

## ORIGINAL ARTICLES

## Venous pH can safely replace arterial pH in the initial evaluation of patients in the emergency department

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### Abstract

**Objective**—This study aims to determine the extent of correlation of arterial and venous pH with a view to identifying whether venous samples can be used as an alternative to arterial values in the clinical management of selected patients in the emergency department.

**Methods**—This prospective study of patients who were deemed by their treating doctor to require an arterial blood gas analysis to determine their ventilatory or acid-base status, compared pH on an arterial and a venous sample taken as close to simultaneously as possible. Data were analysed using Pearson correlation and bias (Bland-Altman) methods.

**Results**—Two hundred and forty six patients were entered into the study; 196 with acute respiratory disease and 50 with suspected metabolic derangement. The values of pH on arterial and venous samples were highly correlated ( $r=0.92$ ) with an average difference between the samples of  $-0.4$  units. There was also a high level of agreement between the methods with the 95% limits of agreement being  $-0.11$  to  $+0.04$  units.

**Conclusion**—Venous pH estimation shows a high degree of correlation and agreement with the arterial value, with acceptably narrow 95% limits of agreement. Venous pH estimation is an acceptable substitute for arterial measurement and may reduce risks of complications both for patients and health care workers.

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Keywords: venous pH; blood gas analysis

Blood gas analysis has an important role in the assessment of patients with severe respiratory and metabolic disease, in particular for the accurate determination of pH. Arterial puncture is however often painful and carries the risk of complications such as local haematoma, infection and occlusion/embolisation of the artery with consequent ischaemic injury to the digits. Additionally, this procedure carries a small but appreciable risk of needlestick injury to health care workers, with the consequent

risk of transmission of blood borne viruses such as hepatitis C and HIV.

Over the past several decades, a number of small studies have shown that pH can be accurately estimated from venous blood and “arterialised” venous blood.<sup>1–7</sup> It has been reported that venous pH is almost identical to arterial pH.<sup>1,6,7</sup> This is supported by a recent small study of patients with diabetic ketoacidosis that showed that venous blood could be substituted for arterial in the assessment of acidosis.<sup>8</sup> Despite this evidence, arterial blood sampling remains the common method of determining acid-base status. There is no published evidence regarding the accuracy of venous pH measurement in the population of emergency department (ED) patients requiring assessment of their acid-base status.

This study aims to determine the extent of correlation of arterial and venous pH with a view to identifying whether venous samples can be used as an alternative to arterial values in the clinical management of selected patients in the ED.

### Methods

This prospective study was conducted in the Emergency Department of Western Hospital, a 250 bed community teaching hospital in Melbourne, Australia. The ED has an annual census of 36 000 adult patients.

Patients were eligible for entry into the study if they were deemed by their treating doctor to require an arterial blood gas analysis to determine their ventilatory or acid-base status. In practice, this limited the study to patients with respiratory or metabolic disease of a severity that warranted blood gas determination as part of assessment. After having the study explained and providing verbal consent, patients had arterial and venous blood gas samples drawn with minimum delay between the taking of samples. For patients receiving supplemental oxygen therapy, this was kept constant for the 10 minute period preceding the taking of samples. Both samples were analysed as soon as possible after collection by the same blood gas analyser. Patients were excluded if verbal consent could not be obtained. Samples were excluded, if after analysis, the sample thought to be arterial in origin proved to be venous.

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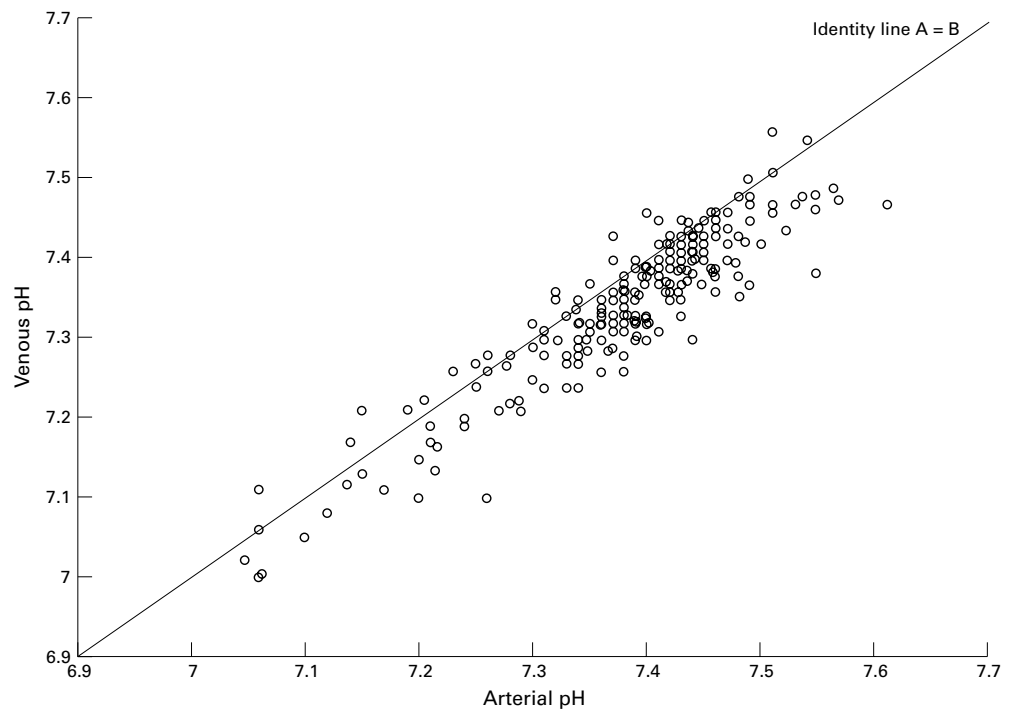


Figure 1 Correlation of arterial and venous pH values.

