

# Topic role of venous blood gases in patients of acute breathlessness presenting in emergency department

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## Abstract

In emergency departments, blood gas analysis is used for two main purposes: establishing acid-base state (mainly pH but also bicarbonate) and assessing respiratory function (mainly pCO<sub>2</sub> but also pH and to a lesser extent pO<sub>2</sub>). The discomfort and possible risks for the patient during this procedure should not be overlooked. Research states the difference in pain experience between arterial and venous punctures and found arterial puncture to be significantly more painful than venous puncture. This test can result in patient discomfort as well as complications such as arterial injury, thrombosis or embolization, hematoma, aneurysm formation, and reflex sympathetic dystrophy. Venous blood sampling is usually easier, less painful and more convenient. The aim is to determine the agreement for pH, pCO<sub>2</sub>, bicarbonate and base excess between arterial and venous blood samples and to identify unanswered questions in agreement between arterial and venous blood gas parameters. The main objective of this study is to examine the agreement between ABG and VBG samples for all commonly used parameters (pH, PCO<sub>2</sub>, and bicarbonate) in acute breathless patients, specifically analyzing multiple paired arterial and venous samples from each patient.

**Key Word:** venous blood gases.

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Received Date: 13/05/2019 Revised Date: 06/06/2019 Accepted Date: 10/07/2019

DOI: <https://doi.org/10.26611/101511119>

## Access this article online

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Accessed Date:  
29 July 2019

## INTRODUCTION

Historically, values obtained via VBG have been criticized for a perceived lack of accuracy in all domains, however the fact is that increasing data shows that for most clinical indications, data from VBG correlates well, and are just as useful as that from ABG. While arterial punctures are not only painful but also cause thrombus,

emboli, hematoma and predispose aneurysm formation, VBGs carry less risk of vascular injury, nerve damage, and cause much less pain to the patient along with lower risk for accidental needle-sticks as compared to ABGs.

Several studies have looked at the correlation between values obtained with VBG and compared them to ABGs

- Zeserson *et al* conducted a prospective cohort study of 156 critically ill patients in the ED and ICU setting to evaluate the correlation between pH and pCO<sub>2</sub> when derived from ABG vs VBG with added pulse oximetry for estimating PaO<sub>2</sub> and concluded that arterial and venous pH and PCO<sub>2</sub> had good correlation.

(Zeserson E, Goodgame B, Hess JD, Schultz K, Hoon C, Lamb K, Maheshwari V, Johnson S, Papas M, Reed J, Breyer M. Correlation of Venous Blood Gas and Pulse Oximetry With Arterial Blood Gas in the Undifferentiated Critically Ill Patient. *J Intensive Care Med.* 2016 Jun 9).

**How to cite this article:** Deepali Rajpal, Utkarsh Khandelwal, Manhar Shah, Manu Mathew Lal. Topic role of venous blood gases in patients of acute breathlessness presenting in emergency department. *MedPulse International Journal of Anesthesiology.* July 2019; 11(1): 94-98. <http://medpulse.in/Anesthesiology/index.php>

- Byrne et al conducted a meta – analysis of 1768 subjects from 18 individual studies and found that peripheral VBG correlates well with ABG with respect to pH but found an unacceptably wide 95% prediction interval when looking at the pCO<sub>2</sub>. (Byrne, A. L., Bennett, M., Chatterji, R., Symons, R., Pace, N. L. and Thomas, P. S. (2014), Peripheral venous and arterial blood gas analysis in adults: are they comparable? A systematic review and meta-analysis. *Respirology*, 19: 168–175.
- A review article by Kelly AM summarized data comparing ABG and peripheral VBG variables in ED all-comers also concluded that venous pH had sufficient agreement however concluded with a word of caution: there is no data to support that this correlation is maintained in shock states. (Kelly AM, McAlpine R, Kyle E. Venous pH can safely replace arterial pH in the initial evaluation of patients in the emergency department. *Emerg Med J*. 2001)

For most parameters, there is good correlation. However, there are a few important scenarios that may be exceptions. Not surprisingly, the major exception is PO<sub>2</sub>; venous PO<sub>2</sub> readings do not correlate well with arterial PO<sub>2</sub>. A workaround to this limitation is to estimate arterial oxygenation using SpO<sub>2</sub>. The VBG analysis plus SpO<sub>2</sub> provided accurate information on acid–base, ventilation, and oxygenation status for patients in undifferentiated patients ED and ICU  
 We decided to compare venous blood gas assessments for variables such as pH, pCO<sub>2</sub>, bicarbonate and base excess between arterial and venous blood samples.

