Automating blood gas improves preanalytical quality

September 2007

Agnes Ivanov
Quality Manager
United Laboratories of
Tartu University Hospital
L. Puusepa 1a
50406 Tartu
Estonia

Tartu University Hospital has improved the quality of blood gas testing in its clinical laboratory and critical care units by introducing an automatic system for blood gas analysis [1].

At Tartu University Hospital, Estonia (see End-note), we wanted to find out if an automatic system for blood gas analysis could help improve the quality in our laboratory as well as in the clinic.

Factors affecting the length and the quality of the preanalytical phase

In our laboratory, blood gas samples are processed 24 hours per day on two blood gas analyzers. The workload is about 130 specimens per day with a peak workload at 5 am – about 35 specimens per hour. Ideally, specimens should not be stored before the analysis. It is recommended that blood collected for special studies (pO_2 (A-a), or "shunt" studies) should be analyzed within 5 minutes [2]. However, in reality, this short period is very difficult to achieve.

Transport time

There are two parameters, with influence on the time between sampling and analysis, which can be reduced. The first parameter is the time for transport of blood samples.

The main intensive care units of TUH are located at a distance of 2-15 minutes' walk from the Department of Clinical Chemistry at UL. Blood samples are drawn by nurses and transported to the laboratory by assistant nurses. The laboratory has created a documented procedure for blood gas analysis to reduce the waiting time of the samples during the peak period in the morning. According to this document:

- Each intensive care unit has a fixed time for sample transport to the laboratory
- The maximum allowable number of specimens that can be sent during any 15-minute period should not be more than five

Storage/wait/mixing time

The second preanalytical time parameter is how long the sample stays in the laboratory before analysis, i.e. registration of the sample, placing the order in the laboratory information system (LIS) and mixing the sample for blood homogenization.

The total preanalytical time in the laboratory with a non-automatic blood gas analysis system is about 1 or 2 minutes for registration and 2 minutes for mixing each sample using a combination of inverting it vertically and rolling it between palms.

Sample mixing is absolutely important for accurate measurement of hemoglobin (Hb), and for a lot of other parameters where the Hb value is an input parameter for special equations (hematocrit, oxygen saturation, shunt, etc.) [2].

Automating blood gas sample registration

The introduction of an automatic blood gas analysis system changed the preanalytical process by eliminating the time for the registration of samples and test orders in the laboratory, since the test order is performed by a nurse using a PDA or a PC in the critical care unit before drawing the blood sample.

The blood drawing procedure is as follows:
The nurses scan (using a PDA or hand-held scanner connected to PC) their own ID, the pre-barcoded sampler ID and the patient ID. They then enter the electronic order of tests and the required input parameters into the PDA or PC and draw the blood sample.

Automating blood gas sample preparation and measurement

After blood sampling and transport of the sampler to the laboratory, the sampler is placed directly in the analyzer for automatic mixing. The sample and the order are recognized automatically by the barcode on the sampler.

The blood gas analyzer contains a module for automatically mixing the blood samples before measurement. The mixing process in the analyzer lasts only a few seconds but is quite intensive, and sample homogeneity after mixing is acceptable for Hb measurement.

After mixing the sample, the analyzer reads the barcode sampler ID and retrieves all information associated with it, such as fraction of oxygen in inspired air (FO2(I)), patient temperature, respiratory quotient (RQ), sample type and the order of tests. The measurement time is 2 minutes.

Automating blood gas sample result delivery

After validation, the results are sent automatically to the critical care unit from which they were ordered. Results are sent back to the PDA or PC interface and are available to the medical personnel. The data can be imported from the interface to a set of documents, such as:

- Patient medical history record document
- Quality Control document

Comparison of automatic and manual mixing

In our critical care units, nurses draw three samples from each patient in the morning; one sample for blood cell count, a second for biochemistry tests and a third for blood gas and acid-base measurements.

After the samples have been measured there are two different hemoglobin results: one from the hematology cell counter, and another from the blood gas analyzer.

We have compared the results of 101 patients for hemoglobin measurement, ranging from 80 g/L to 180 g/L, using automatic and manual mixing on the blood gas analyzer, and compared to the hematology analyzer. The results were compared using mean differences, paired t-test and linear regression.

The regression line for manual mixing on the blood gas

analyzer, compared to the hematology analyzer, was: Hb manual = +0.48 + 1.08 × Hb blood cell counter, R2 = 0.58, and IC95 %. Hb mean difference was 8.5 g/L.

The regression line for automatic mixing on the blood gas analyzer, compared to the hematology analyzer, was: Hb automatic = 3.29 + 0.97 × Hb blood cell counter, R2 = 0.97, and IC95 %. Hb mean difference was 0.2 g/L.

The results from manual mixing on the blood gas analyzer indicate very poor correlation and hemoglobin test values were significantly higher than the hemoglobin values measured by the hematology analyzer.

The results from automatic mixing on the blood gas analyzer indicate a very good correlation and hemoglobin test values were not significantly different from the hematology analyzer.

Conclusion

In our experience the automatic system improved the quality of the preanalytical phase. The time for registration of the sample and ordering the tests has been optimized. Automatic mixing of the sample has reduced the measurement time and improved the effectiveness of the procedure.

References

1. Radiometer Medical ApS, 1st automaticTM blood gas analyzer system, available from www.radiometer.com/1st. Accessed September 20, 2007.
2. Blood gas and pH analysis and related measurements. NCCLS Approved Guideline C46-A, Vol. 21 No.14, 2001
3. Clinicum, SA Tartu Ülikooli Kliinikumi maineraamat, 2007

End-note

Estonia's largest hospital is Tartu University Hospital (TUH), comprising a consortium of 16 clinics. The largest clinic, the Anesthesiology and Intensive Care Clinic, is composed of eight departments including 30 operating rooms. TUH receives around 418,000 outpatient visits per year of which 13 % are made to the emergency medicine units. Of 43,700 inpatients, 78 % of them are admitted due to emergency reasons [3].

The number of blood gas analyses is constantly increasing. In 2006 more than 40,000 blood gas analyses were performed in the United Laboratories (UL), the clinical laboratory of the TUH.