CLINICAL APPLICATION OF ACID–BASE MODELS,CALCULATION OF ARTERIAL ACID–BASE STATUS FROM PERIPHERAL VENOUS BLOOD

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Introduction: Patients residing in the intensive care unit (ICU) typically have indwelling arterial catheters, meaning that measurement of arterial bloodgas status is routine. For patients outside the ICU, measurement of arterial blood gases is via painful arterial punctures. In emergency medicine this means that blood gas and acid–base status is not typically evaluated unless the patient has chronic respiratory disease or dyspnoea. This is despite peripheral venous blood sampling being almost routine in these patients. In departments of pulmonary medicine admitted patients often have numerous arterial punctures taken over days. Arterial samples might be replaced by the arterialisation of peripheral venous sites, but this requires warming of the peripheral site or application of vasodi lative cream (1) and is not routinely performed.
Recently (2) a method has been developed which can calculate arterial blood gas and acid–base status from measurements in peripheral venous blood, supplemented with pulse oximetry. This method is based on a mathematical model of the acid–base chemistry of blood (3),where peripheral venous blood is mathematically arterialised. This abstract summarizes the method and the major results to date.

$tO_{2,v} \rightarrow tO_{2,a} = tO_{2,v} + \Delta O_2$
$tCO_{2,v} \rightarrow tCO_{2,a} = tCO_{2,v} - RQ^* \Delta O_2 \rightarrow pH_a, PCO_{2,a}, PO_{2a}, SO_{2,a} \rightarrow SO_{2,a} = SpO_2$
$BE_v \rightarrow BE_a = BE_v$

Fig. 1. Mathematical arterialisation, see (2) for details.

Method: The mathematical arterialisation method (2) is illustrated in Figure 1. Briefly, values in the peripheral venous blood are used to calculate the total oxygen concentration (tO2), total carbon dioxide concentration (tO2) and base excess (BE) of venous blood (v). Assuming no local strong acid transport into blood, arterial and venous BE are equivalent. Assuming a fixed value of respiratory quotient (RQ), tO2,a and tCO2,a can be calculated from venous values with only one unknown, DO2, the drop in oxygen concentration over the tissues. The resulting values of tO2,a and tCO2,a and BEa can then be used to calculate all other variables for arterial blood. A value of DO2 is selected such that calculated arterial oxygen saturation SO2,a is equal to that measured by pulse oximetry SpO2.

Results and Conclusion: The method has been evaluated in a range of patients including those in intensive care and spanning a wide range of acid–base disturbances (4), and in patients residing in pulmonary medicine (5). Arterial pH can be calculated with very small bias (<0.002) and standard deviation (0.014), as can arterial PCO2 (bias< 0.09 kPa, SD<0.28 kPa). Accurate calculation of PO2 can only be made for SpO2<97 %. Patients studied in the department of pulmonary medicine (5) breathed spontaneously and as such only 4 from 40 patients had SpO2 ‡ 97%. In these patients PO2 could be calculated with a bias of 0.11 kPa and SD = 0.53 kPa, this precision improving with lower values of PO2. The mathematical arterialisation method may be a valuable tool in providing arterial blood gas and acid–base status in situations where arterial catheters are not present.
In doing so it might minimize the number of painful arterial punctures, and maximize the information obtained from routinely taken peripheral venous blood samples.

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