Advancing the Diagnostic Cockpit of the Future: An Opportunity to Improve Diagnostic Accuracy and Efficiency

From:

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The Academy for Radiology & Biomedical Imaging Research ("the Academy") was successful in leading a congressional effort which culminated in the establishment of the Interagency Working Group on Medical Imaging (IWGMI) by action of the National Science and Technology Council; Committee on Science within the White House. The IWGMI was established to coordinate federal investments in imaging research and included representatives from more than a dozen federal agencies, and was co-chaired by the National Institutes of Health (NIH) and the National Institute of Standards and Technology (NIST). The working group developed a roadmap for the full scope of medical imaging research and development , including: basic science, technology, engineering, and math science and technology creation, medical and translational research, evidence generation, clinical implementation, workforce and training support, and export-oriented manufacturing incentives. The roadmap they completed presents a snapshot of key federal research and development programs related to medical imaging, and provides a set of recommendations intended to generate better value for patients, optimize healthcare outcomes, and reduce costs. This paper illustrates a continuation of these efforts.

The roadmap identified "advancing high-value imaging" as the key theme to achieve more efficient and effective healthcare, more impactful research, and better health outcomes. It identified four objectives to guide federal research & development:

- Standardization/interoperability of image acquisition, annotation management, storage, and transfer;

Special Communication

- Application of advanced computation and machine learning to medical imaging;
- Acceleration of development and translation of new, high-value imaging techniques;
- Promotion of best practices in medical imaging.

These form the foundation for a framework of tools to support clinical practice and research to create the "**diagnostic cockpit.**" The diagnostic cockpit is a future-state digital platform to aggregate, organize, and simplify medical imaging results and patient-centric clinical data. It will help clinicians become "diagnostic pilots" in detecting disease early, making accurate diagnoses, driving image-guided interventions, and improving downstream clinical management of patients.

The Academy has for over 20 years advocated for federal research funding, pushed for changes in policy critical to imaging researchers, and promoted technical advances to improve diagnostics and patient care. The Academy, in conjunction with NIST, hosted a workshop to address two of the five priority action items from The Academy's 2017 symposium *Building the Diagnostic Cockpit of the Future* (http://www.acadrad.org/wpcontent/uploads/2018/03/Academy-White-Paper-2018.pdf).

THE 2018 WORKSHOP FOCUSED ON

- Developing (or promoting existing) national standards for encoding, exchange, and quantification of data from multiple sources including: imaging, histology/pathology, genomics, and laboratory data available from the electronic health record (EHR). The first 4 are data; the EHR merely stores it. These standards support the goal of data interoperability that could be validated using national registries/databases.
- Creating an environment that facilitates cooperation and participation across government agencies, industries, and academia in a safe, neutral, precompetitive space. Cooperation and crosstraining among physicians from multiple specialties is essential. The workshop convened experts from medical imaging, histology/pathology, cardiology, oncology, artificial intelligence, and EHR, plus representatives from 9 government agencies and 15 manufacturers.

Three breakout sessions focused on different aspects of the cockpit:

- Defining the scope of the product (what data is available now and what can be done with it);
- Moving from qualitative to quantitative imaging, and the need for standardization;
- Environmental factors (workflow, billing, patient and provider perspectives).

Several common themes emerged. First, is the question of what data are currently available and what can be done with it now. It is important to understand the roles of

diagnosticians as data aggregators, interpreters, and synthesizers, and ways the diagnostic cockpit could prioritize, enable, and enhance these activities. This will help shift the "art" of diagnostics to the "data science" of diagnostics, leading to repeatable and portable clinical results worldwide.

Creation of the diagnostic cockpit, from descriptive to predictive to prescriptive, should start with a tool to aggregate and visualize all case-relevant information before developing advanced analytics and self-learning. There are a number of data streams to identify, gather, and collate including imaging data, radiology test results, standardized clinical quantitative structured reporting, processed or derived images (perfusion, tractography, etc.), laboratory test results, synoptic histology/pathology reporting in cancer, claims data and ICD10 codes. Each source has its own storage and communication standard (eg, Digital Imaging and Communications in Medicine (DICOM) and while it might be tempting to unify them, adopting a common ontology would be far more achievable to ensure semantic interoperability. The use of structured reporting as being developed through efforts of the Radiological Society of North America and the American College of Radiology will accelerate this effort.

