



## Application of Modified Henderson Equation In ABG Interpretation

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Accepted on: 06-03-2016; Finalized on: 31-03-2016.

### ABSTRACT

Arterial blood gas (ABG) analysis is very important for diagnosis of acid –base balance disorders. This diagnostic test should be properly used and the results should be correctly interpreted as occasionally the abnormality may be so severe so as to become a life-threatening risk factor. The current research study tries to emphasize the importance of Modified Henderson equation in arterial blood gas analysis and also insist always, to look at the bicarbonate/carbonic acid ratio and hydrogen ion concentration before ABG interpretation because this will not only make us to understand the cause for acid base disorders but also it is easier to interpret the results to manage the critically ill patients. 100 ABG samples data are collected. The bicarbonate / carbonic acid ratio is calculated. The modified Henderson equation is used to calculate the hydrogen ion concentration and from that pH is calculated. This pH is then compared to the measured pH. If the values are similar, the sample is valid and If the values are far apart, there may be a measurement error.

**Keywords:** Arterial Blood Gas Interpretation, Modified Henderson Equation, Bicarbonate/Carbonic Acid Ratio.

### INTRODUCTION

Arterial blood gases play an important role in the management of critically ill patients. They are used to guide the adjustment of ventilator parameters on mechanically ventilated patients and are also a standard part of the workup of patients who present with unexplained hypoxemia or dyspnea.<sup>1-3</sup>

A thorough understanding of acid–base balance is mandatory that students and physicians should be able to interpret the results of arterial blood gas sampling, determine the patient's acid-base status and assess the adequacy of oxygenation.<sup>3,4</sup>

The accuracy of the ABG report depends not only on the interpretation of the given data but also depends on the knowledge of pre-analytical and measurement errors. Clinically important errors can occur at any of the steps like collecting, handling and analysing the specimen.<sup>5-9</sup>

The most common problems that are encountered include non-arterial samples, air bubbles in the sample, inadequate or excessive anticoagulant in the sample and delayed analysis of a non-cooled sample.

we should make sure that the it is an arterial and not a venous sample. Before making an interpretation of an ABG it is always wise to check for the consistency of the report by the modified Henderson equation.<sup>10,11</sup>

#### Henderson Hasselbalch equation

$$pH = pK_a \text{ H}_2\text{CO}_3 + \log \left( \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \right)$$

pH is the acidity in the blood

$pK_a \text{ H}_2\text{CO}_3$  is the negative logarithm (base 10) of the acid dissociation constant of carbonic acid. It is equal to 6.1 at normal body temperature.

$$pH = 6.1 + \log_{10} \left( \frac{[\text{HCO}_3^-]}{0.03 \times Pa\text{CO}_2} \right)$$

Where,

$[\text{HCO}_3^-]$  is the concentration of bicarbonate in the blood (mEq/L or mmol/L)

$Pa\text{CO}_2$ ( $P_{\text{CO}_2}$ ) is the partial pressure of carbon dioxide in the arterial blood(mm of Hg)

$$[\text{H}_2\text{CO}_3] = k_{\text{H CO}_2} \times p\text{CO}_2$$

$[\text{H}_2\text{CO}_3]$  is the concentration of carbonic acid in the blood(mmol/L)

$k_{\text{H CO}_2}$  is a constant including the solubility of carbon dioxide in blood.

$k_{\text{H CO}_2}$  is approximately **0.03 (mmol/L)/mmHg**

#### Derivation of The Kassirer-Bleich Approximation

The Henderson Equation, which is derived from the Law of Mass Action, can be modified with respect to the bicarbonate buffering system to yield a simpler equation that provides a quick approximation of the  $\text{H}^+$  or  $\text{HCO}_3^-$  concentration without the need to calculate logarithms.<sup>10,11</sup>

$$[H^+] = \frac{K' \cdot 0.03P_{CO_2}}{[HCO_3^-]}$$

Where  $K'$  is the **dissociation constant** from the  $pK_a$  of carbonic acid, **6.1**, which is equal to **800nmol/L**

(since  $K' = 10^{-pK_a} = 10^{-(6.1)} \approx 8.00 \times 10^{-07} \text{ mol/L} = 800 \text{ nmol/L}$ )

By multiplying  $K'$  (expressed as nmol/L) and **0.03 (800 X 0.03 = 24)** and rearranging with respect to  $HCO_3^-$ , the equation is simplified to:

$$[HCO_3^-] = 24 \frac{P_{CO_2}}{[H^+]}$$

The modified Henderson equation is as follows:

$$[H^+] = 24 \times PCO_2 / HCO_3^-$$

The modified Henderson equation is used to calculate the hydrogen ion concentration and from that pH is calculated.

