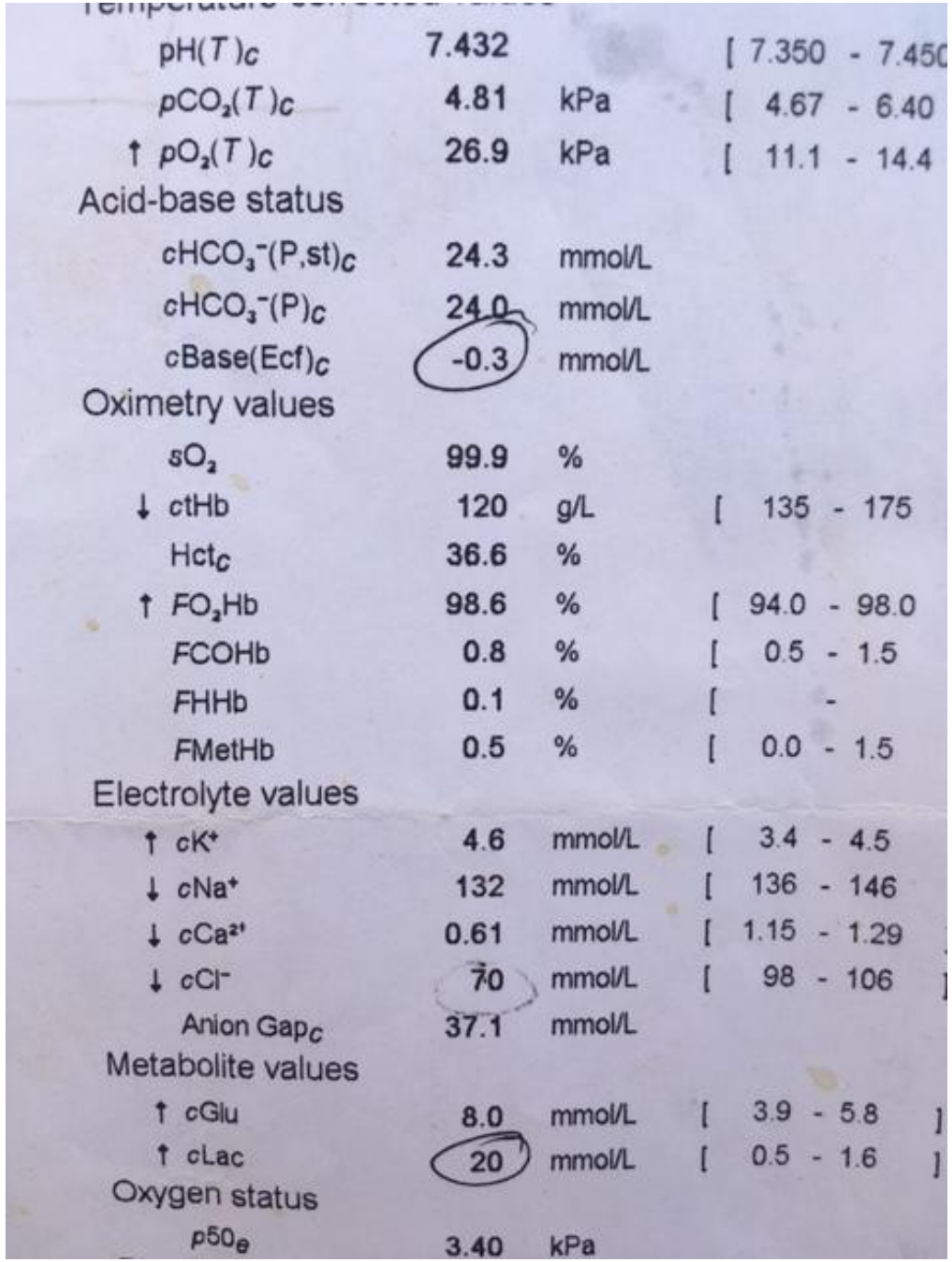
Martin Vančura
Santje Slot

The Traditional approach: bicarbonate as the window into acid base

The Boston approach
Distinguish compensation from superimposed disorder

The Stewart's Approach
Electroneutrality integrates pH and ions

Same reality
different perspectives



