

## ORIGINAL ARTICLE

## Arterialised Capillary Blood Gases in Accident and Emergency Department Patients - a Reliable Alternative to Arterial Sampling?

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**OBJECTIVES:** Many patients with respiratory complaints who present to the Accident & Emergency (A & E) department have an arterial blood gas analysis performed at some point. It is our belief that there is no difference between arterial and capillary blood gas values in patients presenting to the A & E department. It is also anticipated that body temperature and blood pressure may play a part, so these will also be reported and associations will be investigated. **METHODS:** Patients who require arterial blood gas analysis at any stage during their stay in the A & E department at the Northern General hospital of Sheffield are eligible for inclusion in the study. In total there were 32 patients. **PROCEDURE:** Transvasin cream was applied to the ear lobe to improve local blood flow by dilating the capillaries. When ten minutes have elapsed after the application of the Transvasin cream, a capillary sample is taken from the ear lobe by the researchers. **CONCLUSION:** From the t-tests conducted, no significant difference was seen between the arterial and capillary blood gas samples for the parameters  $pO_2$  and  $O_2$  saturation. However, for  $pCO_2$ , pH and  $[HCO_3]$  there were significant differences observed. This result seems to disagree with the findings of most other studies that have so far shown stronger correlations generally for pH,  $pCO_2$  and bicarbonate, than for oxygen measuring parameters.

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### BACKGROUND

Many patients with respiratory complaints who present to the department have an arterial blood gas analysis performed at some point. Normal blood gas values are as follows: pH 7.34-7.45,  $pO_2$  80-100 mmHg and  $pCO_2$  of 35-45mmHg. The idea of an arterial blood gas is to assess the oxygenation of arterial blood and the blood's acid-base balance (1). This test is helpful in determining the root cause of their presenting complaint and it assists in defining and monitoring the necessary treatment. It is a painful procedure that involves taking a small blood sample from the radial artery and complications, such as formation of a hematoma and development of infection, are not uncommon (2).

Patient preparation includes assessment of peripheral circulation on both sides. The artery of choice is the radial artery, which is usually easily palpated at the flexor surface of the arm. If the radial artery is unsuitable as a puncture site, the brachial artery is the second choice, followed by the femoral artery. It is evident that such a procedure can at times be challenging to perform and is generally only performed by medical personnel. A simpler alternative for blood gas analyses has therefore been sought for many years.

It is our belief that there is no difference between arterial and capillary blood gas values in patients presenting to the A & E department. It is also anticipated that body temperature and blood pressure may play a part, so these will also be reported and associations will be investigated.

Several studies, performed as early as the beginning of the 1970s, investigated whether the blood gas results

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from arterialised capillary vessels of the ear lobe would correlate with arterial ones and whether the former technique could replace the latter (3-6). This would have clear benefits as capillary blood sampling is a much easier technique, which can be performed by medical technicians, causing less discomfort to the patient with adverse events being very rare (2). Despite several reports that have supported the use of capillary sampling, arterial blood gases remain to date the 'gold standard'.

Most of the studies performed so far have come from specialised units, such as paediatric wards (7,8), or concentrated in the management of specific conditions such as diabetic ketoacidosis (9). Some of these studies have provided certain evidence to support the use of capillary blood sampling in certain cases. There have been as yet no studies that have investigated the use of the technique in patients with a wide variety of medical conditions, such as those that occur in an A & E department. In such a busy setting the need for arterial blood sampling can at times cause delays in the diagnosis and management of the patient. The question that arises is whether an easier and quicker technique such as capillary blood sampling could give results that are comparable to those coming from arterial sampling, and therefore serve as a reliable and practical alternative.

## METHODS

### Inclusion and exclusion criteria

Patients who require arterial blood gas analysis at any stage during their stay in the Accident and Emergency department at the Northern General hospital of Sheffield, are eligible for inclusion in the study. Patients who require blood gas analysis often experience respiratory distress and on occasions their consciousness may be impaired. Such patients cannot voluntarily take part in the study and were therefore excluded. All other patients were informed about the study and must have been able to understand the procedure before it was undertaken. Consent must be asked for and the necessary forms signed by the patient, and the person conducting the procedure. Participation in the study did not affect the patient's management, and our findings are kept confidential. If for any reason adequate blood cannot be taken from the ear lobe, consent forms and other necessary documents are retained. The research project received ethical approval by the North Sheffield Local Research Ethics Committee.