This pH is then compared to the measured pH. If the values are similar the sample is valid and if the values are far apart, there may be a measurement error.

The normal bicarbonate and carbonic acid ratio is 20. The ratio is changed under abnormal conditions. The changes in pH and hydrogen ion concentration depends on the changes in the bicarbonate/carbonic acid ratio.

## MATERIALS AND METHODS

We have taken 100 arterial blood gas analysis samples. Strict precautions are taken to avoid pre-analytical errors and it is confirmed that it is an arterial and not a venous sample.

The main parameters like measured pH,  $PCO_2$ ,  $HCO_3$  values are noted.

### Calculation of hydrogen ion concentration

Then the modified Henderson equation is used to calculate the hydrogen ion concentration.

$$[H^+] = 24 \times PCO_2 / HCO_3^-$$

### Calculation of pH from calculated $[H^+]$

From the calculated hydrogen ion concentration, pH is calculated as follows.<sup>10,11</sup>

We already know that at a pH of **7.4**, the concentration of **hydrogen ions** is **40 nanomoles/litre**.

For **every 1 nanomoles/litre change** in hydrogen ion concentration, the **pH changes by 0.01** unit.

If the hydrogen ion concentration is known, pH is calculated as follows.

We already know that at a pH of 7.4 the concentration of hydrogen ion is 40 nanomoles/litre.

For every 1 nanomoles/litre change in hydrogen ion concentration, the pH changes by 0.01 unit.

If the **hydrogen ion** concentration is **more than 40**, then the difference in hydrogen ion concentration (**subtracted from 40**) is **multiplied by 0.01** and then the **value is subtracted from 7.4**. **Subtraction** is done here because as the **hydrogen ion concentration increases the pH is decreased**.

If the hydrogen ion concentration is **less than 40**, then the difference in hydrogen ion concentration (**subtracted from 40**) is **multiplied by 0.01** and then the **value is added to 7.4**. **Addition** is done here because as the **hydrogen ion concentration decreases, the pH is increased**.

### Calculation of bicarbonate and carbonic acid ratio

The normal bicarbonate/carbonic acid ratio is **20**. When this ratio is disturbed, acid base disorders will occur.

The carbonic acid concentration is calculated by the formula.

$$H_2CO_3 = 0.03 * PCO_2$$

Then the bicarbonate (mmol/L) and carbonic acid concentration (mmol/L) values are divided and thus the ratio is obtained.

**Table 1:** To verify the consistency of ABG report by the Modified Henderson Equation

#### (Calculation of hydrogen ion concentration & Calculation of pH)

S. No	measured pH	PCO2 mm of Hg	HCO3 mmol/L	Calculated H+ nanomoles/litre	(40-H+)	pH change (40-H+) × 0.01	calculated Ph (7.4 + pH change)
1	7.43	41	27.2	36.18	3.82	0.0382	7.44
2	7.5	30	23.4	30.77	9.23	0.0923	7.49
3	7.38	43	25.4	40.63	-0.63	-0.0063	7.39
4	7.29	60.9	29.2	50.05	-10.05	-0.1005	7.30
5	7.38	58.8	34	41.51	-1.51	-0.0151	7.38
6	7.49	36.5	27.4	31.97	8.03	0.0803	7.48
7	7.36	57.8	32.1	43.21	-3.21	-0.0321	7.37
8	7.52	33	26.9	29.44	10.56	0.1056	7.51