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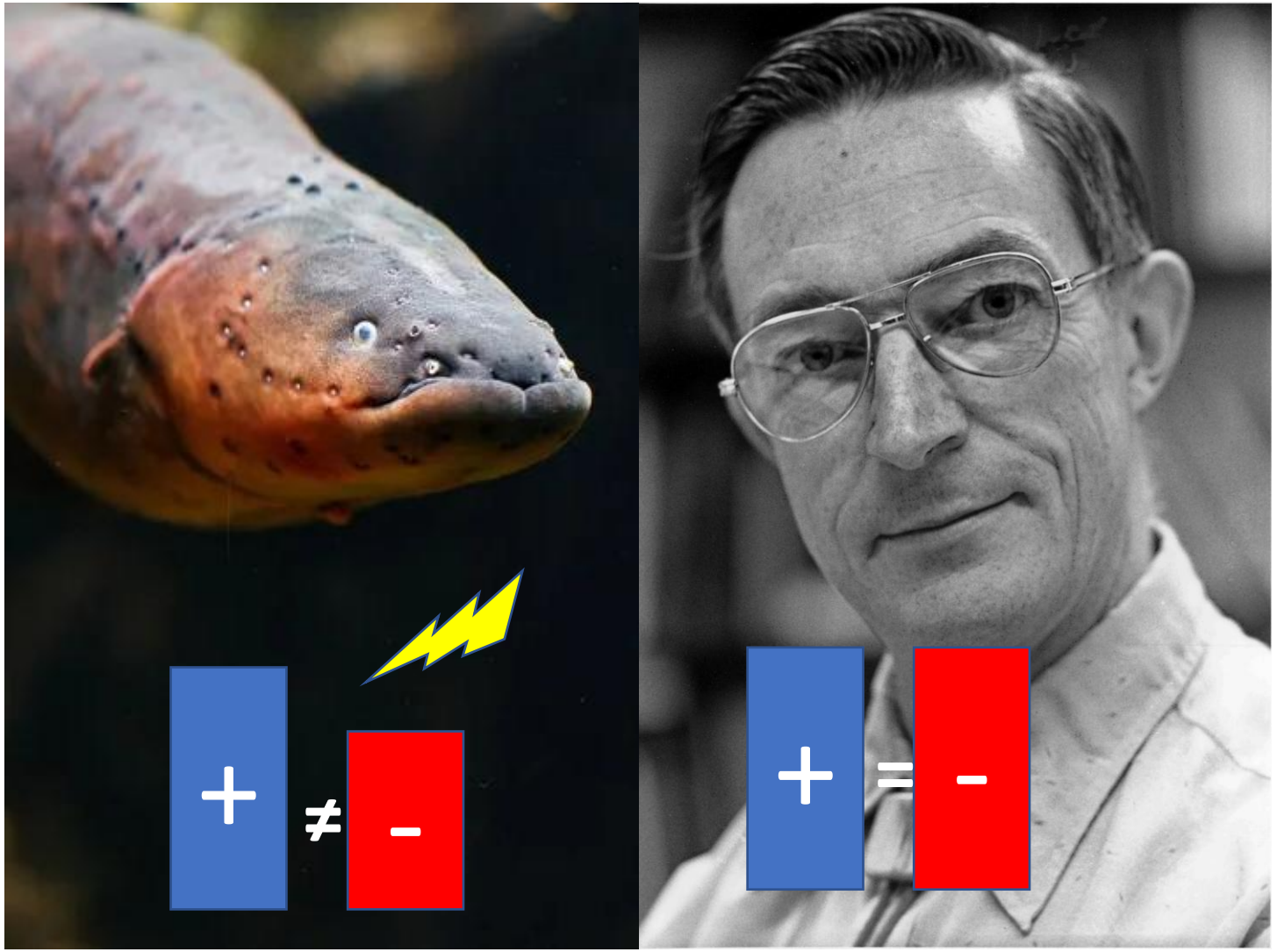
$p50_e$	3.40	kPa	

Male, 34 years, known alcoholic, presents unwell, 3 days of vomiting

«La République n'a pas besoin de chimistes»

M. Robespierre when announcing the death sentence order over Lavoisier

(8th May, 1794)

