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

Eva M. Sevick-Muraca[1], Richard A. Frank[2], Maryellen L. Giger[3], & James Mulshine[4]
representing the National Photonics Initiative (NPI)
[1]The Center for Molecular Imaging, The University of Texas Health Science Center
[2]Siemens Healthineers North America
[3]Department of Radiology, The University of Chicago
[4]Department of Internal Medicine, Rush University

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.

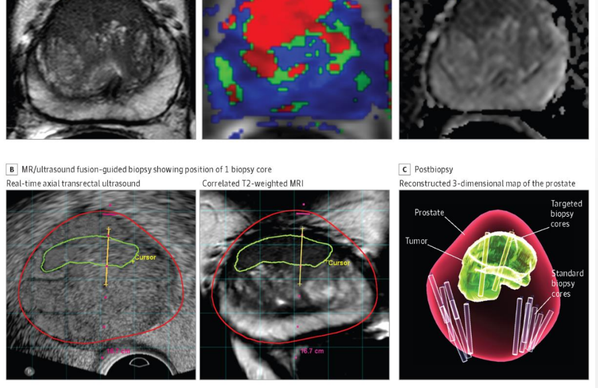
At a workshop entitled, "Improving Early Detection of Cancer and Response to Therapies through Imaging Technologies" in Rockville, Maryland on April 12, 2017, the NPI convened stakeholders including the medical imaging industry, academia, government agencies and patient advocates to identity key issues 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:

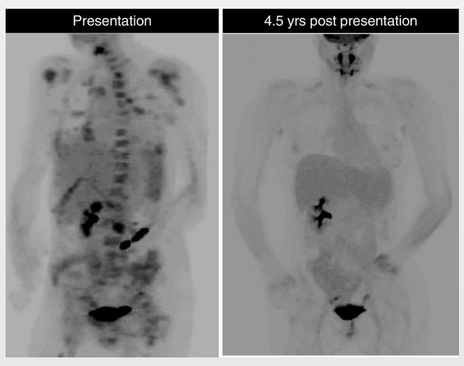
Tumor heterogeneity and the sampling problems associated with repeated tumor biopsies renders incomplete information. Cancer medical imaging is essential to overcome limitations to biopsies, and with machine learning, can potentially yield virtual digital biopsies, which are noninvasive, repeatable and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

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

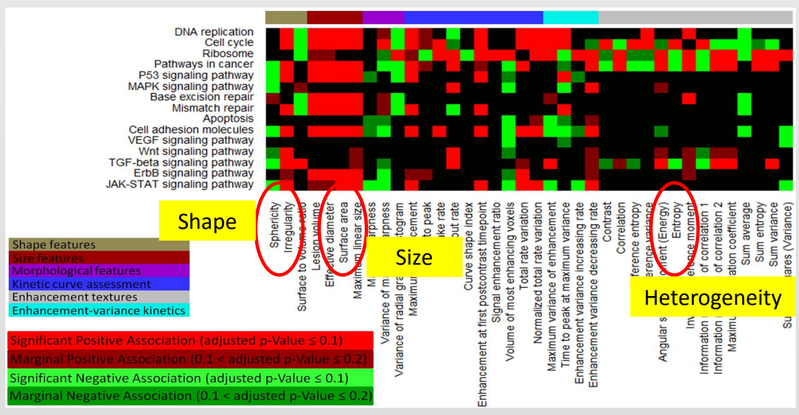
Examples:



Steps for Magnetic Resonance/Ultrasound Fusion–Guided Prostate Biopsy. LEFT: A. Prebiopsy multiparametric magnetic resonance imaging (MP-MRI) that includes anatomical (T2-weighted) and functional (dynamic contrast-enhanced and apparent diffusion coefficient) imaging 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. At0 the time of MR/ultrasound fusion biopsy, a real-time axial transrectal ultrasound is performed to assist with needle guidance. The MR/ultrasound fusion platform overlays the outline of the lesion 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 recreates 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 performed, the location can be recorded as shown here with the yellow line. C. At the conclusion of the biopsy, a 3-dimensional map from the data above is generated, demonstrating the contour of the prostate (red), the location of the tumor lesion (green), the location of the standard extended-sextant biopsies (purple cores) and the location of the targeted MR/ultrasound fusion biopsies (yellow cores). From Siddiqui, MM et al., JAMA, 313, 2014.