Data were analysed using Pearson correlation and bias plot methods. The study was approved by the Clinical Research and Ethics Committee.

**Results**

Two hundred and forty six patients were entered into the study; 196 with acute respira-

tory disease and 50 with suspected metabolic derangement.

The range of arterial blood pH was from 7.05 to 7.61 with a mean of 7.38 and a median of 7.40. Based on the arterial sample, 136 samples were within the laboratory normal range (7.35–7.45). Forty three samples were alkalotic and 67 were acidotic.

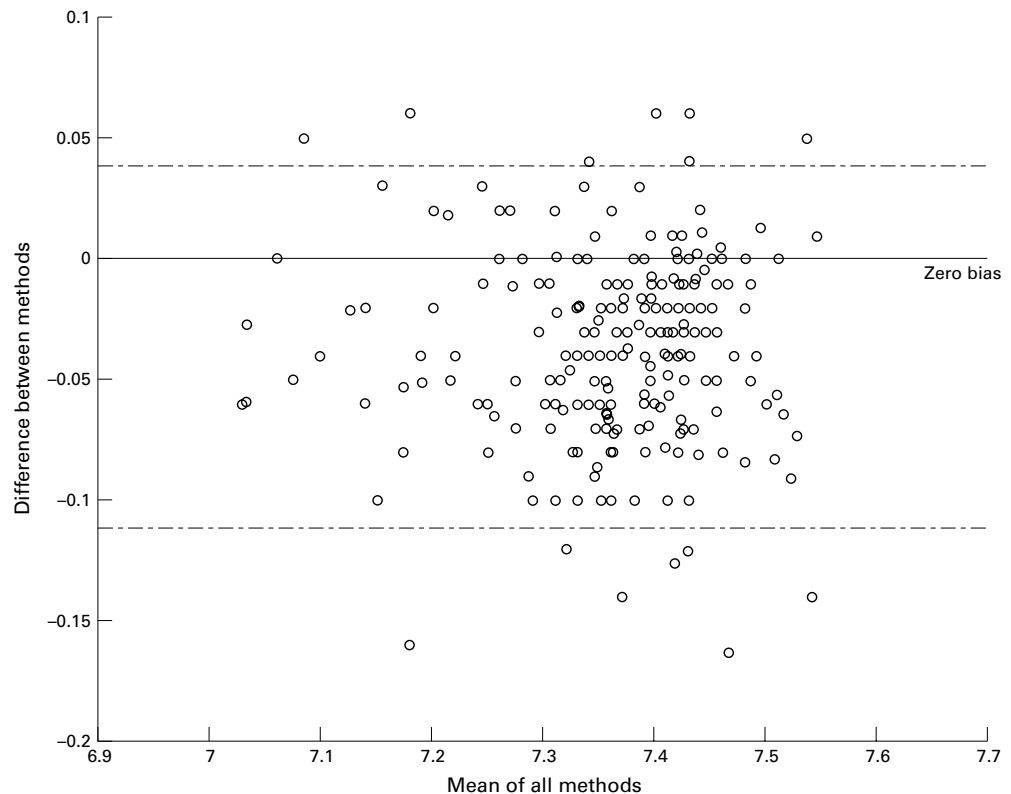


Figure 2 Bias (Bland-Altman) plot showing agreement between arterial and venous pH values and 95% limits of agreement.

The values of pH on arterial and venous samples were highly correlated ( $r=0.92$ , fig 1). The difference between arterial and venous samples ranged between  $-0.16$  to  $+0.06$  units, with an average of  $-0.04$  units.

Altman and Bland<sup>9, 10</sup> suggest that when assessing new tests it is agreement rather than correlation that is important. This can be shown visually in a bias (Bland-Altman) plot that plots the difference between the tests against an estimation of the true result of the test (assumed to be the mean of the test results). The bias plot for arterial versus venous pH is shown in figure 2. This shows excellent agreement with the 95% limits of agreement being  $-0.11$  to  $+0.04$  units.

### Discussion

Arterial blood gas analysis is the standard method for obtaining clinical acid-base assessment. Arterial sampling is however painful and carries a small risk of vascular complications for the patient. It also requires an additional vascular puncture, thus exposing staff to increased risk of needlestick injuries and blood borne infection.

A number of studies have suggested that venous pH measurement is in sufficient agreement with the arterial value to be an acceptable alternative.<sup>1-8</sup> These studies have however been small and venous pH estimation has not gained wide acceptance. To the authors' knowledge, this is the first large study of this question that investigates a population of patients with acute illness. Our study showed a high level of correlation and agreement. The average difference between the tests of  $-0.04$  pH units is not clinically significant. Additionally, the 95% limits of agreement ( $-0.11$  to  $+0.04$ ) are acceptably narrow. The high level of agreement shown suggests that the venous pH estimation is an acceptable substitute for an arterial estimation.

This study has some limitations that should be considered when interpreting the results. The study sample was a convenience sample based on when time and resources allowed patient enrolment. This is however unlikely to

have resulted in systematic bias. As less than half of the sample had abnormal pH values and only approximately one quarter were acidotic, it might be argued that accuracy at the extremes of the pathological pH range has not been tested. The range however was quite broad (7.05 to 7.61) and clinical judgement should be applied when a value of any test does not tally with the clinical picture. The study was conducted at a single institution and for practical reasons required consent to be given in English. Thus the sample is biased towards English speaking Australians and generalisability to other ethnic groups or patient populations might be in question.

In conclusion, venous pH estimation shows a high degree of correlation and agreement with the arterial value, with acceptably narrow 95% limits of agreement. Venous pH estimation is an acceptable substitute for arterial measurement and may reduce risks of complications both for patients and health care workers.

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