



*Many of the new incentives...will result in a further shift of diagnostic responsibility away from clinicians and toward our imaging specialty.*

## PACS 2.0: Rebooting Pandora's box for the next 20 years

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June of this year marked the 20<sup>th</sup> anniversary of the world's first filmless hospital at the Baltimore VA Medical Center and, consequently, the most antiquated PACS. The chief of medicine wisecracked that the VA was "always filmless, anyway, because you couldn't find the films," and as a fledgling chief of radiology just out of fellowship, my primary focus was to eliminate lost/stolen films and make imaging studies available "anytime, anywhere."

Other reasons to go 100% filmless were to take advantage of cine/stacked viewing of CT and MRI, dynamic window/leveling of images, and interactive measurement and quantitative analysis, and to make images available for immediate review. Of course, the other attraction was the fun and adventure associated with reinventing the way radiology had been practiced for the last century. It required a unique combination of timing, luck, vision, creativity, technical skills, and naiveté to help our vendor to pull it off. We learned that the most important thing was not just going filmless, but using PACS to reinvent departmental workflow

and operations, and we were surprised when our operational costs dropped 25% and our reading efficiency went up by 40%.

Going forward with our plans to go filmless despite the admonitions of "pundits" who suggested that filmless radiology was > 10 years away due to technical, quality, and medico-legal issues turned out to be an amazing opportunity and a positive decision for our department. It undoubtedly accelerated the transition from film-based to digital radiology departments around the world. Being first to "jump in the pool" offered us the opportunity to document economic, operational, ergonomic, and social aspects and implications of filmless radiology and to push the envelope subsequently in diverse areas, such as integration with the EMR, advanced visualization, speech recognition, reading-room design, image tagging, CAD, and the human/machine interface in general.

The 20th anniversary brings a new exciting challenge and opportunity. Taking 20 years of lessons learned and research in digital imaging, we have purchased a replacement PACS, which actually represents not

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only a conventional commercial PACS but also includes additional initiatives. This has allowed me to attempt to fulfill a wish list for a system that will serve us for the next 20 years. Our goals for the first PACS were pretty basic – make sure images were available everywhere and that images could be efficiently interpreted and the system integrated with the hospital information system.

The following are a brief synopsis of the characteristics on my wish list for our next generation PACS:

First and foremost, the system has to be “smart.” We have suffered from inexplicably “stupid” systems that too often represented a step back from our much smarter file-room personnel, transcriptionists, and clerical staff who, unlike our PACS, learn over time. Smart includes learning from what I do and adapting to me rather than the other way around. It also includes decision-support tools that are data driven, and applying recent “artificial intelligence” capabilities, such as “Siri” and IBM’s “Watson” to enhance workflow, improve safety, provide surveillance for errors in reports, and suggest possible diagnostic considerations by combining clinical, lab, genomic, and multi-parametric imaging data.

The PACS image-interpretation and other workflows should be as efficient as possible. This includes automatic registration of current and previous studies, advanced visualization, PACS

display of relevant clinical information, including whether prior studies were positive or negative, and creative innovations, such as simultaneous display of multiple CT window/levels on a single image.

Communication and tracking of radiology results and follow-up is abysmal today and must be completely re-engineered and automated. Radiologists are already expected by our patients and the legal system to take at least partial responsibility for follow up of all impactful findings. Natural language processing and/or structured reporting will be used to accurately tag critical, interesting, and unexpected findings and track these for both the radiology department and clinicians.

Radiology has the opportunity to participate in the new era of big data and personalized medicine. We have “gold mines” of research and clinical data in our own local data as well as clinical studies such as the National Lung Screening Trial and yet we do not take advantage of these for decision-making. Every CT study, regardless of indication, such as “evaluate for pulmonary emboli,” has an enormous wealth of “incidental” information, such as bone mineral density of the spine, coronary artery and other vascular calcifications, interstitial lung disease, and dozens of other potentially important information “hidden” in its pixel data. Finding ways to manually or automatically extract those data out-

side of the traditional radiology report offers tremendous potential for next generation PACS. Personalizing radiology also involves providing patients and their providers with access to their own images in the cloud without resorting to CD’s or other portable media.

One of the iconic professors from my residency program, who became an early PACS adopter, presciently warned that PACS would open a Pandora’s Box of issues, such as loss of personal contact with clinicians, image quality, inappropriate utilization, commoditization, turf issues, and the elimination of small radiology practices. He was--as usual--correct, but it hasn’t been the switch from film to digital itself but rather the way in which PACS was implemented that has brought about some of these problems. PACS has, overall, completely changed the practice of radiology to one that is far more efficient, cost-effective, and much more responsive to the demands of today’s practice of medicine. It has made possible and practical new levels of volume and complexity in CT and MRI sequences that would not have been possible in a film-based environment.

I am optimistic that lessons learned in the first 20 years and next generation PACS will reverse some of these unintended consequences, and I am hoping to getting started soon on my wish list for 2033.