EDITORIAL

Revisiting Stewart's Approach toward Assessment of Unidentified or Complex Acid–Base Disorders

Justin Aryabhat Gopaldas

Keywords: Acid–Base disturbance, Albumin-corrected anion gap, Bicarbonate-based arterial blood gas analysis, High anion gap metabolic acidosis, Metabolic acidosis, Metabolic alkalosis, Stewart's approach.

Indian Journal of Critical Care Medicine (2022): 10.5005/jp-journals-10071-24099

Critically ill patients, in particular those who are being managed with the life support systems have simple to complex acid–base disorders and are mostly metabolic in nature.[1] Given that they need monitoring or managing with simple fluid and electrolyte correction to an institution of advanced organ supports, a serial, structured, and reproducible approach is beneficial for the individual clinician. During the evolution of bedside care of critically ill, arterial blood gas (ABG) and less frequently venous blood gas (VBG) analysis has become quintessential part of this process.[2,3] From the lives saved during the polio epidemic with basic measurements of blood gases, ABGs have come a long way and now are being used for more complex decisions and in turn for precision and individualized care.

Arterial blood gases, which express few measured and many derived values, require a structured approach to integrate and interpret. Research into analysis of ABGs went from basic measurement to noting differences between healthy and acutely ill patient profiles, comparison to VBGs, ability to diagnose specific illnesses and comparison of various methods of interpreting from many aspects.[4,5] It's utility is so high that we are now finding ways to curtail its routine use to a more purpose-driven testing.[6,7]

Arterial blood gases help understand oxygenation and ventilation through measurement of partial pressure of the gases in the sample. Coming to the main aspect of the discussion, they also allow assessment of acid–base or metabolic aspects through its direct measurement of CO_2 and pH and derived values of serum bicarbonate (HCO_3) and base deficit. The pattern of the above is interpreted in general with the use of one or more of many methods developed over the last 60 years. Four commonly used ones are given below for reference but not limited to:[8,9]

- CO_2-bicarbonate method (traditionally known as the Boston approach)
- Anion gap (described by Emmit and Narins)
- Base excess/base deficit method (also known as Copenhagen approach)
- Stewart–Fencl method (Stewart approach and its variations)

I note with significant interest the article by Paliwal et al., in this issue where an albumin correction of the traditional approach is pitched against Stewart approach in diagnosing missed acid–base disorders in ABGs that were deemed normal. This study included patients predominantly from a hemato-oncological intensive care unit and with it some factors that may influence either approach. Though theoretically, Stewart approach is considered superior in identifying abnormalities, a finding of clinical equivalence noted in this study is in keeping with the available evidence.[10,11]

Department of Critical Care Medicine, Manipal Hospital, Bengaluru, Karnataka, India

Corresponding Author: Justin Aryabhat Gopaldas, Department of Critical Care Medicine, Manipal Hospital, Bengaluru, Karnataka, India, Phone: +91 8884132998, e-mail: justin.a.gopaldas@gmail.com

How to cite this article: Gopaldas JA. Revisiting Stewart's Approach toward Assessment of Unidentified or Complex Acid–Base Disorders. Indian J Crit Care Med 2022;26(1):5–6.

Source of support: Nil

Conflict of interest: None

One area where the Stewart approach has shown to be superior is in its ability to diagnose complex acid–base abnormalities with or without the help of other approaches. This is in particular with plasma unmeasured anions in setting of metabolic acidosis.[12] But, as lactate is measured in most modern ABGs, the small proportion of nonlactate unmeasured anions and their utility in diagnosis and prognostication is becoming less relevant in day-to-day bedside practice.

The majority of the bedside interpretation is based on the bicarbonate-anion gap approach and lately, there is increasing reliance on the use of base excess or deficit in addition or exclusively to diagnose metabolic pathologies. It is rare in clinical practice to use the Stewart approach in isolation for varying reasons (complicated and requiring multiple other biochemical measurements).

Literature search seems to confirm the long-held opinion that the Stewart approach does not offer better clinical (diagnostic, prognostic, or therapeutic) options that were not already apparent with the use of a more traditional approach.[13–16] The failure of the Stewart approach to be better at diagnosis and prognostication in comparison to traditional approaches has been predominantly due to various factors. Technological differences and measurement errors which could become cumulative are one reason, while reference ranges are another. Last but not the least contributor of inconsistent results being variation in study population (underlying illness, severity, and fluid administered).[17]

While the above approaches have been evaluated on a head-to-head comparison to evaluate the metabolic process while analyzing ABGs of critically ill, it was also noted that these approaches are to be used more complimentary rather than comparative. The simpler the acid–base abnormality, the easier, faster, and better the traditional methods (Boston/anion

© The Author(s). 2022 Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by-nc/4.0/), which permits unrestricted use, distribution, and non-commercial reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

gap approaches) did on their own or with albumin and lactate correction. On the other hand, complex disorders could get help from the Stewart approach (enhancing base excess or anion gap approaches in identification).[18,19]

Conclusion

In the case of metabolic acidosis, a diagnostic algorithm use is likely to improve etiological diagnosis. Unmeasured anion (UA) measurement as part of simple or complex acid–base abnormalities in critically ill attracted extensive research given its association with outcome. A number of approaches used to identify and quantify UA have failed to be superior to one another.

