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ORIGINAL RESEARCH

Reducing Unnecessary Venous Blood Gas (VBG) Testing in the Emergency Department Through Targeted Education

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Objective: Our objective was to evaluate the amount of unnecessary Venous Blood Gas (VBG) tests initiated in the Emergency Department (ED) and to assess the effectiveness of clinical intervention, such as education, in reducing VBG tests.

Methods: 497 consecutive patients were selected between 1 August and 30 September 2019. For Phase 1, 10 volunteer nurses were randomly assigned to 50 cases each and assessed whether they would perform a VBG. A brief educational intervention was then implemented regarding specific clinical indications to perform VBGs. After the education, they were asked the same questions. For Phase 2, the entire ED team was subjected to intervention and education (Phase 2). A monthly prospective audit of VBG testing numbers in St Vincent's Melbourne Emergency Department was compared from March 2022 to December 2022.

Results: The phase 1 educational intervention saw a significant reduction in unnecessary VBG of 24% (p-value < 0.001, odd ratio of 15.8 [confidence interval (CI): 8.5–29.1]). During Phase two, a sustained reduction in absolute VBG testing in the ED was observed of 33.7% (9% adjusted reduction). This simple intervention would save around $22,000 in our ED based on an annual presentation of ~50,000.

Conclusion: Our study highlights the importance of education to support the "Choosing wisely" campaign to reduce VBG testing in EDs. By reducing the number of VBGs, we not only limit unnecessary tests for our patients, but also reduce the cost associated with frequent and unnecessary blood gas analysis.

Plain Language Summary: Our study highlights the importance of education to support the "Choosing wisely" campaign to reduce VBG testing in the Emergency Department.

Keywords: venous blood gas, emergency department, Choosing Wisely, intervention, education

Introduction

Venous blood gas (VBG) analysis is commonly used as part of point of care testing (POCT) of critically ill patients in the emergency department (ED). The implementation of POCT for VBG analysis has enabled rapid, accurate and cost-effective testing for critical patients in the ED. A blood gas provides timely and critical information on the patient's acid base, oxygenation, and ventilation status to assess metabolic and respiratory abnormalities and guide resuscitative interventions.[1] Basic VBG analysers used in EDs typically measure a patient's pH, partial pressure of carbon dioxide (pCO_2), oxygen saturation (sO_2), bicarbonate (HCO_3^-) concentration, and key electrolytes, including sodium (Na^+), potassium (K^+), chloride (Cl^-), and ionised calcium (Ca^{2+}). More advanced VBG analysers can also provide additional parameters such as haemoglobin (Hb) concentration, carboxyhaemoglobin, methaemoglobin, and lactate levels, which

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are critical in assessing metabolic status, oxygen delivery, and potential toxic exposures.[2] However, a lack of governance in providing policy and education around the utility of VBG testing in the ED has led to unnecessary use of VBG testing in other noncritical conditions presenting to the ED. VBG testing is a valuable tool in the ED for assessing critically unwell patients who require urgent resuscitation and continuous cardiopulmonary monitoring. Blood gas analysers allow clinicians to rapidly and accurately evaluate a patient's acid-base status, oxygenation, and metabolic function in conditions such as diabetic ketoacidosis, severe respiratory distress, septic shock, intubated or comatose patients, suspected poisoning or drug overdose, and electrolyte abnormalities.[3] However, the overutilisation of VBG testing in EDs for non-critical conditions can lead to several issues, including unnecessary patient discomfort, increased healthcare costs, and potential mismanagement due to false-positive results. In this manuscript, this inappropriate use is referred to as unnecessary VBG testing.[4]

Implemented in Australia in 2015, the Choosing Wisely campaign and its six core principles aim to challenge the notion that "more is always better" when it comes to healthcare.[5] Choosing Wisely Australia (https://www.choosingwisely.org.au/) is a branch of a worldwide healthcare initiative dedicated to improving the safety and quality of healthcare by fostering a national conversation on avoiding unnecessary tests and treatments, and advocating for evidence-based care. A systematic review of the literature review conducted by Bai et al[6] identified the importance of developing a culture of questioning and educating healthcare professionals in reducing the volume of unnecessary diagnostic tests. The review also emphasised that the addition of guidelines and protocols can reduce unnecessary tests in the ED. The goal of the Choosing Wisely campaign, which is aligned with its foundation, is to reduce non-essential healthcare costs. In a 2022 report written by Walsh et al, healthcare spending comprises 10% of Australia's gross domestic product, and pathology testing specifically contributes to 12% of Medicare expenditure.[7]

In this mixed retrospective and prospective study, we evaluated the amount of unnecessary VBG tests initiated in the ED and evaluated the effectiveness of clinical education in reducing avoidable VBG tests in the ED.