### Procedure

Transvasin cream, commonly used for muscular pain, was applied to the ear lobe to improve local blood flow

by dilating the capillaries. Pulse, blood pressure and temperature are recorded while an arterial sample is obtained in the usual manner, via the radial artery. Both the radial and the ulnar arteries are compressed at a level approximately 1cm proximal to the wrist joint while the patient makes a tight fist for approximately 5 seconds. The patient is then instructed to open the fist in a relaxed fashion. About 2 ml of arterial blood is then collected from the radial artery, a procedure carried out by the attending A & E doctor. This sample was then analysed as soon as possible.

When ten minutes had elapsed after the application of the Transvasin cream, a capillary sample was taken from the ear lobe by the researchers. A puncture was made using a unilet lancet, a drop of blood was allowed to form and was then allowed to suspend from the earlobe. A sample was collected in a 175 mm capillary tube from the centre of the drop of blood. Analysis of the sample was undertaken within no more than five minutes from collection, using the Ciba-Corning 865 ABG analyse. The researchers collecting the data were medical students working with the cooperation of A & E doctors who were doing the routine collection of the arterial blood gases.

### Methods of data analysis

Once both samples had been analysed, the pH, pO<sub>2</sub>, pCO<sub>2</sub>, [HCO<sub>3</sub>] and oxygen saturation levels were recorded for further statistical tests. The strength of relationship between the arterial and capillary blood gas results was analysed using scatter plots, correlation coefficients and t-tests. A two-tailed t-test was used for non-independent samples, at a significance level of p=0.05. This test assumes the data is distributed normally and so plots were carried out to prove this assumption. (appendix 1)

For each set of pH, pCO<sub>2</sub>, pO<sub>2</sub>, [HCO<sub>3</sub>] and O<sub>2</sub> sat values, the data from the capillary samples was plotted against that from the arterial samples.

The correlation coefficient is a measure of how well trends in the predicted values follow trends in the actual values.

## RESULTS

### Data set

32 patients were included in the study. Of these, 19 were males ranging in age from 42 to 86, and 13 were females aged between 19 and 92. The procedure was successful, and a capillary sample obtained, in 26 of the 32 individuals.

## DISCUSSION

From the t-tests conducted no significant difference was seen between the arterial and capillary blood gas

**Table 1.** T-test results of measured blood parameters

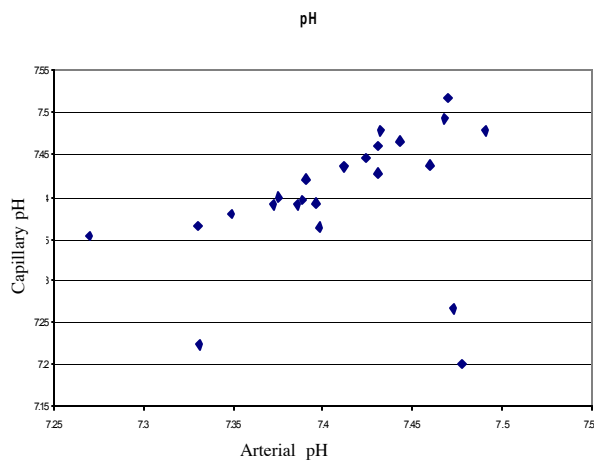
T-test Results	
Mean pH (Arterial)	7.41
Mean pH (Capillary)	7.39
t-test value	5.54
Critical (p) value	2.074
Mean pCO <sub>2</sub> (Arterial)	4.88
Mean pCO <sub>2</sub> (Capillary)	3.84
t-test value	5.43
Critical (p) value	2.074
Mean pO <sub>2</sub> (Arterial)	12.5
Mean pO <sub>2</sub> (Capillary)	13.16
t-test value	-0.49441
Critical (p) value	2.074
Mean HCO <sub>3</sub> (Arterial)	23.53
Mean HCO <sub>3</sub> (Capillary)	20.67
t-test value	2.66
Critical (p) value	2.08
Mean O <sub>2</sub> Sat (Arterial)	96.99
Mean O <sub>2</sub> Sat (Capillary)	96.6
t-test value	1
Critical (p) value	2.571

samples for the parameters pO<sub>2</sub> and O<sub>2</sub> saturation. However, for pCO<sub>2</sub>, pH and [HCO<sub>3</sub>], there were significant differences observed. This seems to disagree with the findings of most other studies that have so far shown stronger correlations generally for pH, pCO<sub>2</sub> and bicarbonate, than for oxygen measuring parameters (7-9,11-16).

