Determination of Hemolysis Thresholds by the Use of Data Loggers in Pneumatic Tube Systems

Bob Barrett: This is the podcast from *'Clinical Chemistry'*. I am Bob Barrett. Transporting patient samples using modern pneumatic tube systems is fast, reliable, and efficient. Yet, the actual transportation of the samples could alter the sample's makeup.

These transportation effects include, hemolysis, which in turn leads to increases in potassium concentration and lactate dehydrogenase activity and other changes. For certified laboratories, it is essential to control pre-analytical factors caused by different means of transportation.

Each installation of pneumatic tube system is dependent on architecture, technical considerations, and length differences. Plus, each system is a unique entity, therefore determining whether or not a system is affecting samples is even more challenging.

In the October issue of *'Clinical Chemistry',* Dr. Thomas Streichert, the Assistant Medical Director of the Department of Clinical Chemistry at Central Laboratories in Hamburg, Germany, proposed a new evaluation method for these tube systems through the use of mini data loggers to measure temperature, humidity, pressure, and acceleration, in combination with the assessment of hematological parameters, standard clinical chemistry variables, blood coagulation, erythrocyte sedimentation rate, and blood gas analysis.

The study was carried out to investigate the influence of transportation via these tube systems at different speeds, compared with transporting blood samples by hand. And it also established a method for evaluation by use of data loggers without the need for repeated blood drawing.

Dr. Streichert is our guest in this podcast. Doctor, pneumatic tube systems are very common in hospitals and have been used for specimen transport for years. Why did you decide to examine these systems?

Thomas Streichert: Yeah. More than two years ago, the University Medical Center in Hamburg-Eppendorf, which is located in the Northern part of Germany, moved into a new building. The University Medical Center has approximately 1,400 hospital beds and in the last year, we treated around 15,000 inpatients. Additionally, approximately, 250,000 outpatients as well as 50,000 emergency patients were treated.

So the new building was constructed with a pneumatic tube system for the transportation of blood specimens to our central laboratories. And during the first test of the pneumatic tube system, we observed an increased

hemolysis in blood specimens. Some of them were shaking pretty hard. So they even showed form building inside.

For certified laboratories that is of major importance to control these pre-analytical factors. Accordingly, we realized the need for a method to check for influencing factors caused by transportation.

Bob Barrett: So what was your approach and why do you believe that it is novel in comparison to previous approaches?

Thomas Streichert: We wanted to understand what happened to our specimens, transported by the pneumatic tube system. Therefore, we asked the company, which installed this system in our hospital, if they could provide information on this topic. But there was no data available.

Actually, when we started thinking about a method to validate our system, we were quite surprised about the small number of publications we could find on the topic. Thus we reasoned which stresses might affect the sample during transport; factors such as temperature, humidity, pressure, and acceleration.

We decided to measure and recall them all by the use of mini data loggers, which are small enough to fit into the carriers, so they could be transported together with the specimens.

As control, we used our classic method for the transportation, hand transport, by courier.

Our first results were astonishing. There were no significant differences in temperature, humidity and pressure between the methods of transport, but we observed significant differences in acceleration.

The peak acceleration expressed in multiples of gravitational force in the pneumatic tube system were pretty high. We measured up to 1500G. This is more than the G-force in a fighter jet.

So we decided to lower the speed of the pneumatic tube system and observe the clear positive correlation between the speed and the acceleration exerted on the blood sample.

Bob Barrett: But aren't blood specimens usually subjected to high acceleration when being centrifuged without exhibiting any hemolysis, why would there be a difference?

Thomas Streichert: Blood samples can be centrifuged with the force up to 1500G for ten minutes, without exhibiting significant hemolysis. So we assumed that it is not the high

acceleration alone that leads to cell destruction. Hemolysis is more likely to be caused by rapid and large acceleration changes.

Bob Barrett: So then acceleration changes cause pre-analytical influences similar to hemolysis?

Thomas Streichert: Yes. And the next step we checked the influences on a panel of analytes, the parameters we are choosing with respect to literature on the evaluation of similar systems. But we decided to analyze and expanded parameters, including differential blood count, coagulation tests, erythrocyte sedimentation rate, electrolytes, enzymes, troponin T, IgG, free thyroxine, procalcitonin, and blood gas analytes.

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As mentioned before, we assumed that not a single peak acceleration causes hemolysis, but the cumulative effect of the forces. Therefore, we analyzed the cumulative effect of these forces by using the distributions of the accelerations and correlated them to the results of our laboratory analyzers.

At the highest speed, we found critical results for potassium, phosphate, ASAT, and LDH, for which the relative exceeded the allowed relative deviation of QCs as specified in the guidelines. We call them RiliBÄK, of the German Federal Medical Council.

These guidelines define many requirements similar to the CLIA proficiency limits in the U.S. for the quality of quantitative test results for laboratories in Germany.

To meet these guidelines, we lowered the speed of the pneumatic tube system and tried to identify the critical threshold. We used the single vector sum of two as a relative cutoff. And the speed of 1.5 meters per second, we found only slight differences between tube and hand transport.

Bob Barrett: Do you think that your cutoff threshold could be used as a general cutoff for all pneumatic tube systems?

Thomas Streichert: Currently not. Each installation of a pneumatic tube system is uniquely characterized by architecture, technical specifications, and differences in speed of length, thus demanding for individual evaluation of every single system.

In addition, each modification or malfunction of the pneumatic tube system could change the forces acting on samples to high enough levels to produce undesirable effects such as excessive hemolysis.

So our approach presumes a basic validation set that has to be preformed the first time the pneumatic tube system is installed. This means that you have to carry out lab tests, recall the acceleration profiles and correlate them up.

But in the following, it is sufficient to check the system with the data logger only. Of course, we try to validate our approach in another pneumatic tube system. We tested a newly installed tube system at the University Hospital in Greifswald, also in Germany.

Here, the data loggers showed areas under the curve below the ones observed at 1.5 meter per second in Hamburg. As expected, the relative changes of LDH is 80 and potassium were between the results for hand-carried transport and also pneumatic tube system at the lowest speed.

Bob Barrett: So what do you think is the bottom line for your results?

Thomas Streichert: We described the use of data loggers for the identification of pre-analytical interferences introduced by the transportation of blood samples in pneumatic tube systems. Our approach could be helpful to determine the critical threshold for hemolysis in a pneumatic tube system and could be applied to different scenarios.

First, tuning of the pneumatic tube system so that the maximum speed and hence the maximum capacity of the pneumatic tube system can be determined.

Second is determining the effectiveness of cushioning, and third, conducting the initial evaluation and subsequent regular control of pneumatic tube systems without the need of repetitive blood drawing and laboratory analyses.

Bob Barrett: So are you planning any future experiments along these same lines?

Thomas Streichert: Yes. In the meantime, we have validated a pneumatic tube system in another hospital in Hamburg and found corresponding results. And at present, we use the recorded data of our pneumatic tube system to simulate a transport in an experimental environment.

And this setting we are trying to develop and test tubes for blood drawing that helped to minimize hemolysis caused by transportation.

We believe that these insights of the new experiments should be of great help for improving transports with similar pneumatic tube systems.

Bob Barrett: Dr. Thomas Streichert is the Assistant Medical Director of the Department of Clinical Chemistry at Central Laboratories in Hamburg, Germany, and has been our guest in this podcast from *'Clinical Chemistry'*.

I am Bob Barrett. Thanks for listening.

Total Duration: 8 Minutes