

EVMS EM Journal Club
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A 62 yo female arrives to the ED brought by family.

She has a history of COPD, PE, and DM. She is in moderate respiratory distress and her pulse ox is 87%.

In addition to the gambit of labs that will be ordered for her evaluation, you would like a blood gas to assess her oxygenation, CO2 level, and pH status. Do you invasively stick a needle in her artery utilizing additional personal that will be called down from the ICU to obtain this ABG, or do you have your techs on hand draw a minimally invasive VBG?

- P: In clinical situations where a blood gas is ordered,**
I: is a VBG preferable
C: to an ABG
O: and is a VBG superior for the patient and the health care system?

Health care system issues:

1.) Arterial blood gas:

a.) arterial blood access in the early part of resuscitation when an arterial line has yet to be established is an additional step in the resuscitation when the vast majority of time a venous IV has already been established.

b.) needlestick risk and blood exposure to staff.

c.) ABGs are painful, and can cause an aneurysm formation, median nerve damage, a hematoma, infection, or occlusion/embolization with subsequent ischemic injury to the digits.

2.) Venous blood gas

a.) venous blood draw is less painful, easier to collect, and can be obtained at the time of drawing other labs.

Statistical info:

1.) Pearson's correlation coefficient

Frequently used to demonstrate the linear relationship between two continuous variables, but does not necessarily establish that they are in agreement.

2.) Bland-Altman analysis of agreement

Uses a plot (called a bias plot) of the difference between two measurements (arterial and venous) against their average.

The mean of the difference is shown by a horizontal "line of agreement" bounded above and below by two parallel lines containing 95% of the differences between the two measurements.

In our journal club studies, the 95% limits of agreement represent the mean difference between each pair of venous and arterial values +/- 1.96 SD, and they estimate by how much a venous value is likely to differ from the criterion standard, the arterial value.

Article	Patient Group	Study Design	Outcomes/Key Results	Conclusions	Study Weakness
1998 Annals of EM: Comparison of Arterial and Venous Blood Gas Values in the Initial ED Evaluation of Patients with DKA: Brandenburg	Adults (no age given), blood glu >250, u dip + ket, EP susp DKA before results of further tests known. Then pt excluded if pH was > 7.35 or serum CO2 was > 20.	Univ teaching hospital, prospect study, convenience sample, VBG from periph vein while obtaining blood draw at time of IV insertion, ABG from r artery obtained "as temporally close to each other as possible." 44 episodes of DKA using 38 pts.	Mean diff between a and v pH values was 0.03. A and v pH results (r=.9689). Only one meas dem a v pH diff from the a pH by greater than 0.1 (and it was 0.11, "which had no diag or ther impl and did not change the pt's outcome). A and v HCO3 (r=0.9543), and a HCO3 and serum CO2 results (r=.8985) were highly correl and showed a high measure of agreement.	VBG meas accurately dem the degree of acidosis of adult ED pts presenting with DKA, and periph v pH meas is a valid and reliable substitute for art pH. Similarly, the v HCO3 can replace the arterial HCO3.	Conv sample, small sample size. Only 4 pts hypoten (SBP<90) on arrival to ED, 5 pts with pH <7.0.
2001 Emergency Medicine Journal: A-M Kelly: Venous pH can safely replace arterial pH in the initial evaluation of patients in the ED	ED pts in Western hospital in Melbourn e (no age range given) deemed by their treating doc to require an ABG to det their vent or acid-base status.	Prospective study, conv sample. Compared pH on an ABG or VBG taken "as close to simultaneously as possible." If on O2 had to be constant for 10 min prior to blood draw. Total of 246 pts: 196 with acute resp disease and 50 with susp metab derangement.	246 pts: 43 alkalotic, 67 acidotic, mean pH 7.38. pH on ABG and VBG were highly correl (r=.92) with an ave diff of typo (see p 342) "0.4" but p342 states 0.04. This diff of 0.04 is not statis sig. 95% limits of agree=- 0.11 to 0.04 units. Figure 1 below shows pH correlated over a range of about 7.05- 7.61.	VBG and ABG show high correl on pH with acceptably narrow 95% lim of agreement. "Venous pH estimation is an acceptable sub. for a pH and may reduce risks of compl for pts and health care workers."	Verbal consent needed so sickest pts may not have been included. "Conveni ence sample based on when time and resources allowed pt enrollme nt."
2006 Emergency	Adult ICU pts, no	VBG and ABG drawn as close	See table 2+3 below. 168 matched sample	Central venous	ICU setting,

