Physicists Role in Digital Imaging Informatics Systems

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Disclaimers

• Speaker is on the Medical Advisory Board of Teramedica and Siemens Medical
• Any opinions expressed are those of the speaker alone (and maybe not even him)
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Talk Overview & Learning Objectives

• Classical Role of Medical Physicist
• Role with DICOM Modalities
• Role in Design of Image Storage, Display, Management, Workflow reengineering, Uptime
• Case Studies of Value Add of Physicists
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Classical Role

• Compliance
  – FDA (MQSA, state)
  – ACR Accreditation
  – Radiation safety, patient dosimetry, shielding

• Education
  – Residents, Techs, Patients

• Optimization
  – Best image quality for the dose
  – Comparative knowledge of imaging offerings from many vendors
Classic Role

• Technology Expert
  – Expected to be abreast of the newest imaging technologies

• Experimental Skills
  – understand the relationships of acquisition variables on imaging equipment
  – Able to conceive and execute experiments to optimize imaging parameters
• Classical Role of Medical Physicist
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Physics Role In Digital Modality

Issues

• Everything the classical physicist does *plus*
  – the analogous features in the DICOM modality world
  – an understanding of Dose vs. Noise instead of Dose vs. Over/Under exposure
  – Reeducation of Techs, Radiologists and others of implications of digital imaging
Role In Digital Modality Issues

• Why the physicist?

• Unique Skill Set Combination
  – We are Data driven
  – Knowledge of radiographic anatomy and examination technique
  – Expert knowledge of imaging parameters, technology, experimental method
  – Expert at QA and process optimization
  – Educator of imaging technologists
Sometimes reticent ...

- I’m already overworked
- I’m board certified and already trained in all this stuff with ongoing CME’s
- There are few regulations that require physics oversight of Digital Imaging
- What’s in it for me?
Esprit de Corps

• What do these people have in common?
  – Wilhelm Roentgen
  – Allan Cormack, Godfrey Hounsfield
  – Ray Damadian

• Answers
  – physicist, inventor of X-ray
  – physicists, inventor of CT
  – MD, but undergrad applied math, inventor MRI
Competitive Advantage

• Benefit to Care Providers going Digital
  – leverage their radiology staff to cover remote in-network sites
  – read for clients seen at non-network sites
  – Any image, anywhere (ideally in EMR)

• Benefit for the Physicist
  – the physicist that can take clients to the “filmless” promised land will be in demand
And One Last Reason

• There are talkers and doers
  – Try to be in the second group
  – Why?
• Less Competition
  – M. Ghandi
Digital (DICOM) Modalities

• Concerns?
  – Dose for Dx image quality (DQE)
  – DICOM functionality (Worklists, Store, Print, PPS, GSPS)
  – Workflow reengineering
  – Exam Fidelity from Modality through Archive and Clinical Viewer
ESE for Dx Images

• Plain Film (400 speed screens)
  – PA chest 12-18 mR

• CR
  – Up to 50% more for same noise

• DR
  – Similar or maybe 20% less then film for same noise (Huda)
DICOM Modality Functionality

- Minimum DICOM requirements for PACS
  - Store, Print, Store Commit, Modality Worklist
- Better for IHE Levels of Integration
  - PGP (e.g. head, neck, chest CT)
  - PPS (permit scanner side QA to update exam status on RIS)
  - GSPS (assure QA work on Scanner is presented to PACS and other downstream systems)
Workflow Reengineering

• Exam Acquisition Workflow
  – Pre-PACS sequence from Order to presentation of films to Radiologist is often “anything goes”
  – Post-PACS requires strict sequence:
    • Order (Pat, Anatomy, Exam code) from HIS to RIS sends orders to PACS
    • Night before PACS kicks off compares prefetch for known orders
    • On Arrival, order goes to Modality Wklist broker
    • Scanner gets exam info. from Broker
    • Exam is QA’ed in PACS and completed in RIS
    • Now, Radiologist sees images
Exam Fidelity from Source to Archive

• How to assure?
  – Random manual check of exam content (demographics, series and image counts, aided via DICOM Store Commit)
  – Manual examination of Image appearance and caliper accuracy on known objects on downstream viewers
  – Preservation of all QA operations across all viewers (aided via DICOM GSPS)
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Role in Radiology Systems Design

• Why the Physicist?
• … well, who else?
  – IT?
  – RT?
  – Radiologist?
  – Bioengineering?
Role in Radiology Systems Design

• Perry Sprawls says:
  – R&D of Technology
  – Equipment Acquisition
  – Facility Planning
  – Evaluation of Equipment Performance and QA
  – Reduce Physical Risk Associated with Medical Imaging Procedures
  – Optimize Imaging Procedures Through Education and Training

