CAPILLARY BLOOD GAS—A MORE 'PATIENT FRIENDLY' ALTERNATIVE TO ARTERIAL BLOOD GAS?

Kerry C, Hassan N, Richter S & Chari A

University of Oxford Medical Sciences Division

Abstract

Background & Aims: Arterial blood gas (ABG) sampling is a commonly used procedure in hospitals but is highly unpleasant for the patient. This systematic review aims to determine whether capillary blood gas (CBG) can provide an accurate and less painful substitute for ABG.

Method: A comprehensive search of EMBASE, PubMED and Web of Knowledge yielded 31 relevant studies examining at least one of pH, pO_2, pCO_2 or sO_2. 12 of these provided primary data which were then analysed further.

Results: There was no significant difference between CBG and ABG for pH, pCO_2 and sO_2 but a significant difference was found for pO_2 ($p = 0.000$). This difference was no longer significant ($p=0.646$) when severely hyperoxic samples (ABG pO_2 > 150mmHg) were excluded. There was excellent correlation for all 4 variables (r^2 = 0.975, 0.990, 0.980 and 0.998 for pH, pO_2, pCO_2 and sO_2 respectively). Patient preference was favoured in 4 out of the 6 studies which examined this issue.

Conclusion: The current body of literature supports CBG as an accurate and less painful alternative to ABG.

Introduction

Arterial blood gas (ABG) sampling is widely accepted as the gold standard technique for measurement of pCO_2, pO_2 and pH. It is common practice in the emergency department and in patients with respiratory and metabolic disorders. However arterial puncture is an invasive and painful technique that almost always needs to be performed by a physician.

There is an alternative that has been extensively used in various clinical settings: the arterialised capillary blood gas (CBG) from the earlobe. Whereas earlobe capillary sampling is only used on some respiratory wards in England, it is routine in Germany. It can be performed by any trained member of staff, facilitating regular monitoring of patients in the absence of a physician. Thompson *et al.* in 2005 showed that the main reasons for not using CBGs in the UK, besides of lack of availability, were lack of awareness and confidence in their accuracy. Given that CBGs have the potential to be more ethical and cost-effective than ABGs, and that they are routine practice in another developed health care system, we undertook a systematic review to answer the following questions:

1) In adults, can CBG provide an accurate substitute for ABG?
2) Do adults prefer capillary samples compared to arterial samples?

Method

Studies were eligible if they compared capillary and arterial blood gas sampling and fulfilled a number of criteria. These included: adult subjects in any setting, written in English, ABG samples from any artery and CBG samples from earlobe only. Simultaneous ABG and CBG samples must have been taken from the same patient and at least one of pH, pO_2, pCO_2 or sO_2 must have been measured. EMBASE, PubMED and Web of Knowledge were searched from the earliest available date up to 13 March 2012. Key words relating to blood gas, arterial, capillary and arterialised/arterialized were searched, using limits according to the eligibility criteria. If primary data for all individual samples of a study were available, that was used in preference to any given means. If standard deviations were not given it was calculated from primary data or from confidence intervals.

Results

31 eligible studies were found involving a total of 1076 patients. Each study provided, for the four variables studied, at least a mean difference and standard deviation for this mean difference, along with the number of paired samples used. Many of the studies used multiple samples from each patient, giving a total of 469 paired samples for pH, 1091 paired samples for pO_2, 802 paired samples for pCO_2 and 184 paired samples for sO_2.

Of those, 12 studies provided primary data for individual sample pairs, which allowed more detailed analysis of correlation. In this context, 148, 203, 144 and 23 paired samples were found for pH, pO_2, pCO_2 and sO_2 respectively. A summary of collated data from all 31 studies is shown in Table 1. Mean differences are weighted according to the number of samples in the study. The data shows that only the pO_2 values are significantly different between ABG and CBG.

From the primary data available, there was extremely good correlation for all four variables (Pearson product moment correlation coefficients r^2 = 0.975, 0.990, 0.980 and 0.998 for pH, pO_2, pCO_2 and sO_2 respectively) . Using two-tailed paired sample t-tests, pO_2 was still significantly different between ABG and CBG. Figure 1 shows the correlation between arterial and capillary pO_2 values.

	pH	PO2 (mmHg)	PCO2 (mmHg)	SO2 (%)
Sample Size	469	1091	802	184
Weighted Mean Difference (Arterial - Capillary)	-0.002	7.123	0.392	0.004
SD	0.375	102.904	22.082	14.930
95% CI	0.034	6.106	1.528	2.157
SIGNIFICANT DIFFERENCE?	NO	YES	NO	NO

