

Evaluating stat testing options in an academic health center: therapeutic turnaround time and staff satisfaction

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We compared centralized vs distributed methods for delivering "stat" test results for blood gas, glucose, and electrolyte assays. The parameters for comparison were as follows: (a) laboratory turnaround time (TAT), (b) therapeutic TAT, and (c) staff satisfaction. Therapeutic TAT, defined as the time from the initiating order to the receipt of the result and the implementation of any indicated change in treatment, was obtained by direct observation of testing procedures at the bedside and timing each step in the process. Observing therapeutic TAT yields information on the impact of laboratory testing methods in the context of clinical decision making. Therapeutic TAT was 1-2 min shorter for bedside testing compared with a satellite laboratory and 9-14 min shorter in the satellite laboratory compared with centralized testing. Satellite laboratories received the highest staff satisfaction scores, followed by bedside testing, with the central laboratory receiving the lowest scores.

Decision making in the management of critically ill and unstable patients requires rapid access to information on key analytes (e.g., blood gases, glucose, and electrolytes). "Stat" testing processes—the sequence of steps required to obtain time-urgent test results—must be structured to fit the context of care where testing services are required (1, 2). New testing modalities have arisen to meet these demands.

We have studied various options for delivering stat testing at the University of Alabama at Birmingham Hospital, a tertiary care, teaching hospital with 746 operating beds. The hospital maintains a central stat labora-

tory with a dedicated pneumatic tube station, five satellite laboratories in critical care areas, and i-STATTM Portable Clinical Analyzers (i-STAT Corp.).³

Three sets of comparators provide the basis for our evaluation of testing options: laboratory and therapeutic turnaround times (TATs)⁴ (1) and staff satisfaction assessments.

Traditionally, TAT is separated into three phases: pre-analytic, analytic, and postanalytic (Fig. 1). The preanalytic phase encompasses the time beginning when an order is given for a test and lasts through the processing of that order and the collection and transport of a specimen to the laboratory. The analytic phase is the time required to produce a verified result and is typically used as a measure of laboratory quality. The postanalytic phase is the time from completed analysis to the reporting of a test result. After this phase, there can be a substantial lag between the posting of a result in a Laboratory Information System (LIS) and the retrieval of that result report by a nurse or physician (3).

Therapeutic TAT, as illustrated in Fig. 1, captures this and other factors by extending the interval to include the time from receipt of a test result at the point of care through to the initiation of a therapeutic intervention based on that result (1). Measuring therapeutic TAT requires a shift in observer perspective from the laboratory to the bedside. Observation at the point of care yields information on the complete testing process and how test results support clinical decision making. A variety of factors not directly associated with laboratory processes and performance affect therapeutic TAT. These factors include preanalytic obstacles to rapid order and specimen processing, delays in accessing and communicating re-

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³ Use of trade names is for identification only and does not represent endorsement by the US Department of Health and Human Services or by the Public Health Service.

⁴ Nonstandard abbreviations: TAT, turnaround time; LIS, Laboratory Information System; CICU, Cardiothoracic Intensive Care Unit; ICU, intensive care unit; and ABG, arterial blood gas.