The Stewart approach and its modifications have improved their ability to identify UAs but once other methods employed simple lactate and/or albumin correction, its superiority is lost. Noting all the above and in keeping with bedside practice, we continue using these approaches in a complementary way rather than comparative to better understand these complex processes.

Orcid

Justin Aryabhat Gopaldas https://orcid.org/0000-0002-0420-6925

References

1. Gunnerson KJ, Saul M, He S, Kellum JA. Lactate versus non-lactate metabolic acidosis: a retrospective outcome evaluation of critically ill patients. Crit Care Med 2006;10(1):R22–R32. DOI: 10.1186/cc3987.
2. Al-Jaghbeer M, Kellum JA. Acid–base disturbances in intensive care patients: etiology, pathophysiology and treatment. Nephrol Dial Transplant 2015;30(7):1104–1111. DOI: 10.1093/ndt/gfu289.
3. Severinghaus JW, Astrup PB. History of blood gas analysis. Part II. pH and acid–base balance measurements. J Clin Monitor 1985;1(4):259–277. DOI: 10.1007/BF02832819.
4. Gunnerson KJ, Srisawat N, Kellum JA. Is there a difference between strong ion gap in healthy volunteers and intensive care unit patients? J Crit Care 2010;25(3):520–524. DOI: 10.1016/j.jcrc.2009.11.001.
5. Puri S, Paul G, Sood P. Interpretation of arterial blood gas. Indian J Crit Care Med 2010;14(2):57–64. DOI: 10.4103/0972-5229.68215.
6. Chandran J, D'Silva C, Sriram S, Krishna B. Clinical utility of arterial blood gas test in an intensive care unit: an observational study. Indian J Crit Care Med 2021;25(2):172–175. DOI: 10.5005/jp-journals-10071-23719. PMID: 33707895; PMCID: PMC7922451.
7. Pande RK. Arterial blood gas: bowling wide and poor wicketkeeping. Indian J Crit Care Med 2021;25(2):119–120. DOI: 10.5005/jp-journals-10071-23735.
8. Gezer M, Bulucu F, Ozturk K, Kilic S, Kaldirim U, Eyi YE. Effectiveness of the Stewart method in the evaluation of blood gas parameters. Turk J Emerg Med 2016;15(1):3–7. DOI: 10.5505/1304.7361.2014.73604.
9. Neligan PJ, Deutschman CS. Acid base balance in critical care medicine. 2005.
10. Paliwal R, Pakavakis A, Divatia JV, Kulkarni AP. Utility of Stewart's Approach to Diagnose Missed Complex Acid-Base Disorders as Compared to Bicarbonate-anion Gap-based Methodology in Critically Ill Patients: An Observational Study. Indian J Crit Care Med 2021;26(1):23–32.
11. Masevicius FD, Dubin A. Has Stewart approach improved our ability to diagnose acid–base disorders in critically ill patients? World J Crit Care Med 2015;4(1):62–70. DOI: 10.5492/wjccm.v4.i1.62.
12. Forni LG, McKinnon W, Hilton PJ. Unmeasured anions in metabolic acidosis: unravelling the mystery. Crit Care 2006;10(4):220. DOI: 10.1186/cc4954.
13. Cusack RJ, Rhodes A, Lochhead P, Jordan B, Perry S, Ball JA, et al. The strong ion gap does not have prognostic value in critically ill patients in a mixed medical/surgical adult ICU. Intensive Care Med 2002;28(7):864–869. DOI: 10.1007/s00134-002-1318-2. PMID: 12122523.
14. Rocktaeschel J, Morimatsu H, Uchino S, Bellomo R. Unmeasured anions in critically ill patients: can they predict mortality? Crit Care Med 2003;31(8):2131–2136. DOI: 10.1097/01.CCM.0000079819.27515.8E. PMID: 12973170.
15. Van Den Akker JPC, Groeneveld ABJ. Do we need alternatives for bicarbonate and anion gap? Minerva Anestesiol 2013;79(10):1111–1112. PMID: 23857449.
16. Kimura S, Shabsigh M, Morimatsu H. Traditional approach versus Stewart approach for acid–base disorders: Inconsistent evidence. SAGE Open Med 2018;6:2050312118801255. DOI: 10.1177/2050312118801255.
17. Jung B, Martinez M, Claessens YE, Darmon M, Klouche K, Lautrette A, et al. Diagnosis and management of metabolic acidosis: guidelines from a French expert panel. Ann Intensive Care 2019;9(1):92. DOI: 10.1186/s13613-019-0563-2.
18. Kasagi T, Imai H, Miura N, Suzuki K, Yoshino M, Nobata H, et al. Acid–base disturbances in nephrotic syndrome: analysis using the CO_2/HCO_3 method (traditional Boston model) and the physicochemical method (Stewart model). Clin Exp Nephrol 2017;21(5):866–876. DOI: 10.1007/s10157-017-1387-8.
19. Mallat J, Michel D, Salaun P, Thevenin D, Tronchon L. Defining metabolic acidosis in patients with septic shock using Stewart approach. Am J Emerg Med 2012;30(3):391–398. DOI: 10.1016/j.ajem.2010.11.039.