Combine data of all laboratory subspecialties and diagnostic imaging in the same report

Integrated diagnostics: a vision for the future of laboratory medicine

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ABSTRACT

Recent progress in diagnostic testing has the potential to enable more accurate diagnosis and improved clinical outcomes. However, diagnostic data are fragmented, being produced and delivered within the "silo" of each diagnostic discipline, and the electronic health record does little to synthesize existing data to be translated in actionable information. Therefore, despite great promise, diagnoses may still be incorrect, delayed, or never made. Integrated diagnostics (ID) represents a vision for the future, wherein laboratory, pathology and imaging data, together with clinical information, are aggregated to support through expert systems, algorithms based on machine learning and artificial intelligence, the provision to clinicians of a more actionable diagnostic information. Advanced information technology is needed for implementing ID and improving diagnostics. Innovative training models, new cultural and professional knowledge and skills are fundamental requisites for future laboratory professionals.

Key words: *laboratory medicine, manifesto, diagnostics*

INTRODUCTION

There are enormous financial, demographic, epidemiological and clinical safety pressures on health care systems around the world. These pressures are well known and are increasing every day. Over the last decades, integrated care has become an essential component of health policy reform worldwide as it may facilitate the system to provide a higher quality of care at fewer cost while improving the health and satisfaction of citizens and patients (1). Integrated care is a broad concept with a multicomponent set of ideas and approaches aimed at improving quality of care overcoming the current fragmentation and siloed delivery of care. In fact, providing quality care to patients requires a coordinated and collaborative effort from different departments and specialties. However, many healthcare systems still operate in silos, with little communication or collaboration between different departments. This approach, known as "siloed clinical practice", can lead to fragmented care, increased costs, and decreased efficiency in healthcare delivery. And, even worse, it cannot assure valuable clinical outcomes. The seminal paper published by Michael Porter in 2010 is considered a milestone in promoting integrated care, highlighting the importance of a change in traditional organization models (2). Porter emphasized that "*Care for a medical condition (or a patient population) usually involves multiple specialties and numerous interventions. Value for the patient is created by providers' combined efforts over the full cycle of care. The benefits of any one intervention for ultimate outcomes will depend on the effectiveness of other interventions throughout the care cycle*" (2). The World Health Organization (WHO) defined integrated care as "*health services that are managed and delivered so that people receive a continuum of health promotion, disease prevention, treatment, disease management, rehabilitation and palliative care services, coordinated across different levels and sites of care within and beyond the health sector, and according to their needs throughout the life course*" (1).

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A significant amount of efforts have been placed at the various levels of integration activities: vertical and horizontal integration are, in fact, used do define different types of integration. Vertical integration relates to care delivery across services areas within a single organization (e.g. a specific hospital), while horizontal integration is used for coordinated care across different settings (3). However, the evidence for strategies to achieve care integration across health systems remains limited (4). Actually, while the principles of Integrated care are simple, their implementation is much more controversial (5).

INTEGRATED DIAGNOSTICS

A body of evidence has been collected to demonstrate that, despite advances in technologies and precision medicine tools, diagnosis remains a fragmented and frustrating process for both clinicians and patients. Clinical laboratories, radiology, and pathology departments, which perform the preponderance of diagnostic tests play an increasing central role in medical diagnostics. However, these disciplines are "*islands of vast data and extraordinary intradisciplinary expertise separated from one another and from clinical colleagues by informatics, physical, and specialty barriers*" (6). The authors of the paper underlined that "*although of immense potential value, our petabytes of data are overwhelming providers and systems*" thus emphasizing the need and expectations of clinicians to receive more integrated and interpretable data (6). Wilson et al. have suggested the need for integrating pathology and laboratory medicine services, thus creating the acronym PALM (pathology and laboratory medicine) (7). According to these Authors, PALM is a "*highly complex set of medical subdisciplines that span the breadth of diagnostic testing that is needed to support all health care*" (7), as shown in Figure 1.

As a matter of fact, for many diseases and medical conditions, PALM testing is the only available method for making and confirming a patient's diagnosis.