## MATERIAL AND METHODS

This Prospective study was conducted at Dr. D.Y.Patil Medical College, Hospital and Research Centre, Nerul, Navi Mumbai by Department Of Emergency Medicine

**Study design:** Cross sectional studies (with exclusion)

**Study duration:** 2 years

**Eligibility Criteria:**

**Inclusion Criteria** – Age above 12 years of either sex Male/Female.

**Exclusion Criteria** – Age below 12 years of either sex Male/Female.

**Sample size:** 50

## DISCUSSION

In evaluating the agreement between arterial and venous blood gas values in the emergency department we conducted the study which took place in an emergency department setting, and comparison between arterial and venous values were made if the treating physician deemed it necessary that an arterial blood sample was obtained.

**PH:** The study conducted at our emergency department has shown an agreement between the ABG and VBG pH values, the values has been grouped in the table below. The values has been reviewed and compared with the other studies conducted elsewhere. We listed the studies we reviewed in table below, representing the number of subjects each study

## OBSERVATIONS AND RESULTS

**Table 1:**

Parameter	Mean	SD
RR (bpm)	31.1	9.7

Its observed that the mean respiratory rate of the study conducted came out to be 31.1 breaths per minute.

**Table 2:**

Parameter	Mean	SD
SpO <sub>2</sub>	89.4	12.0

The mean SpO<sub>2</sub> of the patients observed to be 89.4 at room air.

**Table 3: Comparison of pH**

Method	Mean	SD	Difference	P value
ABG	7.39	0.17	0.06	0.021 (NS); Paired T Test
VBG	7.33	0.16		

The mean pH in arterial blood came out to be 7.39. The mean pH of venous sample observed to be 7.33 The difference between the pH of both the samples is 0.06 with p value of .021.

**Table 4: Comparison of PCo<sub>2</sub>**

Method	Mean	SD	Difference	P value
ABG	32.05	17.9	-7.47	0.087 (NS); Paired T Test
VBG	39.52	18.1		

The mean pCO<sub>2</sub> values of arterial blood observed to be 32.05 The mean pCO<sub>2</sub> value of the venous blood samples was observed to be 39.52 The difference between the mean pCO<sub>2</sub> values of both arterial and venous samples observed to be -7.47.

**Table 5: Comparison of HCo<sub>3</sub>**

Method	Mean	SD	Difference	P value
ABG	17.79	6.3	-2.25	0.10 (NS); Paired T Test
VBG	20.05	5.2		

The mean arterial HCO<sub>3</sub> level in the sample came out to be 17.79 The mean venous HCO<sub>3</sub> value in the sample came out to be 20.05 The difference between the mean of arterial and venous HCO<sub>3</sub> level is -2.25

**Table 6: Comparison of PO<sub>2</sub>**

Method	Mean	SD	Difference	P value
ABG	91.74	9.0	26.2	0.0012 (S); Paired T Test
VBG	64.45	17.2		

The mean PO<sub>2</sub> level of arterial blood came out to be 91.74. The mean PO<sub>2</sub> level of venous blood came out to be 64.45. The difference between the mean values of the PO<sub>2</sub> level of both arterial and venous sample came out to be 26.2.

researched, the blood gas values for which a comparison has been made and the clinical presentation of the researched patients. We grouped the findings for each included study in table below, which represents the values for mean arterial pH, mean venous pH, mean difference between arterial and venous pH and degree of correlation (r value).