Methods

Study Design / Setup

Phase 1

497 consecutive patient triages were collected between 1 August 2019 and 30 September 2019. Ten registered nurses (RN) and critical care nurses (CCRN) were randomly assigned to 50 emergency presentations each and asked to state whether they would perform a VBG based on the triage notes and the assigned Australasian Triage Scale (ATS).[8]

After the 497 triages were evaluated, the research team implemented a brief educational intervention to inform the 10 nursing staff of the specific clinical indications for the performance of VBG based on the Australasian College of Emergency Medicine (ACEM) and Royal College of Pathologists of Australasia (RCPA) guidelines for pathology testing in the ED.[6] Based on current clinical guidelines, VBG testing is indicated for patients with the following suspected diagnoses: overdose or altered conscious state, diabetic ketoacidosis (DKA), sepsis, and dyspneic patients requiring resuscitation. After the intervention, the 10 nursing staff were again asked to state whether they would perform a VBG based on the same clinical scenarios. To prevent any coercion in responses, data was collected anonymously, and no additional feedback sessions or incentives were provided for correct answers.

Phase Two

All clinical ED staff were targeted with ongoing education on the indications of VBG testing in the ED. The result of the Phase One findings was also presented to the ED team. The intervention was carried out through regular education sessions for nursing and medical staff, Email correspondence, and visual reminder posters. For the final phase, the research team expanded the intervention to remove all VBG syringes from trolleys in the ED, except resuscitation trolleys. A monthly prospective audit of VBG testing was compared, extending between March 2022 - July 2022 (pre educational phase) and August 2022 - December 2022 (during and after intervention).

Data Sources/Measurement

We used Microsoft Excel 2020 and SPSS version 27 to analyse the data. Qualitative data with frequency and confidence intervals were presented. We use McNemar's test (nonparametric pair test) to check for statistical differences between the pre- and post-intervention phases.

Ethics

Ethics approval was obtained from the St Vincent's Human Research Ethics Committee (HREC). The approval reference number is: 23035.

A waiver of consent was granted by St Vincent's HREC for conducting a retrospective study and reviewing the VBG data of 497 ED presentations. The approval was given to A/Prof Hamed Akhlaghi, Ms Kate Wallis, Ms Kate Urie and Ms Kelly Mullins. The collected VBG data did not contain any sensitive information about patients. All RNs and CCRNs consented to be a part of the research project. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Results

Phase One (Education Phase)

A total of 497 ED presentation reviews were performed. 275 (55.3%) of the ED presentation reviews were completed by RNs and 222 (44.7%) by CCRNs. Examining whether the RN or CCRN would perform a VBG based on the classification notes and the ATS classification category, a total of 247 (49.7%) VBG tests were indicated as "No", while 250 (50.3%) responded "Yes" before the intervention. After the intervention, 367 (73.7%) were indicated as "No" and 130 (26.2%) were highlighted as "Yes" to perform a VBG. An exact McNemar test determined that there was a statistically significant difference in the proportion of VBG tests before and after intervention, $p < 0.001$, with an odd ratio of 15.8 [Confidence interval (CI): 8.5–29.1] (Table 1).

46.5% (128) of the VBGs were declared "no" by the RNs prior to the intervention. The number climbed to 76% (209) after the intervention. Among CCRNs, the frequency of "No" to VBG increased from 53.6% (119) before intervention, to 71.2% (158) after intervention (Table 1).

Table 1 Number of VBG Tests Performed by RNs and CCRNs During Phase 1 of the Study

	Pre-Education (N, %)		Post-Education (N, %)		Total (N, %)
	Yes	No	Yes	No	
Staff					
RN	147 (53.5%)	128 (46.5%)	66 (24%)	209 (76%)	275 (55.3%)
CCRN	103 (46.4%)	119 (53.6%)	64 (28.8%)	158 (71.2%)	222 (44.7%)
Total	250 (50.3%)	247 (49.7%)	130 (26.2%)	367 (73.7%)	497 (100%)
Triage					
Category 1	11 (68.8%)	5 (31.3%)	8 (50%)	8 (50%)	16 (3.2%)
Category 2	71 (70.3%)	30 (29.7%)	46 (45.5%)	55 (54.5%)	101 (20.3%)
Category 3	139 (49.1%)	144 (50.9%)	68 (24%)	215 (76%)	283 (56.9%)
Category 4	28 (29.8%)	66 (70.2%)	8 (8.5%)	86 (91.5%)	94 (18.9%)
Category 5	1 (33.3%)	2 (66.7%)	0 (0.0%)	3 (100%)	3 (0.6%)

Abbreviations: RN, registered nurse; CCRN, critical care nurse.

