Short Communication

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Automation in small labs

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Abstract

Objectives: The following report describes the development and implementation of a small-lab automation solution for small hospitals.

Methods: It uses a new generation of collaborative robots instead of the traditional laboratory automation lines with their input and output units and connected analyzers. After the Proof of Concept during fall 2018, both a centrifuge and several routine analyzers were integrated.

Results: The run-up phase ended after successful test operations in continuous mode in 2019. Routine operations were launched in October 2020 in a MVZ routine lab after a delay caused by the pandemic.

Conclusions: Apart from the direct cost savings for night duty or compensation for the lack of personnel, the mentioned solution delivers a significant upgrading of the laboratory technicians' activities and an improvement in their working conditions.

Keywords: labautomation; nightshift; robot; small hospital lab; work-relief.

The potential of robotics in the clinical laboratory has been known since the late 1980s [1]. In the last 30 years, robotics and automation focused on high-throughput laboratories [2], full laboratory automation, and was later influenced by AI integration efforts [3]. Today, we look at the other side of the labs: staffing issues in the small hospital lab and appropriate technical solutions. Laboratory technicians in small hospitals have a very demanding job as they work frequent night, late and weekend shifts. It is rather common for them to reach the statutory maximum of eight shifts per month. Alternative options include transition to point-of-care testing, although this means shifting the workload to the care staff, which also tends to be

understaffed, and application of different reference ranges depending on the test method, or commissioning sample shipment to the nearest major hospital laboratory operating 24 h a day.

The workload of simple unskilled tasks, particularly sample handling from receiving and centrifugating to placing them in racks and archiving them, has been increased in comparison to skilled tasks. These simple manual tasks could easily be done by automation systems – as used in large laboratories – whose high cost, however, is not financially viable for small laboratories.

New opportunities: A new trend has emerged in robotics in recent years. Robots have become smaller, more lightweight and are easier to program. Their main advantage is that they can work side by side with humans in a “collaborative mode.” Therefore, this type of robots has become known as “cobots”.

The Sawyer[®] robot presented here, produced by Rethink Robotics GmbH (Bochum, Germany), part of the HAHN Group, is a cobot with the following features:

- Range: 1.25 m
- Number of joints: 7
- Weight: 19 kg
- Payload capacity: 4 kg
- Repeat accuracy: 0.1 mm
- Easy-to-exchange gripper
- Two camera – “eyes,” one of which is integrated in the gripper hand
- Easy to program
- Connectors to control additional equipment
- Communication with LIS

Thanks to their optimal design, the gripper fingers are not only able to handle sample tubes but also equipment racks, centrifuge inserts, and to screw off caps (see Figure 1).

The cobot's software can easily handle simple tasks, such as archiving processed samples. Complex tasks, such as stand-alone operation for several hours, are supported by automation software.

Connectivity with the laboratory information system enables bidirectional communication, e.g., sending order numbers with information on material and cap color and interpreting the response from the LIS.

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Figure 1: Installation of the Sawyer in the medical lab.

This new generation of robots enables small laboratories to implement an affordable automation solution. As in large solutions, the testing procedures of the analyzers are not affected in any way. Cobots may take charge of the entire sample logistics for several hours at a time, e.g., during a night shift, or provide assistance while running in parallel mode during routine operation. In combination with instruments, which have level detection and HIL-check opportunities (as it is e.g. for the used Sysmex CS2500 based on the Preanalytical Sample Integrity Check) relevant security features are established.

Solution: A typical workflow is described below. A hospital worker places samples on an input tray (currently

a rack based device system) and activates Sawyer. No further human action is required for the time being. A stationary camera over the tray identifies the cap color and the position of the tubes, and then the robot moves to the samples. Sawyer places samples that can be clamped at the cap directly into a gripper mounted on the tray. Flat lying samples are clamped from the top and positioned vertically in a gripper. Afterwards they are, clamped once again and turned in front of the barcode reader until the barcode has been successfully read. If a barcode is not readable, the robot put the sample in a separate “error box” for further activities of the staff filling/controlling the input/output area. The further procedure depends on the type of sample.

The samples for coagulation and clinical chemistry tests are placed into the appropriate centrifuge inserts, making sure they are arranged symmetrically considering any compensating vessels that may be necessary. Once all samples are positioned in the inserts, the inserts are placed into the centrifuge (see Figures 2 and 3).

Sawyer detects the position of the centrifuge pods with its arm camera. Therefore, any position in the centrifuge can be filled. To reach the centrifuge pod on the opposite side, the cobot turns the rotor head towards the front (again, camera-controlled) and the appropriate insert is placed into the centrifuge. Once all inserts are in their positions, Sawyer closes the lid and starts the centrifuge.

