Research Article

Graphical Analysis of Arterial Blood Gas Analysis Using Standard Base Excess

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ABSTRACT

Arterial blood gas (ABG) analysis is very essential for the treatment of critically ill patients. The aim of the current research study is to determine the correlation between standard base excess, pH, pCO_2, HCO_3 and the ratio of HCO_3/H_2CO_3 and to apply them in arterial blood gas analysis for better understanding.120 arterial blood samples were collected and analysed using ABG analyser. The consistency of the ABG report was checked by using the Modified Henderson Equation. ABG parameters like pH, pCO_2, and HCO_3values were noted. Standard base excess was calculated from the obtained data. Carbonic acid was derived from PCO_2 values and the ratio between HCO_3 and carbonic acid (HCO_3/H_2CO_3) was found. The relationship between Standard Base Excess, pH, HCO_3, PCO_2 and the ratio of HCO_3/H_2CO_3 was graphically analysed.

Keywords: Standard Base Excess, HCO_3, PCO_2, HCO_3/H_2CO_3.

INTRODUCTION

Arterial blood gas (ABG) analysis plays a vital role in the management of intensive care unit patients especially for critically ill patients.[1,2] In ABG analysis, the pH, pCO_2 are measured parameters but bicarbonate concentration is a calculated parameter derived from the Modified Henderson Equation.[3]

Base excess is defined as the amount of strong acid that must be added to each litre of fully oxygenated blood to return the pH to 7.40 at a temperature of 37°C and a pCO_2 of 40 mmHg. A negative base excess indicates the presence of base deficit. Actual base excess is the base excess of the blood, while standard base excess is the base excess of the extracellular fluid at haemoglobin concentration of 5 g/dl. The normal level for standard base excess is −2 to +2 mEq/L.[4, 5]

The understanding of acid-base disturbances, classifying and analyzing the ABG data is sometimes challenging and difficult but very important because earlier detection may help in the treatment of clinical derangements.[6,7,8]The arterial blood gas analysis report should be clinically correlated before interpretation.[9,10,11]

The aim of the current research study is to determine the correlation between standard base excess, pH, pCO_2, HCO_3 and the ratio of HCO_3/H_2CO_3 and to apply them in arterial blood gas analysis for better understanding.

MATERIALS AND METHODS

120 arterial blood gas analysis samples were collected during the months of June and July 2017 at Shri Sathya Sai Medical College and Research institute. Strict precautions were taken to avoid pre-analytical errors and it was confirmed that it is an arterial and not a venous sample.[12] The samples were analyzed using ABG Analyzer GEM PREMIER 3000. Arterial Blood Gas Analysis data were collected and the consistency of the ABG report was checked by using the Modified Henderson Equation.[3]

The main parameters like measured pH, pCO_2, HCO_3values were noted. Carbonic acid concentration was calculated from pCO_2. The ratio between HCO_3 and carbonic acid was calculated and represented by HCO_3/H_2CO_3.

Calculation of Carbonic Acid Concentration

The carbonic acid concentration (**mmol/L**) was calculated by the given formula.

$$H_2CO_3 = 0.03 \times pCO_2$$

Calculation of HCO_3/H_2CO_3

Carbonic acid was derived from pCO_2 values and the ratio between HCO_3 and carbonic acid (HCO_3/H_2CO_3) was found.

Calculation of Standard Base excess (Base Excess of the extra cellular fluid)

The standard base excess (**mmol/L** or **mEq/L**) is calculated by the following given formula.[13]