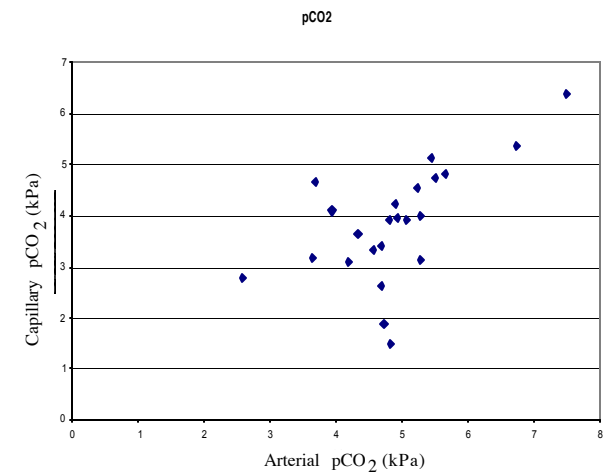
Any problems faced in the preparation and the data collection periods could have affected the overall results. With more training, the technique of taking a capillary sample would have made the study more successful. Approximately 20% of the patients willing to take part in the study were not actually able to participate as an insufficient amount of blood could be

taken from the ear for a proper reading. A possible way to get around this problem would be to use capillary samples from the fingertip, where more blood could possibly be obtained. This technique has been successful in some studies (9), though it is associated with more pain, removing one of the major advantages of capillary sampling. On occasions researchers may have failed to stab the correct part of the ear - the inferolateral aspect of the pinna (10). Also, as the capillary sample was small, if any air were to contaminate it, there would be a large difference noticed. However, since the arterial sample is larger, a small amount of air would not noticeably affect the overall results. Air contamination causes the pO<sub>2</sub> to be raised.

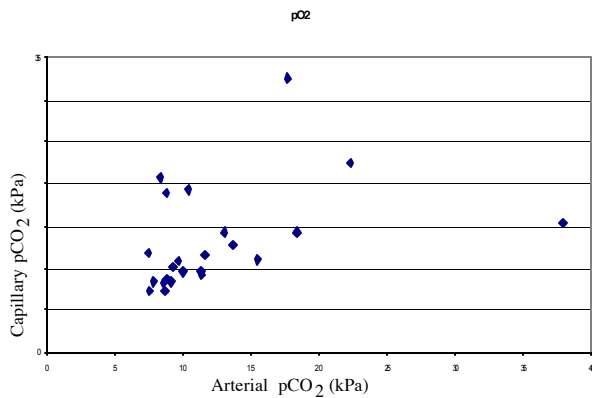
It was extremely difficult to conduct the capillary sampling at the same time as the arterial sampling. A time delay occurred, due to the 10 minute wait for the Tranvasin cream to take effect. Taking blood from the fingertip would help reduce this time delay (9). Due to the time delay between the two samples, the patient could have been administered oxygen during the interval and clearly, this would have altered the results. Studies that conducted the two methods simultaneously had the best results (2). Due to the nature of the setting, if oxygen needed to be administered to a patient, the treating doctors of the A & E department could not wait for the researchers to conduct the capillary sampling. Occasionally, when a capillary sample was taken there was a queue for the analysing machine. Putting the sample in ice to prevent degeneration of white cells may have helped in that circumstance. Other technical problems were also encountered such as machine calibration faults.