Table 1: Data from 31 studies

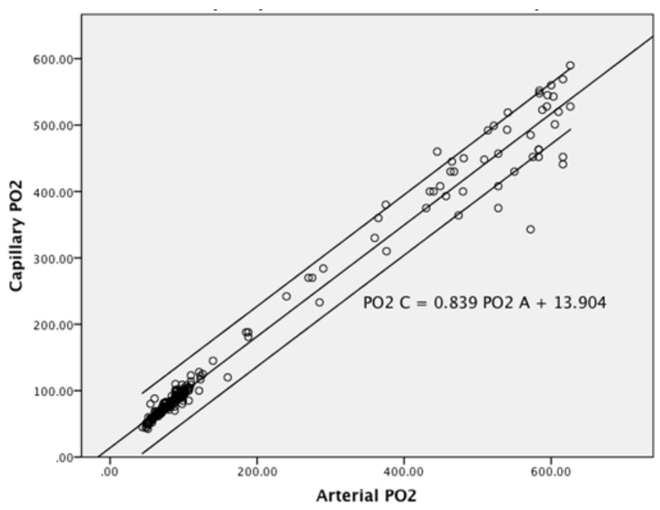

Figure 1: Scatter plot for pO_2 with the corresponding regression line equation. Normal pO_2 reference range: 90—120mmHg

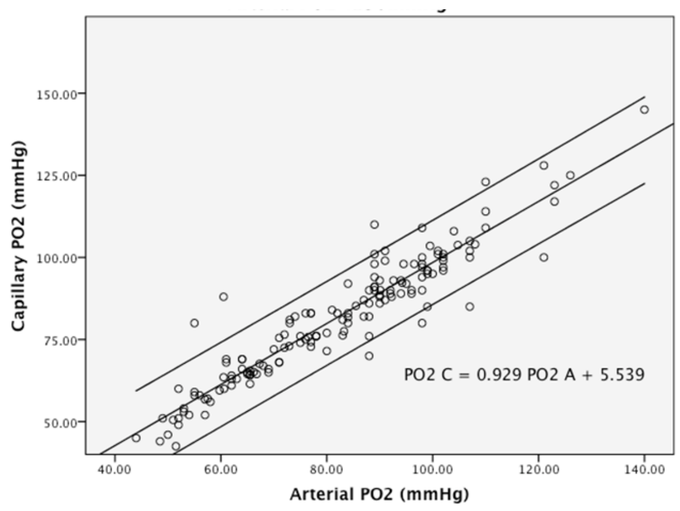

Figure 2: Scatter plot for pO_2 for values <150mmHg with the corresponding regression line equation

It seems that the correlation of pO_2 is more accurate at normoxic and hypoxic states and less accurate at hyperoxic states. The individual sample data was reanalysed for pO_2 using an arterial pO_2 cut-off of 150mmHg (Figure 2). This cut-off left 149 paired samples with a lower correlation coefficient (0.940 vs 0.990) but the two-tailed paired sample t-test shows that the samples are now not significantly different (p=0.646 vs p=0.000).

Many of the studies also used different patient groups to derive their samples. 21 studies gave the status of the patients used and these were grouped into 4 categories: healthy, lung disease, peri-operative and shocked. These groupings did not account for exercise status or the presence of supplemental oxygen (Table 2).

Only 6 of the studies addressed patient preference. Four suggested that earlobe sampling was preferred, although only one study had measured this objectively using a Likert scale. Two suggested that arterial sampling was preferred, although again only one had measured this objectively.

Clinical context	pO_2			
	No of samples	Weighted mean difference	SD	SE
Lung disease	325	15.666	93.922	5.210
Healthy	165	6.404	28.794	2.242
Shocked	310	2.461	28.747	1.633
Peri-operative	96	0.156	7.907	0.807
ALL DATA	1091	7.123	102.904	3.115

Table 2: Subgroup analysis according to different patient groups

Discussion

The data convincingly shows that there *is* a direct correlation between CBG and ABG values for all four variables and there is no significant difference for pH, pCO_2 and sO_2. There is a significant difference for pO_2, but this seems to be limited to severe hyperoxia >150 mmHg, which is rarely encountered out of an intensive care setting. However this is only based on data obtained from 149 samples. The large mean difference seen in lung disease in Table 2 can be explained by the hyperoxic state that was induced in these patients by administration of 100% oxygen. When these patients were allowed to breathe room air, CBG and ABG values for pO_2 were almost identical.

A common doubt over the use of CBGs is their validity in shocked patients who are likely to be peripherally shutdown. However data in Table 2 shows that this does not appear to a problem, with a mean difference even lower than that found in healthy patients.

An important aim of our review was to determine patient preference. From the 6 studies which examined this, more patients seem to favour CBG over ABG. However, only 2 studies measured this objectively.

In summary, CBGs seem to provide an accurate and less painful substitute for ABGs but further evidence is needed to confirm both these findings.

Acknowledgements

We would like to thank Dr Elize Richards and Dr Annabel Nickols at the Oxford University Hospitals NHS Trust for their help and support.

For a full list of references or any further information, please contact the author at claire.kerry@medschool.ox.ac.uk