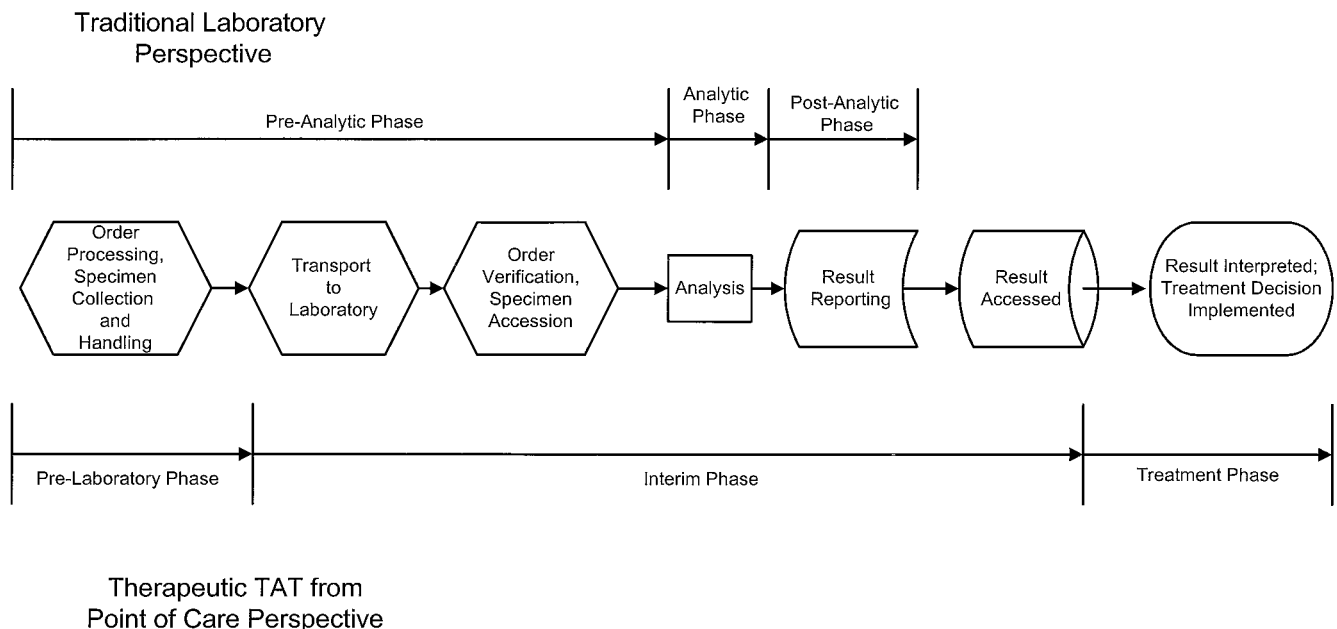


Fig. 1. TAT phases.

sults to decision makers, and presence or absence of algorithms or critical pathways for prompt use of laboratory information.

Because of the change in perspective, the testing phases take on different meanings. We subdivide therapeutic TAT into prelaboratory, interim, and treatment phases (Fig. 1). The prelaboratory phase ends with the dispatch of a specimen to the laboratory or analysis at the bedside. The interim phase begins with dispatch of a specimen to the laboratory, or the start of bedside analysis, and ends with the receipt of a report at the bedside. Parts of the preanalytic phase and all of analytic TAT are subsumed in the interim phase of therapeutic TAT. The interim phase also includes transport time and the interval between a verified test result being posted in the LIS and that result being accessed or received at the bedside.

Rapid testing putatively provides more accurate information on a patient’s current condition and improves the efficiency of the decision-making process. When results are available in a short time, nurses and physicians are able to remain focused on the clinical decision that laboratory information is intended to support. This phenomenon is referred to as “physician capture” (4).

Materials and Methods

Our study focused on differences in laboratory and therapeutic TATs among the central blood gas laboratory, a satellite laboratory in the Cardiothoracic Intensive Care Unit (CICU), and i-STAT analyzers used in the Neurological Intensive Care Unit and in the Heart Transplant Intensive Care Unit. Observations of therapeutic TAT for the central blood gas laboratory were made in the Heart Transplant Intensive Care Unit. We calculated laboratory

TATs, using data from the University of Alabama at Birmingham Hospital LIS, as the interval between accession into the LIS and the posting of a verified result. Our data consisted of 11 284 blood gas or glucose reports from the CICU satellite laboratory and 5394 blood gas or stat glucose reports from the central laboratory, all reported over a 3-month period from November 1996 through January 1997.

We conducted a study in the intensive care units (ICUs) to record the time required by nursing staff to process orders, obtain, prepare, and transport specimens, and retrieve results, or to conduct tests at the bedside. Fig. 2 charts the steps involved. The endpoint occurs when a treatment decision is made and acted on. The process is simplified for the satellite laboratory. There is no need to enter the order into the LIS or to place the specimen in a bag with ice, as is required for transport to the central laboratory. Result retrieval is also simplified by an LIS interface with a bedside clinical information system, the CareVue 9000 (Hewlett-Packard Corp.), providing result reports immediately after verification in the LIS. Bedside testing simplifies order entry, obviates the need for specimen labeling and transport, and provides immediate results. Data from analyzers are uploaded daily into the LIS for billing, quality control, and quality-improvement purposes.