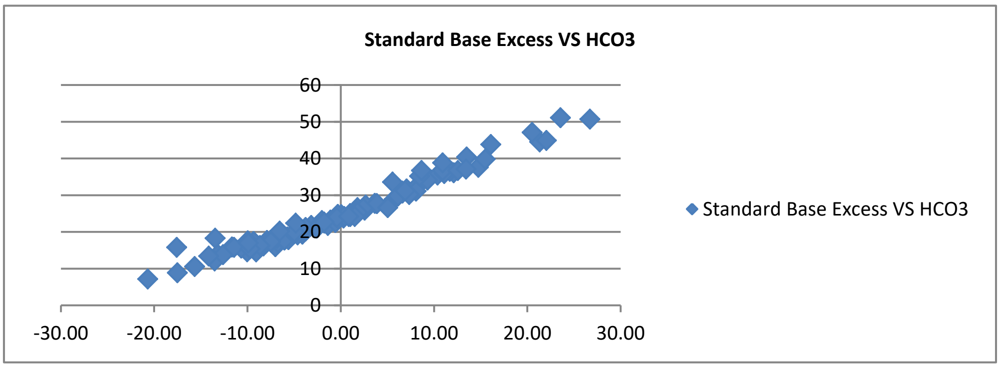
Std Base Excess (STD BE) = $HCO_3 - 24.8 + 16.2\,(pH - 7.4)$

Table 1: Calculation of bicarbonate/carbonic acid ratio and Standard Base Excess

S.NO	Measured pH	PCO2 mmHg	H_2CO_3 mmol/L	HCO3 mmol/L	HCO_3/H_2CO_3 Ratio	STD BE mmol/L
1	7.41	50	1.5	31.7	21.13	7.06
2	7.45	52	1.56	36.1	23.14	12.11
3	7.4	43	1.29	26.6	20.62	1.80
4	7.42	25	0.75	16.2	21.60	-8.28
5	7.47	20	0.6	14.6	24.33	-9.07
6	7.35	32	0.96	17.7	18.44	-7.91
7	7.48	26	0.78	19.4	24.87	-4.10
8	7.52	46	1.38	37.6	27.25	14.74
9	7.45	36	1.08	25	23.15	1.01
10	7.51	20	0.6	16	26.67	-7.02
11	7.4	59	1.77	36.5	20.62	11.70
12	7.45	46	1.38	32	23.19	8.01
13	7.5	57	1.71	44.5	26.02	21.32
14	7.52	55	1.65	44.9	27.21	22.04
15	7.45	29	0.87	20.2	23.22	-3.79
16	7.26	31	0.93	13.9	14.95	-13.17
17	7.47	41	1.23	29.8	24.23	6.13
18	7.28	37	1.11	17.4	15.68	-9.34
19	7.43	28	0.84	18.6	22.14	-5.71
20	7.46	32	0.96	22.8	23.75	-1.03
21	7.44	33	0.99	22.4	22.63	-1.75
22	7.49	32	0.96	24.4	25.42	1.06
23	7.4	27	0.81	16.7	20.62	-8.10
24	7.37	30	0.9	17.3	19.22	-7.99
25	7.23	38	1.14	15.9	13.95	-11.65
26	7.5	29	0.87	22.6	25.98	-0.58
27	7.47	33	0.99	24	24.24	0.33
28	7.44	41	1.23	27.8	22.60	3.65
29	7.46	25	0.75	17.8	23.73	-6.03
30	7.4	27	0.81	16.7	20.62	-8.10
31	7.38	60	1.8	35.5	19.72	10.38
32	7.31	21	0.63	10.6	16.83	-15.66
33	7.38	39	1.17	23.1	19.74	-2.02
34	7.45	44	1.32	30.6	23.18	6.61
35	7.45	73	2.19	50.7	23.15	26.71
36	7.47	20	0.6	14.6	24.33	-9.07
37	7.41	43	1.29	27.3	21.16	2.66
38	7.43	30	0.9	19.9	22.11	-4.41
39	7.41	39	1.17	24.7	21.11	0.06
40	7.4	55	1.65	34.1	20.67	9.30
41	7.46	27	0.81	19.2	23.70	-4.63
42	7.46	39	1.17	27.7	23.68	3.87
43	7.46	24	0.72	17.1	23.75	-6.73
44	7.4	58	1.74	35.9	20.63	11.10
45	7.46	25	0.75	17.8	23.73	-6.03
46	7.34	68	2.04	36.7	17.99	10.93