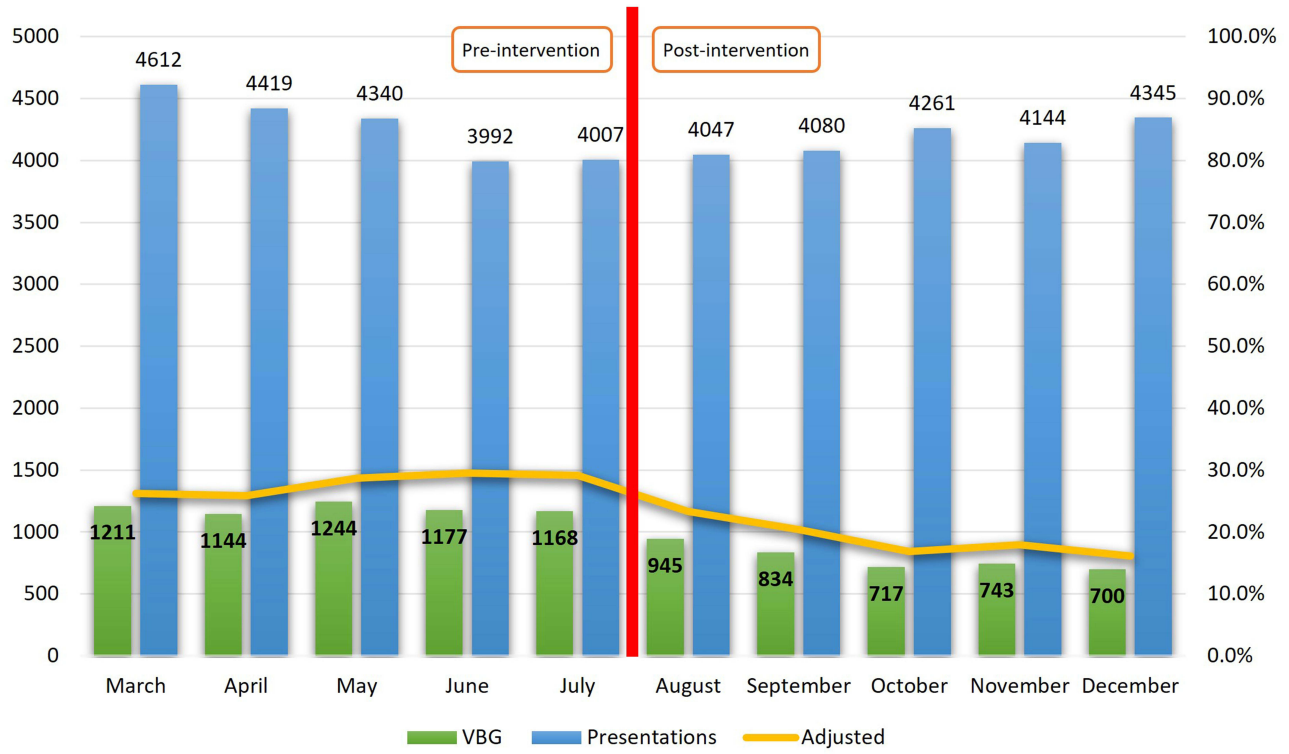

Figure 1 Monthly number of blood gases and total presentation of ED in 2022. Adjusted for the total monthly presentation, there is a clear downward trend in the total number of blood gas venous tests after intervention. The numbers on the green bars represent monthly venous gas tests, while the numbers on the blue bars represent monthly ED presentations.

16 VBGs were assigned ATS Category 1 (3.2%), 101 were assigned ATS Category 2 (20.3%), 283 were assigned ATS Category 3 (56.9%), 94 were assigned ATS Category 4 (18.9%), and three were assigned ATS Category 5 (0.6%) (Table 1). After education, a reduction in VBG testing was observed in all categories, with the most noticeable differences seen in Category 5 (33.3%), followed by Category 3 (25.1%) and Category 2 (24.8%).

Phase Two (Intervention Phase)

The monthly VBG testing numbers were compared over two periods: March 2022 – July 2022 is preintervention and August 2022 – December 2022 are during and after intervention. During the preintervention period, an average of 1188.8 VBGs were conducted per month (27.9% adjusted for ED presentations), while in the postintervention period, only an average of 787.8 VBGs were conducted per month (18.9% adjusted for ED presentations). This resulted in an absolute reduction of 33.7% in the VBG tests (9% adjusted reduction) (Supplementary Table 1 and Figure 1).

Discussion

This project aimed to explore the overuse of VBG testing in a large metropolitan ED in Melbourne. This study confirmed that the simple intervention of providing evidence-based education[6,9] can significantly reduce unnecessary VBG tests at the bedside in the ED. CCRNs and RNs' decisions to obtain a VBG showed a significant reduction after receiving short education and setting guidelines on VBG testing.[6] The reduction in VBG tests continued for several months after the intervention, which confirmed the effectiveness of the intervention strategies amongst both medical and nursing personnel. The novelty of this study lies in its demonstration of how an effective and targeted educational intervention can bridge the gap between simulated learning environments and real-world clinical practice. This study provides evidence that structured education can translate into tangible improvements in clinical decision-making through practical application of learned skills in emergency settings.