Medicine Journal: P Middleton, A-M Kelly: Agreement between arterial and central venous values for pH, bicarbonate, base excess, and lactate	specified age. 2 Australia hospitals. Prosp conven sample of pts deemed by their doc to require a blood gas.	to simultaneously as possible ("within 5 minutes") from an in situ art and central venous line.	pairs from 110 pts. 62 acidotic, 14 alkalotic. Agreement between ABG and VBG was good for all variables and for clusters with pt as the cluster bias, with narrow 95% limits of agreement. Mean diff between ABG and VBG of pH was 0.03 units, bicarb 0.52 mmol/l, lactate 0.08 mmol/l, base excess 0.19 mmol/l.	sampling can be used for measuring pH, bicarbonate, lactate, and base excess, and arterial blood gas is not necessary for these measureme nts.	not ED. Conv sample. Kelly is editor for the EMJ. Multiple samples from same pt. Central v line, not periph. No dx or severity of illness info.
2007 Emergency Medicine Journal: Comparison of arterial and venous pH, bicarbonate, pCO2 and pO2 in initial emergency department assessment: Malatesha	95 ED pts, ave 52 yo. %: 18 COPD, 18 PNA, 16 sepsis, 11 acute on CRF, 10 ACS, 8.5 DKA, 7.4 sys malig, 6 acute gastroent, other.	Pros study of a conv sample of pts deemed by the doc to req an ABG. Tert care teaching hospital in India. Verbal consent from pt or relative. ABG and VBG taken as close in time as poss (always <2 m).	The ABG and VBG values of pH, bicarb, and pCO2 show acceptably narrow 95% limits of agreement as seen in Table 1 below titled "2007 Study." Agreement in po2 measurement was poor.	VBG for pH, bicarb, and pCO2 may be a reliable substitute for ABG analysis in the initial eval of an adult pt pop presenting to the ED.	Conv sample... "this is unlikely to have introduce d any systemic bias in the pt profile sampled." N of 95.
2010 Emergency Medicine Australasia: A Review Article: Can venous blood gas analysis replace arterial in emergency medical care	Adult pts with any condition in an ED setting. Excluded central v analyses, studies only reporting correl or regress	Review article. MEDLINE search '66- Jan10: studies comparing a+periph vbg values for pH, pCO2, bicarb, and base exc. Outcome int was mean diff between a and v meas wt'd for	Wt'd mean AV diff pH=0.035 (n=1252), with narrow limits of agree. 265 DKA pH diff 0.02. 239 COPD pH diff 0.03. Wt'd mean AV diff pCO2= 5.7 mmHg (n=760) with 95% limits of agree up to +/- 20 mmHg. COPD subgroup (n=244) diff was 6.3. Four studies	V pH,bicarb, and base excess have suff agree to be clin interchange able for a values. A and v pCO2 have a wt'd mean diff of about 6 (she	Insuf data for shock, mixed A/B disorders. Data coll by 1 inves unblinde d to project aims=wro ng data, errors/ty

<p>equations (because agree is the clin rel end point)</p>	<p>study sample size with 95% limits of agree. Subgroup analyses: pH in DKA: pCO2 in COPD: v pCO2 as a screening test for arterial hypercarbia.</p>	<p>used v pCO2 as screen test for a hypercarbia, 3 lab tested, 1 POC. 3 labs=100% sn at pCO2 of 45 mmHg. POC sn 79%. Pooled, predicts 36%ABGs avoided if v screen 4 hypercarbia. Bicarb, wt mean diff between a and v= -1.41 mmmol/L (n=905), 95% limits of agree - 5.8 to +5.3 mmol/L. One study: base excess: n=103, mean diff 0.089 mmol/L 95% agreement -0.974 to +0.552.</p>	<p>states 5 but wt diff=5.7 so should be 6). Agree b/w a and v pCO2 is too poor and unpred to be clin useful as a one-off test but v pCO2 useful to screen for a hypercarbia or monitor trends in pCO2.</p>	<p>pos!? Ex: pCO2 Malatesh a has a m diff of 8 but how if 95% agree doesn't include 8! Also ave pCO2 are 42+ 39. She didn't report mean diff 4 bicarb so unsure how this occurred.</p>
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<p><i>2011: Annals of Thoracic Medicine: Comparison and agreement between venous and arterial gas analysis in cardiopulmonary patients in Kashmir valley of the Indian subcontinent: Koul</i></p>	<p>650 bed tertiary care hospital in North India at alt of 1584m. Does not specifically state where the pts were during the blood draw. Done in the "Dept of Int and Pulm Med."</p>	<p>Pro study of "100 randomly selected pts who were adjudged to require ABG analysis by the treating phys." All pts admitted: 63 COPD, 20 CAP/sepsis, 11 CHF, 5 ILD, 3 post TB fibrosis, 1 OSA. Periph VBG drawn within 5 m of ABG and pulse ox sat obtained from a finger pulse ox.</p>	<p>See Table 1 and Fig 5. V meas of pH, pCO2, pO2, bicarb, and dig O2 sat highly correl with corresponding a meas. The diff in pO2 meas between v and a was high, the a sat and finger ox revealed a good degree of agreement with clinically acceptable bias. Mean bias pH=0.030 (95% lim agree -0.088-0.028) Mean bias pCO2=4.05 (95% lim agree -12.8-4.7) Mean bias bicarb=0.86 (95% lim agree -3.35-5.09) Mean bias pO2=22.34 (95% lim agree -52.2-7.5) Mean bias meas O2 sat</p>	<p>Periph VBG assess in conj with finger pulse ox can obviate the routine use of a punct in cardiopulmonary pts req ABG analysis.</p>	<p>Done at altitude. N of 100. Unsure on what pt pop study was done...ED ? Wards? ICU?</p>
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(SaO₂) and dig pulse ox
 (SpO₂)=1.44 (95% lim
 agree -18.7-15.8)