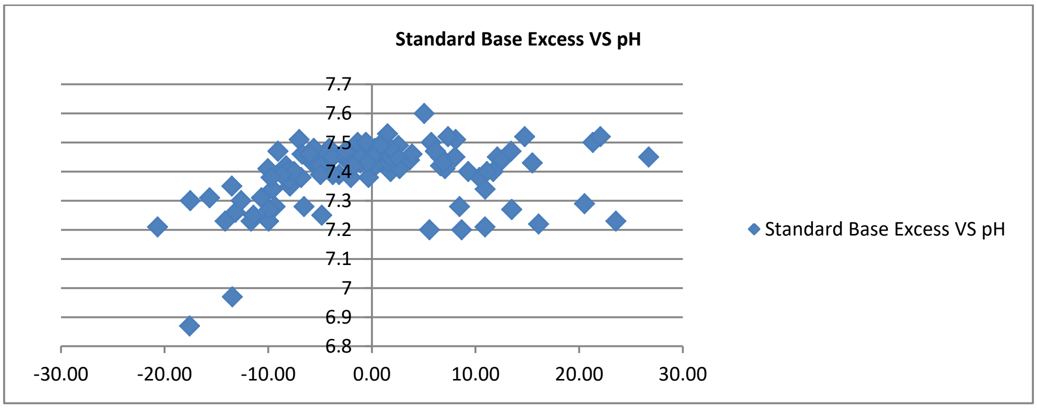
47	7.45	26	0.78	18.1	23.21	-5.89
48	7.42	48	1.44	31.1	21.60	6.62
49	7.35	22	0.66	12.1	18.33	-13.51
50	7.38	42	1.26	24.8	19.68	-0.32
51	7.28	37	1.11	17.4	15.68	-9.34
52	7.44	32	0.96	21.7	22.60	-2.45
53	7.39	36	1.08	21.8	20.19	-3.16
54	7.34	30	0.9	16.2	18.00	-9.57
55	7.46	39	1.17	27.7	23.68	3.87
56	7.48	32	0.96	23.8	24.79	0.30
57	7.5	37	1.11	28.9	26.04	5.72
58	7.45	29	0.87	20.2	23.22	-3.79
59	7.43	39	1.17	25.9	22.14	1.59
60	7.21	18	0.54	7.2	13.33	-20.68
61	7.45	31	0.93	21.5	23.12	-2.49
62	7.51	39	1.17	31.1	26.58	8.08
63	7.3	18	0.54	8.9	16.48	-17.52
64	7.43	35	1.05	23.2	22.10	-1.11
65	7.3	28	0.84	13.8	16.43	-12.62
66	7.45	33	0.99	22.9	23.13	-1.09
67	7.47	41	1.23	29.8	24.23	6.13
68	7.38	31	0.93	18.3	19.68	-6.82
69	7.48	24	0.72	17.9	24.86	-5.60
70	7.23	42	1.26	17.6	13.97	-9.95
71	7.41	23	0.69	14.6	21.16	-10.04
72	7.49	34	1.02	25.9	25.39	2.56
73	7.5	28	0.84	21.8	25.95	-1.38
74	7.39	35	1.05	21.2	20.19	-3.76
75	7.46	25	0.75	17.8	23.73	-6.03
76	7.47	29	0.87	21.1	24.25	-2.57
77	7.5	31	0.93	24.2	26.02	1.02
78	7.49	30	0.9	22.9	25.44	-0.44
79	7.5	29	0.87	22.6	25.98	-0.58
80	7.47	29	0.87	21.1	24.25	-2.57
81	7.46	34	1.02	24.2	23.73	0.37
82	7.43	36	1.08	23.9	22.13	-0.41
83	7.5	31	0.93	24.2	26.02	1.02
84	7.45	37	1.11	25.7	23.15	1.71
85	7.41	31	0.93	19.6	21.08	-5.04
86	7.4	28	0.84	17.3	20.60	-7.50
87	7.23	32	0.96	13.4	13.96	-14.15
88	7.42	30	0.9	19.5	21.67	-4.98
89	7.31	31	0.93	15.6	16.77	-10.66
90	7.27	88	2.64	40.4	15.30	13.49
91	7.39	27	0.81	16.3	20.12	-8.66
92	7.47	41	1.23	29.8	24.23	6.13
93	7.25	36	1.08	15.8	14.63	-11.43
94	7.38	26	0.78	15.4	19.74	-9.72
95	7.39	33	0.99	20	20.20	-4.96