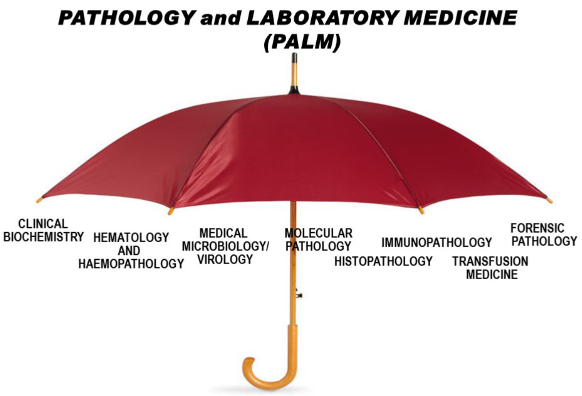

Figure 1
Subdisciplines included in pathology and laboratory medicine (PALM)

For example, most cancer diagnoses require anatomical pathology services for interpretation of biopsy specimens, while for most infectious diseases (including HIV, tuberculosis, and malaria), the diagnosis of the causative agents and detection of antimicrobial resistance require access to microbiology or virology laboratory services.
Similarly, many liver diseases, kidney diseases, and thyroid conditions can only be detected through testing provided by clinical laboratory services; many of these diseases and conditions are asymptomatic during early stages and, therefore, are unlikely to be detected clinically. This issue has been finally clearly understood not only by clinicians, but also by patients and citizens during the COVID-19 pandemic (8). Moreover, early detection of asymptomatic disease should result in better disease management and less consumption of the scarce resources available in almost all health care systems. As a matter of fact, "*Pathology and Laboratory Medicine (PALM) services are cross-cutting, intersectoral, and provide the foundation for safe, effective, and equitable health-care delivery, population health, and global health security*" (7). PALM, therefore, is a model of diagnostic integration involving all subdisciplines of laboratory medicine. A further integration which is receiving increasing interest and concern is that between clinical laboratories, pathology and radiology. In 2020, the European Society of Radiology (ESR) and the European Federation of Laboratory Medicine (EFLM) signed a memorandum of understanding confirming international support of integrative diagnostics (ID) between both disciplines (9). It has been underlined that *"modern imaging technologies provide high-resolution morphologic information but limited information on tissue metabolism and potential function and no systems information. In contrast, clinical laboratory medicine measures thousands of biochemical and molecular markers with moderate to high tissue specificity in various body fluids, but it rarely gives a pinpoint morphologic information that radiology can provide". Several lines of evidence attest that the role of the so-called "integrated diagnostics"*, defined as "*convergence of imaging, pathology, and laboratory tests with advanced information technology (IT)*", will overwhelmingly emerge in the foreseeable future, allowing to make earlier and more accurate diagnoses, but also contributing to save a large amount of human and economic resources (10).

Lippi et al. in a recently published paper, have emphasized that "*better comprehension of several biological pathways, coupled with emerging technological advances, will foster a paradigm shift in the way diagnostics has been for long acknowledged, paving the way to a new model of healthcare where integration of many different data will be more rapid, efficient and straightforward. This, in turn, may facilitate the acknowledgment, right interpretation and utilization of diagnostic information for an effective clinical reasoning and patient management*" (11). In their work, Lippi et al. have provided evidence of the value of integrated diagnostics in several clinical-therapeutic pathways such as cardiovascular diseases (in particular for myocardial infarction), stroke, venous thromboembolism, cancer and infectious diseases, and sepsis. Further evidence of the need for closer and better integration of diagnostic information has been collected during the COVID-19 pandemic (8). Integrated structured reports which provide reliable data aggregation, in conjunction with outcome data may allow the development and optimization of front-end clinical decision support (CDS) systems. These tools, incorporating artificial intelligence and machine learning methodology, can provide referring providers with real-time probabilistic differential diagnoses for individual patients and enable the development of management paradigms for specific diseases and large populations (12). In addition, the new management paradigms of integrated diagnostics can close the loop from the post-analytical back to the pre-analytical phase by suggesting the most appropriate tests for the referring physician's next patient with similar symptoms and health problems. The already mentioned issue of the enormous volumes of different information (the so-called "big-data") from one side may promote a paradigmatic change into personalized medicine, but, from another side it should challenge the mind of clinicians and healthcare professionals. The combination of big data and artificial intelligence, referred by some as the fourth industrial revolution, will change laboratory, radiology and pathology along with other medical specialties, particularly if ID may allow to provide a unified structured report. As predicted by some authors, because pathology and radiology have a similar past and a common destiny, these specialties should perhaps be merged into a single entity, the "information specialist," whose responsibility will not be exclusively to extract information from laboratory data, images and histology, but to manage the information extracted by artificial intelligence in the clinical context of the patient (13). This, in turn, is one of the main reasons to include ID in the Manifesto for the future of laboratory medicine, as "*innovative training and the development of new skills and competences are needed for future laboratory professionals*" (14). A further challenge is represented by the need to integrate, particularly as concerns laboratory tests, the data from decentralized testing [point-of-care (POCT), near-patient and home testing] and wearables (15). Although POCT and decentralized testing have been promoted and progressively adopted for critical care and also in many other clinical settings, the COVID-19 pandemic offered the opportunity to implement decentralized POCT even in rural and remote locations improving access to timely laboratory services, thus reducing inequities. (16). In addition, in the last decade, wearable devices have attracted much attention from the academic community and industry and have recently become very popular. The most relevant definition of wearable electronics is the following: "*devices that can be worn or mated with human skin to continuously and closely monitor an individual's activities, without interrupting or limiting the user's motions*" (17). Today, the range of wearable systems, including micro-sensors seamlessly integrated into textiles, consumer electronics embedded in fashionable clothes, computerized watches, belt-worn personal computers (PCs) with a head mounted display, glasses, which are worn on various parts of the body are designed for broadband operation. The field of wearable health monitoring systems is moving toward minimizing the size of wearable devices, measuring more vital signs and laboratory parameters (glucose, ions, cardiac biomarkers, and so on) and sending secure and reliable data through smartphone technology.

