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The Role of Total Laboratory Automation in Evaluation of Urological and Renal Diseases

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Abstract

First announced in the early 1980s, the concept of Total Laboratory Automation (TLA) led to a global revolution in the automation of clinical laboratories. It was proved that TLA significantly improved laboratory service efficiency, including reduced Turnaround Time (TAT) and increased laboratory productivity, and thereby enhance quality of patient care. Establishment of TLA also decreased the total costs on the long term. However, several disadvantages and limitations of TLA existed for evaluation of urological and renal diseases. Hence, it is important to utilize the advantages and to solve the limitations of TLA in the future, ultimately enhancing laboratory service efficiency and thereby the quality of patient care. In the era of automation, it is believed that TLA will continue to evolve in the clinical laboratory.

Keywords: clinical laboratory, total laboratory automation, turnaround time.

Introduction

Total Laboratory Automation (TLA) was first introduced in the early 1980s [1], subsequently leading to a global revolution in the automation of clinical laboratories [2]. Characterized by comprehensive integration and automatic operation of all analyzers and accessory equipment in connection to sample-transport tracks or assembly lines, TLA promised automating sample transportation, classification, pretreatment, detection, result reporting, and post-storage. Nowadays, TLA could be integrated with most analyzers performing different clinical testing, such as hematology, hemostasis, clinical chemistry, immunochemistry, and so forth. Meanwhile, a variety of sample matrices could be analyzed on TLA, including whole blood, heparinized or citrated plasma, serum, spot urine, cerebrovascular fluid, pleural fluid, ascites and so on. With the implementation of TLA, the efficiency of laboratory services was greatly increased with shortened Turnaround Time (TAT) and labor savings, improved the level of laboratory quality and lean management [3,4], ultimately leading to acceleration of overall diagnostic process and enhancement of quality in patient care [5].

The pros and cons of total laboratory automation

Accumulating evidence revealed that well-designed TLA substantially reduced TAT and increased laboratory throughput (or productivity) [6-11], thereby providing accessibility to mid- and high-volume clinical laboratories. TLA also decreased personnel need for performing identical volumes of tests, as TLA implementation produced lower staff congestion in the laboratory [11]. In addition to the benefit of efficient laboratory services, the TLA model was shown to successfully lower the costs of laboratory diagnostics [11,12]. It was reported that the total costs decreased by €55,048.73, or corresponding to 12.55% of the total costs, after introduction of TLA in a clinical laboratory [11]. Though it was observed that equipment costs increased initially after TLA introduction, a 24-hour/7-day service is guaranteed and the costs should be lower on the long term. Besides, TAT was generally reduced after TLA introduction, particularly in the routine exams [11]. Another study in a regional central hospital found that, after introduction of TLA, the mean TAT for chemistry and immunology was reduced from 3.5 hours to 50 minutes and from 5.5 hours to 71 minutes, respectively [2]. It was also reported that TLA guaranteed consistent and predictable performance to shorten TAT, leading to over 90% of completions being within 40 minutes [10].

It was reported that approximately 80% of clinical biochemistry work could be covered and completed by TLA [10]. However, certain exams and laboratory platforms still need skilled manpower especially in the pre-analytical processing, such as electrophoresis, High-Performance Liquid Chromatography (HPLC) and tandem mass spectrometry (MS/MS). Another major consideration for implementing TLA was space requirement or infrastructure constraints. As it could be a challenge to accommodate multiple analyzers and new hardware into a pre-existing environment, particularly when the laboratory was not purpose-built or fit for the scope of TLA. Besides, the workplace could be flooded with excessive warming and increased exposure to electrical noise due to the consolidation of many analyzers in a narrow environment [13]. Most importantly, human psychological dependence on automation would be inevitable [14]. As a consequence, skill deterioration and inefficient service resumption of manual functioning could be encountered once automation failed. This crisis could also be magnified for junior staff having little experience to deal with manual laboratory work, thus paralyzing the laboratory and not unable to provide data timely to healthcare providers, which could eventually affect quality of patient care and even patient health.

The potential applications of total laboratory automation in evaluation of urological and renal diseases

Laboratory studies of urinalysis and biochemistry, such as evaluation of renal function, electrolyte imbalance and adrenal gland disorders, are commonly performed in assessing patients who may suffer from urological and renal diseases. These exams are available in the analysis using TLA. However, there are still certain exams for further evaluation of urological and renal diseases not accessible or not prevalent on the TLA platform. Among these, skilled manpower is required in the pre-analytical processing and there is challenge to incorporate certain analyzers into TLA configurations. For example, it is not easy to integrate the Fourier Transform Infrared Spectroscopy (FTIR), which is utilized for chemical composition analysis of urinary calculi, into the workflow of TLA. Additionally, the detection of metal ions, vitamin D or certain chemicals that could lead to nephrotoxicity is operated based on the methodology of MS/MS, in which pre-analytical procedures are labor-needed and operator-dependent. Though MS/MS could be automated, there is still challenge to incorporate these technologies into TLA [15]. To solve these, the programmed robotic platform with automated robotic arm may be suitable for TLA integration by automating the pre-analytical procedures in the future.

Conclusion

In the era of automation, it is believed that TLA will continue to evolve in the clinical laboratory. Notably, TLA must match the specific work volumes and needs of each laboratory. Finally, it is important to utilize the advantages and to solve the limitations of TLA in the future, ultimately enhancing laboratory service efficiency and thereby the quality of patient care.

Author contribution

Chih-Chun Chang and Jung-Li Ho worked as co-first authors. Correspondence should be addressed to Dr. Chih-Chun Chang. All the authors have read manuscript and approved submission.

Competing interests

None.

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