Radiology Reports of the Future are Here Now

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The NIH Clinical Center PACS shown here
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Overview

- Consistent quantification is paramount in oncologic reporting
  - Should be sufficient to determine therapeutic response
- We developed tools and workflows to accomplish this
  - Multimedia reporting, digital data exporting
  - Additional goal of eliminating handwriting; manage digitally
- Share successful experience applying these tools and workflows
  - Some generalizable to benefit those awaiting advanced tools
- Introduce other medical specialties using multimedia reporting
Improved Reporting: Technology and Workflow

• Within PACS tumor data management (eliminate handwriting)
  – Carestream Health v 12.0 (Rochester, NY)
  – We have scripted open-source interface* manage exported data
  – Although vendor dependent, workflow/ script may be generalizable

• Workflow: Radiologists measure previously linked annotations
  – Reports more concordant with Radiologist Assistant (RA) help
  – RA verifies baseline date and target lesions, measures, relates

• Ideal: radiology report includes RECIST calculations same day

Experience with Multimedia Radiology Reporting

- We have been using now for over two years (started Feb 2015)
- More efficient process, fewer errors, duplicate efforts
- Radiologist assistants measure/ close communication gaps
  - They can solve tedious measurement discrepancies
    - Fewer radiologist interruptions for measurements (hours saved daily)
- Result: more informative, interactive radiology reports
- Can allow for oncologists to have same day tumor response
- Tumor data on all patients in trial batch exported for analysis
NIH Clinical Center Oncologist, Radiologist Survey*

• We aimed to improve prior tumor assessment “process”
  – Surveyed radiologists and oncologists preferences on reporting
  – Prior schema was disjoint, inconsistent, tedious, inefficient

• We found oncologists often measure lesions independently
  – Or search for measurements buried in our prior text only reports
  – It was tedious trying to match target lesions on images in PACS

• Survey verified oncologists and radiologists prefer hyperlinks
  – The report hyperlinks take clinicians to annotated measurements

Are Radiologists Reports Adequate for Oncology Assessment?

*Folio LR. Quantitative Radiology Reporting in Oncology: Survey of Oncologists and Radiologists. AJR. 2015*
Radiologists’ Satisfaction with Current Clinical History

Question: Current clinical history on imaging requests is satisfactory for radiologists to provide tumor assessments.
Question: How would you prefer tumor measurements presentation in radiology reports?
FINDINGS:

Chest CT:
Lungs, pleurae: Unchanged lung nodules for example right upper lobe (0.8 cm x 0.4 cm) (series 4, image 84)
Mediastinum, heart, great vessels: Unchanged mediastinal adenopathy for example subcarinal (2.5 cm x 1.4 cm) (series 2, image 27) and right hilar adenopathy for example (5.1 cm x 2.4 cm) (series 2, image 32) and (2.1 cm x 1.4 cm) (series 2, image 25)

Abdomen CT:
Lymph nodes, abdominopelvic vascular: unremarkable
Liver, spleen, biliary, gallbladder, pancreas: unremarkable
GU Kidneys, ureters, adrenal glands: unremarkable
GI Small and large bowel, mesentery, peritoneum: unremarkable
Pelvic CT: Central pelvis, sidewalls: Unchanged anterior pelvic wall mass.
Osseous structures, spine, body wall, soft tissues: unremarkable

IMPRESSION:
1. Unchanged lung nodules
2. Stable mediastinal and hilar adenopathy/masses
3. Unchanged anterior pelvic wall masses
4. No evidence of new soft tissue mass
RECIST 1.1

<table>
<thead>
<tr>
<th>Evaluation of target lesions</th>
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<tbody>
<tr>
<td>Complete Response (CR)</td>
<td>Disappearance of target lesions (LN&lt;1cm)</td>
</tr>
<tr>
<td>Partial Response (PR)</td>
<td>≥30% decrease from baseline sum of target lesions size</td>
</tr>
<tr>
<td>Progressive Disease (PD)</td>
<td>≥20% increase from baseline or best response + absolute increase ≥ 5mm on target or Non target lesions / New lesions</td>
</tr>
<tr>
<td>Stable Disease (SD)</td>
<td>Neither CR or PD</td>
</tr>
</tbody>
</table>

Radiology Report Impression: “Stable metastatic lesions”

Patients can get conflicting messages in Patient Portal

This number is what “counts”
FINDINGS:

Chest CT:
Lungs, pleurae: Unchanged lung nodules for example right upper lobe (1.9 cm x 1.5 cm) (series 4, image 81)

Minimizes crosscheck

Metadata automatically included
x,y,z location, who measured, when, relation and designation, name, lesion type
Body CT Hyperlink Usage

PACS upgrade

Feb 14% 44% 62% 69% 88%
Mar 5% 44% 62% 69% 88%
Apr 69% 88%
May 2015
Jun 2016
April

Feb
Mar
Apr
May
Jun
April 2015
April 2016

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Improved Target Lesion Concordance

- Multimedia radiology reports are more concordant (78%) with oncologist records over text only reports (52%)
  - Of note, oncologist records are used to determine therapeutic response (all that matters)

* Machado L, Folio L. Multimedia Radiology Radiology Reports with Hyperlinks Improve Target Lesion Selection and Measurement Concordance in Cancer Trials. AJR.
Improved Efficiency

It was about 3 times faster for our radiologist assistant to extract measurements from multimedia reports than traditional text only reports.