9	7.33	62	32.7	45.50	-5.50	-0.0550	7.34
10	7.36	61	34.5	42.43	-2.43	-0.0243	7.38
11	7.38	34	20.1	40.60	-0.60	-0.0060	7.39
12	7.49	31	23.6	31.53	8.47	0.0847	7.48
13	7.36	62	35	42.51	-2.51	-0.0251	7.37
14	7.33	50	26.4	45.45	-5.45	-0.0545	7.35
15	7.3	72	35.4	48.81	-8.81	-0.0881	7.31
16	7.41	40	25.4	37.80	2.20	0.0220	7.42
17	7.26	19	8.5	53.65	-13.65	-0.1365	7.26
18	7.38	41	24.3	40.49	-0.49	-0.0049	7.40
19	7.48	28	20.9	32.15	7.85	0.0785	7.48
20	7.52	24	19.6	29.39	10.61	0.1061	7.51
21	7.44	29	19.7	35.33	4.67	0.0467	7.45
22	7.29	75	36.1	49.86	-9.86	-0.0986	7.30
23	7.45	36	25	34.56	5.44	0.0544	7.45
24	7.41	54	34.2	37.89	2.11	0.0211	7.42
25	7.41	28	17.7	37.97	2.03	0.0203	7.42
26	7.31	104	52.4	47.63	-7.63	-0.0763	7.32
27	7.4	73	45.2	38.76	1.24	0.0124	7.41
28	7.37	37	21.4	41.50	-1.50	-0.0150	7.39
29	7.18	28	10.5	64.00	-24.00	-0.2400	7.16
30	7.46	67	47.7	33.71	6.29	0.0629	7.46
31	7.42	55	35.7	36.97	3.03	0.0303	7.43
32	7.44	32	21.7	35.39	4.61	0.0461	7.45
33	7.41	54	34.2	37.89	2.11	0.0211	7.42
34	7.4	32	19.8	38.79	1.21	0.0121	7.41
35	7.29	21	10.1	49.90	-9.90	-0.0990	7.30
36	7.29	17	8.2	49.76	-9.76	-0.0976	7.30
37	7.31	19	9.6	47.50	-7.50	-0.0750	7.33
38	7.2	42	16.4	61.46	-21.46	-0.2146	7.19
39	7.45	32	22.2	34.59	5.41	0.0541	7.45
40	7.39	47	28.5	39.58	0.42	0.0042	7.40
41	7.35	29	16	43.50	-3.50	-0.0350	7.37
42	7.49	32	24.4	31.48	8.52	0.0852	7.49
43	7.43	44	27.2	38.82	1.18	0.0118	7.41
44	7.49	37	28.2	31.49	8.51	0.0851	7.49
45	7.46	38	27	33.78	6.22	0.0622	7.46
46	7.45	52	36.1	34.57	5.43	0.0543	7.45
47	7.48	29	21.6	32.22	7.78	0.0778	7.48
48	7.4	31	19.2	38.75	1.25	0.0125	7.41
49	7.35	101	55.8	43.44	-3.44	-0.0344	7.37
50	7.44	40	27.2	35.29	4.71	0.0471	7.45
51	7.42	82	53.2	36.99	3.01	0.0301	7.43
52	7.48	31	23.1	32.21	7.79	0.0779	7.48
53	7.42	86	55.8	36.99	3.01	0.0301	7.43
54	7.18	23	8.6	64.19	-24.19	-0.2419	7.16

