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A Comparative Study of Arterial and Venous Blood Gas Analysis in Critically Ill Patients

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ABSTRACT

Background: Measurement of blood gases is increasingly becoming an essential part of diagnosis, management and monitoring of critically ill patients. In our study we used PVBG and four variables po2, pc02, hco3 and ph of PVBG was compared with ABG and their agreement and correlation assessed.

Objective: To study the relationship between ABG and VBG in critically ill patients and to assess the usefulness of VBG as a surrogate for ABG in the initial management of critically ill patients.

Methodology: 100 random patients who were considered critically ill based on SOFA score value >/ = 7 admitted in GRMC, Gwalior were taken. P value <0.05 was taken as significant. IBM SPSS was used for analysis.

Results: The pHA and pHV shows good correlation and agreement (mean difference is 0.04 (p<o.000) Correlation coefficient is 0.832.(p<0.000) 95% limits of agreement are -0.2 to .16 mm Hg). pCO2 A and pCO2V shows good correlation and agreement (mean difference is about 5.7 mmHg (P<0.000),Pearsons correlation coefficient is 0.916.(p <0.000) , 95% limits of agreement is -16 to 4mm Hg). HCO3A and HCO3V shows good agreement and correlation(mean difference between hco3A and hco3V is 1.22(p<0.001), Pearsons correlation coefficient is 0.960 (p<0.000) ,95% limits of agreement is from 6 to -8 mmHg). pO2A and pO2V shows poor correlation and agreement (mean difference is 55.191 (p <0.000),Pearsons correlation coefficient is 0.166 (p< 0.099),95% limit of agreement is 4 to 120 mmHg).

Conclusion: In our study we found that there is excellent agreement between pH, pCO2 and HCO3 between ABG and VBG in critically ill patients.. The agreement between arterial and venous pO2 is very poor and venous pO2 cannot be reliably used instead of arterial value.

Keywords: *ABG, VBG, pH ,pCO2, pO2 , Bicarbonate.*

INTRODUCTION

Measurement of blood gases is increasingly becoming an essential part of diagnosis, management and monitoring of critically ill patients. Because of poor patient tolerance and requirement of a higher degree of skill there was always a search for a viable alternative which was less risky , patient friendly and required lesser skill. A lot of studies were conducted using peripheral venous blood gas, central venous blood gas, finger prick capillary blood with or without spo2 measurement. In our study we used PVBG and four variables pO2, pCO2, HCO3 and pH of PVBG was compared with ABG and their agreement and correlation assessed. Patients who were critically ill and with different pathophysiologies were taken randomly for the study.Peripheral venous blood gas (PVBG) analysis was first described as an alternative to ABG sampling by Dautrebande, Davis and Meakins in 1923 when they measured

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the CO_2 content of venous blood obtained from the basilica vein in four experiments and found a close correlation with that of arterial blood if the hand was immersed in hot water .[1] Most of the studies have showed a good agreement between arterial and venous values especially between pH , pCO2 and HCO3 and poor agreement between pO2. A handful of studies have questioned the agreement between arterial and venous values. Two studies in mechanically ventilated patients concluded that pH ,pCO2 and base excess have not sufficient clinical equivalence and PVBG cannot replace ABG in mechanically ventilated patients. [2] Most of the studies seem to agree that pH and hco3 show a high degree of agreement. Agreement between arterial and venous pCO2 is disputed. Almost all studies show poor agreement between arterial and venous pO2. PVBG has been in many cases proposed as a suitable screening test for acidosis and hypercapnia , acid- base disorders. [3,4] Major advantage of PVBG is the ease with which sampling can be done. Successive arterial sampling is very difficult. So a role may be seen in patient monitoring to assess improvement or deterioration during treatment as successive sampling is easier.It may prove difficult to find a uniform relation between abg and vbg as the underlying pathology changes like differential co2 unloading at tissue level in different conditions can lead to differing relationship between ABG and VBG. In patients with circulatory collapse with slow venous return the PCO2V may be more than expected from the arterial pco2 and vice versa. Also O2 consumption immediately distal to sampling site- changes affinity of Hb for CO2 [Haldane effect].

METHODS AND METHODOLOGY

Study Centre: Gajra Raja Medical College and JA Group of Hospitals, Gwalior

Sample size: 100 patients.

Duration of Study: February 2016 to September 2017

Study Design: Prospective

Inclusion Criteria:

Individual of either sex with age >18 years presenting to Medicine ICU/Ward who fulfill the criteria for critically ill patients in whom ABG is deemed to be necessary.