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P = 0.032, \text{ } N = 295
\]
Integrated Radiologist, Radiologist Assistant Oncology Dictation Workflow

- On baseline; radiologists select index lesions (later verified)
- Radiologists agreement to measure previously measured lesions
- Occasionally keep report preliminary while awaiting measurements
  - From radiologist assistant, radiologist or oncologist
- Saves radiologist time while preventing measuring of unspecified lesions
- In background: CIPS radiologist, RA and technologist
  - Meet with oncologists to agree on baseline target lesions
  - Also agree on criteria to use and measurement styles
  - Helps close communication gaps
  - Save key images and/ or presentation state

Tirkes T. Response criteria in oncologic imaging: review of traditional and new criteria. Radiographics. Sep 2013
Outdated and Revised workflows

Outdated workflow:
- Radiologists measure “random” index lesions
- Oncologists select target lesions independently
- Oncologists consult radiologists to verify/measure targets
- Oncology staff type measurement data into EMR
- Oncology staff handwrite measurement data on RECIST worksheets
- Data managers retype data into Research Clinical Database

Revised workflow:
- Oncologists & Radiologists agree on targets selected at baseline exam
- Radiologist assistant verify/relate targets on follow-up exams for graphing and exportation
- Oncology staff export and upload Measurement Data to database using ENABLE
Data Management Optimization

• AJR Survey* showed tumor measurement data was handwritten
  – Increasing potential of transcription errors, duplicated efforts
• Most oncologists surveyed (93%) would prefer to manage measurements and calculations within PACS at the SSOT
• We created the ability to export to RECIST forms and databases**
  – SSOT: Single Source Of Truth (PACS)
    • Original measurement carried through workflow
  – It is where the radiologist (or radiologist assistant) measures

* Folio LR. Quantitative Radiology Reporting in Oncology: Survey of Oncologists and Radiologists. AJR. 2015
Limitations

- Technology and/or workflows may not be generalizable
  - Not all centers have advanced systems or available staff
  - However, there may technical and workflow options
- Annotations on images can be distracting
  - For radiologists or ordering providers, can be toggled off however
- Our radiologists reports do not replace tumor assessments
  - But near 100% concordance helps everyone involved
- Vendor dependent technologies, compatibility issues
  - Awaiting AIM* and other annotation sharing standards (DICOM4IQ**)?
- Data management interface requires programing to modify

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* Mongkolwat P. NCIP AIM Model J Digit Imaging. 2014
** Fedorov A, Rubin D, et al. Interoperable Communication of Quantitative Image Analysis Results Using the DICOM Standard. RSNA 2016
Tumor and other Quantification, Workflow, Multimedia Digital Systems

- Agfa Healthcare (Mortsel, Belgium)
- Carestream Health VuePACS v 12.0 with LMA
- Cerner Clinical Imaging (Kansas City, MO)
- Click*View 7i Analytics
- ePAD (Stanford University)
- Median Technologies (Woburn MA)
- Mint Lesion™ (Mint Medical: Dossenheim, Germany)
- Medstreaming (Redmon, WA) ‘All in one’ vascular information system
- Multi-Modality Tracking Tool (MMTT) application (Phillips Healthcare, IntelliSpace Portal, Koninklijke Philips Electronics N.V.)
- Orpheus Medical (New York, NY)
- OneDx (Westport, CT)
- Precision Imaging Metrics; MGH (Dana Farber)
- Lexmark Healthcare’s solutions (Lexington, KY)
- SCC's Genetics Information Systems Suite® (Clearwater, FL)
- Sectra Medical Systems (Sweden)
- Siemens Syngo.via for Oncology
- Eclipse™ Treatment Planning System. Varian

Some now with Hyperlink Ability
UVA multimedia report referred to NIH CC on a cancer patient
Summary

• Consider our radiology end product in oncologic reporting
  – Sufficient quantification to determine therapeutic response
• We therefore aim to produce consistent quantitative reports
  – We co-developed tools to accomplish this; but also workflows
    • Multimedia reporting, digital data exporting (aim: no handwriting)
• Shared successful experience applying these tools and workflows
  – Hopefully generalizable to benefit those without needed tools
• Introduced other medical specialties using multimedia reporting