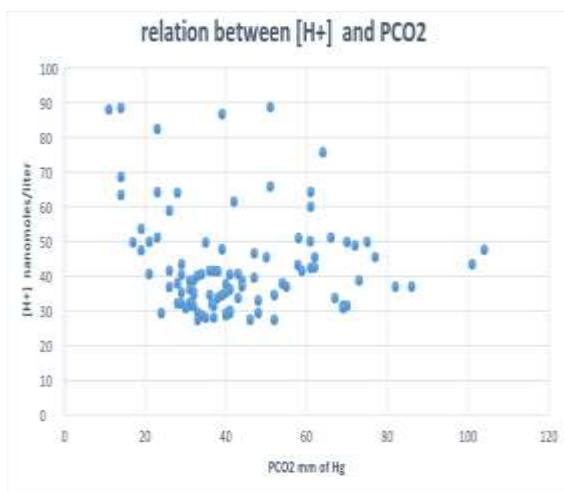
55	7.49	69	52.6	31.48	8.52	0.0852	7.49
56	7.32	47	24.2	46.61	-6.61	-0.0661	7.33
57	7.38	29	17.2	40.47	-0.47	-0.0047	7.40
58	7.45	39	27.1	34.54	5.46	0.0546	7.45
59	7.49	70	53.3	31.52	8.48	0.0848	7.48
60	7.51	41	32.7	30.09	9.91	0.0991	7.50
61	7.21	61	24.4	60.00	-20.00	-0.2000	7.20
62	7.31	39	19.6	47.76	-7.76	-0.0776	7.32
63	7.37	36	20.8	41.54	-1.54	-0.0154	7.38
64	7.53	40	33.4	28.74	11.26	0.1126	7.51
65	7.42	26	16.9	36.92	3.08	0.0308	7.43
66	7.42	44	28.5	37.05	2.95	0.0295	7.43
67	7.38	21	12.4	40.65	-0.65	-0.0065	7.39
68	7.37	38	22	41.45	-1.45	-0.0145	7.39
69	7.29	70	33.7	49.85	-9.85	-0.0985	7.30
70	7.52	40	32.7	29.36	10.64	0.1064	7.51
71	7.54	37	31.6	28.10	11.90	0.1190	7.52
72	7.05	39	10.8	86.67	-46.67	-0.4667	6.93
73	6.97	11	3	88.00	-48.00	-0.4800	6.92
74	7.19	14	5.3	63.40	-23.40	-0.2340	7.17
75	7.28	58	27.3	50.99	-10.99	-0.1099	7.29
76	7.11	64	20.3	75.67	-35.67	-0.3567	7.04
77	7.04	14	3.8	88.42	-48.42	-0.4842	6.92
78	7.18	61	22.8	64.21	-24.21	-0.2421	7.16
79	7.22	26	10.6	58.87	-18.87	-0.1887	7.21
80	7.54	35	29.9	28.09	11.91	0.1191	7.52
81	7.04	51	13.8	88.70	-48.70	-0.4870	6.91
82	7.55	33	28.9	27.40	12.60	0.1260	7.53
83	7.55	46	40.2	27.46	12.54	0.1254	7.53
84	7.29	35	16.9	49.70	-9.70	-0.0970	7.30
85	7.33	77	40.6	45.52	-5.52	-0.0552	7.34
86	7.52	48	39.2	29.39	10.61	0.1061	7.51
87	7.07	23	6.7	82.39	-42.39	-0.4239	6.98
88	7.15	14	4.9	68.57	-28.57	-0.2857	7.11
89	7.46	43	30.6	33.73	6.27	0.0627	7.46
90	7.43	31.1	20.6	36.23	3.77	0.0377	7.44
91	7.38	32.9	19.7	40.08	-0.08	-0.0008	7.40
92	7.37	26	15	41.60	-1.60	-0.0160	7.38
93	7.52	41	33.5	29.37	10.63	0.1063	7.51
94	7.55	52	45.5	27.43	12.57	0.1257	7.53
95	7.28	23	10.8	51.11	-11.11	-0.1111	7.29
96	7.17	51	18.6	65.81	-25.81	-0.2581	7.14
97	7.5	69	53.8	30.78	9.22	0.0922	7.49
98	7.47	48	34.9	33.01	6.99	0.0699	7.47
99	7.28	66	31	51.10	-11.10	-0.1110	7.29
100	7.53	34	28.4	28.73	11.27	0.1127	7.51