Our findings highlight an important difference between RNs and CCRNs in relation to the number of VBGs performed in the ED. As the CCRNs have completed a university postgraduate certificate in emergency care, we can assume these nurses have a more in depth understanding of the pathophysiology behind VBG analysis and the critical thinking capacity to determine what patients require a VBG test. After our intervention, there was a reduction in VBG use of 29.5% for RNs compared to 17.6% for CCRNs, highlighting the need for more departmental education with a focus on non-postgraduate nurses. These findings are in line with the study by Baxter and Edvardsson's study,[10] where postgraduate critical care trained nursing staff reported higher degrees of confidence in their clinical evaluation, planning, and evaluation of patient care.

Additionally, 77.2% (384) of the VBGs analysed were performed on patients classified as Category 2 and 3. When considering the ACEM and RCPA pathology testing guidelines along with the ATS guidelines, we can consider our findings in line with the clinical presentations that require VBG analysis. For example, patients with moderate respiratory distress are allocated Category 2 according to the ATS and patients with hyperglycaemia and signs of dehydration are allocated a Category 3.[8] With the majority of VBGs analysed falling into these categories, after the intervention, we found a consistent and significant reduction in the unnecessary use of VBGs.

Since the beginning of this project, another metropolitan ED in Melbourne has carried out a comparable study.[4] The authors found that only 32% of the randomly reviewed cases were indicated for VBG tests and a brief intervention showed a reduction of 33% in unnecessary VBGs, which is very similar to our findings. The main difference in our study is the clinical indications for VBG testing in the ED. This study identified nine indications to complete a VBG based on a literature review, rather than our method of using the RCPA and ACEM guidelines for pathology testing in the ED[9] to identify four indications. We believe that a list of four indications for VBG testing is succinct and reduces the possibility of confusion when deciding whether to perform a VBG test. In addition to this, our larger sample size allowed us to capture a true representation of our emergency presentations, thus a diversity of patients requiring blood gas analysis.

Phase 2 of this quality improvement project identified that the educational intervention established in phase 1 has had a significant impact on the amount of VBG tests performed in our department. The effect on monthly testing numbers was immediate, with a 5.7% reduction (adjusted based on monthly ED presentations) in testing in the first month. The reduction was sustained, demonstrating that five months after implementation, VBG testing remained reduced with 13% less VBGs conducted in December 2022 (five months after intervention). However, monthly test numbers are only one indicator of understanding the change in VBG tests. Although we did not actively record the outcomes of every patient during the second phase of the study, there were no reports of inadvertent consequences or harm to patients during this period.

The monthly costs involved in the use and maintenance of the ABL90 FLEX blood gas analyser[11] equates to $3.28 per test, with a box of 100 blood gas syringes costing $116. Our study showed an average reduction of 34% in VBG in the ED every month after intervention, which is equal to $1780.44 in savings per month (annual savings of $21,365.28). Extrapolating this conservative saving to 8.8 million ED presentations in Australia in 2022[12] will equate to approximately $3.8 million in savings to the healthcare system.

Our findings have some limitations that should be considered when interpreting the results. Firstly, in Phase One nursing participants were only assigned the patient's triage note and were unable to physically assess the patient or interpret their vital signs at the time of blood collection. Second, our study was completed in a single metropolitan ED; therefore, we have not captured a true representation of nursing staff. We recommend that further studies be completed at multiple sites across the state. Furthermore, each ED presentation review was assigned only to one nurse, potentially resulting in individual bias. To avoid this, each classification should have been assigned to multiple nurses, allowing cross-referencing and reducing potential bias.

There are other factors that could have influenced the monthly test numbers, such as the acuity of the patients which is the nature of an ED. However, we believe that the sustained reduction in the number of monthly VBG tests after the intervention was due to a reduction in unnecessary VBG tests.

Conclusions

Our study highlights a significant reduction in unnecessary VBG testing with targeted and concise education without compromising patient outcomes. By reducing the number of avoidable VBG tests, we not only limit unnecessary tests for our patients, but also reduce the cost associated with frequent and unnecessary blood gas analysis.

The findings highlight the importance of evidence-based education in reinforcing best practices and supporting initiatives such as the Choosing Wisely campaign, which aims to reduce unnecessary investigations in healthcare. Furthermore, the study highlights the potential for similar educational strategies to be implemented in other healthcare settings to promote responsible test utilisation and enhance patient care.

Data Sharing Statement

Unidentified data from this project will be available upon formal request from the correspondence author.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

There is no competing interest among the authors.

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