2001 Study:

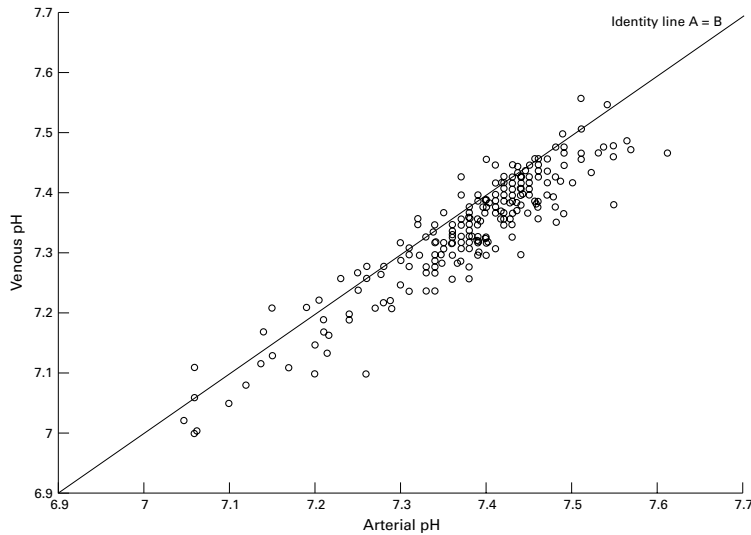


Figure 1 Correlation of arterial and venous pH values.

2006 Study:

Table 2 Agreement between arterial and venous pH, bicarbonate, lactate, and base excess (all samples)

Variable	No. of samples	Mean difference (venous - arterial)	95% limits of agreement
pH	168	-0.03 pH units	-0.07 to 0.01
Bicarbonate	168	0.52 mmol/l	-1.81 to 2.85
Lactate	167	0.08 mmol/l	-0.27 to 0.42
Base excess	165	0.19 mmol/l	-1.86 to 2.24

Table 3 Agreement between arterial and venous pH, bicarbonate, lactate, and base excess (cluster analysis)

Variable	No. of samples	Mean difference (venous - arterial)	95% limits of agreement
pH	110	-0.03 mmol/l	-0.07 to 0.01
Bicarbonate	110	0.32 mmol/l	-1.75 to 2.40
Lactate	109	0.07 mmol/l	-0.31 to 0.45
Base excess	107	0.24 mmol/l	-1.63 to 2.10

2007 Study:

Table 1 Results of arterial and venous blood gas analyses (n = 95)

Parameters	ABG (mean (SD))	VBG (mean (SD))	Bland-Altman 95% limits of agreement
pH	7.384 (0.124)	7.369 (0.12)	0.13 to -0.1
PCO ₂ (mm Hg)	39 (15.11)	42 (20.71)	6.8 to -7.6
Bicarbonate (mEq/l)	23.58 (8.86)	24.32 (9.43)	4.3 to -5.8
PO ₂ (mm Hg)	115 (64.5)	50 (24.39)	145.3 to -32.9

ABG, arterial blood gas; CI, confidence interval; PCO₂, partial pressure of carbon dioxide; PO₂, partial pressure of oxygen; VBG, venous blood gas.

