Editorial

Breakthrough Technologies Revolutionizing IVD and Laboratory Medicine : *Predicting the Lab of the Future*

It was my great pleasure to attend the special 40th anniversary conference of the Société Tunisienne de Biologie Clinique (STBC). This annual meeting brought together scientists and industry professionals in the field of medical biology for a rich and diverse scientific program that included timely presentations from global experts, poster presentations from young scientists,a large industry exhibition, sponsor workshops, and more. Better yet, this conference provided the perfect backdrop to come together in celebration of the 40th anniversary of the STBC. My congratulations to STBC and particularly Dr. Manel Chaabane, the STBC president, for the strong scientific program and your excellent organization of the event.

The STBC has been a very active member of the International Federation of Clinical Biochemistry and Laboratory Medicine (IFCC) for many years. Throughout the years, the STBC has made important contributions to the field of medical biology by promoting the dissemination and exchange of evidence-based information as well as supporting continuing education and development for the discipline. Their hard work has not only supported their mission but also the overall mission of IFCC to advance excellence in laboratory medicine for better healthcare worldwide.

As recently presented by the expert biologists of the STBC and invited speakers, the field of medical biology and laboratory medicine is confronting a time of many technological advancements that will change the face of our profession. Indeed, our field has seen many recent innovations, adding substantial value and visibility to the role of modern laboratory medicine in healthcare. Many areas have transformed thanks to noteworthy innovations such as laboratory automation, genetic sequencing, nuclear magnetic resonance spectroscopy, mass spectrometry, microfluidics, and electronic tools. These advancements have ultimately improved the preventative, diagnostic, prognostic, and monitoring capabilities of the laboratory, resulting in improved patient care.

In recent decades, automation has changed the face and scope of laboratory medicine, improving efficiency, increasing throughput, expanding assay menus, and reducing errors [1–3]. While all modern clinical chemistry and hematology analyzers are highly automated, very few total laboratory automation (TLA) platforms are commercially available. Such TLA systems have immense power to improve performance and efficiency as well as decrease costs and errors [4-5]. As we continue to incorporate TLA into the modern laboratory, we must consider compatibility with the laboratory information system and potential effects on laboratory personnel and workflow.Future work should also assess how implementation of TLA systems impacts patient outcomes.

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Aside from general improvements in the laboratory, significant technological advancements have expanded the field of omics, including genomics, transcriptomics, metabolomics, and proteomics [6]. We have seen a paradigm shift in both genomics and transcriptomics with the development of single-cell sequencing (SCS) techniques, which enable accurate quantification of cellular and genetic heterogeneity within a tissue sample, thereby improving upon traditional bulk DNA and RNA analyses [7].Transcriptomics has also recently evolved thanks to advancements in high-throughput RNA sequencing and microarrays, which can leverage the advantages of next-generation sequencing (NGS) for diagnosis and monitoring of various conditions [8,9]. The application of NGS for the quantification of circulating tumor DNA from plasma has also introduced the concept of liquid biopsy in oncology. Not only does this technology have clear advantages over traditional tissue biopsies, such as reduced invasiveness and increased accessibility, but it supports clinical application of precision oncology, including therapy response prediction, residual disease monitoring, treatment resistance monitoring, and early cancer detection [10,11]. Both proteomics and metabolomics have also undergone great transformation with advances in nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry (MS), which has improved identification of novel biomarkers and therapeutic targets for various disease pathologies. Now, single-cell genome-wide approaches have enabled the ability to simultaneously evaluate various molecules (e.g. DNA, RNA, protein, chromatin), introducing the concept of “multi-omics” [12].

Advancements in analytical chemistry, bioengineering, and microtechnology have led to the miniaturization of many traditional core laboratory tests. In recent years, we have seen the development of microfluidic devices such as the “lab-on-a-chip” (LOC) or micro total analysis system (μTAS). Microfluidic devices allow for the integration of multiple laboratory processes on a miniature interface composed of microchannel or nanochannel networks [13]. Such devices are optimal for point-of-care (POC) testing due to their small size, small sample volume requirements, and fast turnaround time. For example, new handheld critical care point of care devices offer various cartridges with microfluidic technology that can measure various hematology, cardiac, blood gas, or chemistry markers. While POC testing does not replace the core laboratory, it has substantially narrowed the clinical-laboratory interface to improve timely clinicaldecision-making. It is expected that these devices and the field of POC testing will continue to revolutionize the delivery of laboratory medicine, particularly single cell-based microfluidic devices that have the potential to provide more personalized diagnostic test results as well as interpretation when combined with electronic tools and artificial intelligence.

Certainly, one thing these innovations all have in common is that they have made it easier and cheaper than ever before to analyze patient samples, leading to the generation of extremely large datasets of laboratory test results, known as big data [14]. Harnessing big data using machine learning and other artificial intelligence methods has the potential to develop signatures that are clinically relevant

for disease risk assessment, diagnosis, prognosis, treatment, and monitoring. Together, multi-omics and big data analytics are paving the way for an era of precision and personalized medicine [15]. To continue to change the face of laboratory medicine for improved patient care, future work should focus on the clinical applications and implementation of artificial intelligence and precision medicine within the various laboratory disciplines.

Again, congratulations to STBC on your 40th anniversary celebrations and for organizing such a great scientific and social program. My best wishes to you all for many decades to come.

Prof Khosrow Adeli
IFCC President

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