**Table 2:** Calculation of bicarbonate/carbonic acid ratio

S.NO	measured pH	PCO2 mm of Hg	HCO3 mmol/L	CALCULATED H+ nanomoles/litre	H2CO3 mmol/L	HCO3/H2CO3 ratio
1	7.43	41	27.2	36.18	1.23	22.11
2	7.5	30	23.4	30.77	0.9	26.00
3	7.38	43	25.4	40.63	1.29	19.69
4	7.29	60.9	29.2	50.05	1.827	15.98
5	7.38	58.8	34	41.51	1.764	19.27
6	7.49	36.5	27.4	31.97	1.095	25.02
7	7.36	57.8	32.1	43.21	1.734	18.51
8	7.52	33	26.9	29.44	0.99	27.17
9	7.33	62	32.7	45.50	1.86	17.58
10	7.36	61	34.5	42.43	1.83	18.85
11	7.38	34	20.1	40.60	1.02	19.71
12	7.49	31	23.6	31.53	0.93	25.38
13	7.36	62	35	42.51	1.86	18.82
14	7.33	50	26.4	45.45	1.5	17.60
15	7.3	72	35.4	48.81	2.16	16.39
16	7.41	40	25.4	37.80	1.2	21.17
17	7.26	19	8.5	53.65	0.57	14.91
18	7.38	41	24.3	40.49	1.23	19.76
19	7.48	28	20.9	32.15	0.84	24.88
20	7.52	24	19.6	29.39	0.72	27.22
21	7.44	29	19.7	35.33	0.87	22.64
22	7.29	75	36.1	49.86	2.25	16.04
23	7.45	36	25	34.56	1.08	23.15
24	7.41	54	34.2	37.89	1.62	21.11
25	7.41	28	17.7	37.97	0.84	21.07
26	7.31	104	52.4	47.63	3.12	16.79
27	7.4	73	45.2	38.76	2.19	20.64
28	7.37	37	21.4	41.50	1.11	19.28
29	7.18	28	10.5	64.00	0.84	12.50
30	7.46	67	47.7	33.71	2.01	23.73
31	7.42	55	35.7	36.97	1.65	21.64
32	7.44	32	21.7	35.39	0.96	22.60
33	7.41	54	34.2	37.89	1.62	21.11
34	7.4	32	19.8	38.79	0.96	20.63
35	7.29	21	10.1	49.90	0.63	16.03
36	7.29	17	8.2	49.76	0.51	16.08
37	7.31	19	9.6	47.50	0.57	16.84
38	7.2	42	16.4	61.46	1.26	13.02
39	7.45	32	22.2	34.59	0.96	23.13
40	7.39	47	28.5	39.58	1.41	20.21
41	7.35	29	16	43.50	0.87	18.39
42	7.49	32	24.4	31.48	0.96	25.42

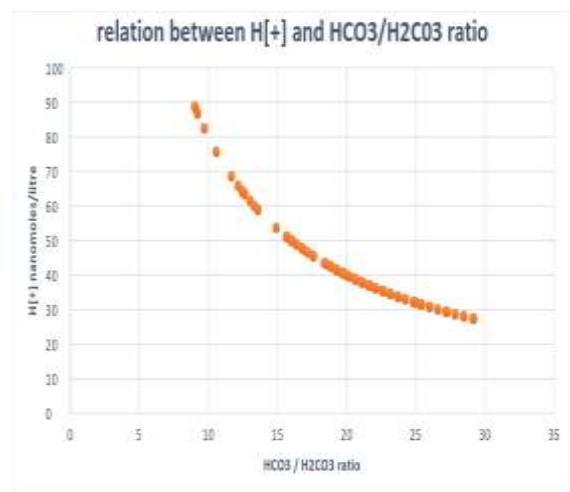
43	7.43	44	27.2	38.82	1.32	20.61
44	7.49	37	28.2	31.49	1.11	25.41
45	7.46	38	27	33.78	1.14	23.68
46	7.45	52	36.1	34.57	1.56	23.14
47	7.48	29	21.6	32.22	0.87	24.83
48	7.4	31	19.2	38.75	0.93	20.65
49	7.35	101	55.8	43.44	3.03	18.42
50	7.44	40	27.2	35.29	1.2	22.67
51	7.42	82	53.2	36.99	2.46	21.63
52	7.48	31	23.1	32.21	0.93	24.84
53	7.42	86	55.8	36.99	2.58	21.63
54	7.18	23	8.6	64.19	0.69	12.46
55	7.49	69	52.6	31.48	2.07	25.41
56	7.32	47	24.2	46.61	1.41	17.16
57	7.38	29	17.2	40.47	0.87	19.77
58	7.45	39	27.1	34.54	1.17	23.16
59	7.49	70	53.3	31.52	2.1	25.38
60	7.51	41	32.7	30.09	1.23	26.59
61	7.21	61	24.4	60.00	1.83	13.33
62	7.31	39	19.6	47.76	1.17	16.75
63	7.37	36	20.8	41.54	1.08	19.26
64	7.53	40	33.4	28.74	1.2	27.83
65	7.42	26	16.9	36.92	0.78	21.67
66	7.42	44	28.5	37.05	1.32	21.59
67	7.38	21	12.4	40.65	0.63	19.68
68	7.37	38	22	41.45	1.14	19.30
69	7.29	70	33.7	49.85	2.1	16.05
70	7.52	40	32.7	29.36	1.2	27.25
71	7.54	37	31.6	28.10	1.11	28.47
72	7.05	39	10.8	86.67	1.17	9.23
73	6.97	11	3	88.00	0.33	9.09
74	7.19	14	5.3	63.40	0.42	12.62
75	7.28	58	27.3	50.99	1.74	15.69
76	7.11	64	20.3	75.67	1.92	10.57
77	7.04	14	3.8	88.42	0.42	9.05
78	7.18	61	22.8	64.21	1.83	12.46
79	7.22	26	10.6	58.87	0.78	13.59
80	7.54	35	29.9	28.09	1.05	28.48
81	7.04	51	13.8	88.70	1.53	9.02
82	7.55	33	28.9	27.40	0.99	29.19
83	7.55	46	40.2	27.46	1.38	29.13
84	7.29	35	16.9	49.70	1.05	16.10
85	7.33	77	40.6	45.52	2.31	17.58
86	7.52	48	39.2	29.39	1.44	27.22
87	7.07	23	6.7	82.39	0.69	9.71
88	7.15	14	4.9	68.57	0.42	11.67