2011 Study:

Table 1

Summary statistics showing mean, standard deviation (SD), 95% confidence limits of mean (CI), median, and range of the various studied parameters

Parameter	Mean (SD)	95% CI	Median	Range
pH (Arterial)	7.46 (0.56)	7.45–7.47	7.47	7.257–7.59
pH (Venous)	7.43 (0.06)	7.42–7.44	7.43	7.176–7.58
pCO ₂ (Arterial, mmHg)	37.77*	35.88–39.75*	36.35*	20.70–71.00
pCO ₂ (Venous, mmHg)	41.69*	39.60–43.89*	40.10*	26.00–74.00
pO ₂ (Arterial, mmHg)	60.69 (16.63)	57.39–63.99	60.50	16.00–114.0
pO ₂ (Venous, mmHg)	38.35 (10.66)	36.23–40.46	38.00	13.00–75.00
HCO ₃ (Arterial mmol/l)	27.98 (6.23)	26.74–29.21	26.7	9.30–45.80
HCO ₃ (venous, mmol/l)	28.84 (6.88)	27.48–30.2	27.8	12.1–52.7
SaO ₂ (%)	89.08 (10.89)	86.9–91.27	92.6	21.7–99.0
SpO ₂ (%)	90.53 (7.31)	89.08–91.98	92.5	56.0–99.0

*Data not distributed normally have been back transformed after logarithmic transformation

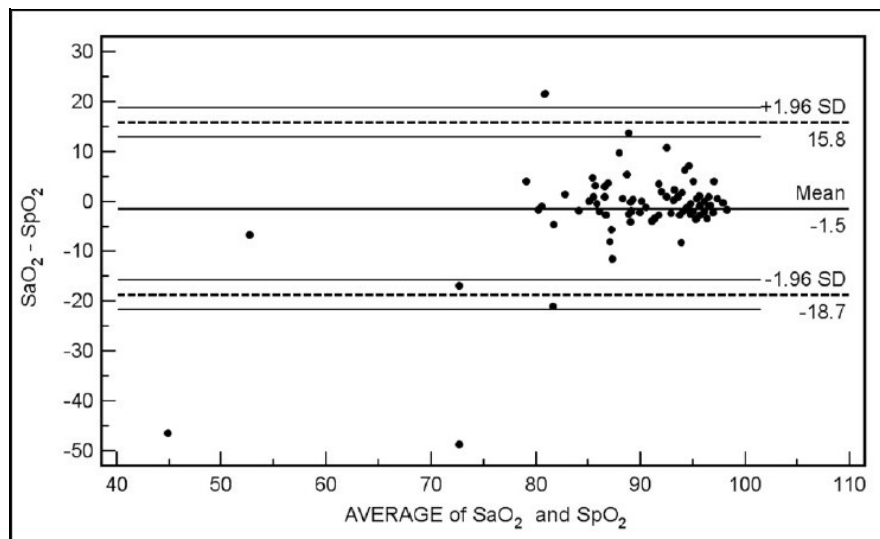


Figure 5

Bland Altman plots of measured oxygen saturation (SaO₂) and on pulse oximetry (SpO₂) (Average vs. Difference)

Overall Summary and Clinical Bottom Line

The studies reviewed did not look at outcome effects.

For pH in any disease process it appears the difference between VBG and ABG is approximately 0.03 with a narrow interval of which the vast majority (at least 95%) of all measurements will be. Therefore, pH from a VBG can replace the ABG value, and an ABG should be eliminated if desiring a pH measurement.

The same conclusion applies to bicarb and the difference is approximately 1.

For pCO₂, the difference appears to be 6. Many studies have narrow 95% limits of agreement, however some studies have wider limits up to a difference of +/- 20 mmHg.

pCO₂ with a venous value of less than 45 has a near 100% sn in ruling out arterial hypercarbia.

For pO₂, the arterial value and venous values are correlated but do not agree. In the vast majority of cases, a sat monitor is sufficient clinical information for oxygenation status.

The future of blood gas analysis should focus on studying venous gases to avoid the health care system issues concerning ABGs.

Interestingly, the VBG can offer more information than the ABG in terms of cellular oxygenation. The venous blood saturation may be lower in septic states when the tissues are extracting all the oxygen. This drop in venous saturation may occur before the lactate rises, and at the same time the arterial saturation may still be 100%. Therefore, the VBG may not only be better for the health care system, but it may be superior in terms of clinical information than the ABG.