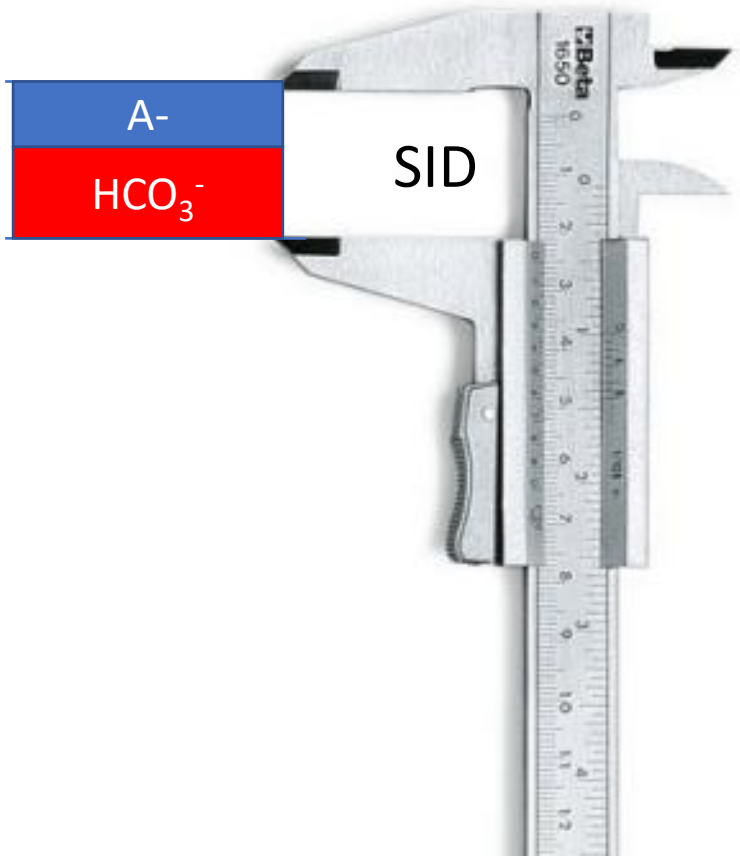


Key concept: BE partitioning

SID defines anion space shared by A^- a HCO_3^-

1 mM change of each parameter changes BE by 1mM

In principle, this change could be either due to change in SID, or A-



Five parameters to look at

1. $[Na^+]$-$[Cl^-]$ difference
2. Albumin
3. BE and lactate
4. pCO_2
5. Context

1 Look at ions and estimate SID_a influence

$$SID \sim [Na^+]-[Cl^-]$$

Normal value of $[Na^+]-[Cl^-]$ = **34 mM**
$[Na^+]-[Cl^-] >> 34$ = High SID alkalosis
$[Na^+]-[Cl^-] << 34$ = Low SID alkalosis

Quantitatively = deviation from 34 = BE attributable to SID changes

Example: $[Na^+]-[Cl^-]$ = 24 mM leads to BE -10mM if no other disorder
Limitation: Applies for pH near normal,
in extremis SID norm increases by 3mM for each 0.2 pH decrease

(D. Story, BJA 2004 / modified by J. Mallat 2017)

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Oxygen status			
p50e	3.40	kPa	

Na-Cl = 62 mM

BE = 62-34 = 28 mM

2

Estimate A^- influence

10g/L Albumin ~ 3 mM A^-

Normal value = 40 g/L = 12 mM
Alb << 40 g/L = alkalosis

Quantitatively = for each 1g of albumin below 40g/L
BE rises by 0.3 mM

Example: Albumin = 20 g/L leads to BE +6 mM if no other disorder

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Albumin 22g/L
BE predicted +
6mM

3

Look at BE on blood gas strip

Is it different from what we predicted from $[Na^+]$-$[Cl^-]$ and Albumin?

If yes, unexplained BE = strong ion XA^-

Lactate (seen)
Other: ketons or poisons

(D. Story, BJA 2004 / modified by J. Mallat 2017, L. Giosa 2023 and M. Krbec 2025)

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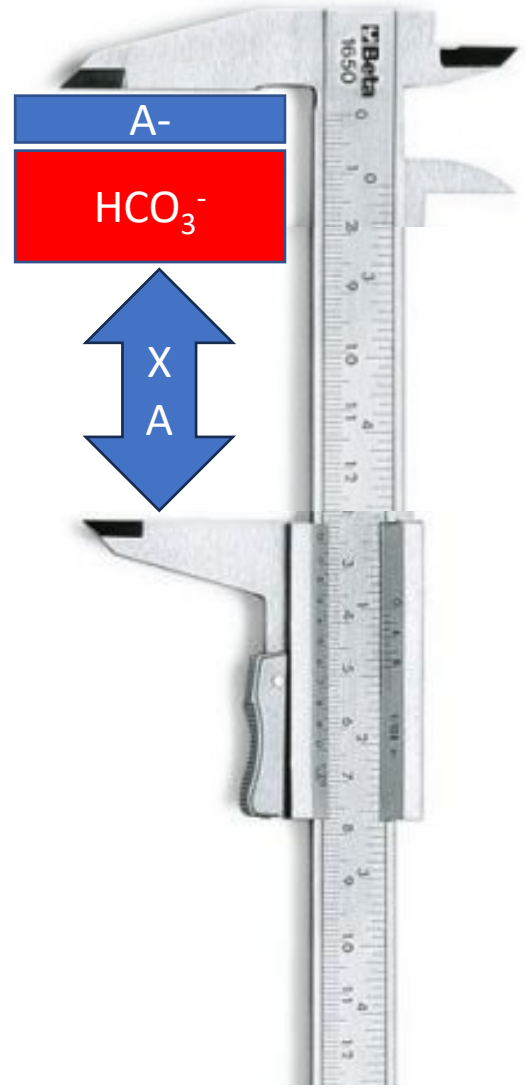
BE from Na-Cl = +28mM
BE from = + 6mM
Predicted BE = +34 mM