89	7.46	43	30.6	33.73	1.29	23.72
90	7.43	31.1	20.6	36.23	0.933	22.08
91	7.38	32.9	19.7	40.08	0.987	19.96
92	7.37	26	15	41.60	0.78	19.23
93	7.52	41	33.5	29.37	1.23	27.24
94	7.55	52	45.5	27.43	1.56	29.17
95	7.28	23	10.8	51.11	0.69	15.65
96	7.17	51	18.6	65.81	1.53	12.16
97	7.5	69	53.8	30.78	2.07	25.99
98	7.47	48	34.9	33.01	1.44	24.24
99	7.28	66	31	51.10	1.98	15.66
100	7.53	34	28.4	28.73	1.02	27.84



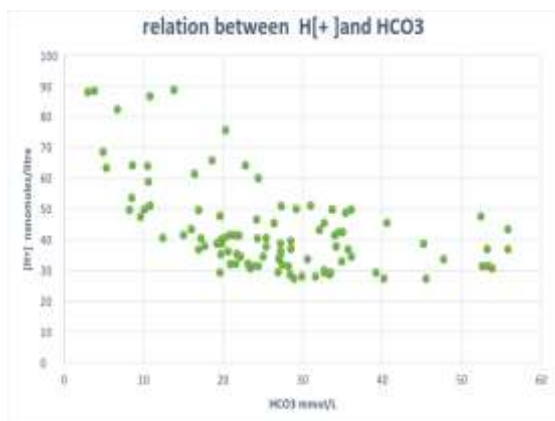
**Graph 1**

The PCO<sub>2</sub> values in mm of Hg are taken in X: axis and hydrogen ion concentration values are taken in Y: axis.



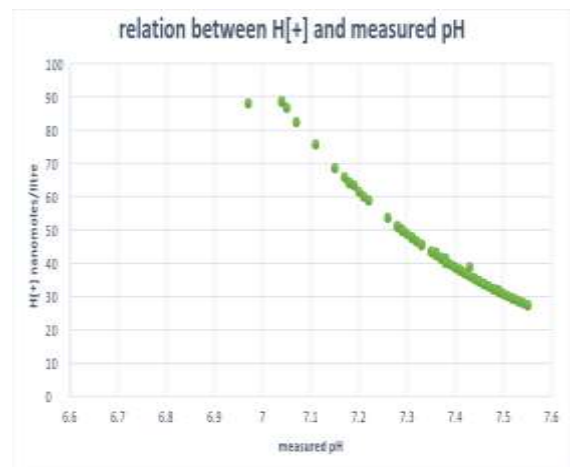
**Graph 3**

The HCO<sub>3</sub> / H<sub>2</sub>CO<sub>3</sub> ratio values are taken in X: axis and hydrogen ion concentration values are taken in Y: axis.