For therapeutic TAT, the data consist of 38 observations made for the central laboratory testing process, 40 for the CICU satellite laboratory, and 81 observations of bedside testing using i-STAT analyzers. Times were measured by stopwatch and recorded for each step in the process, up the point when a result was reported and treatment initiated based on that result (when applicable);

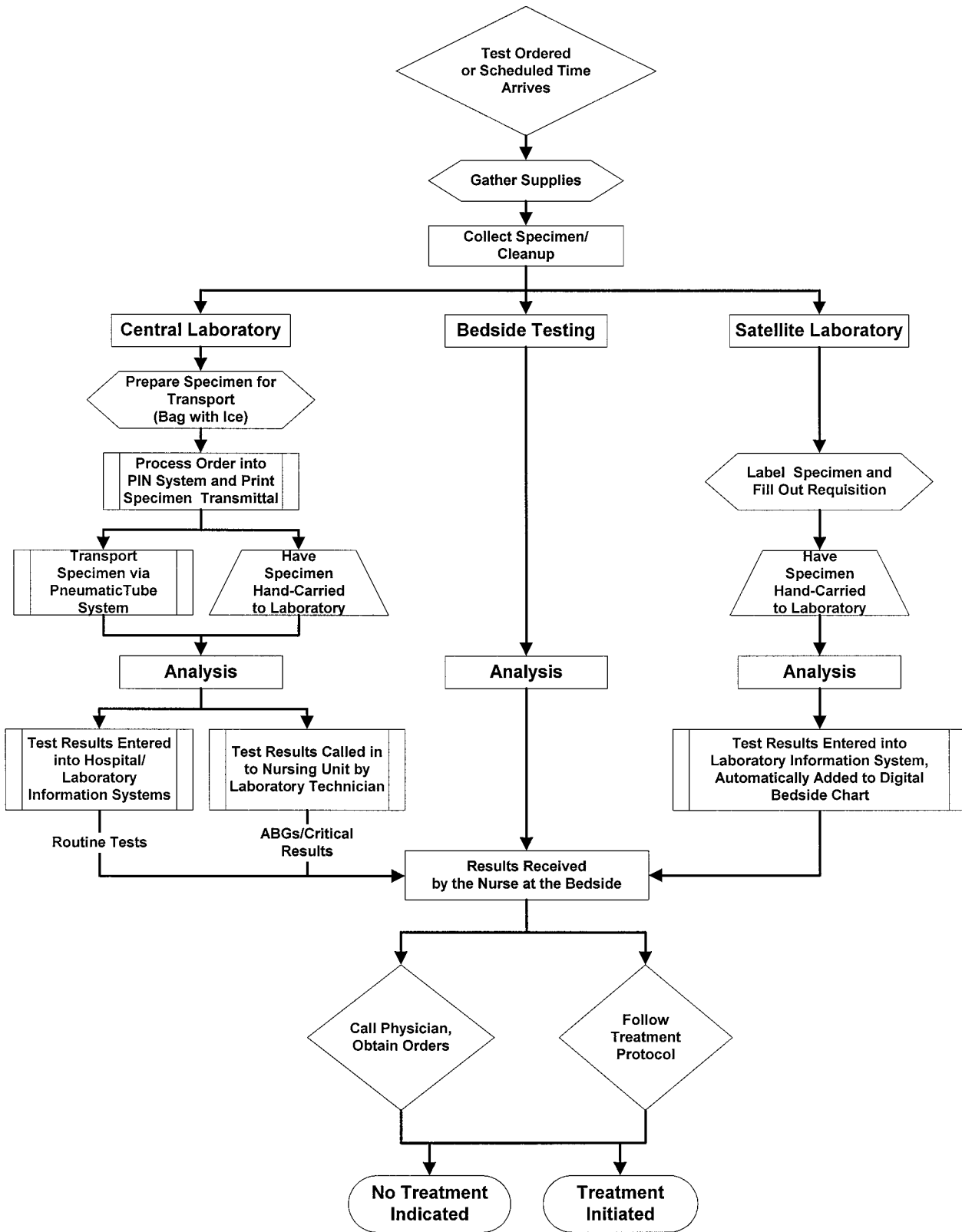


Fig. 2. Flowchart for stat testing processes.