On the strip = 0 mM
This means 34 mM of strong acid

- Lactate 20 mM
- Unmeasured 14 mM



4 Assess respiratory component

- Assess pCO_2
- Normal, primary disorder, compensation?

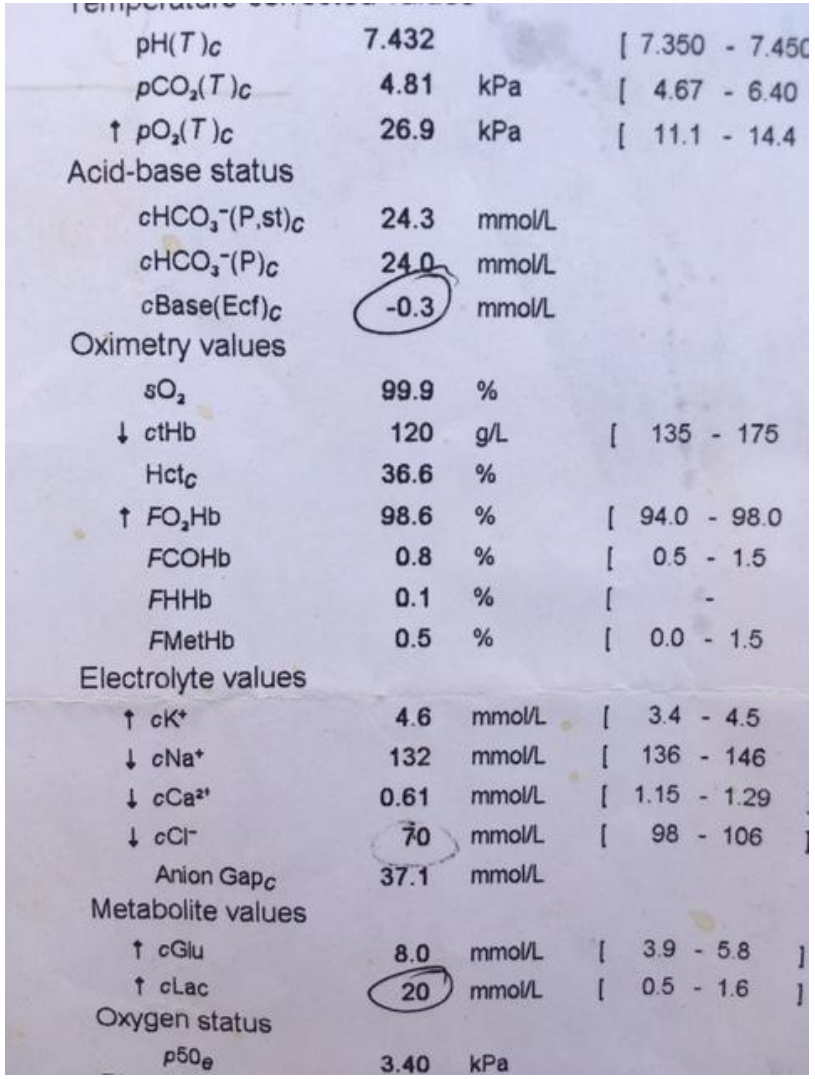
Winters formula, predicting pCO2 in metabolic acidosis

pCO_2 = Bicarb/5 + 1 **kPa** [±0.3]

5 Look at clinical context and summarise

- Recapitulate disorders you have found
- Put them in clinical context and try to find
  - The underlying disease
  - The physiological adaptation (or lack of it)
  - Iatrogenic influences (drugs and fluids)

Summary



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Male, 34 years, known alcoholic, presents unwell, 3 days of vomiting

Severe high SID alkalosis : vomiting, cirrhosis?

Lactic acidosis:

- shock, failing liver

Unmeasured anions: ketons, poisons, AKI?

