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Point-of-care peripheral venous blood gas in the elderly demographic in the emergency department; a pilot study

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Key words: elderly, emergency department, point of care testing, re-presentation, venous blood gas

ABSTRACT

Background: The peripheral venous blood gas (PVBG) has gained popularity over the arterial blood gas and electrolytes-urea-creatinine panel in non-critical situations in the emergency department (ED). Despite its convenience and rapid result return, it is costly and potentially over-utilized.

Aim: To assess the utility of point of care (POC) PVBG samples in predicting re-presentation of elderly patients (over the age of 65) to the ED within 72 hours, who were discharged without inpatient admission directly from ED.

Method: A retrospective audit was performed on patients of the above demographic, who presented to three Monash Health EDs between January 2011 and October 2015 and had a single POCPVBG sample taken. The individual POCPVBG values were compared between those who re-presented within 72 hours to those who did not, as were demographic data.

Results: In the 723 eligible cases in the study period, 127 (18%) re-presented within 72 hours whilst 596 (82%) did not. The median ages were similar 76 [70;82] and 77 [71;83] as was proportion of males (50%, 51%). The most common presenting complaints in both groups were shortness of breath and abdominal pain. Categorical analysis showed a statistically significant ($p < 0.05$) association between low base excess (Odd Ratio: 2.5; 95% Confidence Interval 1.2-4.9) and low potassium (OR: 2.5; 95% CI: 1.2-3.8) with re-presentation. However, these results had unclear clinical significance; the sensitivity and likelihood ratios for each were 16% and 2.2 and 15% and 1.9.

Conclusion: The PVBG may have some utility as a predictor of re-presentation in non-critical presentations of elderly patients to the ED. However, the role of a single POCPVBG sample in assessment of such patients remains unclear, and further research and guidelines need to be established to avoid over-utilization.

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There is no conflict of interest to declare.

Significance of the study

Known: PVBG have an excellent sensitivity for abnormal values. There is good evidence for PVBG use over ABGs in patients without shock or mixed acid-base disturbances, particularly those with COPD.

New: Patients over the age of 65 presenting to the ED were more likely to re-present within 72 hours if they had low base excess or hypokalaemia. However, individual PVBG values predict re-presentation, owing to poor sensitivity.

Implications: The PVBG may be overused in the ED in non-critical presentations of elderly patients. Further research is needed to determine its use in assessing suitability for discharge.

INTRODUCTION

The peripheral venous blood gas (PVBG) is an investigation that has recently gained popularity as a point of care (POC) blood test in the emergency department (ED) [1;2]. Automated analyzers can provide results within five minutes of patient assessment and are now widely used; PVBG results can be rapidly incorporated into the patient assessment and guide clinical management. The PVBG reports the values of venous pH (pH), bicarbonate (BIC), partial pressure of carbon dioxide (P_VCO_2), base excess (BE) and lactate (LAC); these values are the venous counterpart to the arterial blood gas (ABG). Other reported indices include the haemoglobin (Hb), sodium (Na), potassium (K), chloride (Cl), creatinine (Cr) and blood glucose level (BGL).

In the last decade, the PVBG has gradually become an acceptable substitute for ABG analysis. PVBG values reasonably agree with the traditionally ABG-only values of pH, BIC and BE [3;4]. Whilst the P_VCO_2 agrees poorly with the arterial partial pressure of carbon dioxide (P_ACO_2), a P_VCO_2 of less than 45 mmHg has a high sensitivity in excluding arterial hypercarbia [5;6]. A normal venous lactate also confidently excludes arterial lactate abnormalities [4].

There is good evidence for POCPVBG use in assessing patients who are not in shock or have mixed acid-base disturbances, especially for patients with chronic obstructive pulmonary disease (COPD) [4]. However, the test may be over-utilized in the ED. In particular, it is unclear whether the POCPVBG has any advantages in the biochemical assessment of elderly patients with non-critical presentations compared to the cheaper, but slower, laboratory-assayed electrolytes-urea-creatinine (EUC) panel. Convenience and rapid results are often used to justify use of the POCPVBG in this context; this may result in an increased cost burden to the ED [7].