Critical illness was defined arbitrarily as SOFA score >/7.

Exclusion criteria:

Patients in whom treatment had been initiated in the ICU/WARD and those who do not meet the criteria for critically ill patients (SOFA score <7) were excluded from the study.

Patients who did not give consent were excluded from the study.

In unconscious patients consent was taken from patients attendants.

All the data were analyzed using IBM SPSS Ver. 20 software. Data were expressed as percentage and mean±SD. The data was analyzed with "the independent samples t-test." This was significant if the p-value is <0.05.

FINDINGS

Mean age of study population was 52.12±1.98 years which range from 16-98 years. Most of the patients belong to the age group of 51-60 years [26 (26%)] followed by 61-70 years [19 (19%)] Majority of the patients were males [(65%)].

In our study the most common presenting diagnosis was renal disorder (34%). Other disorders like respiratory (12%), cvs(12%), neurological(18%), metabolic conditions(13%),hepatic(11%) were also included

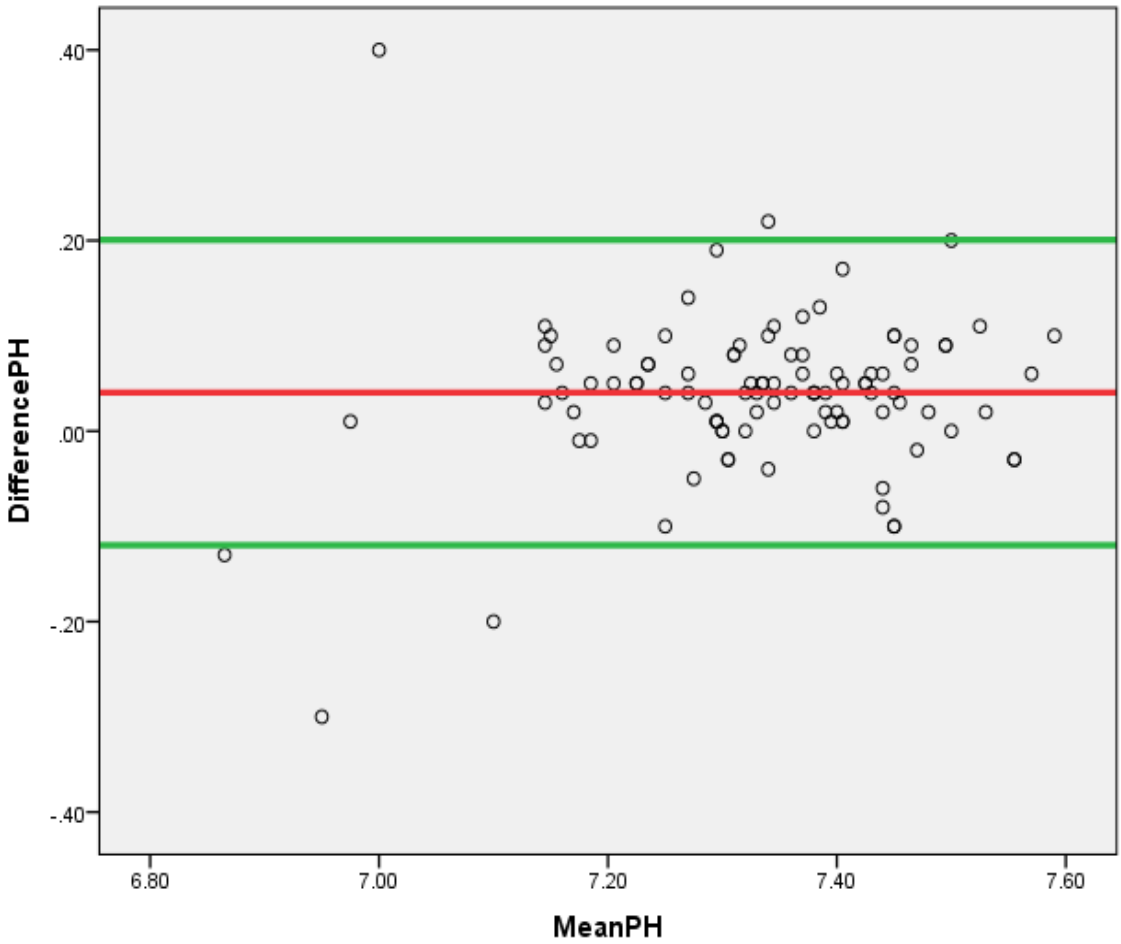
Comparison of pHA and pHV

Table 1: Comparing pH of artery and pH of vein in study cohort

Mean		Paired Differences					t	df	P Value
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 1	ApH - VpH	.04040	.08176	.00818	.02418	.05662	4.941	99	.000

Comparison of arterial and venous pH was significant (7.353±0.145vs7.3131±0.135) (p=0.000) with pHV<pHA with a bias of 0.04.

