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Automation in Haemostasis

Αυτοματία, in ancient Greek a goddess of luck, a surname of Tyche, then later in Latin called Fortuna, is a goddess who manages things according to her own will. Translated literally, it means to move by itself or to happen by its own will without human engagement.

Somewhat later automation and data processing in pathology were commented by T.P. Whitehead [1]. «There it is noted that automatic methods are important companions in the laboratory today and will be increasingly so in the future. Not so the computer, it is a hard task master, demanding considerable wisdom and often intuition to interprete its output». Building instruments and machines to support and improve quality and outcome has always been a human challenge. From Venetzian wharfs or shipyards to Henry Ford's car assembly lines, automation has always enhanced speed, quality and output in its employed field. Standardized, partially or fully automated processings of goods are ubiquiously present throughout our modern world.

Automation in Laboratory Medicine

The field of clinical chemistry was the forrunner of automation in Laboratory Medicine. Initially laborious manual methods were automated through relatively simple stand-alone instruments. These instruments were able to measure one, later a few parameters in an automated fashion using one method, i.e., photometry. Later more and more instruments were capable of measuring different parameters using a variety of methods such as photometry, turbidimetry and electrosensing. Due to the high demand, large instruments for routine parameters used in clinical chemistry such as sodium, potassium, bilirubin, liver enzymes and cardiac markers became available. Perfection of this instrumentation in the years 1960 through 1980 allowed for a higher throughput, improved precision, shorter turnaround time and reduction in cost. In the 90's, total laboratory automation became available. These systems allowed for an assembly of different instruments with different capabilities and an automated handling of the preanalytical phase (aliquoting, centrifugation, transportation to the different instruments, quality control) and the automation in the postanalytical phase (aliquoting, retesting, storage). In the most recent years, laboratory automation systems have become available not only for classic clinical chemistry parameters but also for parameters elaborated in different fields of laboratory medicine such as haematology or haemostaseology. Nowadays modern total laboratory automation systems are capable of delivering results of approximately 250 parameters utilising five or more different methods with an output of approximately 1000 results per hour. The quality of the analysis has continuously improved as the use of specimen volume has decreased significantly at the same time. Together, total laboratory automation in clinical chemistry allowes for rapid, precise and extensive laboratory testing in modern health care settings.

Automation in Coagulation

Coagulation testing has experienced a dramatic change over the last 50 years. Even in the 50's, 60's and maybe 70's, coagulation tests were performed manually. Reagents were manufactured by the laboratory staff of larger hospitals processing animal or human brains in a batchwise fashion. These reagents were then used in the respective coagulation test such as Prothrombin Time (PT), Activated Partial Thromboplastin Time (APTT) and other global coagulation tests. Equipped with a centrifuge, a stop watch, a pipette and a test tube, the laboratory technician determined the clotting capability of a patient specimen utilising a fine needle with a hook. According to her or his judgement the stop watch was stopped when a small fibrine clot was detected on the tip of the hook. Later, in order to standardize and optimize testing, small instruments were invented that took advantage of photometry to document the generation of small clots and its consequence on light transmission or inhibition of movement of small beads as the clot grows. Over time the instruments were improved, enlarged and expanded so

Summary

Automatia (Αυτοματία), an ancient Greek goddess of luck who makes things happen by themselves and on her own will without human engagement, is present in our daily life in the medical laboratory. Automation has been introduced and perfected by clinical chemistry and since then expanded into other fields such as haematology, immunology, molecular biology and also coagulation testing. The initial small and relatively simple stand-alone instruments have been replaced by more complex systems that allow for multitasking. Integration of automated coagulation testing into total laboratory automation has become possible in the most recent years. Automation has many strengths and opportunities if weaknesses and threats are respected. On the positive side, standardization, reduction of errors, reduction of cost and increase of throughput are clearly beneficial. Dependence on manufacturers, high initiation cost and somewhat expensive maintenance are less favourable factors. The modern lab and especially the modern lab technicians and academic personnel in the laboratory do not add value for the doctor and his patients by spending lots of time behind the machines. In the future the lab needs to contribute at the bedside suggesting laboratory testing and providing support and interpretation of the obtained results. The human factor will continue to play an important role in testing in haemostasis yet under different circumstances.