Study	Mean arterial pH	Mean venous pH	Mean pH difference	95% limits of agreement
Rang <i>et al.</i> (5)	7.39	7.35	0.036	-0.05 to 0.05
Gennis <i>et al.</i> (23)	7.40	7.35	0.056	NS
Kelly <i>et al.</i> (3)	7.38	NS	.04	-0.11 to 0.04
Malatesha <i>et al.</i> (4)	7.384	7.369	NS	-0.1 to 0.13
My study	7.39	7.33	0.06	-0.06 to 0.06

Pooled data analysis (n=635) showed us a mean difference between venous and arterial pH of 0.043 pH units and in the three studies reporting 95% limits of agreement the ranges went from -0.11 to 0.13 pH unit

**HCO<sub>3</sub>**: The study conducted at our emergency department has shown an agreement between the ABG and VBG HCO<sub>3</sub> values, the values has been grouped in the table below. The values has been reviewed and compared with the other studies conducted elsewhere. In reviewing the value of venous HCO<sub>3</sub> in the emergency department setting we selected four studies which were compatible with our inclusion criteria and addressed our research question.

Study	Mean arterial HCO <sub>3</sub>	Mean venous HCO <sub>3</sub>	Mean HCO <sub>3</sub> difference	95% limits of agreement
Rang <i>et al.</i> (5)	22.6	24.0	1.5	-3.5 to 3.5
Gennis <i>et al.</i> (23)	23.72	24.93	1.21	NS
Kelly <i>et al.</i> (3)	28.86	NS	1.2	-5.13 to 2.73
Malatesha <i>et al.</i> (4)	23.58	24.32	NS	-5.8 to 4.3
My study	17.79	20.05	-2.25	-4.5 to 4.5

Pooled data analysis reveals a mean HCO<sub>3</sub> difference of 1.51 mmol/l and three studies reporting agreement between arterial and venous pH report 95% limits of agreement ranging from -5.13 to 4.3 mmol/l hypercarbia

**pCO<sub>2</sub>**: The study conducted at our emergency department has shown an agreement between the ABG and VBG pCO<sub>2</sub> values, the values has been grouped in the table below. The values has been reviewed and compared with the other studies conducted elsewhere in comparing venous to arterial pCO<sub>2</sub>. We selected 4 studies which applied to our research criteria. All the researched values will be expressed in mmHg unless stated otherwise. We summarized the reviewed results in table below and calculated the pooled mean differences between arterial and venous pCO<sub>2</sub>

Study	Mean arterial pCO <sub>2</sub>	Mean venous pCO <sub>2</sub>	Mean pCO <sub>2</sub> difference	95% limits of agreement
Rang <i>et al.</i> (8)	43.5	49.6	6.0	-6.6 to 6.6
Gennis <i>et al.</i> (23)	36.61	46.99	7.38	NS
Ibrahim <i>et al.</i> (7)	41.8	45	3.3	-17.4 to 23.9
Malatesha <i>et al.</i> (4)	39	42	8	-7.6 to 6.8
My study	32.05	39.52	-7.47	-6.7 to 6.7

Pooled data analysis shows a pooled mean difference between venous and arterial pCO<sub>2</sub> of 6.16 mmHg and three studies reported 95% limits of agreement ranging from -17.4 to 23.9 mmHg.

**Arterial versus venous blood gas analysis:** Arterial puncture is commonly used in the emergency department to evaluate the acid-base and respiratory status of the patient. The discomfort and possible risks for the patient during this procedure should not be overlooked. A systematic study performed on 271 patients by Giner *et al.* researched the difference in pain experience between arterial and venous punctures and found arterial puncture to be significantly more painful than venous puncture. In their research, venous blood gas was also retrieved more successful on first attempt. In another study on patient experience in the intensive care unit (ICU) arterial puncture was reported as the

most frequent unpleasant experience. We found several studies reporting on the possible complications of arterial puncture. One case report mentioned the development of a large false aneurysm of the radial artery leading to compartment syndrome of the forearm due to repeated arterial punctures on the same site. In another report severe edema and ischemia occurred six hours after arterial puncture and was only corrected after surgical intervention. We wanted to find out the relative occurrence of these complications and found one study reporting on this topic. Mortensen *et al.* performed a study on 2360 patients of whom complete hospital records were available up to 24 hours after