The correlation coefficient between pHA and pHV is 0.832 with a p value of 0.000.



Graph 1 : Bland-Altman comparing difference and mean of pH in arterial and venous blood Comparison of pO2A and pO2V

The pO2 between artery and vein was significantly different (p<0.001). pO2 of artery (95.194±39.06) was higher compared to vein (40.03±12.79)

Correlation coefficient between pO2A and pO2V is 0.166 with a pvalue of 0.099 .

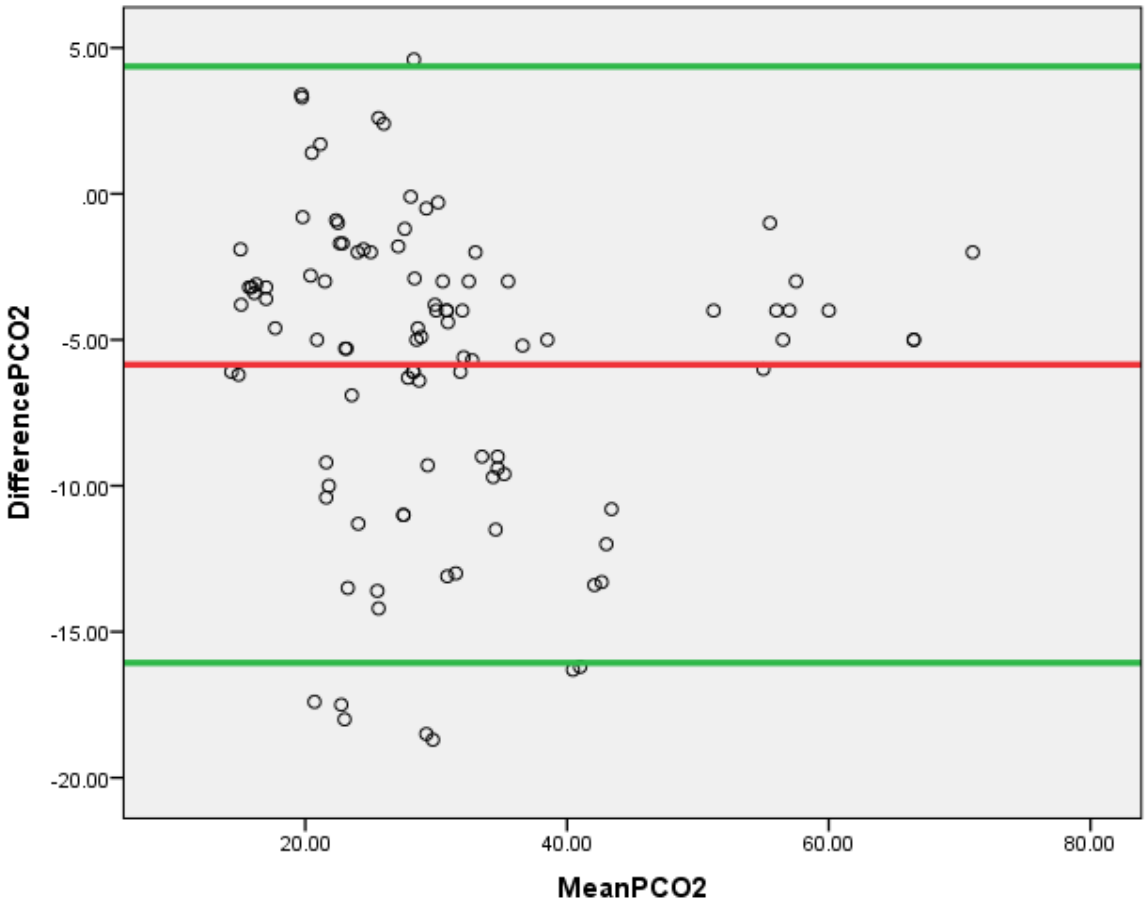
Comparison of pCO2A and pCO2V

Table 2 : Comparing pCO2 of artery and pCO2 of vein in study cohort

Mean		Paired Differences					t	df	P Value
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 1	ApCO2 - VpCO2	-5.8510000E0	5.2124462	.5212446	-6.8852624	-4.8167376	-11.225	99	.000

pCO2 of artery and vein was comparable (27.64±12.37 vs 33.49±12.76; p=0.000) showing pCO2A is significantly lower than pCO2V.

