

# Role of Venous Blood Gas (VBG) Analysis in Patient Triage in the Adult Emergency Department

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## **Abstract—Background:**

**In emergency and critical care settings, can a venous blood gas analysis improve clinical decision-making and patient outcomes?**

## **Methods:**

**This is a cross-sectional study, conducted between January and June 2022 at a tertiary hospital in Saudi Arabia.**

## **Results:**

**A total of 100 patients were included, using a convenience sample technique. Their mean age was 54 years, and their main chief complaints were shortness of breath (30%), abdominal pain (15%), and altered level of consciousness (14%). The venous blood gas (VBG) result was abnormal in 86 patients, and predicted the need for early intervention in 69 patients (69.7%). A significant association was found between patients requiring early intervention and those with an abnormal VBG ( $p=0.0005$ ). Furthermore, the VBG results changed the Canadian Triage and Acuity Scale (CTAS) level in 32 patients (33.68%). A logistic regression analysis revealed that pre-testing factors such as age, and chief complaints were not predictors of VBG results, the need for early intervention, or altered CTAS level.**

## **Conclusion:**

**Our study concludes that VBG analysis can play an important role in patient triage in the emergency department (ED), allowing for earlier intervention and potentially improving outcomes.**

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**Index Terms—Emergency Department, Point-of-Care Test, Triage, Venous Blood Sampling**

## I. INTRODUCTION

In emergency and critical care settings, the blood-tests menu, which also provides for bedside testing of selected electrolytes, lactates, and blood gases, can remarkably improve clinical decision-making and patient outcomes. Emergency and critical care physicians should work alongside laboratorians to continuously appraise emerging technologies, such as point-of-care testing (POCT) solutions, with a view to optimising rapid test results and eventual clinical decisions. This can also facilitate operational cost-cutting and improved staff efficiency, which may further upgrade the clinical outcome [1]. Patients in respiratory distress or with altered acid-base status must be evaluated in the emergency department (ED). However, a weak pulse or patient movement can make it difficult to obtain an adequate sample for arterial blood gas (ABG) analysis, which is commonly used to estimate acid-base status, oxygenation, and carbon dioxide concentration in ill patients. As a less invasive, more convenient alternative to ABG analysis, venous blood gas (VBG) analysis has been proposed [2].

VBG analysis is a multi-component serum assessment of pH, blood gas tensions ( $PvO_2$  and  $PvCO_2$ ), bicarbonate ( $HCO_3$ ), and base excess. The sample can be drawn from an intravenous (IV) catheter along with other blood work. Unlike ABG, it does not reflect the partial pressure of oxygen ( $PaO_2$ ) in arterial blood [3]; however, it can be used to assess acid-base status, as VBG pH closely approximates ABG pH [2][4][5]. VBG has been found to have a sensitivity of 89% and a specificity of 92% in detecting metabolic acidosis [5]. For patients in

respiratory distress, VBG can be used to detect CO<sub>2</sub> retention. The VBG-derived bicarbonate level can be used to estimate PaCO<sub>2</sub>, which can be helpful in detecting hypercarbia in patients with COPD [6]. VBG has several advantages over ABG. It is easier and less invasive to obtain, as the sample can be drawn from an IV catheter along with other blood work. Thus, it does not necessitate arterial puncture, which can cause complications and delay care [7, 8], and can therefore be a valuable tool in ED patient triage.

Several studies have compared the agreement between VBG and ABG in the evaluation of acid-base status, oxygenation, and carbon dioxide concentration. A systematic review and meta-analysis of the literature reporting agreement between arterial and venous pH, PCO<sub>2</sub>, bicarbonate, base excess, and lactate found that VBG pH was highly correlated with ABG pH, and VBG bicarbonate levels were highly correlated with ABG PaCO<sub>2</sub> levels [4]. A comparison of central venous blood gas to arterial blood gas found that VBG pH, PCO<sub>2</sub>, and bicarbonate levels were highly correlated with ABG levels [7]. A study comparing VBG-derived bicarbonate levels to ABG-derived PaCO<sub>2</sub> levels found a strong correlation between the two measures, with VBG-derived bicarbonate levels able to accurately predict PaCO<sub>2</sub> levels [9].

VBGs have also proved a useful alternative to ABGs in the assessment of acid-base status, as they have been found to provide similar results [3, 5]. Furthermore, they are useful in Chronic obstructive pulmonary disease (COPD) patients, where the detection of CO<sub>2</sub> retention is important for treatment, as VBG analysis can detect the presence of hypercarbia [9].

However, it is still unclear whether VBG has any utility or benefits in patient triage. This study aims to explore the role of VBG analysis in ED patient triage.

