Training and Clinical Best Practices
for Using CAD Systems

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Learning Objectives

- Understand benefits of PACS integration of CAD.
- Identify potential issues with off-label use of CAD.
- Understand the importance of user training relating to CAD devices.
- Learn about areas of CAD user training and QA that could benefit from further research.

What is the Problem We are Trying to Address?

- Improvement in radiologist performance with CAD is poor, even when the CAD performs well in the lab.
- Examples from the recent literature:
  - Fenton et al.
  - Dachman et al.
The Problem

• 684,956 women who received more than 1.6 million film-screen mammograms
• “CAD use ... is associated with decreased specificity but not with improvement in the detection rate ... of invasive breast cancer”
• CAD led to increased detection of DCIS
• Were radiologists using CAD as a crutch & not reviewing the mammograms as diligently?

Fenton et al., JNCI 2011

The Problem

• 100 CTC cases, 19 radiologist readers
• CAD sensitivity in the lab: 91.8%
• Sensitivity of the radiologists without and with CAD: 46.6%, 52.1%

Dachman et al., Radiology 2010

Overview

• To achieve the highest possible benefit from CAD systems, best practices are required for clinical implementation and use of CAD

• Summary of opinions of the AAPM CAD Subcommittee
CAD best practices – Important issues

• Importance of training in the use of CAD devices
• Pitfalls of off-label use
• Research opportunities

Rationale for CAD

• Reduce interobserver variability
  - Level the playing field
  - Less trained can perform closer to experts
• Reduce perceptual error
  - Find abnormalities missed by radiologists
  - Improve reproducibility

User training - Topics

• Importance of understanding the effect of improper use of CAD on sensitivity and specificity
• Frequency and type of training
• Training the vendors: Feedback on CAD performance
• Storing CAD marks long term for training/auditing purposes
CAD best practices – User training

• Training is important for reading images without CAD:
  - Residencies, fellowships, special certifications
• Inexperienced readers benefit more from CAD
• Training for reading images with CAD
  - Little published research
• Educate the physicians on the intended use of the CAD

CAD User training – It Helps!

• Mammography CAD in the United Kingdom National Breast Screening Program
  - FJ Gilbert et al., Radiology 2006
  - CADET II Trial, FJ Gilbert et al., NEJM 2008

CAD User training

• 2 month training of radiologists
  - Initial training by vendor
  - Practice using 6 sets of 75-100 cases
  - Truth provided after each set to improve performance
  - Cancer prevalence progressively reduced from 25% to 5%
• Results
  - Single reader with CAD had comparable sensitivity to double reading without CAD
CAD User training – Other Results

- Short-term feedback may not help
  - Lung nodules on CXR with CAD, De Boo et al., Eur Radiol 2012
- Focused training with CAD may reduce training requirements
  - Polyps on CTC, Taylor et al., Br J Radiol 2008

Training Occurs During CAD Use

- Learning curve for radiologist use of CAD changes over the course of a year
- Breast radiologists initially doubled their recall rate when using CAD (6.2% to 13.4%), but over a year, the recall rate decreased to near the level before CAD implementation (6.75%)
  - Dean and Ilvento AJR 2006

User training – Important Questions

- How can we encourage radiologists to spend time getting trained?
- Does the absence of training impair CAD performance in the clinic?
- Is there an association between radiologist performance and attitudes towards CAD before and after training?
User training – What?
• Sensitivity and average false positives per image
• Characteristics of false negatives and false positives (knowledge of latter benefits efficiency)

User training – What?
• Unique strengths and weaknesses of a particular CAD (target lesions; susceptibility to artifacts)
• Meaning of the various CAD marks
• Absence of CAD mark should not discourage recall
• Learning curve for use of CAD in actual clinical use

User training – When?
• At initial installation
• Annually or via CME
• At time of CAD updates or modifications
• During residency (currently implemented for breast imaging rotations under ACR guidelines)
User training – How?