We performed an audit assessing the association between individual POCPVBG values and re-presentation of patients over age 65, who were discharged without inpatient admission. We aim to determine the utility of the POCPVBG in this setting through its ability to predict re-presentation.

METHOD

This was a retrospective audit of patients presenting to any of three Monash Health EDs between 1 January 2011 and 28 October 2015. Monash Health is a major health network in Melbourne with an annual ED census of approximately 200,000 presentations across three hospitals: Monash Medical Centre (tertiary), Dandenong and Casey (district) hospitals. This study was approved by Monash Health and the Monash University Human Research and Ethics Committee.

Selection

Eligible cases for this study were those over age 65 on presentation who were discharged without inpatient admission and had single PVBG sample in the ED. Cases were excluded where multiple PVBG samples were taken or there was incomplete PVBG data.

Cases were identified through the ED medical records (Symphony, EMIS Health, Leads, UK) between 1 January 2011 and 28 October 2015 by electronically filtering for patients over age 65 on presentation who were discharged without inpatient admission. All PVBG samples during this time were then identified through the pathology database (Webstro, LRS Health, Australia), and both datasets were exported to a de-identified Microsoft Excel spreadsheet. Cases where a PVBG was sampled during the presentation were identified using Structured Query Language (SQL), and cases with multiple PVBG samples excluded. The remaining cases were hand-searched for errors in PVBG output, and cases with incomplete analyzer output excluded.

Case data were obtained from the electronic medical records and pathology systems, including: age, sex, presenting problem and hours before the next presentation to ED. The initial vital signs of heart rate, blood pressure, respiratory rate, oxygen saturation by peripheral oximetry and temperature were obtained by hand-searching the medical records. The PVBG values of pH, P_VCO_2, BIC, BE, BSL, Na, K, Cl and LAC were obtained.

Analysis

Included cases were divided into two groups based on re-presentation status. The re-presentation group was defined as having an unexpected re-presentation within 72 hours of the index visit; the control group was defined as all other cases.