Therefore, ID should take into account also the fusion of heterogeneous datasets from different diagnostic systems (both centralized and decentralized sites), different institutions and across different modalities presenting a powerful opportunity to drive knowledge discovery in biomedicine and improving clinical practice, as shown in Figure 2 (18). The challenge remains how to harmonize this information to allow a safe acknowledgment, interpretation and utilization of diagnostic data.

CURRENT BOTTLENECKS AND PERSPECTIVES

Local reimbursement systems present formidable barriers to change, as the fee-for-service reimbursement systems offer little incentive to develop integrated diagnostics and to adopt bundled payment programs. A further major limitation to joint efforts to implement ID is current Information technology (IT). In most academic centers IT remains separated and fragmented, not only between radiology and laboratory medicine, including pathology, but also with the hospital electronic health record (EHR). Advanced IT for improving diagnostics should require three steps:

- digitizing medical information and establishing connectivity so that data can be rapidly accessed and shared;
- implementing advanced analytical techniques across data types to change information overload into insights;
- integrating these insights into healthcare workflow to inform decisions.

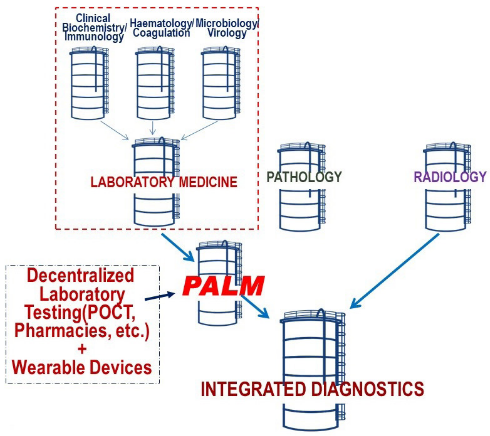

Figure 2
Integrated diagnostics: convergence of laboratory medicine, pathology, radiology and decentralized testing

Costs are one of the major obstacles to building and maintaining the infrastructure for advanced IT. However, achieving digitization and connectivity is expensive but may assure benefits for both clinicians and patients and, finally, increases efficiency (19).
ID initiatives may also reveal “unmet needs” of complex patients within and beyond health care, eventually leading to reduce extra costs and assuring savings thanks to avoidable admissions to hospitals and unnecessary duplications of diagnostic tests. This is increasingly important issue taking into consideration the growing burden of health needs for chronic conditions, multi-morbidity and frail patients. Awareness of frailty and associated risks for adverse health outcomes can improve care for this most vulnerable subset of patients and represents a further reason to promote the implementation of ID. However, it should be highlighted that cultural barriers still exist, being based on the desire to maintain individual department resources: this may represent the most critical obstacle to the implementation of ID. Only the cooperation between academic centers, organizational bodies and scientific societies should overcome current bottlenecks, through active involvement of other stakeholders including clinicians, administrators, politicians and patient representatives.

CONCLUSIONS

Today, the business model involved in delivery of laboratory and other diagnostic services seems to be “*primarily designed and executed in individual silos driven by internal activities and managed according to performance metrics that match the discipline itself rather than the products of services to improve clinical pathways, clinical and economical outcomes and patient safety*” (20). In particular, clinical laboratories are increasingly organized as focused factories, with the goal of maximizing productivity, improving internal efficiency (e.g. by reducing the cost per test) and consolidating structures in mega-laboratories or even outsourcing testing to independent facilities. Several initiatives propose a rigorous team-building transformational organizational change, with a radical departure from the current hierarchical, silo-oriented, medical practice modes to implement transformational patient-centered medical care. ID plays a fundamental role in this paradigmatic change overcoming cultural, political and technological boundaries for developing the discipline of the future. The possible convergence of laboratory, pathology and imaging test results within the same medical report is a valuable goal to foster earlier and more accurate diagnoses, and personalized medicine. This, in turn, requires innovative training models, new professional knowledge and skills and the availability to be part of multidisciplinary diagnostic teams.

CONFLICT OF INTEREST

None

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