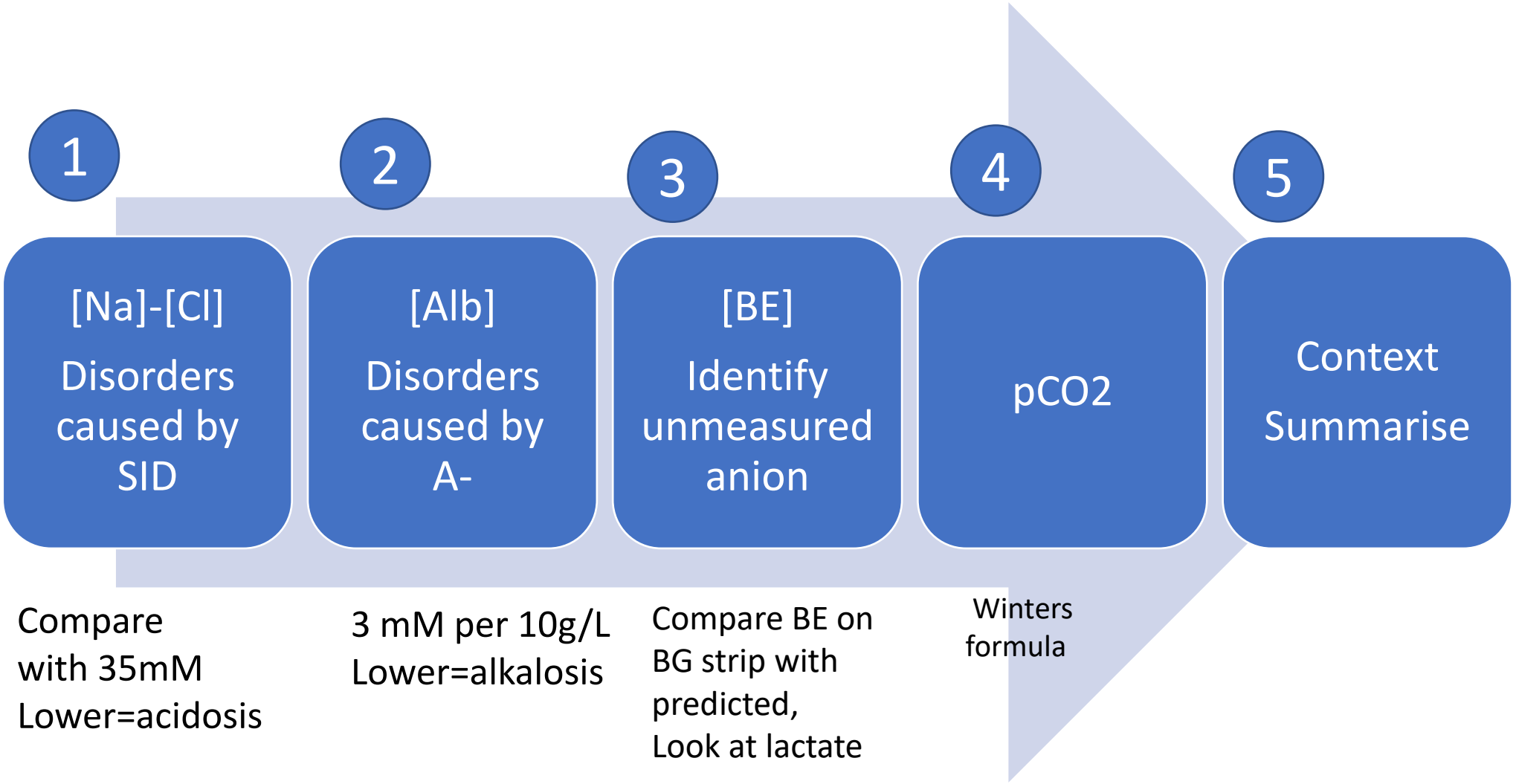
What it really was?

- Patient had acute-on-chronic liver failure due to alcoholic hepatitis (MELD 37)
  - Lactate 21.0 mmol/L, INR 3, bili 100 umol/l
  - ALT 4908 IU/L (normal range <40)
- Akute kidney injury
  - Crea 310 umol/l, urea 10.2mmol/l phosphate 3.08 mmol/l
- Died 20 hours after admission after being refused by a transplant centre

Limitations

- Extremes pH shifts Na-Cl reference range 35 mM
  - It increases by 3mM for each pH drop by 0.2
  - It decreases by 3mM for each pH increase by 0.2
- Unmeasured cations (Li++)

Algorithm for acid base cases



Tobin
Monnet
Ince
Ostermann
Wendon
Hahn
Heunks
Takala
Bělohlávek
Balík

‘Physiology is the only polar star we have’
L. Gattinoni

esicm
The intensive connection

Česká Společnost Intenzivní Medicíny