not all test results lead to treatment changes). The same observer made all observations between November 1996 and January 1997. Units were visited, during both day and night shifts, at times when testing activity was expected to be high because of full census.

We surveyed direct care providers to learn their opinions of the three options for laboratory testing. A questionnaire was developed and piloted to ensure that the questions were clear to respondents. Respondents graded testing methods in five categories: timeliness, accuracy, convenience, labor conservation, and promotion of improved patient care. Information collected included the respondent's professional title (e.g., RN, resident, attending physician), the critical care area in which the respondent practiced, and testing options most frequently used for stat blood gas, electrolytes, and glucose results. Letter grades from the staff satisfaction surveys were entered into a spread sheet program, then coded numerically from a letter grade of F = 0 (worst) through A = 4 (best). Overall scores for each testing option were computed by averaging the grades for the five grading categories.

The respondents included 90 ICU nurses and 65 resident and attending physicians practicing in critical care areas. ICU nurses were surveyed at staff meetings in various units to yield a representative sample of nurses using various testing options, and their 90 responses constitute a 100% response rate. Physicians were surveyed using a campus mailing of the survey instrument. The 65 responses come from 180 physicians practicing primarily in critical care areas (a 36% response rate). The data on nursing staff satisfaction is therefore more complete than the data from physicians.

Data management and statistical analysis were performed using the SAS[®] System, Ver. 6.11 (SAS Institute). Laboratory TATs were calculated from accession and result verification times, sorted by analyte and test site, and then analyzed with respect to median and percentile distributions (5). A Wilcoxon rank sum test (6) was used to test whether observed differences in TATs were statistically significant. Therapeutic TATs were calculated by summing the median values for each of the timed process steps. Interquartile (25–75%) ranges and 95th percentiles were calculated as indicators of TAT variability. The prelaboratory, interim, and treatment phases for each testing option were examined to determine the reasons for TAT differences between testing methods.

Staff satisfaction survey responses were sorted by critical care unit and the testing option used for the three classes of analyte (arterial blood gases (ABGs), glucose, and electrolytes). A Duncan's multiple range test was performed to determine the extent to which satisfaction scores differ significantly, whether physicians and nurses graded testing options differently, and how familiarity through use affects user satisfaction (7). Principal components and factor analyses were done to identify which factors correlated most closely with overall satisfaction

scores and, according to staff perceptions, with better patient care (8).

Results

We first considered laboratory (analytic) TAT. The satellite laboratory reported results significantly ($P < 0.0001$) more rapidly (median TAT, 4 min) than the central stat laboratory (median TAT, 10 min). Comparable TAT for bedside devices is the time required to process the specimen after the cartridge is inserted, between 2 and 2.5 min, except when errors occur. Known error rates averaged 6.8%, and system or operator errors require repeating the analysis step, increasing analytic TAT by an additional 2–2.5 min.

The CICU satellite laboratory reported 59% of its ABGs within 3 min, and >96% within 12 min (Fig. 3A); for glucose results, 51% were reported within 3 min, and 96% within 12 min (Fig. 3B). From the central laboratory, 4.5% of ABG results were reported within 3 min, 67% within 12 min, and 95% within 48 min (Fig. 3C). For central stat laboratory glucose results (limited to stat requests and critical values), 6% of results were reported within 18 min, and 94% of results were reported within 60 min (Fig. 3D).