**Graph 2**

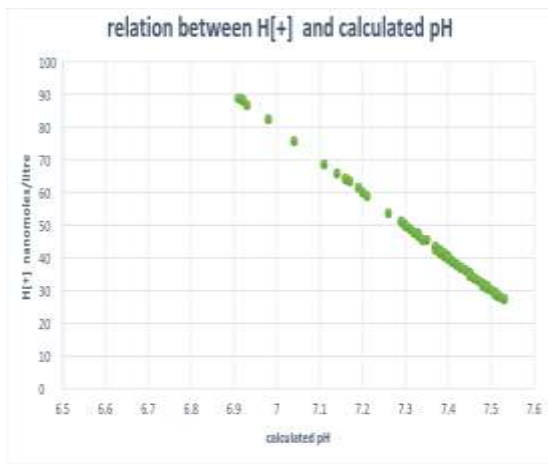
The HCO<sub>3</sub> concentration values are taken in X: axis and hydrogen ion concentration values are taken in Y: axis.



**Graph 4**

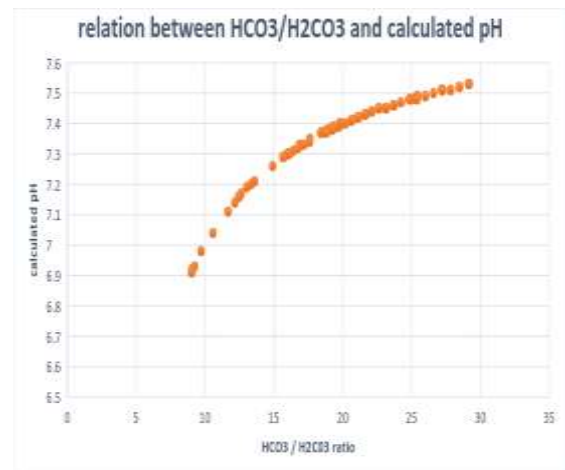
The measured pH values are taken in X: axis and hydrogen ion concentration values are taken in Y: axis.





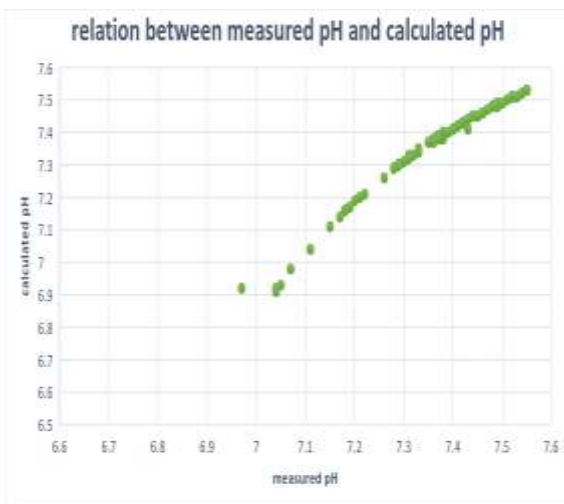
**Graph 5**

The calculated pH values are taken in X: axis and hydrogen ion concentration values are taken in Y: axis.



**Graph 8**

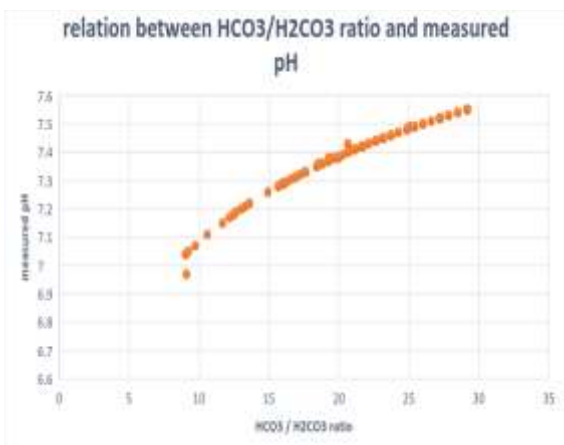
The HCO<sub>3</sub>/H<sub>2</sub>CO<sub>3</sub> values are taken in X: axis and calculated pH values are taken in Y: axis.



