Clinical Note

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Blood Gases

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MEASUREMENTS OF BLOOD GASES and hydrogen ion concentration (pH) have developed in most hospitals without a parallel development of training and quality control. While the growth of blood gas services has been exceedingly rapid, little has been done to ensure that machines meet standards of accuracy and reliability, especially for partial pressure of oxygen (Po_2). The manufacturers have not had to prove the same assurance of reliability as even the simplest new drug, even though most have tried hard, no rigorous standards exist. The results of the analysis can appear deceivingly accurate, yet can be dangerously incorrect; the cost of error and machine dissatisfaction is borne by the patient in dollars and well-being.

We have operated a quality control program in Los Angeles for more than one year. Iced blood samples with known values are delivered directly to subscribers at nominal cost. As a result, we have learned several important facts about blood gas machines as they function in the community and of those who use them. First, we have found that better trained people, whether in pulmonary laboratories or clinical chemistry, operate the less automatic machines and get the most reliable results by a considerable margin. We have also found that those automated machines made for small hospitals are, in fact, most prone to subtle error. In our study, the IL-313 type of machine averages more than 10 mm of mercury, and sometimes 20 mm of mercury, higher than the true value for blood Po_2. Our initial limited testing of the ABL-1 type of machine with known blood Po_2 values suggests it also needs sophisticated supervision. The Po_2 is higher than our values by 5 mm of mercury over a wide range. While this machine calibrates itself with liquid, it is not entirely clear that the liquid is the entire explanation for this difference. On the other hand, the nonautomatic models (113 and 213 of IL) read well within the required ± 2 mm of mercury tolerance on the average. Corning Model 165 reads slightly greater than tolerance;[1,2] Radiometer BMS-2 and 3 are within tolerance. All machines average to tolerance for carbon dioxide pressure (Pco_2) and pH.

We have concluded that the smarter the machine, the smarter must be the people who run it. Do not expect to replace well-trained pulmonary technicians or analysts, and proper supervision, by elaborate electronics without first acquiring the necessary biomedical engineers and the supervision required.

We suggest that instead of automation, half the money should be spent for straightforward nonautomatic machines and the other half on training operators. Quality control begins with well-trained analysts. Next, tonometer blood at Po_2 ranges from 40 to 80 mm of mercury or exchange iced blood samples regularly with other units. Agreement to ± 4 mm of mercury for Po_2 and Pco_2 is barely acceptable; larger differences must be explained. Do not expect much agreement at first. The magnitude of the disagreement, in fact, may be startling. Continued checking one with another results in surprising reliability if the differences are honestly resolved.

Quality control includes the director of the blood gas laboratory. This physician must review blood gas results for aberrant or impossible results. Patient breathing sea level room air, the sum of the arterial Po_2 and Pco_2 cannot be greater than 150 mm of mercury; the Po_2 value is very doubtful if the sum is greater than 140 mm of mercury. Sums are lower at higher altitudes. A sum less than 80 mm of mercury suggests, but does not prove, the sample is venous blood. The pulmonary specialist managing a blood gas laboratory is in the best position to note values inconsistent with the patient's problem. As he adds his interpretation of blood gas values, he also comes to know the clinical situation as well.

Finally, responsibility for quality control rests with the clinician who uses arterial blood gas results. He should particularly be skeptical of "machine numbers" as well as such interpretations. Inconsistency between results and his evaluation of his patient must be explained. This might take another arterial blood sample, or an education.

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