A significant challenge in aggregating these data is ownership and access. There are multiple entities across the healthcare enterprise (radiology, histology/pathology, vendors, etc.) seeking to access data, and the current fragmented stewardship of diagnostic data makes it difficult to identify stakeholders that will drive aggregation in the provider community. There is an urgent need to concisely summarize presentation of data across multiple systems (eg, EHR, Health Information Exchange). The types of data required vary by specialty and the desire for personalization of data presentation. To overcome barriers to aggregating data, we should create open-access, exemplar datasets through multi-institutional collaboration that is driven by government bodies (funding institutions) to ensure public availability. In addition to establishing data and technical standards, the aggregated data can stimulate development of data visualization tools and analytics that represent the next layer of the cockpit.

Quantitative metrics are needed for performing discrete measurements and/or gauging therapeutic response. These metrics are important to physicians reading imaging studies (eg, radiologist) as well as users interacting with the data downstream (eg, oncologists, surgeons). The problems today are threefold:

- Lack of standardized measurements and techniques for rapidly and accurately performing volumetric measurements. Response Evaluation Criteria In Solid Tumors (RECIST) and other 2D measurements, while widely used are tedious, have notable interobserver variability, and are often not graphically documented. The linkage between measurement in the report to the image and annotation of the measurement is of great value to downstream users and speeds comparison reviews for future studies.

- Lack of a standard interchange mechanism for structured measurement data as documented in the interpreting physician's report. While there is structured measurement data available from devices (DICOM SR), there is no similar process to capture final values, including metadata the reader has made or accepted during interpretation. Enhancing report output could take several forms but requires consensus.

- Paucity of standardized reference studies such as those from the National Cancer Institute and the NIH (eg, The Cancer Imaging Archive from the National Cancer Institute((NCI)/National Institutes of Health(NIH)); phantoms that provide reference standards for metrology (eg, for MRI studies by NIST and vendors), and synthetic Digital Reference Objects from the Radiological Society of North America's Quantitative Imaging Biomarkers Alliance. We need an archive of images acquired with phantoms/studies from a variety of devices (vendors, modalities) to validate accuracy, simplify comparison, and speed validation and quality of new image quantification technologies (eg, Artificial Intelligence (AI) and applications for devices to the Food & Drug Administration).

Advancing ideas for commercialization and use will require coordinated efforts across industry, academia, standard organizations and imaging societies, including Society for Imaging Informatics in Medicine, Healthcare Information and Management Systems Society, American College of Radiology, American Association of Physicists in Medicine, and other accrediting bodies.

Rapid query mechanisms for source data (eg, HL7 FHIR) must be adopted, as should AI and natural language processing, extraction of summary data with easy ways to drill down into the source of the summarized data to gauge context and validate the summary, and a means of importing discrete summarized data into the current report. Diagnostic cockpits need to be interoperable, most likely based on disease and condition, with the intention of being utilized by the entire healthcare team. Dashboard building blocks need to be created with well-defined application programming interfaces to facilitate more complex applications. Common data elements need to be defined, similar to information captured in the DICOM standard (eg creation of an open-source standard dataset would help manufacturers and researchers develop and test tools that end users could evaluate).

Finally, there are two additional key issues: (1) the practical impact of data influx on the end user, and (2) the impact of AI on the imaging pathway - from acquisition, to interpretation to payer pathways and the need for proactive approaches. Data management standardization is a necessary prerequisite for accelerating AI. Disparate systems for data transfer, especially those involving handwriting and retyping, are error prone, inefficient, resource intensive, and inhibit progress. Dashboards are required for tracking and feedback of performance, validation of information, and co-registration of images and data. They must be customized to the task, populate the radiology report with the final

tailored impression, and improve efficiency while maintaining diagnostic accuracy. This would reduce user stress and the tedium that accompanies existing inefficiencies.

ACTION ITEMS

The Academy will create an interdisciplinary Task Force to further develop the framework for the cockpit of the future; bring together key stakeholders in a variety of strategic forums; and educate funding agencies about the importance of funding cockpit development-related efforts. The following efforts will require financial support and/or participation of numerous imaging societies.

- Task Force will identify a neutral third party to validate de-identification, manage the dataset(s), and ensure interoperability.
- The neutral third party will collect 100 cases (imaging, labs, histology/pathology, reports, patient records, etc.) from 10 institutions in hepatocellular carcinoma, coronary artery disease, and prostate cancer. This information is collected from the medical record in an anonymized fashion.
- The Task Force and Academy will refine the core functional requirements of the diagnostic cockpit.
- The Task Force and Academy will identify potential funding sources for resultant initiatives.
- The Academy will create a compendium of existing standards (eg, ACR Registry of Standards and Interoperability) to avoid duplication, utilize existing resources, and ensure transparency. Options include the utilization of "connectathons" at technical meetings (Healthcare Information and Management Systems Society and Society for Imaging Informatics in Medicine), and polling society Executive Directors.

We look forward to the improvement in healthcare that is likely to arise from the efforts stemming from the report published by the Interagency Working Group on Medical Imaging.