PET/CT Monitoring Response to Adjuvant Immunotherapy in High-Risk Pediatric Sarcomas. RIGHT: FDG- PET scans taken at presentation of 24 years of age showing disseminated Ewing Sarcoma involving kidney, bone, bone marrow and lungs. She received standard cytotoxic therapy followed by immunotherapy. The image on the left demonstrates FDG-PET scans taken at 4.5 years following presentation. She remains free of disease with no evidence of recurrence. From Merchant, MS et al., Clin. Cancer Res., 22, 13; 3182 2016.



Datamining of Radiomics-Genomics Associations in Breast Cancer Discovery. LEFT: Heatmap representation of statistically significant associations between radiomic phenotypes and transcriptional activities of some cancer-related genetic pathways. In the heatmap, genetic pathways are rows and radiomic phenotypes are columns. From Zhu, Y et al., Nature Scientific Reports 5:17787, 2015.

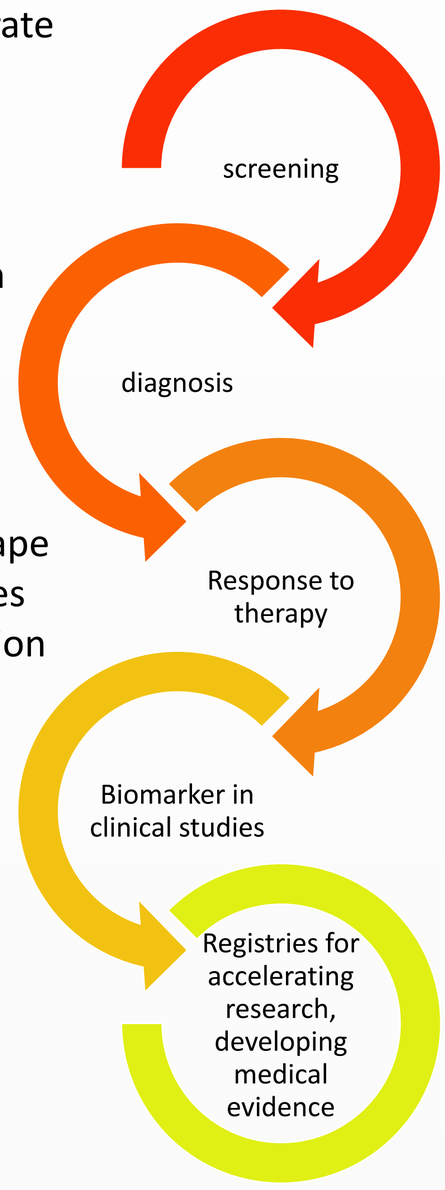
When used as a quantitative biomarker, imaging can provide surrogate endpoints for accelerating clinical trials. Because of its importance in screening, diagnosis and monitoring response to therapy, imaging data needs to be included in registries, databases and the "cancer knowledge network" as a necessary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

Carolyn "Bo" Aldigé	Prevent Cancer Foundation
Rick Avila	Accumetra
Sue Bunning	Medical Imaging and Technology Alliance
Peter Choyke	National Cancer Institute Center for Cancer Research
Bonnie Clarke	Society of Nuclear Medicine and Molecular Imaging
Laurie Fenton Ambrose	Lung Cancer Alliance
Claudia I. Henschke	Icahn School of Medicine at Mount Sinai
Edward Jackson	Univ. of Wisconsin School of Medicine and Public Health
Maciej Mazurowski	Duke University
Robert Nordstrom	National Cancer Institute
Etta Pisano	Harvard Medical School, Beth Israel Deaconess Medical Center, and American College of Radiology
Berkman Sahiner	Food and Drug Administration, Division of Imaging and Applied Mathematics
Michael Sapienza	Colon Cancer Alliance
Faina Shtern	AdMeTech Foundation (Non-Profit Corporation for the Advancement of Medical Technologies)
M. Minhaj Siddiqui	University of Maryland Medical Center
Eric Stahlberg	National Cancer Institute Frederick National Laboratory for Cancer Research
Peter Weems	Medical Imaging and Technology Alliance
David Yankelevitz	Icahn School of Medicine at Mount Sinai

Acknowledgments:

The NPI is a collaborative alliance of the American Physical Society (APS), IEEE Photonics Society (IEEE), Laser Institute of America (LIA), The Optical Society (OSA) and SPIE, the International Society for Optics and Photonics (SPIE) that seeks to collaborate with industry, academia and government to increase coordination to advance both conventional (nuclear, CT, MRI, US) and emerging biophotonics-driven medical imaging technologies and data management tools, among other optics and photonics technology applications across all economic sectors.