96	7.44	54	1.62	36.7	22.65	12.55
97	7.52	37	1.11	30.2	27.21	7.34
98	7.2	86	2.58	33.6	13.02	5.56
99	7.28	75	2.25	35.2	15.64	8.46
100	7.23	122	3.66	51.1	13.96	23.55
101	7.2	94	2.82	36.7	13.01	8.66
102	7.29	98	2.94	47.1	16.02	20.52
103	7.27	88	2.64	40.4	15.30	13.49
104	7.21	97	2.91	38.8	13.33	10.92
105	7.22	107	3.21	43.8	13.64	16.08
106	7.47	41	1.23	29.8	24.23	6.13
107	7.42	35	1.05	22.7	21.62	-1.78
108	7.43	60	1.8	39.8	22.11	15.49
109	7.45	38	1.14	26.4	23.16	2.41
110	7.48	34	1.02	25.3	24.80	1.80
111	7.47	51	1.53	37.1	24.25	13.43
112	7.43	47	1.41	31.2	22.13	6.89
113	7.25	51	1.53	22.4	14.64	-4.83
114	7.28	43	1.29	20.2	15.66	-6.54
115	7.27	37	1.11	17	15.32	-9.91
116	7.6	22	0.66	26.6	40.30	5.04
117	7.53	27	0.81	24.2	29.88	1.51
118	7.49	31	0.93	24.2	26.02	0.86
119	6.87	61	1.83	15.8	8.63	-17.59
120	6.97	63	1.89	18.3	9.68	-13.47



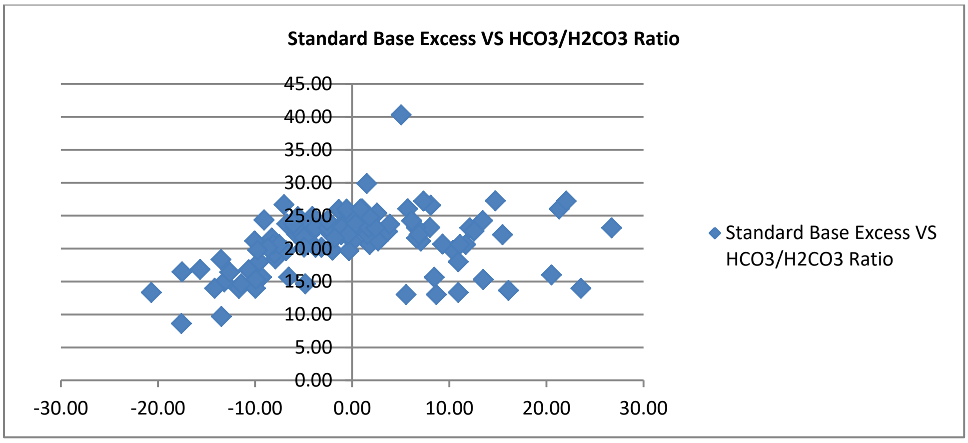
Graph 1: Relationship between Standard Base Excess VS HCO3

The Standard Base Excess values in mmol/L were taken in X: axis and HCO3 in mmol/L values were taken in Y: axis.