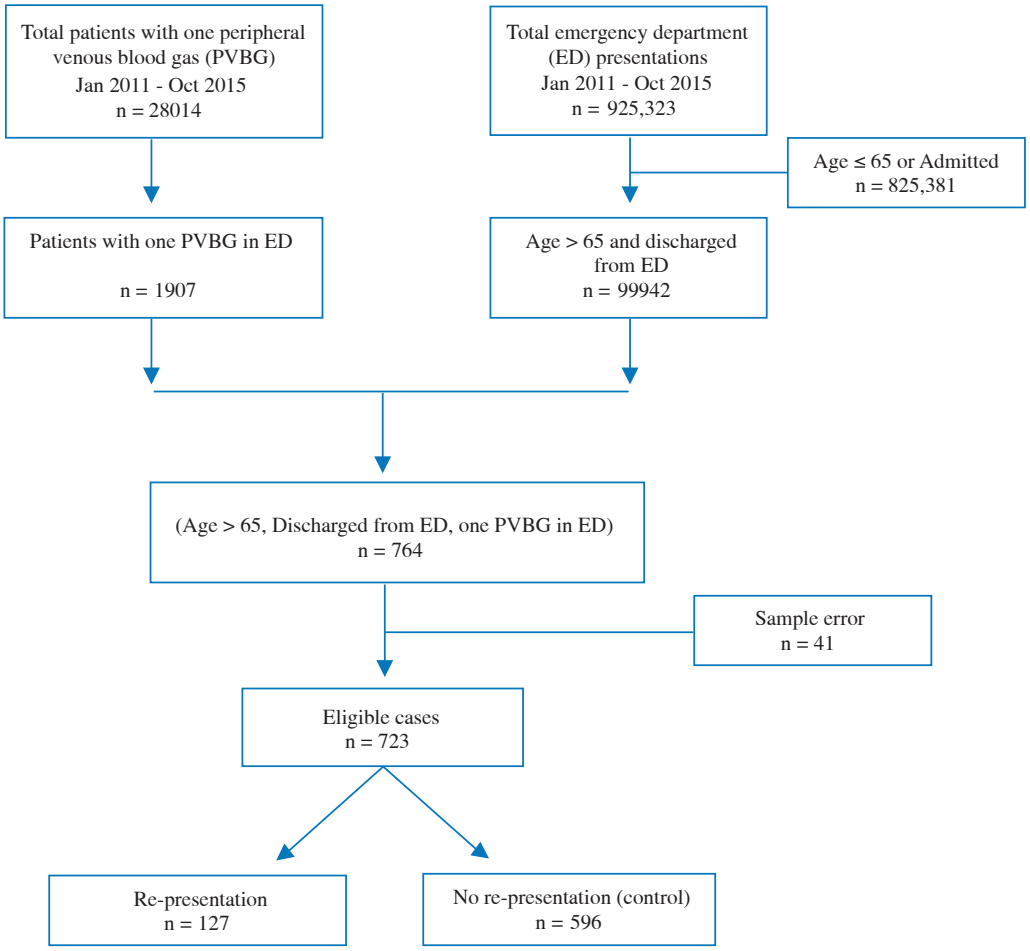

Figure 1: The age distribution was similar between the groups, as was sex distribution. This was also true with vital signs. The most common presenting problems in both groups were shortness of breath and abdominal pain and most of the re-presentations were within the same category.

The two groups were compared for age, sex distribution, presenting problems as well as vital signs. Individual PVBG values were thereafter dichotomized into normal or abnormal by pre-defined ranges (see **Table 1**) and compared between the two groups. Where a significant association existed between abnormal PVBG values and the outcome of re-presentation, the abnormal values were further categorized into low, normal or high and the association with re-presentation re-tested.

Value Range

Potential of hydrogen (pH)	7.35 - 7.45
Partial pressure of carbon dioxide (P_vCO_2)	35 - 45 (mmHg)
Bicarbonate (BIC)	20 - 24 ($mmol.L^{-1}$)
Base excess (BE)	-3 - + 3
Sodium (Na)	135 - 145 ($mmol.L^{-1}$)
Potassium (K)	3.5 - 5 ($mmol.L^{-1}$)
Chloride (Cl)	95 - 107 ($mmol.L^{-1}$)
Blood sugar level (BSL)	4 - 12 ($mmol.L^{-1}$)
Lactate (LAC)	less than 2 ($mmol.L^{-1}$)

Continuous data are presented as medians with interquartile ranges. Categorical comparisons of the two groups are made using Fisher's exact test, with statistical significance defined at $p = 0.05$.

Outcomes

The primary outcome of interest is the odds ratio of low or high PVBG values in predicting re-presentation. A clinically significant odds ratio is defined as 2 in this study. Other outcomes of interest are the sensitivity and specificity of low or high PVBG values in predicting re-presentation, as well as the positive likelihood ratios.

RESULTS AND ANALYSIS

A total of 127 cases were identified in the re-presentation group compared with 596 cases in the control group.

In both groups, there were many biochemical values outside of the defined normal range (see **Table 3**). There was an association between abnormal BE and re-presentation OR [95% CI] 1.62 [1.10, 2.38], *p* value = 0.01, as well as abnormal K and re-presentation 1.75 [1.02, 2.82], *p* value = 0.02.

Table 1: Characteristics of re-presentation and control groups. Values are reported as median (interquartile range). SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, RR: respiratory rate, SpO_2: peripheral capillary oxygen saturation, T: temperature.