- Web-based
- One-on-one
- Case-based

User training – Implementation

- Case-based examples of changes in CAD behavior after updates or modifications
- Technologist training, especially if radiation dose or patient positioning affect CAD

Training the CAD Vendor

- Continuous feedback about missed lesions, false positives
- Recording callbacks that have no CAD marks, CAD marks that cause additional callbacks, recalling CAD marks on prior exams when current exam is being read
Storing CAD Marks

• Controversial
• Medicolegal aspects have been emphasized, patient benefits have not
• CAD has been used in the courtroom and has helped defendant radiologists
  • Brenner et al., AJR 2006

Storing CAD Marks - Benefits

• Facilitate automatic monitoring of the stability of the CAD system performance over time
• Help the radiologist learn the characteristics of dismissed CAD marks on prior exams that turn out to be true lesions in current exams
• Enable CAD system to use previous readings to improve its current performance
• Enables CAD prospective performance evaluation in large populations

Storing CAD Marks - Implementation

• Some CAD operates on raw data or processed images not shown to the radiologist
• Example: ultrathin CT images for CTC
• Such raw data would also need to be stored along with CAD marks
• Record CAD metadata in DICOM header or using Annotation Imaging Markup (AIM)
Off-label Use

• Use of device in a manner that is not specifically stated in the FDA-approved indications for use
• Physicians may use any FDA-approved product off-label according to their professional judgment concerning the needs of their patients
• Potential problem: CAD used off-label to improve productivity rather than sensitivity
• Second reader > Concurrent reader > First reader

Off-label Use

• CAD should be used on ALL cases, not just selected ones, since radiologist cannot know in advance which cases will be false negatives without CAD

Colon Cancer in Americans

• 2nd leading cause of cancer death
• 131,000 diagnosed annually
• 55,000 annual mortality
• 6% will develop colon cancer during their lifetime (40% die)
1.4 cm polyp in transverse colon found by CAD

Reading Paradigm

- First read
- Concurrent read
- Second read

First Read

- Radiologist reviews only CAD results, not entire colon
- Fast interpretation time
- High specificity
- Lower sensitivity
- Presently unlikely to be used clinically
- Sometimes used for mammography CAD (microcalcifications)
**Concurrent Read**
- CAD marks visible during radiologist’s primary image interpretation
- Radiologist evaluates CAD marks as they appear in the image

**Concurrent Read**
- Reduced interpretation time
- CAD marks may distract radiologist from other findings in vicinity (“satisfaction of search” error)

**2nd Reader**
- Radiologist reviews images and arrives at preliminary diagnosis
- Then evaluates CAD marks, revises preliminary diagnosis to arrive at final diagnosis
- Used for mammography CAD (masses)
2nd Reader

- Highest sensitivity (↑ 9 - 25%) 
- Lowest specificity (↓ 2 - 14%) 
- Longest interpretation times (↑ 2 - 4 min.)

CAD as 2nd Reader

7 mm TA in rectum found by 3 readers with CAD

N. Petrick et al., Radiology 2008

Discouraging Off-label Use

- Hard to see how off-label use of CAD benefits patients rather than physicians
- Record or track reading behavior
- Record radiologist’s findings prior to displaying CAD output (auditing; RIS integration of CAD)
- Control the workflow by modifying the display protocols (requires PACS integration of CAD)
PACS Integration of CAD

- Improves usability
- Increases reader sensitivity with minimal impact on interpretation time
  - Lung nodule study, Bogoni et al J Digital Imaging 2012
- Integration hampered by deficiencies in IHE
  - Welter et al Comput Methods Programs Biomed. 2011
  - Le et al. IJCARS 2009

Standardization

- File formats and reported data elements
- APIs for PACS/RIS integration of CAD
- Quality control
- Reporting
- Limited to encourage buy-in from vendor community

CAD best practices – Research opportunities

- Assessment of radiologist performance and training methods
- Monitoring CAD performance changes and effectiveness over time using large electronic health records
- Funding opportunities
Research opportunities - Training

• Number of cases
• Generalizability: local or global cases
• Re-training requirements
• Overcalls, recall rates, FNs, FPs, efficiency, subtle lesions, pitfalls, radiation exposure
• Patient preparation and acquisition-specific issues
• Reading paradigms
• Content-based image retrieval

Research opportunities

• Effect of CAD marks (shape, type) on performance
• Human perception research
• Estimating the likelihood of malignancy of a lesion
• Automated lesion size measurement and segmentation

Distributed human intelligence for observer performance assessments

Sensitivity

ROC curve - All Detections

Static
Video
Radiologist Static
Radiologist Video

Summers et al. MIPS Conference 2011; McKenna et al., MedIA 2012
Future Directions

• CAD keeps improving
• Reimbursements on downward trend
• Physician extenders will increasingly provide care
• First-read paradigm will ultimately prevail
• Satisfaction of search errors (i.e., the Fenton paper) could become more prevalent

Conclusions

• Use of best practices optimizes benefit of CAD
• Areas of improvement to be had in training users, discouraging off-label use
• Consensus from members of the CAD community
• Has to be done in a way that is not punitive …
• … but that keeps a sharp focus on benefiting the patient

To Learn More …

www.cc.nih.gov/drd/summers.html

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