A Cost-Effective, High-Performance Approach to Critical Care Testing

In 1996, our 450-bed community hospital needed to improve critical-care laboratory test turnaround time and reduce the cost of laboratory services for the intensive care units. The value of rapid test-result availability for critically ill patients is well-established.1-3 With advances in laboratory technology, point-of-care systems can provide these rapid results.4,5 Our goal was to select a point-of-care system that would have minimal impact on nursing responsibilities and duties and maintain the central laboratory oversight and laboratory data integration. Our approach to these somewhat conflicting objectives was through real-time-monitored point-of-care testing.

Background

Fresno Community Hospital was using a traditional approach to critical care testing. Laboratory staff manually processed physician's orders. The stat laboratory, established in 1983 on the 10th floor near the intensive care unit, was staffed 12 hours a day by medical technologists and provided basic chemistry testing (electrolytes, glucose, blood urea nitrogen), blood gas analysis (P_O₂, P_O₉, pH), CBC, and activated clotting time. Laboratory services in off-hours were divided between the central laboratory located on another floor and the intensive-care-unit staff. The intensive-care-unit nurses used a freestanding point-of-care analyzer (GemStat; Malinkrodt, St Louis, Mo) with capability for blood gas analysis, pH, and electrolytes, and the laboratory test results obtained with this analyzer were manually entered in the laboratory information system by stat laboratory staff the next day. The central laboratory provided other services not available with the GemStat analyzer.

The quality of the stat laboratory testing, performed by licensed and experienced technologists, was a boon to patient care. However, some problems were identified regarding laboratory services for patients on intensive care units, and included inadequate service during off-hours, inconsistent laboratory testing (ie, different staffing and different methods used on different shifts), and serious lag-time in capturing the results of off-hours testing in the laboratory information system. Keeping the stat laboratory staffed full-time with laboratory professionals was an inefficient and costly exercise that became more burdensome with the advent of diagnosis related groups (DRG)-based reimbursement and managed care. We needed to find a system or solution that would address our issues without sacrificing quality or timeliness.

Options Considered

We evaluated four options for improved critical care testing. All options considered were to be used by the nursing staff and to be implemented on all shifts.
Option 1—To extend the use of the GemStat analyzer operated by the nurses on the night shift to all shifts. Advantages of this system were previous experience of staff and demonstrated reliability. Disadvantages were the lack of a real-time monitoring option for the central laboratory, lack of data capturing, and the high cost of reagents.

Option 2—Implementing use of the i-STAT (i-STAT Corp, East Windsor, NJ) point-of-care analyzer, which was already in use on the telemetry unit, for point-of-care testing. Advantages of the i-STAT were portability and ease of use. Disadvantages again centered on lack of a real-time monitoring option. Although apparently easy to use, the i-STAT had not gained favor with our busy medical unit nurses, and had seen little use despite the availability of nearly immediate results. High reagent costs were also of concern.

Option 3—A new-generation pneumatic tube system connecting the intensive care units with the main laboratory and the pharmacy was suggested. This option was not further considered because the pharmacy was in the process of evaluating other systems for drug distribution, which were adopted. The pneumatic tube system for laboratory use alone was not cost-effective owing to the construction required.

Option 4—To switch to a blood gas and chemistry analyzer with the then newly developed Remote Automated Laboratory System (RALS; Medical Automation Systems, Charlottesville, Va). The strength of RALS was the presence of a computer communications link between the floor-based analyzer and the central laboratory.

Option four was selected as the solution that met our primary objective of a real-time monitoring point-of-care system. The information system support provided maximal ease of use for nursing personnel while maintaining low test costs and central monitoring. Other advantages included an interface with the hospital information system for displaying results and easily selecting patients from a list, and familiar performance and maintenance parameters from laboratory-grade analyzers. Because of this electronic link to the laboratory equipment on the medical floors, the central laboratory has as much control on these sites as it does with its main benchtop instruments. In essence it is an extension of the bench, thanks to electronic linkage.

Based on our need for a complete critical care menu that included blood gases, pH, electrolytes, glucose, blood urea nitrogen, and hematocrit, we chose Stat Profile 10 (Nova Biomedical, Waltham, Mass) blood gas/chemistry analyzers to run with the RALS system.

System Operation
Each RALS workstation maintains a list of the unit census via the connection to the hospital clinical information system. Using the RALS touchscreen (much like an automatic teller machine), nurses locate the patient by name and medical record number, select desired analytes, then introduce the sample to the analyzer. After the analysis is completed, the results are transmitted by local area network to the central laboratory. At that point the laboratory is alerted by an audible chromatic scale that results are pending. A medical technologist in the laboratory reviews the results on the RALS screen and accepts or rejects them. The results are then printed at the unit-based RALS workstation and are simultaneously uploaded into the laboratory and hospital information systems. If the technologist finds the results not acceptable, the critical care site is notified to take appropriate action according to previously established criteria (eg, delta check failure, critical value, instrument error flag).

