National Photonics Initiative (NPI) Cancer Moonshot Task Force: Medical Imaging Used to Accelerate Progress

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Introduction:
Eight of the ten focus areas, recommended by the Cancer Moonshot Blue Ribbon Panel and implemented under the direction of the National Cancer Institute, require the support of medical imaging. At a workshop entitled, “Improving Early Detection of Cancer and Response to Therapies through Imaging Technologies” in Rockville, Maryland on April 12, 2017, the NPI convened stakeholders including the medical imaging industry, academia, government agencies and patient advocates to identify key issues and propose solutions for more effective use of medical imaging to accelerate the translation of innovations into clinical practice.

The Unique Value of Medical Imaging:
Tumor heterogeneity and the sampling problems associated with repeated tumor biopsies renders incomplete information. Cancer medical imaging is essential to overcome limitations to biopsies, and with machine learning, can potentially yield virtual digital biopsies, which are noninvasive, repeatable and cover the entire tumor.

Today and in the future, imaging drives diagnosis and decision-making in effective and efficient cancer patient care.

Examples:

**Steps for Magnetic Resonance/Ultrasound Fusion-Guided Prostate Biopsy.** LEFT: A. Prebiopsy multiparametric magnetic resonance imaging (MRI-MRI) that includes axial (T2-weighted) and functional (dynamic contrast enhanced and apparent diffusion coefficients) images is obtained and reviewed by a radiologist. Axial images all demonstrate a lesion suspicious for prostate cancer (yellow arrowheads). This lesion would be marked by a radiologist in preparation for fusion biopsy. B. At the time of MRI/ultrasound fusion biopsy, a real-time axial transrectal ultrasound is performed to assist with needle guidance. The MRI/ultrasound fusion platform overlays the outline of the lesions suspicious for prostate cancer green line and contour of the prostate (red line). The platform also synchronizes the transrectal ultrasound image with a location in the prostate and rescues an axial MRI based on the T2-weighted image to correlate with the location of the ultrasound image. A dotted red line demonstrates the path of the needle and, when a biopsy is obtained, it can be marked on the ultrasound image in yellow (yellow line). LEFT: C. At the conclusion of the biopsy, a 3-dimensional map from the data alone is generated, demonstrating the location of the prostate (red), the location of the tumor lesions (green), the location of the standard sextant based location (purple cores) and the location of the targeted MRI/ultrasound fusion biopsies (yellow cores). From Kallath, BMA et al., JAMA, 103, 2016.

When used as a quantitative biomarker, imaging can provide surrogate endpoints for accelerating clinical trials. Because of its importance in screening, diagnosis and monitoring response to therapy, imaging data needs to be included in registries, databases and the "cancer knowledge network" as a necessary accelerant for translating innovation into clinical practice.

**Challenges/Opportunities:**
Developed as part of the Precision Medicine Initiative, the national IT "cancer knowledge network," which aims to house and integrate genomic information from tumors with clinical response data and outcomes information, does not currently include medical imaging data – that is digital and ideally suited for machine learning on "big data."

Imaging data provides a wealth of information, which can be computer extracted to yield "radiomics," e.g., quantitative descriptors of tumor size, shape and heterogeneity, allowing image features to be related to protein and gene expression through artificial intelligence and deep learning. Imaging and radiomics datasets could be shared on the cancer knowledge network and "data-mined" to advance medical discoveries and accelerate translation of innovations into clinical practice.

Also, given variations in image acquisition protocols, developments to standardize across vendors is needed so that imaging data can be compared and utilized across different clinical sites for purposes of research and medical evidence development.

**Recommendations:**
Collaboration is required to develop application-specific standards and protocols to accelerate contributions of medical imaging to the cancer knowledge network.

Medical data registries need to be developed to accommodate medical imaging datasets for rapid collection, computer image analyses and sharing that will accelerate patient benefit and quality outcomes assessments across sites and providers.

Patient stakeholders need the ability to contribute to and access their own medical images and clinical diagnostics with privacy guidelines in order for the cancer knowledge network to evolve into a database that facilitates translational research and clinical evidence development.

Workshop Participants

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**SCREENING**
**DIAGNOSIS**
**RESPONSE TO THERAPY**
**BIOMARKER IN CLINICAL STUDIES**
**REGISTRIES FOR ACCELERATING RESEARCH, DEVELOPING MEDICAL EVIDENCE**