arterial puncture. They found a total complication rate of 13% of which 2.6% were major complications, which was defined as arterial puncture ending in long-term functional impairment, additional hospitalization or fatal complications. They stressed that most of the minor complications due to arterial puncture go unnoticed due to inadequate follow-up observations and therefore the incidence in clinical practice seems lower than it actually is. In their study they also researched predisposing factors in developing complications and found among other things that patients older than 65 years had an increased risk of complications. Other risk factors were hypertension, arteriosclerosis, the use of anticoagulants and aortic insufficiency. Some of these risk factors often occur with certain presentations in the emergency setting, and in our specific subset the link between COPD and high age resulting in an increased risk of complications from arterial puncture should be stressed. This is also the case for the combination of diabetes and arteriosclerosis. Arterial blood gas analysis is a well established a useful technique but should be used only when it is strictly necessary. Furthermore, venous blood gas analysis can, as we researched, often be a good alternative. Another advantage of venous blood gas samples is the ease and availability. Most patients in need of an arterial blood gas analysis also receive an intravenous line or additional venous blood tests which would enhance the ease of incorporating a venous blood gas sample to be taken during this procedure, relieving the burden on the patient as well as being more cost-effective.

## CONCLUSION

The data we reviewed revealed us that venous blood gas analysis has the potential to be of great importance in the emergency department in general as well as for patients presenting with diabetic ketoacidosis or acute exacerbation of COPD. The blood gas values for pH and HCO<sub>3</sub> showed excellent agreement and correlation and can be considered clinically interchangeable with arterial values. On venous pCO<sub>2</sub> we found differing results and therefore suggest the possible implementation of arterialization of venous blood gas which will make all these values even more accurate and will allow the use of venous pCO<sub>2</sub> in the clinical setting. The use of venous blood gas values has shown to be cost-effective and implementation of this procedure in the routine venous blood sampling will prove to be time and money saving, as it as well will reduce the risk factors for the patient and the health care worker. In presentations were pO<sub>2</sub> values have to be determined precisely or in patients presenting with severe circulatory failure our data is not concise enough

and therefore we still recommend arterial blood gas analysis in these situations.