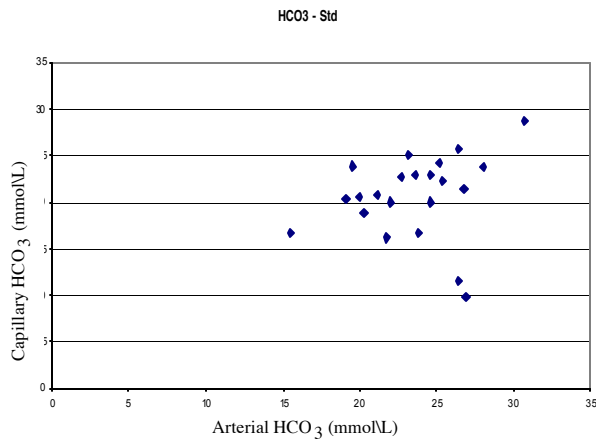
**Figure 1.** Scatter plots and correlations of Arterial and Capillary parameters. The scatter plot for pH shows an apparent positive correlation between the arterial and capillary samples, consistent with the two methods giving similar results.



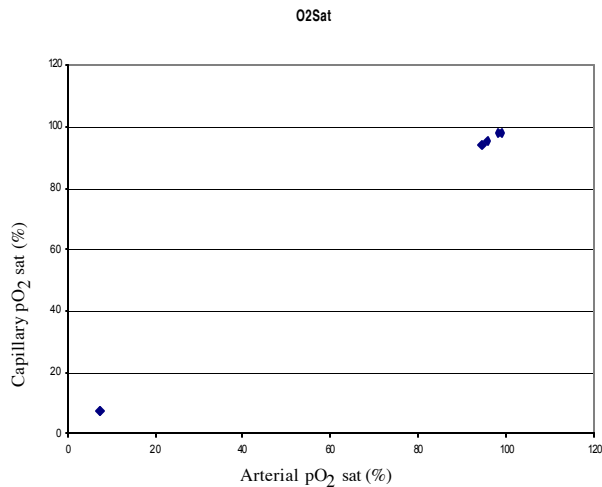
**Figure 2.** The scatter plot for pCO<sub>2</sub> seems to show a positive correlation between the arterial and capillary samples, with a definite clustering around 4.5/5 kPa, consistent with the two methods giving similar results.



**Figure 3.** The scatter plot for pO<sub>2</sub> shows an apparent positive correlation between the arterial and capillary samples with a large clustering around 10kPa and a few points, which are very scattered, consistent with the two methods giving similar results.



**Figure 4.** The scatter plot for HCO<sub>3</sub><sup>-</sup> shows a fairly positive correlation between the arterial and capillary samples, consistent with the two methods giving similar results



**Figure 5.** As there were very few samples taken for the O<sub>2</sub> saturation it is hard to tell how the strong the correlation is between the methods however we are able to see that there is still a positive correlation.

Greater accuracy and a reduction in bias could have been achieved had the sample size been larger. Due to time limitations the study had to be restricted to a small population size, which compromises the significance of the results. From data that was previously collected it has been calculated that a sample size of 165 patients will be required to demonstrate a difference in pH of 0.03, calculated with 80% power at p=0.05 level. Similarly, a sample size of 232 patients would be needed to detect a difference in pCO<sub>2</sub> of 0.05 mmHg at the same power and significance level. Finally, a sample size of 332 patients would be required to detect a difference in pO<sub>2</sub> of 0.05 mmHg at the above levels of power and significance. We would therefore recommend that the data collection be continued up to a sample size of approximately 332 patients. If the Senior House Officers were collecting the capillary sample every time they took an arterial one, the desired sample size could probably be reached in a much smaller time period. Time delays between the two samplings could also be avoided to a great extent.

Our study was also too small to show any correlation of the main variables measured with data such as patient sex, age, pulse, temperature, blood pressure, respiratory rate, oxygen therapy, sample volume and quality. From the above list, blood pressure, as an indication of the hemodynamic condition of the patient, seems to be of great significance (7,8). Further studies could also try to correlate the value of inter-changeability between the two techniques for various specific conditions. These studies may also attempt varying the severity of these conditions and varying the patient age groups.

The importance of identification of patients definitely requiring admission at the point of triage has been highlighted at the recent government paper "Reforming Emergency Care" (10). This strategy would serve the concept of "streaming," allowing patients to be admitted to a hospital bed in the most efficient manner. Other than routine observations and a brief clinical assessment, few tools are available to the triage nurse at present to facilitate this function. It may be that capillary blood gases could aid this process. In conclusion the authors would feel satisfied with capillary blood gas analyses if they were patients in the A & E department.

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