Table 1 gives a breakdown of prelaboratory, interim, and treatment phases, encompassing therapeutic TAT for central and satellite laboratory testing and for bedside (i-STAT) testing. Therapeutic TAT was not significantly different for bedside and satellite laboratory testing, but was significantly longer ($P < 0.0001$) in the central laboratory. Indeed, the preanalytic component for central laboratory testing is greater than that for the complete bedside testing process.

Another worthwhile set of findings involves the frequency that tests results prompted treatment changes. We found that CICU satellite laboratory testing prompted treatment changes 57% of the time. In the Neurological Intensive Care Unit, 26% of i-STAT test results prompted changes in treatment. In the Heart Transplant Intensive Care Unit, i-STAT tests were acted on 38% of the time, and central blood gas laboratory tests were acted on 21% of the time.

Results from the staff satisfaction survey (F = 0 to A = 4) favored distributed testing methods. The central blood gas laboratory received high marks for accuracy (mean, 3.27), but poor overall scores (mean, 2.21). In contrast, respondents gave i-STAT analyzers high overall scores (mean, 3.37), but lower scores for accuracy (mean, 2.87). The highest marks for accuracy and overall satisfaction (mean, 3.55 and 3.49, respectively) went to the satellite laboratories. The lowest score for any parameter went to the central blood gas laboratory for timeliness (mean, 2.83). ANOVA showed the differences in scores between laboratories to be significant ($P < 0.0001$). Ratings by physicians and nurses were not found to be significantly different ($P < 0.475$) for any score.

Using Duncan's multiple range test, we found that nurses and physicians who used the central blood gas

