EDITORIAL

The (Heart and) Soul of a Human Creation: Designing Echocardiography for the Big Data Age

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> In most people's vocabularies, design means veneer. . . . But to me . . . design is the fundamental soul of a human-made creation that ends up expressing itself in successive outer layers of the product or service.
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> —Steve Jobs

Machine learning (ML) and big data hold the potential to revolutionize cardiovascular imaging.[1] In echocardiography, ML has been used for image enhancement, view classification and guidance, chamber quantification, and even diagnosis. With or without ML, big data analytics can power increasingly scalable outcomes research and quality improvement.

Machine-learning performance is inextricably linked to the data it is trained and tested on.[1,2] Furthermore, efficient and effective data storage and organization can have significant benefits to hospital systems and patient care.[3] However, legacy echocardiography picture archiving and communication systems (Echo-PACS) are not designed to leverage clinical imaging and related metadata for big data analytics. Historically, echocardiogram data design was considered only in as much as it supported day-to-day clinical operations. With increased need to access echocardiographic data quickly and at large scale across institutions, current data design falls unacceptably short.

For example, despite conformance statements, metadata accompanying Digital Imaging and Communications in Medicine (DICOM) imaging is not optimally standardized across manufacturers and lacks specific tags that would greatly aid data mining, curation, and preprocessing[4] (Figure 1). Image deidentification is hampered by burned-in patient health information (PHI). Measurements performed on ultrasound machines are not seamlessly interoperable with Echo-PACS across manufacturers, causing measurements obtained on cart to frequently be lost.[5] Databases for clinical measurements storage and query are inefficient, outdated, and/or proprietary.

These obstacles make it challenging to perform clinical quality control and education, to mine and harmonize data for research, to connect echocardiographic data to the rest of the electronic health record, and to collaborate across institutions and with industry.[3] Even large, well-resourced medical centers face these obstacles; smaller health care entities are doubly affected and are therefore at risk of being excluded from the big data revolution, at great cost to the goal of inclusive, unbiased analytics.

A big data–enabled future for echocardiography requires redesigning clinical data processing and storage at the level of ultrasound hardware and software manufacturers to be inclusive of all health care settings (Figure 1). This will need investment and cooperation across institutions and with industry partners but will offer several benefits. Redesigning ultrasound data will improve the cost-efficiency and quality of patient care as well as lower the activation energy for research. Ultimately, manufacturers who do not solve these problems may become marginalized as users migrate to systems that provide seamless big data functionality.

We ask our industry partners to further standardize DICOM metadata, address burned-in PHI, provide and support better database tools, and offer software development kits for implementation research using ML algorithms in the clinical workflow. Where manufacturers may already offer these capabilities, we ask them to help us implement them at our institutions.

With a proliferation of cardiovascular ultrasound technologies including three-dimensional imaging, intracardiac echocardiography, and therapeutic ultrasound as well as platforms like point-of-care ultrasound and cloud solutions, ultrasound data will only become more complex. The time to update data design for echocardiography is now.

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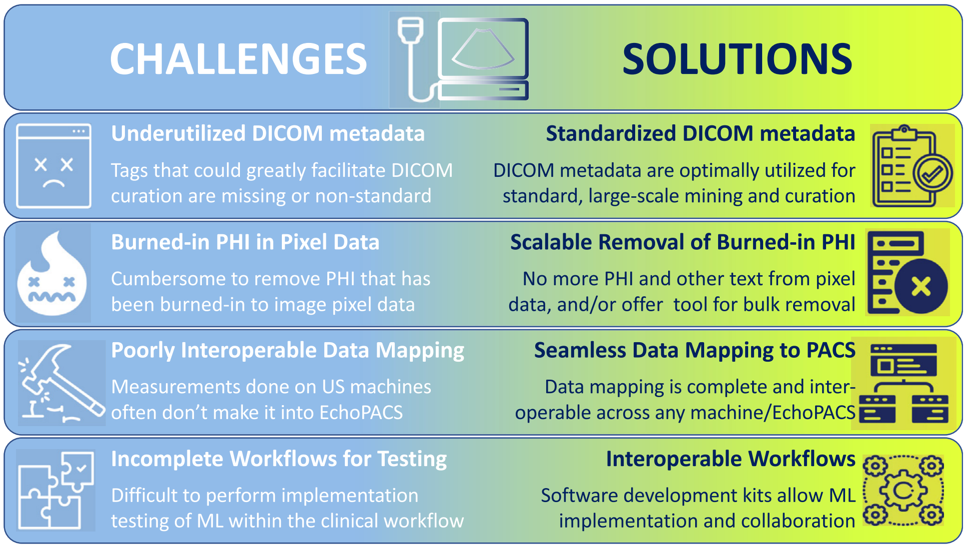

Figure 1 Improving speed, quality, and efficiency of echocardiographic data can improve big data research, testing, collaboration, and patient care.

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