## REFERENCES

1. Criscuolo C, Nepper G, Buchalter S. Reflex sympathetic dystrophy following arterial blood gas sampling in the intensive care setting. *Chest*. 1995 Aug;108(2):578-80. PubMed PMID: 7634906.
2. Barker W. Arterial puncture and cannulation. In: Roberts JR HJ, eds., editor. *Clinical procedures in emergency medicine*. 3rd ed. Philadelphia: WB Saunders; 1998. p. 308–22.
3. Kelly AM, McAlpine R, Kyle E. Agreement between bicarbonate measured on arterial and venous blood gases. *Emergency medicine Australasia : EMA*. 2004 Oct-Dec;16(5-6):407-9. PubMed PMID: 15537402.
4. Malatesha G, Singh NK, Bharija A, Rehani B, Goel A. Comparison of arterial and venous pH, bicarbonate, PCO<sub>2</sub> and PO<sub>2</sub> in initial emergency department assessment. *Emergency medicine journal : EMJ*. 2007 Aug;24(8):569-71. PubMed PMID: 17652681. Pubmed Central PMCID: 2660085.
5. Rang LC, Murray HE, Wells GA, Macgougan CK. Can peripheral venous blood gases replace arterial blood gases in emergency department patients? *Cjem*. 2002 Jan;4(1):7-15. PubMed PMID: 17637143.
6. Gennis PR, Skovron ML, Aronson ST, Gallagher EJ. The usefulness of peripheral venous blood in estimating acid-base status in acutely ill patients. *Annals of emergency medicine*. 1985 Sep;14(9):845-9. PubMed PMID: 3927796.
7. Brandenburg MA, Dire DJ. Comparison of arterial and venous blood gas values in the initial emergency department evaluation of patients with diabetic ketoacidosis. *Annals of emergency medicine*. 1998 Apr;31(4):459-65. PubMed PMID: 9546014.
8. Ibrahim I, Ooi SB, Yiong Huak C, Sethi S. Point-of-care bedside gas analyzer: limited use of venous pCO<sub>2</sub> in emergency patients. *The Journal of emergency medicine*. 2011 Aug;41(2):117-23. PubMed PMID: 18930370.
9. Giner J, Casan P, Belda J, Gonzalez M, Miralda RM, Sanchis J. Pain during arterial puncture. *Chest*. 1996 Dec;110(6):1443-5. PubMed PMID: 8989058.
10. Turner JS, Briggs SJ, Springhorn HE, Potgieter PD. Patients' recollection of intensive care unit experience. *Critical care medicine*. 1990 Sep;18(9):966-8. PubMed PMID: 2394120
11. Matsagas MI, Mitsis M, Rigopoulos C, Theodossiou V, Koulouras V, Polyzoidis K, *et al*. A large radial artery false aneurysm after repeated arterial punctures, causing compartment syndrome of the forearm. *Intensive care medicine*. 2003 Jun;29(6):1032. PubMed PMID: 12728306 McCready RA, Hyde GL, Bivins BA, Hagihara PF. Brachial artery puncture: a definite risk to the hand. *Southern medical journal*. 1984 Jun;77(6):786-9. PubMed PMID: 6729563.
12. Mortensen JD. Clinical sequelae from arterial needle puncture, cannulation, and incision. *Circulation*. 1967 Jun;35(6):1118-23. PubMed PMID: 6026202.
13. Kelly AM. Review article: Can venous blood gas analysis replace arterial in emergency medical care. *Emergency medicine Australasia : EMA*. 2010 Dec;22(6):493-8. PubMed PMID: 21143397.
14. Treger R, Pirouz S, Kamangar N, Corry D. Agreement between central venous and arterial blood gas measurements