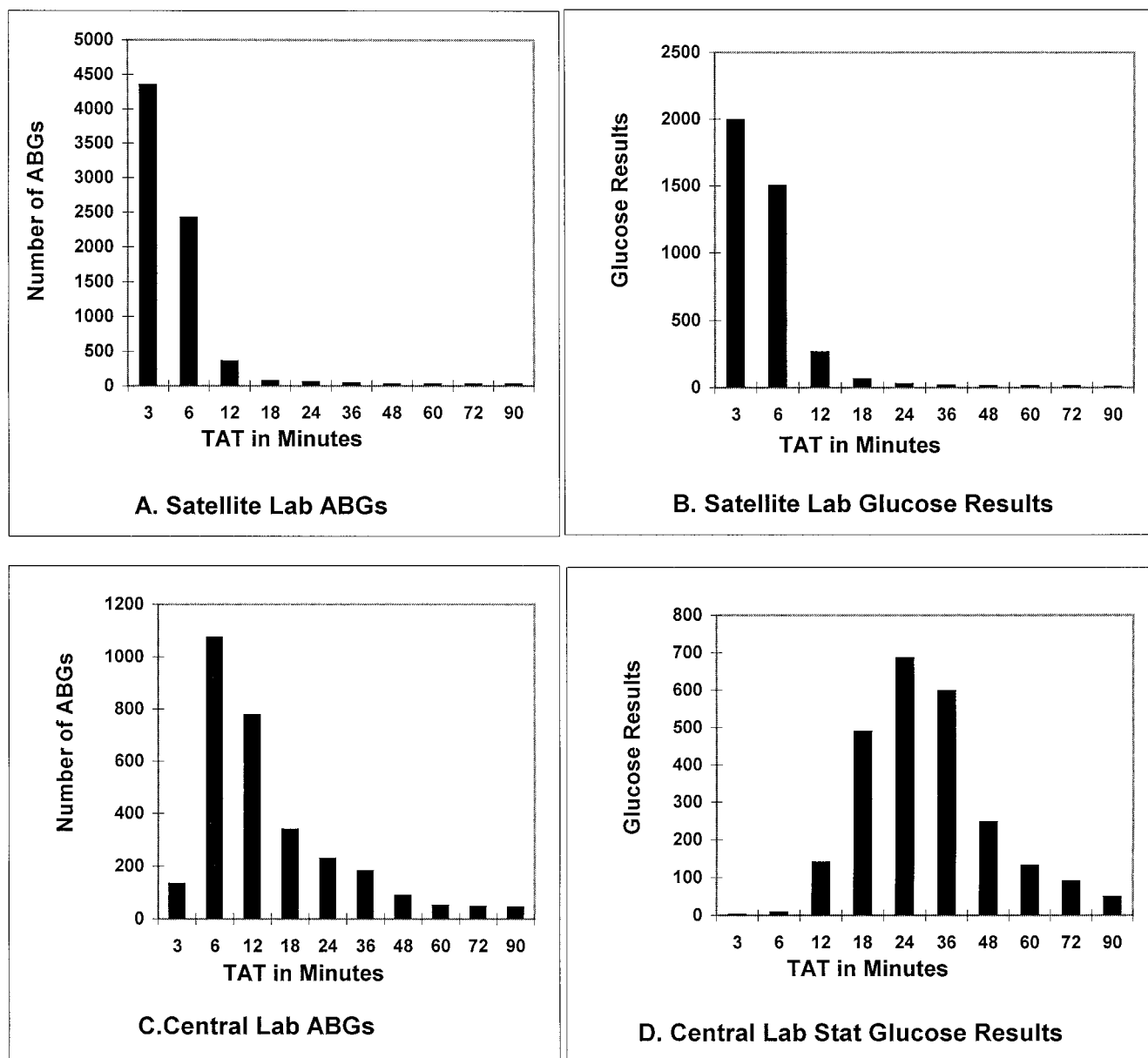


Fig. 3. Laboratory TATs.

laboratory for ABGs (30% of respondents) rated the central laboratory one-half of a letter grade higher ($P < 0.05$). Those who used i-STAT analyzers (43% of respondents) rated i-STAT three-fourths of a letter grade higher overall and almost a full grade higher for accuracy ($P < 0.05$). Principal components analysis showed that timeliness ($r = 0.88$) correlated more closely with overall satisfaction than did accuracy ($r = 0.44$). The closest correlations were between contribution to improved patient care, convenience, and the conservation of labor ($r = 0.93$ in each case).

Discussion

Data on laboratory TAT can be obtained with relatively little effort, but can omit important factors outside the

laboratory that impact the way testing processes support (or fail to support) clinical decision making. Therapeutic TAT provides a clearer picture of the context in which stat testing takes place, but requires considerable resources to measure. Differences in the prelaboratory, interim, and treatment phases, as well as information on the extent to which test results influence treatment decisions in various settings, demonstrate that direct observations provide relevant insight into stat testing processes.

Prelaboratory time was much higher for the central laboratory than either satellite laboratory or bedside testing. There were two reasons for this. First, central laboratory testing requires a nurse to confirm an order and print a transmittal form, using a laborious hospital information system. This process adds ≥ 2 min to the process; an

Table 1. Therapeutic TATs and testing options.

Testing option	n	Prelaboratory phase, min			Interim phase, min			Treatment phase, min			Therapeutic TAT, min		
		Median	Interquartile range	95th percentile	Median	Interquartile range	95th percentile	Median	Interquartile range	95th percentile	Median	Interquartile range	95th percentile
Central laboratory	38	8	5–16	28	12	9–18	45	5	3–11	14	25	18–45	87
CICU satellite laboratory	40	3	2.5–5	7.5	9	7–11	14	1	0.5–1	3	12.5	10–17	25
i-STAT analyzers	81	3	1.5–6	10.5	3.5	3–4	5.5	7	3–12	27	13	8–22	43

example of the fact that computerized systems need not be more efficient than paper requisitions. Second, as noted above (Fig. 2), central laboratory testing requires several additional steps in specimen handling and transport that are not required for satellite laboratory or bedside testing. Specimens were frequently hand-carried to the central laboratory rather than placed in the pneumatic tube system. Nurses felt that hand-carried specimens received more prompt attention (although we saw no objective evidence that such was the case). For both the satellite laboratory and i-STAT analyzers, the proximity of testing to the bedside allows for easier communication and smoother integration of the laboratory testing process into a critical care setting.