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that not only coagulation tests but also photometric and tests on an immunological basis were supported on the same platform. Coagulation tests have the advantage of mimicking a process in vitro quite in a comparable fashion to phenomena occurring in vivo. However, these tests are prone to many different influences such as haemolysis, medication and lipidemia in vitro. Today, coagulation testing has been integrated into total laboratory automation systems as the principle of testing and the clinical context of such testing does not differ from requirements in clinical chemistry, clinical immunology or haematology.

It is respected that patients suffering from certain diseases or conditions do not fall into one traditional discipline only. They often show aberrant results in haematology, coagulation, immunology and clinical chemistry at the same time. Together, the advantages of automation and especially of total laboratory automation have overcome the traditional modernization renitency of lab personnel. Utilising modern automation techniques will allow for rapid, precise and competent coagulation testing in the future.

Strengths, Weaknesses, Opportunities and Threats (SWOT) of automation

Current strengths and the available automated systems in coagulation testing are certainly an improvement of quality and a standardization of both the process and the quality. Further, a reduction of errors, especially sample mix-up, is achieved. Turnaround times are not necessarily shorter, however remain the same whether the sample load is large or small. Further, the laboratory staff, i.e., technicians, is freed from timeconsuming yet very simple tasks such as waiting for the centrifugation to stop, aliquoting specimens, filling racks and carrying them to different instruments and work places. Depending on the automation system, reduction in flexibility can be observed as the process cannot be interrupted or changed easily. However, modern instruments have so-called «stat» capabilities through which an urgent sample can be rapidly introduced into the system and analyzed at once. In addition, a dependence from the supplier and a high demand on technical skills for maintenance of the instruments are necessary together with at times quite high maintenance costs. In the future opportunities will outweigh the disadvantages. The well-trained staff is freed from non-productive, non-creative work and can be shifted into developing new tests, validating the results and supervising more and complex quality control requirements. Also, cost savings are possible as personnel cost can be saved. Further, a bigger testing menu can be offered for the clinician at all times, even for tests that are not commonly required or difficult to perform. Possible threats include dependence on an industrial supplier and high initial investment costs for the automation systems. In addition, the value of laboratory medicine and coagulation testing needs to be outpointed by better service provision, interpretation and consultation of the results together with the clinical context. The laboratory staff, especially the academic members, is freed from working hours behind the machines and thus able to communicate and collaborate with the clinicians at the bedside as a valuable partner.

SWOT-analysis of automation vs manual testing

Strenghts	**Weaknesses**
Process improvement Quality improvement Standardization Turnaround time Throughput High availability Overall cost	Dependence on manufacturer Dependence on IT Reduced flexibility Stat handling Cost for maintenance
Opportunities	**Threats**
Use of scilled staff for more complex tasks Cost savings Reduction of unnecessary tasks/steps Involvement of academic lab staff for support of clinicians, patients on bedside Improvement of interpretation of results	High initial investment cost Overexpanding test menue Loss of technical skills Dependence on supplier

Future

The future in haemostasis testing will allow for miniaturization in respect to the sample volume on one side but also in the dimension of the instruments. The new instruments will be smaller, more rapid, with a higher precision and increased robustness. Through software support, validation and interpretation will be enhanced. Laboratory testing will shift even more from a manual repetitive laborious task to a highly complex job that requires understanding of mechanics and electronics. In addition, added value for the patient will not be in the work done in the lab on the machine, but will come from interpretation and support of the clinician. Which test should be performed under which conditions for the answer of what question? Automation will help to provide a relatively cheap and rapid result for many patients. Together, the reduction of all unnecessary steps during production could be eliminated using sophisticated automation systems. However, it is clear that there always will be many tasks that need special requirements such as function testing of thrombocytes (Aggregometry). Lean-Production [2] proposes to avoid unnecessary travel distances, avoid unnecessary work steps, enhance standardization and shorten long intervals between different steps in the working process. Before automation is introduced in a haemostasis lab, the work process needs to be examined in detail [3]. Only then, automation can be embedded into an appropriate concept of space, quality, IT-capability and staffing.

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