Preanalytical Errors Introduced by Sample-Transportation Systems: A Means to Assess Them

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Preanalytical errors are introduced by sample-transportation systems, which contribute to delays in returning high-quality clinical laboratory results to the patient bedside. Sample quality can be compromised by exposure to extremes of temperature and physical forces during transportation. Uncontrolled temperature-induced errors are well understood and are often prevented by using environmentally controlled transportation containers. The effects of excessive physical forces on medical samples are poorly understood, however. For example, pneumatic tubes are in widespread use for transporting medical samples to the laboratory, because they substantially reduce turnaround times and are a less expensive alternative to creating satellite laboratories. While in transit in pneumatic tubes, samples are subjected to roller-coaster-type rapid accelerations during “takeoff,” radial gravitational forces when turning sharp corners, and sudden decelerations when arriving at their destination. These harsh physical forces have long been thought to contribute to preanalytical errors, owing to stress to or even rupture of plasma membranes of erythrocytes and lymphocytes. Although previous studies have demonstrated aberrant analytical results due to pneumatic transportation, they have not measured causative factors directly. Recent technological advancements have made it possible to measure the environmental factors that influence medical samples while en route to the laboratory in a pneumatic tube carrier.

In a study reported in this issue of Clinical Chemistry, Streichert et al. (7) used small recording accelerometers to capture temporal environmental data and correlate it with laboratory-reported values for pediatric blood samples. Subminiature electronic-motion and environmental-factor recorders have been developed because this kind of information is increasingly used in cell phones and gaming devices. The miniaturized electronic 3-axis accelerometer, hygrometer, thermomter, and barometer used in the study of Streichert et al. produced concrete evidence for a causative link between physical forces and changes in serum parameters, demonstrating quite conclusively that the magnitude of the accelerations in the pneumatic tube trip to the laboratory was directly correlated with aberrant serum indices for a large number of analytes. Only potassium, phosphate, lactate dehydrogenase, and aspartate aminotransferase, however, demonstrated changes that were considered critical. The authors went further and replicated their studies in another local hospital. Apparently, the length of the pneumatic tube and the degree of tortuosity of the path to the laboratory are contributory factors that correlate with increased sample errors. Interestingly, temperature, pressure, and humidity showed no significant effects on sample analytes. Although an effect of sample transportation via pneumatic tubes on blood gas concentrations has previously been demonstrated (8), this finding was not replicated in the study of Streichert et al., possibly because of the range of unique pneumatic tube path geometries found in each institution. Thus, the authors of this report advocate regular monitoring and controlling of pneumatic tube forces, given that pneumatic tubes are often adjusted or even modified during hospital renovations.

Because of these studies, one can anticipate the availability in the near future of a product that enables the monitoring of environmental factors in pneumatic tubes so that they can be adjusted to subthreshold values for the sample stressors. Alternatively, samples at risk for transportation-induced errors, such as those obtained from cancer patients and pediatric patients, could be marked for alternative manual or automated transportation methods. For example, mobile robots have been used quite successfully for the affordable movement of samples throughout a hospital, including riding in elevators (9).

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