## II. METHOD

*Study Design:* This was a cross-sectional study conducted in the emergency department of a single urban tertiary care centre. Data were collected retrospectively from chart reviews, and were reviewed by the authors. The study was conducted in

accordance with the principles of the Declaration of Helsinki.

*1) Study Population:* The study included a convenience sample of 100 patients who presented to the ED between January and June 2022. Patients were included if they were 14 years of age or older and had a VBG analysis ordered in the ED. Patients were excluded if they were younger than 14 years old or had incomplete medical records.

Data were collected from electronic medical records, and included demographic information (age, gender), comorbidities, chief complaints, initial CTAS levels, and VBG results. The time from triage to VBG results was also recorded.

We utilised the CTAS scale as a triage system due to its wide application in emergency departments across Saudi Arabia [10].

*2) Data Analysis:* Data were analysed using descriptive statistics, including means, standard deviations, ranges, frequencies, and percentages. The chi-square test of independence was used to assess the relationship between VBG results and the need for early intervention. Logistic regression analysis was conducted to evaluate the effect of age on the need for VBG analysis in triage, and on its influence on early intervention and altered CTAS levels. A p-value lower than 0.05 was considered statistically significant. The statistical analysis was performed using the IBM Statistical Package for Social Sciences (SPSS), version 26 (IBM, Armonk, NY, USA).

## III. RESULTS

There were 100 patients in our analysis, with a mean age of 54 years ( $\pm 23.35$ ), ranging from 14 to 105 years old. 49 patients were male (49%) and 51 were female (51%). Comorbidities were present in 83 (89.2%) patients, while 10 (10.75%) were medically free. The patients' comorbidities are illustrated in Table 1.

The initial CTAS scores for the sample group were as follows: 9 patients (9%) scored level 1; 41 patients (41.4%), level 2; 46 patients (46.4%), level 3; and 3 patients (3%), level 4. Table 2 illustrates the main chief complaints conveyed by the patients in the triage station.

*Venous blood gas results and the need for early intervention:*

The VBG result was abnormal in 86 patients (86%), predicting the need for early intervention in 69 patients (69.7%). A chi-square test of independence demonstrated a significant relationship between VBG results and the need for early intervention;  $X^2(1, N=99)=37.50, p=0.0005$ . This indicates that patients who required early intervention were more likely to have abnormal VBG results.

*Venous blood gas results and the change in CTAS level:*

The results of the VBG analysis altered the CTAS level in 32 patients (33.68%). A chi-square test of independence was performed, and no significant relationship was noted between normal/abnormal VBG results and the change in CTAS level;  $X^2(1, N=95)=2.76, p=0.096$ .

*Predictors for the need for VBG analysis in triage:*

A logistic regression was performed to predict the effects of age on the likelihood that patients would require VBG analysis at triage. The finding was not statistically significant;  $X^2(1, N=100)=-40.27, p=0.51$ . Likewise, age was not a predictor for the need for early intervention based on VBG results;  $X^2(1, N=99)=-60, p=0.977$ , or their influence on the CTAS level;  $X^2(1, N=95)=-60.49, p=0.52$ .

A chi-square test revealed that gender was associated with the need for VBG at triage. We noted an association between this factor and the need for early intervention;  $X^2(1, N=99)=3.79, p=0.051$ , as well as a change in CTAS level;  $X^2(1, N=95)=5.69, p=0.017$ .

The VBG results of female patients were more likely to predict the need for early intervention (40 females vs 29 males), as well as alter the CTAS level (22 females vs 10 males).

*Comorbidities:*

Comorbidities are also associated with the need for VBG analysis, which in turn predicts the need for early intervention;  $X^2(10, N=92)=22.67, p=0.012$ .

Patients with DM, cancer, renal disease, and cardiac history were more likely to have VBG results that influenced a decision for early intervention. The

VBG results of medically free patients were less likely than those of patients with comorbidities to trigger any early intervention (8 vs 2 patients). However, comorbidities did not influence the CTAS level;  $X^2(9, N=88)=11.459, p=0.249$ .

*Chief complaint:*

The various chief complaints conveyed by the patients at the point of triage did not influence the need for VBG analysis. Fisher's exact test revealed no statistically significant association between chief complaints and normal/abnormal VBG results;  $p=0.127$ . Likewise, we found no statistically significant association between the chief complaints and the need for early intervention;  $X^2(15, N=99)=18.81, p=0.22$ , or change in CTAS level;  $X^2(15, N=95)=16.86, p=0.33$ .