The interim phase includes the time taken to access a test result after it has been posted. In a study by Winkelman et al. (3) focusing on stat complete blood count results, considerable time lags were observed between results being posted to the LIS and those results being accessed by caregivers. The present study found similar effects. Bedside testing provides an immediate result, and the information system used in the CICU satellite laboratory automatically posts results in an electronic record that nurses access easily and frequently. Most central laboratory results (in this case involving only blood gases and electrolytes) were either accessed via the hospital information system or reported by telephone to a unit secretary who then relayed them to the patient's nurse. The more difficult results are to retrieve, the longer the lag in attempting to retrieve those results.

Treatment phases varied for different reasons and were shorter and less variable for the satellite and central laboratories than for bedside testing. The principal source of variation was the presence or absence of treatment protocols prescribing interventions such as potassium replacement or insulin administration based on test results. In many cases for bedside testing, the nursing staff had to relay results to physicians and obtain orders for treatment. In most cases where central and satellite laboratory testing were used, nurses treated patients according to protocols or standing orders.

We found that physician capture is seldom an issue. Most stat testing arises not from a request from a physician for immediate information, but from orders to monitor blood gases or chemistries on a regular basis, and

then to initiate treatment or communicate with the physician when test results warrant. We are indebted to an anonymous reviewer for the observation that bedside testing appears to achieve its greatest efficiency where no decision making by physicians is required. We speculate that the primary reason that fewer tests run in the central laboratory produce treatment changes is that these tests were usually blood gases. Where a blood gas indicates that a patient is being well ventilated, as is frequently the case, no change in treatment is indicated. Glucose and electrolyte testing produced treatment changes much more frequently than did blood gas testing. The central laboratory was not used by any unit for stat glucose testing. Only rarely were stat electrolytes sent to the central laboratory for analysis.

We would prefer to have a larger number of observations for each of these methods to have more confidence in generalizing our findings. Gathering such observations, however, requires skilled observers who can grasp the relationship of laboratory findings to treatment decisions in critical care settings. An observer must wait in an ICU until a test is performed, and then monitor the process. In this study, it could take up to 8 h to gather four or five observations in some units. Thus, the investigation of therapeutic TAT requires a substantial investment. Because few of our findings are in any way counterintuitive, the question arises whether additional resources expended in a single institution would yield much more worthwhile information.

The survey findings support the hypothesis that staff satisfaction is higher for familiar testing methods. The results of the principal components analysis also suggest that clinicians are willing to trade off some degree of accuracy for timeliness and ease of use. On the other hand, inappropriately ordered stat tests degrade the ability of the laboratory to deliver truly time-urgent information. A laboratory presented with an influx of specimens in excess of processing capacity suffers degradation in TAT (9).

The menu of alternate-site testing options is growing, and costs are declining. In some cases, alternate-site testing has been shown to cost less than centralized testing (10, 11); other studies indicate the opposite (12, 13). Even when costs are higher, arguments for alternate-site testing are made in terms of cost-effectiveness. Putative

benefits include improved patient management, productivity gains, decreased error rates, enhanced communication, improved patient focus from physicians, blood conservation, decreased lengths of stay, and better outcomes with lower overall treatment costs (14, 15). There are, however, studies suggesting that these benefits may not materialize in practice (16). The crucial point for laboratory managers and health systems administrators is that they consider and, if indicated, implement credible alternatives to central laboratory testing, whether satellite laboratories or bedside testing devices.

Questions remain as to the true therapeutic requirements for timeliness, accuracy, and precision. A clearer picture is needed of the testing processes in the context of clinical decision making and the variety of circumstances (e.g., clinical protocols and critical pathways) that affect the timeliness of treatment. Finally, how do patient outcomes relate to therapeutic TAT and the timeliness of interventions based on critical results? The clinical value of a test rests on the impact the result has on treatment decisions. Therapeutic TAT may be a factor in determining clinical value, but to what extent and in what circumstances remains uncertain. Our findings indicate that many stat tests do not get used for time-urgent clinical decisions; therefore, the faster results cannot impact on outcomes. Attempts have been made to model the cost-effectiveness of minimizing TAT (11, 17), but no empirical confirmation of improved outcomes has been documented. This is a fruitful area for further research.

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