While the centrifuge is running, the hematology samples are placed directly into the appropriate instrument racks, while checking the position of the barcode label and positioning it towards the window of the rack. Then, the rack is inserted into the hematology analyzer and the analyzer is started.

Figure 2: Sample entry: Robot picks tubes.

Figure 3: Robot interaction with centrifuge.

Once the centrifugation process is completed, Sawyer opens the centrifuge lid and removes the inserts, again monitored by the camera. If the analyzer operates in closed tube mode, the samples are moved from the centrifuge inserts to the appropriate rack, after verifying the position of the label, thus ensuring that the barcode is clearly visible in the window.

If the analyzer works with open sample tubes, they are placed into the gripper which holds the sample while the robot removes the cap. The cap is then discarded and the now open sample tube is placed into the appropriate rack after the position of the barcode label has been verified. The racks are then placed into the analyzers and the analyzers are set in operating mode.

The last step of the procedure is the output of the processed racks. The samples are made available for manual archiving. Free racks are withdrawn from the rack magazines for the next runs.

The analyzers may operate in stand-alone mode with robot assistance, in a mixed mode, or without robot assistance. In mixed operating mode, a laboratory worker places the sample racks directly into an instrument, e.g., the hematology analyzer. The robot will also remove these racks from the analyzer once they have been processed as the position of the racks to be removed is tracked with the hand camera. This helps to manage workload peaks.

As described, that robot is stationary and combined with the input/output unit, but the working location of the robot can be selected by the lab owners based on their demands, available space and internal workflow needs. In periods during which analyzers are to operate without robot assistance, the robot can be easily disconnected from the instruments together with the input and output unit and parked to the side. This is done usually each day

during the main shift with the highest workload. This is also done during maintenance sessions to enable full access to the analyzers.

Economical alternative for small lab automation: The solution with Sawyer developed by Rethink Robotics GmbH and Siemens Healthcare GmbH (Eschborn/Germany) advances small laboratories to a level of automation comparable to large labs with automated sample tracks. In addition, it enables labs to dedicate a shift to process routine testing without lab staff assistance. The ideal arrangement is in a laboratory test cluster, where several small laboratories are supplied and monitored by a large central laboratory for backup. One lab with an assistant who can control the other unmanned labs via webcam and intervene by making phone calls to the staff at the stations or in urgent situations by going to the lab, managing malfunctions, controls, etc. The results must be validated from a physician, independent if this is done from a person in the hospital or from extern via internet. This person has also to understand flags coming from the instruments and reported by the LIS. Together with the staff from the center of the lab-cluster decision should be made, if urgent interventions can be done by staff in the hospital/physician/station or if a person from the center-lab has to go to the satellite lab. Due to the individual infrastructure it is in the hands of the hospital management to decide, how far away the different labs of the clusters can be. Even if this solution can run autonomously for a few hours, it is always a system to support technicians, but never to replace human staff. The variety of tube formats, the number of tubes in the peak hour in the morning, Rili-BAEK [4] requirements, instrument preparation, maintenance and reagent refills require the presence of competent personnel for at least one shift/day during the day. Apart from the direct cost savings for night duty or compensation for the lack of personnel, this results in a significant upgrading of the laboratory technicians' activities and an improvement in their working conditions.

Outlook: Easy control of the robot through the automation software enables rapid adjustments during the pilot project phase and with regard to the other planned installation sites.

The fact that the grippers are easy to exchange opens up plenty of possibilities for cobot deployment in any kind of laboratory. The ability to handle anything from small test tubes to micro-titer plates offers the ability to transfer individual samples or sample racks reliably and without pauses. This makes it an interesting tool for working e.g., with radioactive substances or infectious samples.

To sum it up, small labs will continue to require the input of humans, but robots will improve their working conditions.

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Informed consent: Informed consent was obtained from all individuals included in this study.

Ethical approval: Research involving human subjects complied with all relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration (as revised in 2013), and has been approved by the authors' Institutional Review Board.

References

1. Felder RA, Boyd JC, Savory J, Margrey K, Martinez A, Vaughn D. Robotics in the clinical laboratory. *Rev Clin Lab Med* 1988;8:699–711.
2. Wheeler MJ. Overview on robotics in the laboratory. *Ann Clin Biochem* 2007;44:209–18.
3. Lippi G, Da Rin G. Advantages and limitations of total laboratory automation: a personal overview. *Clin Chem Lab Med* 2019;57: 802–11.
4. Bundesärztekammer. Neufassung der "Richtlinie der Bundesärztekammer zur Qualitätssicherung laboratoriumsmedizinischer Untersuchungen – Rili-BÄK". *Dt Arztebl* 2019:A1–33.