	Overall [n = 723]	Re-presentation [n = 596]	Control [n = 127]
Demographic information			
Age	76 [70,83]	77 [71,83]	76 [70,82]
Sex	365 [50%]	63 [50%]	302 [51%]
Presenting complaints	Short of breath [18.5%] Abdominal pain [13.7%] Chest pain – cardiac[8.4%] GI bleed (upper/lower) [6.2%] 48 others [53.1%]	Short of breath [19.7%] Abdominal pain [15.7%] Generally unwell [7.1%] Fall [6.3%] 28 others [51.2%]	Short of breath [18.3%] Abdominal pain [13.3%] Chest pain – cardiac [9.6%] GI bleed (upper/lower) [6.5%] 46 others [52.3%]
Vital signs			
SBP [mmHg]	138 [122,155]	138 [118,155]	138 [123,155]
DBP [mmHg]	71 [62,82]	70 [62,80]	72 [62,83]
HR [beats per minute]	77 [66,87]	79 [67,88]	76 [66,86]
RR [breaths per minute]	18 [16,20]	18 [17,20]	18 [16,20]
SpO_2 [%]	97 [95,99]	97 [95,98]	97 [95,99]
T [degrees, Celsius]	36.2 [36.0,36.7]	36.4 [36.0,36.8]	36.2 [36.0,36.6]

Categorizing BE and K into low, normal and high, a low BE (less than -3) was associated with an increased likelihood of re- presentation OR [95% CI] 2.4 [1.16, 4.92], *p* value = 0.018, as was low serum K (less than 3.5 mmol.L^{-1}) 2.1 [1.15, 3.83], *p* value = 0.016.

Table 2: Comparison of groups by abnormal PVBG values using Fisher's exact test. OR: odds ratio, CI: confidence interval, $PVCO_2$: partial pressure of venous carbon dioxide, BIC: bicarbonate, BE: base excess, Na: sodium, K: potassium, Cl: chloride, BGL: blood glucose level, LAC: lactate.

	Re-presentation [n = 127]	Control [n = 596]	OR [95%CI]	p-value
pH	42 [33.1%]	173 [29.0%]	1.21 [0.80, 1.82]	0.37
$PvCO_2$	60 [47.2%]	339 [56.9%]	0.68 [0.46, 1.00]	0.05
BIC	104 [97.2%]	495 [83.1%]	0.92 [0.56, 1.52]	0.75
BE	62 [48.8%]	221 [37.1%]	1.62 [1.10, 2.38]	0.01
BGL	12 [9.4%]	55 [9.2%]	1.03 [0.53, 1.98]	0.94
Na	25 [19.7%]	81 [13.6%]	1.56 [0.95, 2.56]	0.08
K	28 [22.0%]	83 [13.9%]	1.75 [1.02, 2.82]	0.02
Cl	33 [26.0%]	110 [18.5%]	1.55 [0.99, 2.43]	0.87
LAC	30 [23.6%]	145 [24.3%]	0.96 [0.61, 1.51]	0.84

Further analysis showed low K had sensitivity of 15% (95% CI: 8.8% to 22.4%) and specificity of 92% (95% CI: 89.9% to 94.4%) for re-presentation, with a positive likelihood ratio of 1.94 (95% CI: 1.1 to 3.3). Low BE had a sensitivity of 16% (95% CI: 8.3% to 25.7%) and specificity of 93% (95% CI: 89.9% to 95.1%), with a positive likelihood ratio of 2.17 (95% CI: 1.2 to 4.0) for re-presentation.

Table 3: Comparison of groups by categorising PVBG values into low, normal and high using Fisher's exact test. OR: odds ratio, CI: confidence interval, BE: base excess, K: potassium.