- in the intensive care unit. *Clinical journal of the American Society of Nephrology* : CJASN. 2010 Mar;5(3):390-4. PubMed PMID: 20019117. Pubmed Central PMCID: 2827573.
15. Kim BR PS, Shin HS, Jung YS, Rim H. Correlation between peripheral venous and arterial blood gas measurements in patients admitted to the intensive care unit: A single-center study. *Kidney Research and Clinical Practice*. 2013 March;32(1):32-8.
  16. McCanny P, Bennett K, Staunton P, McMahon G. Venous vs arterial blood gases in the assessment of patients presenting with an exacerbation of chronic obstructive pulmonary disease. *The American journal of emergency medicine*. 2012 Jul;30(6):896-900. PubMed PMID: 21908141
  17. Ak A, Ogun CO, Bayir A, Kayis SA, Koynu R. Prediction of arterial blood gas values from venous blood gas values in patients with acute exacerbation of chronic obstructive pulmonary disease. *The Tohoku journal of experimental medicine*. 2006 Dec;210(4):285-90. PubMed PMID: 17146193.
  18. Raoufy MR, Eftekhari P, Gharibzadeh S, Masjedi MR. Predicting arterial blood gas values from venous samples in patients with acute exacerbation chronic obstructive pulmonary disease using artificial neural network. *Journal of medical systems*. 2011 Aug;35(4):483-8. PubMed PMID: 20703542.
  19. Koul PA, Khan UH, Wani AA, Eachkoti R, Jan RA, Shah S, *et al*. Comparison and agreement between venous and arterial gas analysis in cardiopulmonary patients in Kashmir valley of the Indian subcontinent. *Annals of thoracic medicine*. 2011 Jan;6(1):33-7. PubMed PMID: 21264169. Pubmed Central PMCID: 3023869.
  20. Kelly AM, Kyle E, McAlpine R. Venous pCO<sub>2</sub> and pH can be used to screen for significant hypercarbia in emergency patients with acute respiratory disease. *The Journal of emergency medicine*. 2002 Jan;22(1):15-9. PubMed PMID: 11809551.
  21. Lim BL, Kelly AM. A meta-analysis on the utility of peripheral venous blood gas analyses in exacerbations of chronic obstructive pulmonary disease in the emergency department. *European journal of emergency medicine* : official journal of the European Society for Emergency Medicine. 2010 Oct;17(5):246-8. PubMed PMID: 19996974.
  22. Celli BR, MacNee W, Force AET. Standards for the diagnosis and treatment of patients with COPD: a summary of the ATS/ERS position paper. *The European respiratory journal* : official journal of the European Society for Clinical Respiratory Physiology. 2004 Jun;23(6):932-46. PubMed PMID: 15219010.
  23. Kelly AM, Kerr D, Middleton P. Validation of venous pCO<sub>2</sub> to screen for arterial hypercarbia in patients with chronic obstructive airways disease. *The Journal of emergency medicine*. 2005 May;28(4):377-9. PubMed PMID: 15837016.
  24. Tygesen G, Matzen H, Gronkjaer K, Uhrenfeldt L, Andreassen S, Gaardboe O, *et al*. Mathematical arterialization of venous blood in emergency medicine patients. *European journal of emergency medicine* : official journal of the European Society for Emergency Medicine. 2012 Dec;19(6):363-72. PubMed PMID: 22082876.
  25. Toftegaard M, Rees SE, Andreassen S. Evaluation of a method for converting venous values of acid-base and oxygenation status to arterial values. *Emergency medicine journal* : EMJ. 2009 Apr;26(4):268-72. PubMed PMID: 19307387
  26. Lemoel F, Govciyan S, El Omri M, Marquette CH, Levraut J. Improving the Validity of Peripheral Venous Blood Gas Analysis as an Estimate of Arterial Blood Gas by Correcting the Venous Values with SvO<sub>2</sub>. *The Journal of emergency medicine*. 2012 Aug 23. PubMed PMID: 22921853.
  27. Toftegaard M, Rees SE, Andreassen S. Correlation between acid-base parameters measured in arterial blood and venous blood sampled peripherally, from vena cavae superior, and from the pulmonary artery. *European journal of emergency medicine* : official journal of the European Society for Emergency Medicine. 2008 Apr;15(2):86-91. PubMed PMID: 18446070.
  28. Oddershede L, Petersen SS, Kristensen AK, Pedersen JF, Rees SE, Ehlers L. The cost-effectiveness of venous-converted acid-base and blood gas status in pulmonary medical departments. *ClinicoEconomics and outcomes research* : CEOR. 2011;3:1-7. PubMed PMID: 21935326. Pubmed Central PMCID: 3169975.
  29. Zavorsky GS, Cao J, Mayo NE, Gabbay R, Murias JM. Arterial versus capillary blood gases: a meta-analysis. *Respiratory physiology and neurobiology*. 2007 Mar 15;155(3):268-79. PubMed PMID: 16919507
  30. Adroque HJ, Rashad MN, Gorin AB, Yacoub J, Madias NE. Assessing acid-base status in circulatory failure. Differences between arterial and central venous blood. *The New England journal of medicine*. 1989 May 18;320(20):1312-6. PubMed PMID: 2535633.
  31. Bilan N, Behbahan AG, Khosroshahi AJ. Validity of venous blood gas analysis for diagnosis of acid-base imbalance in children admitted to pediatric intensive care unit. *World journal of pediatrics* : WJP. 2008 May;4(2):114-7. PubMed PMID: 18661766
  32. Shirani F, Salehi R, Naini AE, Azizkhani R, Gholamrezaei A. The effects of hypotension on differences between the results of simultaneous venous and arterial blood gas analysis. *Journal of research in medical sciences* : the official journal of Isfahan University of Medical Sciences. 2011 Feb;16(2):188-94. PubMed PMID: 22091230. Pubmed Central PMCID: 3214302.

Source of Support: None Declared  
Conflict of Interest: None Declared