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Physicist Training

• Formal training in the imaging chain
  – *acquisition, display, storage, and distribution*

• Broad experience in radiology operations
  – *needs of technologists, radiologists / referring physicians*

• Experience with medical devices
  – *hardware and software*
  – *specification, installation, and acceptance*
  – *service activities*

• Familiar with sources of technical information

• Inherent interdisciplinary training

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Physicist Communication

• Ability to tailor communications
  – *Vocabulary (jargon) is specialized and parochial*
    • IS *vs.* RT *vs.* Clinical Engineer *vs.* Physician *vs.* Administrator
  – *Must summarize details and report*
    • both oral and written communications critical
Physicist Status

• As a member of the Medical Staff of the Hospital, the Medical Physicist ...
  – represents the interests of the Medical Staff.
  – interacts with the Medical Staff as a peer.
  – is included in closed meetings that involve discussion of QA incidents, such as Morbidity and Mortality.
  – carries greater authority with hospital staff.
  – is expected to design and direct the QA program, rather than to conduct it personally.
Storage Issues

• Brand New 64 slice CT scanner
  – will the Radiologist/CT-Vendor be thinking about explosion of data about to hit the PACS archive?
  – Will the networking team at the hospital be ready with Gbit links to the scanner and PACS workstation?
  – Will IT or PACS vendor be thinking about the RAM needs of PACS workstations?
Display Issues

• Is the image fidelity maintained from:
  – modality console to
  – PACS displays to
  – Clinical viewer?

• Are measurements accurate from modality to PACS to Clinical Viewer?

• Does the Display offer the proper JNDs required for the task (Dx, Clinical)?
Management and Archive Issues?

- Are imaging exams routed to required targets (EMR, research, Rad-Onc) in a timely manner?
- Is archive depth sufficient for needs given exam growth and modality changes?
- Are images used for non-clinical purposes properly de-identified?
- Are mission critical systems fault tolerant?
- Are vendors compliant with industry standards (DICOM, IHE)?
Workflow Reengineering

• How is QA performed to assure consistent image appearance everywhere?
• Are checks in place to assure all orders are ultimately processed, QA’ed and Reported with accurate demographics?
• How is post-exam 3D processing coordinated with normal exam workflow?
Post-Processing Workflow

Primary Send → 3D Workstation → Post 3D, secondary send

Scanner Console → Primary Send → PACS/Archive

Reporting Workflow

Radiologist → Clinician

Clinician → Clinician

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Uptime Issues

• Perfect World
  – Physicists solves Workflow and Image Quality then pursues other interests

• Reality
  – Systems break
  – Downtime procedures in a filmless world are more complex and require highly adaptable/targeted downtime plans
  – Physicist to the rescue!
Uptime Issues

PACS Lottery (99% System Up = 3.6 days/year of outage/degraded performance)

\[ .99^7 = 93.2\% \text{ System uptime} \quad .995^7 = 96.5\% \text{ System up} \quad .999^7 = 99.3\% \]
Break-fix & Dashboard

• Downtime Plans
  – have to respond to what is down
  – but, they may not be obvious

• Need a System Dashboard
  – Collects all logs/conditions from critical components in one place for Display and Monitoring

• Downtime plans
  – respond to what is broken
Dashboard

DICOM Rcv Performance

DICOM Sender Performance
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Case Study 1: Archive

• Challenge: the vendor’s workflow design had modalities going into Archive first
  – Then the PACS would retrieve the exams
  – The exam would be QA’ed and Reported
  – Finalized exam would go back to the archive
Case Study 1: Archive

- Why would the vendor design such a serpentine path?
  - Because, their licensing model was based on number of DICOM inputs

- Resolution
  - Physicist redesigned data flow through PACS with one input to Archive
  - Saved $4M
  - Vendor rethought licensing model
Case Study 2: Clinical Viewer

• Challenge: Clinicians require Clinical Viewers have same 3 Mpixel Dx Gray-Scale displays as PACS workstations

• Response: Designed ROC experiment
  – compared Sensitivity/Specificity of Clinicians across 4 displays under exam room conditions
  – Differences statistically insignificant for 3 displays, but the Sens. scores were higher on non-3 Mpixel display in contrast to self-reported assessment
Case Study 2: Clinical Viewer

• Resolution
  – Institution decided on business class displays
  – Savings: > $10K per seat (500 seats and counting)
Summary

• Suggested roles for physicist
  – leadership role in selection of modalities
  – leadership role in architecting data and workflow
  – lead designer of QA program, exam fidelity across all display systems
  – Large participant in design of Imaging Informatics Systems for performance, fault tolerance and other user/IT concerns
  – Chief negotiator/tormentor of vendors
References