Cost Benefits
Problems with the stat laboratory included high fixed and variable costs, inefficient use of trained laboratory personnel, and excessive laboratory contribution to total turnaround time, as well as increased allocated instrument space outside the main laboratory. The stat laboratory supply costs (reagents, quality control materials, parts) was about $115,000 per year, compared with about $40,000 per year with the RALS/Stat Profile system. The cost of GemStat test cartridges used by

Diane Huffman, RN, processes specimens on the Stat Profile (Nova Biomedical, Waltham, Mass) analyzer, which is linked to the clinical laboratory by the Remote Automated Laboratory System (Medical Automation Systems, Charlottesville, Va).
the night shift personnel was the major contributor to the supply cost for the stat laboratory. Personnel savings have been even more dramatic: $132,000 vs $36,000 per year (Table 1). Total cost savings are $171,000 yearly.

**System Performance**

In terms of laboratory utilization, test volume has increased, with a different mix of tests available with the RALS/Stat Profile system. Whereas the stat laboratory had been available only 12 hours each day, the RALS/Stat Profile system allows consistent operations 24 hours a day. With regard to turnaround time, the stat laboratory averaged 40 minutes for typical test results, compared with an average 5.9 minutes per test with RALS/Stat Profile (Table 2).

**Regulatory Compliance**

Maintenance and monitoring of the RALS/Stat Profile system is regarded as the same as for any laboratory instrument to meet the requirements for proficiency and quality control. Instrumentation quality control is performed every 8 hours by medical technologists. External proficiency testing is performed quarterly through the College of American Pathologists' program. Correlation studies are performed twice a year to ensure accuracy and precision of results between similar instruments.

**Staff Acceptance**

We were extremely sensitive to labor and professional issues often encountered when a new system and new technology are introduced. A training program for both laboratory staff and RALS/Stat Profile users was the key to overcoming issues such as resistance to change. One perception was that the new system would take jobs from medical professionals in the laboratory. In reality, a staffing plan provided for the stat laboratory staff to transfer to areas of the laboratory that had position openings. The system depends on trained and experienced laboratorians who know best how to analyze, interpret, and verify results. To alleviate these fears, we discussed the issues openly during training sessions.

We anticipated and received resistance from nurses who were trained to use the new system. Several expressed objections such as wanting the old system back, with the laboratory on the medical floors. We tried to meet resistance with sensitivity.

We allotted plenty of time for question-and-answer sessions during training. We emphasized the ease of use and advantages of near-immediate results. The impact on critical-care nurse staffing was not significant, and no additional nurses were required after implementation of the system.

We believe this point-of-care system has preserved testing quality. The RALS/Stat Profile point-of-care system has convinced us that a user-friendly, real-time monitoring system that preserves test quality, holds costs down, and improves turnaround time is possible.

**Further Development**

After installation of the initial RALS system at Fresno Community Hospital, our hospital initiated a merger with the local county hospital, adding in October 1996 another 300-bed hospital to our system. Laboratory operations were integrated from the start of merged operation of the hospitals, and the RALS system with the Stat Profile Ultra analyzer was installed in the emergency department and operating room areas of the University Medical Center, University of California at San Francisco, the newly merged hospital. Further expansion of RALS installations is under consideration, and may include outpatient clinics on the teaching hospital campus.
Summary and Conclusions

Our search for improved performance and productivity in critical care testing at Fresno Community Hospital led us beyond the realm of point-of-care instruments to the era of the “distributed instrument,” made possible with computer networking and interfaces to existing hospital and laboratory information systems.

This approach has allowed us to reduce costs substantially for critical-care metabolic testing and to simultaneously improve test result turnaround time dramatically. These goals have been accomplished with a system that provides high-quality laboratory-grade analysis with efficient use of both intensive-care-unit and central laboratory personnel. Consistent 24-hour operation adds uniformity to intensive care-unit patient management. Extensive education and involvement of both laboratory and nursing personnel helped to improve the acceptance and use of the new technology on both ends.

The success of the system was further ratified by successful installations in a second hospital site to meet the needs of the operating room and emergency department for rapid turnaround time of test results. Expansion of the concept and the system is anticipated. The potential for adding increased hematology testing capability has been introduced in discussion, and we are evaluating additional sites and additional analytes for use in the “distributed instrument” networks.

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References