**Graph 6**

The measured pH values are taken in X: axis and calculated pH values are taken in Y: axis.

It is clear that the measured pH values and calculated pH values are similar.



**Graph 7**

The HCO<sub>3</sub> / H<sub>2</sub>CO<sub>3</sub> values are taken in X: axis and measured pH values are taken in Y:axis.

**DISCUSSION**

The process of analysis and monitoring of arterial blood gas (ABG) is an essential part of diagnosing and managing the oxygenation status and acid–base balance of the high-risk patients, as well as in the care of critically ill patients in the Intensive Care Unit.<sup>1-4</sup>

So, a thorough understanding of acid–base balance is mandatory for any physician. However, the understanding of ABGs and their interpretation can sometimes be very confusing.

For rapid and accurate interpretation of ABG, first we should make sure that the sample is arterial and not a venous blood.<sup>5-9</sup> The best way to do this is to observe how the blood comes back into the blood gas syringe as the sample is drawn. Pulsatile flow is seen with an arterial sample but would be lacking with a venous sample.

Similarly, arterial samples usually fill the syringe quickly, while venous samples move much more slowly into the syringe. We cannot always rely on the colour of the blood to tell that it is arterial because a very hypoxemic patient will have dark, "venous-appearing" blood. We should make sure that there are no measurement errors and this can be done by Modified Henderson Equation.<sup>10,11</sup>

Before making an interpretation of an ABG it is always good to check for the consistency of the report by the Modified Henderson Equation. The equation is used to calculate the pH that we would expect based on the measured PCO<sub>2</sub> and HCO<sub>3</sub><sup>-</sup>. This pH is then compared to the measured pH. If the values are similar, the sample is valid and if the values are far apart, there may be a measurement error.

In our current study, 100 ABG samples are analysed. The modified Henderson equation is used to calculate the hydrogen ion concentration and from that pH is calculated. This pH is then compared to the measured pH which is shown in table 1.



We have seen that the measured pH and calculated pH values are similar which is shown in graph 6. Thus the modified Henderson equation can be applied to check for the consistency of the ABG report before ABG interpretation.<sup>12-15</sup> We calculated the bicarbonate and carbonic acid ratio which is shown in table 2.

It is found there is no clear relationship between hydrogen ion concentration and partial pressure of carbon dioxide (PCO<sub>2</sub>) values (graph 1) and hydrogen ion concentration and bicarbonate concentration values (graph 2).

From the graph 3, it is very clear that the hydrogen ion concentration and bicarbonate/carbonic acid ratio values are inversely related. As the ratio increases, the hydrogen ion concentration decreases and vice versa. Graph 4 and graph 5 shows that the hydrogen ion concentration is inversely related to the pH (both measured and calculated pH).

The pH values and the bicarbonate carbonic acid ratio is directly related. As the bicarbonate carbonic acid ratio increases, the pH also increases and as the bicarbonate carbonic acid ratio decreases, the pH also decreases which is shown in graph 7 and 8.

## CONCLUSION

Arterial blood gas analysis is very essential in emergency and critical conditions.<sup>1-4</sup> The correct interpretation of ABG report is very essential in timely management of critically ill patients. ABG analysis is subjected to pre-analytical and analytical errors.<sup>5-9</sup>

We conclude our study by saying that before the ABG interpretation is done we should make sure that there are no measurement errors. It is always good to check for the consistency of the report by the modified Henderson equation.<sup>10,11</sup>

The bicarbonate/carbonic acid ratio and calculated hydrogen ion concentration parameters provide a better understanding of the arterial blood gas analysis. This will help not only in interpretation of the ABG data but also in timely management of critically ill patients.<sup>12-15</sup>

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Source of Support: Nil, Conflict of Interest: None.