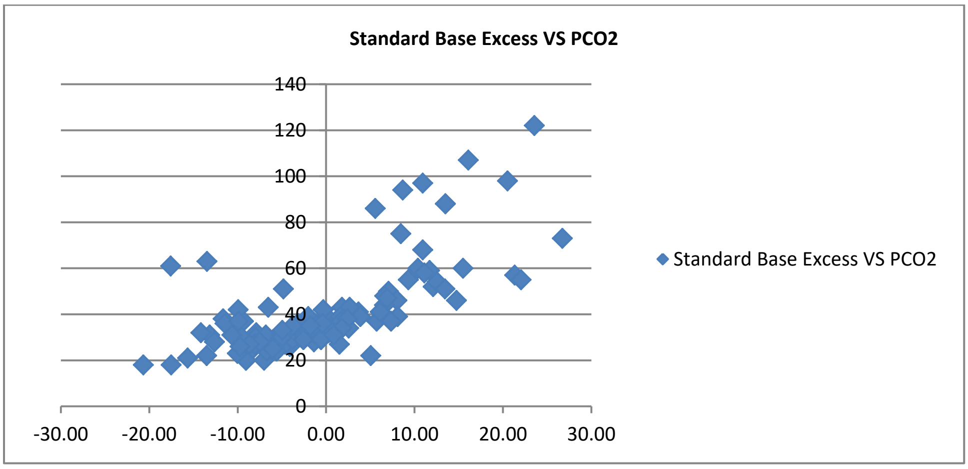
Graph 2: Relationship between Standard Base Excess VS pH

The Standard Base Excess values in mmol/L were taken in X: axis and measured pH values were taken in Y: axis.



Graph 3: Relationship between Standard Base Excess VS HCO_3/H_2CO_3 Ratio

The Standard Base Excess values in mmol/L were taken in X: axis and HCO_3/H_2CO_3 Ratiovalues were taken in Y: axis.



Graph 4: Relationship between Standard Base Excess VS PCO_2

The Standard Base Excess values in mmol/L were taken in X: axis and PCO_2 values in mm of Hg were taken in Y: axis.

DISCUSSION

The arterial blood gas analysis is very essential for the management of critically ill patients.[1,2] The understanding of acid-base balance and ABG interpretation is sometimes difficult and confusing.[6,7,8] The knowledge of acid-base analysis, its interpretation and clinical correlation is essential for any physician.[9,10,11]

Before analysis the sample should be checked that it is arterial and not a venous blood.[12]The consistency of the laboratory report should be checked by using Modified Henderson Equation.[3]

In our current study, 120 Arterial Blood Gas (ABG) samples were analysed. The bicarbonate/carbonic acid ratio and standard base excess were calculated for all the 120 samples which is shown in table 1.

The standard base excess and bicarbonate value plotted in graph1 clearly shows that they are directly related to each other. As the bicarbonate values increase the standard base excess also increase and as the bicarbonate values decrease the standard base excess values also decrease. Both standard base excess and bicarbonate parameter denote the metabolic component of the arterial blood gas analysis. The standard base excess level below – 2.0 mmol/L or decreased bicarbonate levels represent metabolic acidosis and standard base excess level above 2.0 mmol/L or increased bicarbonate levels represent metabolic alkalosis.

The relation between standard base excess and measured pH values and standard base excess and bicarbonate/carbonic acid ratio are shown in graph2and graph 3 respectively. It is very clear that there is no clear correlation because the measured Ph values depends both on the metabolic and respiratory component (PCO_2) values.

The graph 4 shows the relation between standard base excess and PCO_2 values. This graph roughly separates the various acid-base disturbances. The normal level for standard base excess is ± 2mmol/L and for PCO_2 is between 35 to 45 mm of Hg.

ThePCO_2 value above 45 mm of Hg represent respiratory acidosis and PCO_2 values below 35 mm of Hg represent respiratory alkalosis. The standard base excess value above 2 mmol/L represent metabolic alkalosis and value below -2 mmol/L represent metabolic acidosis.

The simple acid-base disorders (if the disturbance is pure) can be clearly shown by the graph 4 (standard base excess VS PCO2). But if the compensatory changes (depending on the extent of compensatory change) take place or in case of mixed disturbances then it cannot be clearly demarcated in this graph 4.

CONCLUSION

Arterial blood gas analysis and interpretation is sometimes challenging and difficult but thorough understanding is very essential. The relationship between standard base excess, bicarbonate, bicarbonate/carbonic acid ratio, measured pH and PCO2 may help for better understanding of the acid-base disturbances which when applied at the appropriate time results in timely management.

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