

# Analysis of acid-base disorders in an ICU cohort by using a computer script

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## Background

Acid-base status is important for understanding pathophysiology, diagnosis, planning treatment and monitoring progress of critically ill patients. Manual calculations are cumbersome. Therefore, we developed an automated assessment of acid-base status.

## Methods

A MATLAB script processing all available theory to date was applied on 8,875 initial blood gas analyses, drawn immediately after admission to ICU, during the years 2011-2021, at Skåne University Hospital, Adult Critical Care Unit, Lund, Sweden.

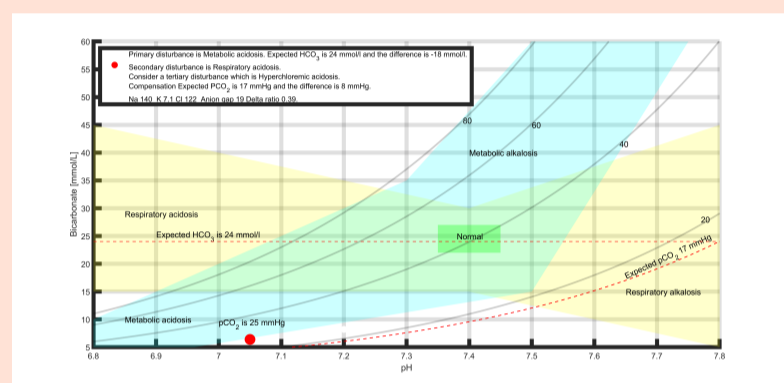
An experienced physician analyzed manually 100 randomly chosen blood gases and the result was the same as the script in all instances. The script has a basic structure of four levels of complex calculation steps and the output from each level is transferred to the next, however the final level accepts input from all previous levels. The time frame for the script to calculate all 8,875 blood gases in the cohort was 30 s. The script contains ~500 rows, there is one calculation per row, giving  $8,875 \times 500 = 4,437,500$  calculations for the complete cohort.

Level	Function
1 ↓	Initial input variables are pCO <sub>2</sub> and pH. The script estimates a most probable start-scenario including a primary disturbance for certain pH/pCO <sub>2</sub> combinations on which further calculations are carried out in the next level.
2 ↓	The input variables are the primary disturbances from level 1. The compensation variables; pCO <sub>2</sub> for metabolic and bicarbonate for respiratory disturbances are determined. Full compensation (100 %) is defined according to the Boston formulas. If the compensation is partial the script defines a second disturbance that interacts with/counteracts the compensation mechanism.
3 ↓	The input variable into level 3 is the diagnosis of metabolic acidosis from level 2. The script calculates the anion gap and the delta ratio in order to evaluate a possible tertiary disturbance in case of a primary or secondary disturbance of metabolic acidosis. Anion gap is calculated as $[Na^+] + [K^+] - [Cl^-] - [bicarbonate]$ . The traditional delta ratio is further calculated for all anion gaps >16 by using the formula $[AG-12]/[24-bicarbonate]$ .
4 ↓ ↓ ↓	The results from the previous levels 1-2-3 are inserted in a final fourth evaluation level where the diagnosis is compared to special criteria. To date the fourth level is not fully built and it serves as possibility to further expand the script. Finally, a graph is drawn where pH is placed on the X axis giving an instant understanding whether the result is an acidosis or an alkalosis. Bicarbonate level is placed on the Y axis. In addition, a superficial layer consisting of pCO <sub>2</sub> isopleths, created by using the Henderson-Hasselbach equation solved for bicarbonate, is placed on top of the graph.

## Interpretation on a single blood gas, example

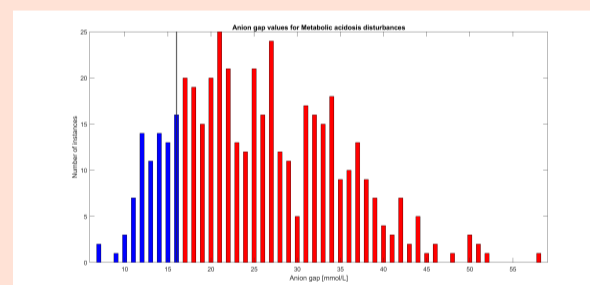
**Blood gas values; pH 7.05 bicarbonate 6 mmol/L pCO<sub>2</sub> 25 mmHg Na<sup>+</sup> 140 mmol/L K<sup>+</sup> 7.1 mmol/L Cl<sup>-</sup> 122 mmol/L.**

Primary disturbance; metabolic acidosis with a deviation from the baseline of -18 mmol/l, with an elevated anion gap of 19. Secondary disturbance; respiratory acidosis because the compensation is not full, there is a 8 mmHg difference (actual pCO<sub>2</sub> value is 25 mmHg) to full which would be 17 mmHg. Delta ratio is 0.39. The  $[Na^+ - Cl^-]$  difference is 18 mmol/l and the script returns a tertiary disturbance as a hyperchloremic acidosis.

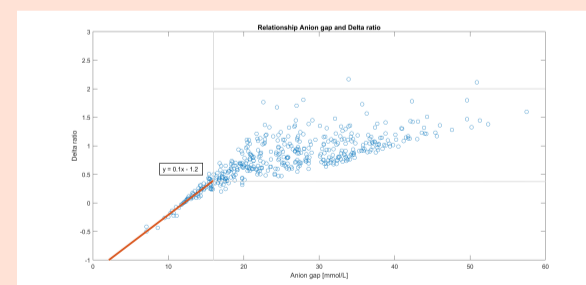


## Analysis on cohort level, examples

Most of the metabolic acidoses in the cohort (83%, 385/464) showed an elevated anion gap >16 mmol/L.



For anion gaps >16 mmol/L the delta ratios deviated. If <0.4 or >2 a suggestion of a third disturbance was returned by the script.



SID<sub>e</sub> did not correlate with pH in the cohort. Not for metabolic acidoses (green) or for metabolic alkaloses (purple). Normal blood gases are shown in black.