Correlation coefficient between pCO2A and pCO2V is 0.915 with p value 0.000.



Graph 2 : Bland-Altman study comparing difference and mean pCO2 in ABG and VBG

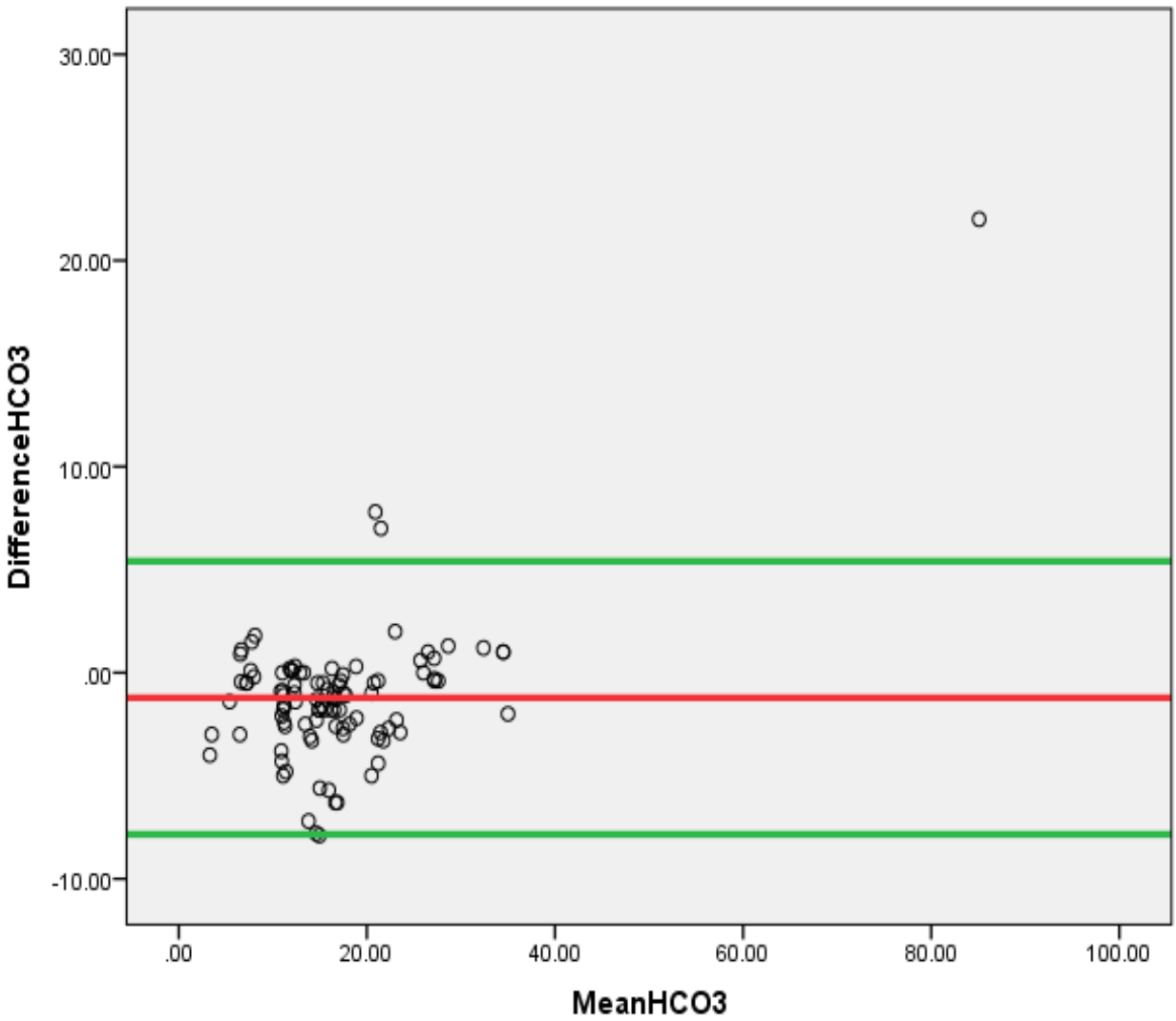
Comparison of HCO3A and HCO3V

Table 3 :Comparing HCO3A of artery and HCO3Vof vein in study cohort

Mean		Paired Differences					t	df	P Value
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
Pair 1	AHCO3 - VHCO3	-1.2164000	3.3794846	.3379485	-1.8869631	-.5458369	-3.599	99	.001

HCO3 of artery and vein was comparable (16.25±10.71vs 17.47±8.73; p=0.001 with HCO3A significantly higher than HCO3V.