#### IV. DISCUSSION

This study analysed the relationship between venous blood gas (VBG) results and the need for early intervention and altered CTAS scores. The results showed that abnormal VBG was significantly associated with the need for early intervention; while there was no significant relationship between VBG results and the change in CTAS level. Logistic regression showed that patients' age was not a predictor of the need for VBG analysis, early intervention, or altered CTAS level. Gender was found to be associated with the need for VBG at triage and influenced both the need for early intervention and a change in CTAS level. Comorbidities were also associated with the need for VBG, which influenced the decision for early intervention. The patients' chief complaints at presentation did not predict the need for VBG analysis, the need for early intervention, or a change in CTAS level.

Due to rising patient numbers, emergency departments must make smart decisions about the allocation of beds, based on patients' presenting conditions. In the event of an emergency, doctors must prioritise which patients are seen right away and which ones can wait. Many people are involved in making such decisions, from the government (via the Ministry of Health) to individual hospitals and

**Table 1.** Frequency of comorbidities in the included patients.

<b>Comorbidities</b>	<b>Frequency (N)</b>	<b>Percentage %</b>
Diabetes mellitus and hypertension	17	18.3
Diabetes mellitus only	14	15.1
History of cancer	12	12.9
Renal disease	12	12.9
Asthma/chronic obstructive pulmonary disease	5	5.4
Epilepsy	4	4.3
Cardiac history: atrial fibrillation and/or heart failure	9	9.7
History of stroke	4	4.3
Miscellaneous: gastric sleeve, pulmonary embolism	5	5.4
Metabolic disease in childhood	1	1.1

**Table 2.** Frequency of initial symptoms.

<b>Chief complaint at triage</b>	<b>Frequency (N)</b>	<b>Percentage %</b>
Abdominal Pain	15	15
Chest Pain	11	11
Altered level of consciousness	14	14
Trauma	7	7
Aphasia	1	1
Dizziness	2	2
High blood sugar reading at home	1	1
Fever	3	3
Gastrointestinal bleeding	2	2
Leg pain	1	1
Poor oral intake	1	1
Seizure	2	2
Shortness of breath	30	30
Agitation	1	1
Vomiting	3	3
Weakness	6	6

clinics, to individual doctors. For this reason, it is crucial to have reliable resources, including triage scales [6], to help determine the most effective emergency health interventions. Nowadays, VBG analysis should be used more often to triage patients [5].

The use of VBG analysis has been proposed as an alternative to ABG analysis for the assessment of ED patients in respiratory distress or with altered acid-base status [1]. VBG analysis is a multi-component serum assessment that can be drawn from an IV catheter along with other blood work, making it easier and less invasive to obtain than ABG. While it does not accurately reflect the partial pressure of oxygen in arterial blood, VBG pH closely approximates ABG pH and can be used to

assess a patient’s acid-base status [3][4][5][8].

VBGs provide comparable information, are easier to draw, and are less painful for the patient. Because newer blood gas analysers can report electrolyte values and glucose in addition to pH, this diagnostic process could theoretically be condensed [11].

The current study aimed to explore the role of VBG analysis in ED patient triage, and to determine whether VBG results can predict the need for early intervention. It also examined the timing from triage to VBG result, and whether VBG abnormalities are correlated with comorbidity. The majority of patients (89.2%) in this study had comorbidities, with diabetes mellitus and hypertension being the most common. In addition, VBG was abnormal in the majority (86%), and abnormal VBG results were

associated with the need for early intervention. These findings suggest that VBG analysis may be a useful tool to identify patients requiring urgent intervention, and thus allow healthcare providers to focus on their care and potentially improve outcomes. Our findings suggest that VBG analysis may be useful across a wide range of patient populations and that all patients presenting to the ED could potentially benefit from it.

We also found that the VBG result influenced the CTAS level in approximately one third of patients, although this finding was not statistically significant. Further research is necessary to determine the relationship between VBG results and CTAS levels, and to identify other factors that may contribute to changes in CTAS levels.

Despite its utility in assessing acid-base status and oxygenation, VBG testing does present certain drawbacks, and its limitations should be addressed. Firstly, financial constraints may hinder its routine use due to the associated costs [3-5]. Moreover, the possibility of haemolysis during sample collection carries the potential for erroneous results, which can lead to misinterpretation of a patient's condition and subsequent incorrect triage decisions. Acknowledging these limitations is essential for a comprehensive understanding of the role of VBG analysis in effective ED triage [4, 5, 8].

## V. CONCLUSION

In conclusion, our study suggests that VBG analysis may be a valuable tool in ED patient triage, allowing for early identification of patients requiring urgent intervention. Further research is needed to validate these findings and determine the optimal timing and frequency of VBG analysis in the ED setting.

## VI. LIMITATIONS

This study was limited by its small sample size and its single-centre design. The findings may not be generalisable to other populations, and the results should be interpreted with caution.

## VII. REFERENCES

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