	Re-presentation	Control	OR [95%CI]	p-value
Low BE	12 [65 normal]	29 [375 normal]	2.4 [1.2, 4.9]	0.02
High BE	50 [65 normal]	192 [375 normal]	1.5 [1.0, 2.3]	0.50
Low K	17 [99 normal]	42 [513 normal]	2.1 [1.2, 3.8]	0.02
High K	11 [99 normal]	41 [513 normal]	1.4 [0.7, 2.8]	0.36

DISCUSSION

In our study, we have assessed cases where a single PVBG was performed during the ED presentation. In these cases, it plays the role of a highly sensitive triage test, to identify patients that require admission. However, its poor performance suggests an uncertain role as a rule-out test for discharge; the only gain in efficiency is possibly time to results.

There is currently little evidence regarding the utility of the POCPVBG in non-critical presentations to the ED. Our study is the first to show an association between PVBG value abnormalities and re-presentation within 72 hours, in patients aged over 65 who were discharged from ED without inpatient admission. However, clinical significance was not compelling; a low base excess had an OR of 2.4 and a LR+ of 2.17 for re-presentation, whilst hypokalaemia had an OR of 2.1 and a LR+ of 1.94. Furthermore, these poorly predict safe discharge due to their low sensitivity for re-presentation at 16% and 15% respectively.

Overall, our results indicate that individual PVBG values have little clinical utility in predicting re-presentation, owing to poor sensitivity, and thus guiding discharge in this clinical context.

There are several aspects of the PVBG we have not explored in this study. The predictive ability of PVBG values can only be indirectly measured by its association with re-presentation, due to its nature as an instantaneous analysis of physiology. This is further limited by our exclusion criterion of multiple PVBG samples; however, multiple PVBG sampling is likely to reflect critical situations where the trend of PVBG values is used in patient assessment. Our use of univariable analysis may also partially explain the findings, as mild value derangements may contribute disproportionately to the findings due to all abnormal values being categorized equally.

We note that the most common presenting complaints were shortness of breath and abdominal pain, common situations where clinicians may be more inclined to perform a PVBG. However, the PVBG was performed on less than 1% of 99942 presentations; it is not clear why the PVBG was performed on this subgroup of patients in the absence of clinical information that has guided the use of the PVBG. Generalization is uncertain as a result, and our findings may not be representative of all patients over age 65 who present to the emergency department.

This audit has a number of limitations. Despite POCPVBG analyzers being calibrated to standard ranges, there are individual differences between the three hospitals that cannot be accounted for. Whilst hospitals are also notified of unexpected deaths following recent discharge, we did not contact the Coroner's Court of Victoria regarding unexpected deaths. A strength of the study is the low risk of attrition bias, as patients are likely to re-present to the same health network due to the large geographical area covered. Furthermore, exclusions due to incomplete PVBG data were minimal.

Our results demonstrate that there is potential over-use of a single PVBG in the ED for non-critical presentations, where a PVBG trend is not required for patient assessment. Guidelines on the indications for PVBG use in the ED do not yet exist for either non-critical or critical situations, despite PVBG use overtaking the ABG in critical situations due to its comparable accuracy and less invasive nature. Whilst our study did not indicate a major cost burden of PVBG ordering, costing AUD$33.70 in addition to the EUC panel at $17.70, further research into the clinical utility of the POCPVBG in the ED is important.

Finally, the retrospective nature of this audit allows only hypothesis generating results, which require prospective evaluation to assess their clinical applicability. In particular, a paired cohort study or randomized controlled trial where the intervention investigated is the POCPVBG may delineate its utility. Cost-benefit analysis is also an avenue for further research.

CONCLUSION

In our retrospective analysis of patients over the age of 65, who were discharged from the ED without admission, there was an association between unexpected re-presentation within 72 hours and **low base excess** or **hypokalaemia**. While these differences were statistically significant, the PVBG has unclear clinical utility as a predictor of re-presentation in non-critical presentations of elderly patients to the ED owing to poor sensitivity. Further research is required to avoid its overuse.

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