Correlation coefficient between HCO3A and HCO3V is 0.960 with a pvalue of 0.000.



Graph 3: Bland-Altman study comparison Of HCO3A and HCO3V In Patients

DISCUSSION

The pH showed a mean arterial – venous diff of 0.04 with a p value of 0.000. This shows that arterial pH is slightly more than venous pH. The Pearson correlation coefficient between arterial and venous pH is o.832 which shows a very good positive correlation. Bland Altman analysis showed 95% diff interval from 0.2 -0.16. This can be taken as a reasonable degree of agreement. Tricia Mckeever[5] conducted a study in COPD patients with RF. The study showed good correlation and agreements between pH arterial and pH venous with mean diff of 0.03 and LOA between 0.54 to -.11. Arterial sampling is more difficult than venous and requires more skill. Agreements could allow initial evaluation of COPD based on VBG and spo2 and VBG can be used as a screening test. Kim et al conducted a study of patients admitted in ICU. 151 paired samples were used.[4] Mean A- V difference 0.03 +/- 0.050 with a 95% limit of agreement of -.184 to o.311 shows a good agreement. Peripheral venous pH may be used as an alternative to arterial ph in ICU. Such use reduces the number of arterial punctures needed.

In our study comparison between arterial and venous bicarbonate showed a mean difference of - 1.22 with p value of 0.001. This shows that venous hco3 is slightly more than arterial bicarbonate. The Pearson correlation coefficient between arterial and venous values is 0.960 showing a very high positive correlation. Bland Altman analysis shows 95% difference interval between 6 to -8. This shows a very good degree of agreement .Kim etal[4] – study done in ICU patients. Mean A-V diff -1+/-2.75 shows good agreement with 95% LOA between 0.429 to 0.242. The agreement is excellent and venous hco3 can replace arterial bicarbonate. Tricia McKeever[5] – good agreements between HCO3 arterial and venous with mean diff 0.04 with LOA -2.90 to 2.82. Venous HCO3 shows good correlation and agreement with arterial hco3 and can be used as a screening evaluation.

In our study comparison between arterial and venous pco2 shows a mean difference of -5.85 with a p value < 0.000 which shows venous pCO_2 more than arterial pCO_2.The Pearson correlation coefficient between arterial and venous values is 0.916 which shows a very good positive correlation. Bland Altman analysis shows a 95% difference interval ranges from -16 t0 4 mm Hg .The pCO2A and V shows good correlation and the limits of agreement are good enough to be considered as an initial screening test.

Kim etal[4] – mean A- V diff -.54 with LOA of -0.328 to - 0.006.shows good agreement.pCO_2V can replace pCO_2A.Gupta etal[6]pCO_2 A and V shows significant difference in their means. pCO_2 A and V shows good agreement with each other and pCO_2V can replace pCO_2A in ED.

Comparison between arterial and venous pO2 shows a mean difference of 55.191 mmHg with a p value < 0.000 showing arterial value much higher than venous value. The Pearson correlation coefficient is 0.166 which shows very poor positive correlation. Bland Altman analysis shows 95% difference intervals ranges from 4 to 120 mm Hg. All studies show significant difference in pO2A and pO2V with very poor correlation. A study by Malatesha etal[7] of patients admitted in the ED of AIIMS shows a very poor agreement between arterial and venous pCO_2 with limits of agreement between 145.3 to -32.9.[7] The agreement is very poor and venous pO_2 cannot be used as a surrogate for arterial pO_2. A meta analysis by Byrne et al[8] shows pO2A – pO22V as around 36.9 mm Hg and the summary credible interval was -2.5 to 76.3 mmHg. pO2V cannot substitute for pO_2A.

CONCLUSION

In our study we found that there is excellent agreement of pH and HCO_3betweenABG and VBG in critically ill patients.

The agreement between arterial and venous pCO_2 was good and venous pCo_2 may be used as a screening test in the initial management of patients.

The agreement between arterial and venous pO2is very poor and venous pO2cannot be reliably used instead of arterial value.

The agreement of pH and HCO_3 between ABG and VBG may be stronger in primarily metabolic disorders like renal disorders.

Conflict of Interest Statement

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other

equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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