Reporting Workflow in Radiology using DICOM SR integration

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Begin with the End in Mind

• Effective Communication
  – efficiency
  – uniform representation of observations
  – enhance understanding with other HCPs
  – content & feature extraction
  – “databaseable reporting”
Structured Reporting at all...

From the literature:

– „The ARRS (American Roentgen Ray Society) should recommend a standardized nomenclature to be used in writing roentgenological reports.“

– „...suggest to check 100 reports for those who are seeking membership in ARRS.‘‘

– Dr. Hickey, AJR, 1922
Structured Reporting at all...

Radiology

a monthly journal devoted to clinical radiology and allied sciences
PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA, INC.

The Coding of Roentgen Images for Computer Analysis as Applied to Lung Cancer

GWILYM S. LODWICK, M.D., THEODORE E. KEATS, M.D., and JOHN P. DORST, M.D.
Structured Reporting and Radiologists
Strength

- Predefined structure of relevant topics
- Direct link with imaging and measurements (DICOM SR)
- Comprehensive presentation
- Useful for follow-up studies
- Improved integration into eHealth-Solutions
Opportunities

• Could be linked with database systems
• Support of classification (TNM, other scores)
• Findings could trigger recommendations (Decision support)
• Quality improvement, e.g. follow-up on recommendations
• Audit improvement, e.g. double-reading for residents
• Multilanguage-Support
• Research
Weaknesses

- Adoption by most RIS / HIS vendors
- Sometime focused on *sophisticated* solutions for subsets
- General accepted terminology
Threats

- Limited interest by Radiology Community
- Implementations not supportive for workflow
Presentation of Reports

• For more than 100y, reports almost prose text
• Sometimes very „diplomatic“ (vague)
  – „cannot rule out“, „minimal“, „may represent“, „questionable“...
• SR could enable easier & better reception of facts / conclusions
Structured Reports: Value

Improving Communication of Diagnostic Radiology Findings through Structured Reporting

Purpose: To compare the content, clarity, and clinical usefulness of conventional (i.e., free-form) and structured radiology reports of body computed tomographic (CT) scans, as evaluated by referring physicians, consulting radiologists, and radiology fellows at a tertiary care cancer center.

Materials and Methods: The institutional review board approved the study as a quality improvement initiative, as written consent was required. Three radiologists, three radiation oncologists, and two medical oncologists evaluated 200 randomly selected conventional and structured radiology reports of body CT scans. For radiologists, reports were randomly selected from patients with diagnoses relevant to the physician’s area of specialization. Each physician read 15 reports in each format and rated both the content and clarity of each report from 1 (very dissatisfied or very confusing) to 5 (very satisfied or very clear). By using a previously published radiology report grading scale, physicians graded each report’s effectiveness in advancing the patient’s position on the clinical spectrum. Mean-effectiveness models were used to test differences between report types.

Results: Mean content satisfaction ratings were 7.61 (95% confidence interval [CI]: 7.16, 8.07) for conventional reports and 8.23 (95% CI: 7.82, 8.64) for structured reports, and the difference was significant (P < .0001). Mean clarity satisfaction ratings were 7.45 (95% CI: 7.04, 7.85) for conventional reports and 8.02 (95% CI: 7.71, 8.33) for structured reports, and the difference was significant (P < .0001). Grade ratings did not differ significantly between conventional and structured reports.

Conclusion: Referring clinicians and radiologists found that structured reports had better content and greater clarity than conventional reports.

The Radiology Report as Seen by Radiologists and Referring Clinicians: Results of the COVER and ROVER Surveys

Purpose: To investigate and compare the opinions and expectations regarding the radiology report of radiologists and referring clinicians and to identify trends, discrepancies, and discrepancies.

Materials and Methods: A total of 2000 clinicians and 250 radiologists were invited to participate in two internet surveys, COVER (for clinical specialists and general practitioners) and ROVER (for radiologists). Respondents were asked to state their level of agreement with 48 statements according to a Likert scale. Unbiassed results were compared by using the χ² statistic.

Results: Eight hundred seventy-three completed forms were prepared for analysis, corresponding to a response rate of 28%. Most clinicians declared themselves satisfied with the radiology report. A large majority considered it an indispensable tool and accepted that the radiologist is the best person to interpret the images. Nearly all agreed that they need to provide adequate clinical information and more clearly what clinical question they want to have answered. Formalized reporting was preferred for complex examinations by both the clinicians and the radiologists. A minority in both groups were concerned that learning in report needs to be taught in a structured way.

Conclusion: The surveys emphasize the role of the radiologist as a well-informed medical imaging specialist; however, some of the preferences of radiologists and clinicians diverge. Fundamentally from the way radiology is practiced and taught today, and implementing these preferences may have far-reaching consequences.
Impact on Reporting and Decision Making

Structured Reporting of Multiphasic CT for Pancreatic Cancer: Potential Effect on Staging and Surgical Planning

- 48 SRs vs 72 non-SRs
- 12 key features for surgical planning
- 7.3+/-2.1 key features in non-SR vs 10.6+/-0.9 in SR
- Significant difference for planning (84 vs 44%)
• Measurements of lesions could be fed into templates
• Linked with imaging location (using DICOM SR)
• Identification of corresponding lesions in follow-up study
  – Reduction of reading time by about 50% (René et al. ECR 2014)
Planning for electronic reporting

• What are your goals?
  – Better capture of sonographer measurements into report
  – Add key images into reports
  – Ability to do research / data mining

• What kinds of reports do you need?
  – Text only
  – Text + image references
  – Structured text
  – Structured text + coded content
  – Multimedia
Impact on Reporting Workflow

• Full integration with existing reporting IT-solution important

• SR² : Structured Reporting & Speech Recognition

• Scores

• Recommendations

• Audits and Patient-Recalls could initiated by triggers
This is Process Re-engineering!

• Transition to electronic reports is hard
  – New systems
  – New architectures
  – New policies and procedures
  – Organizationally disjunct costs/benefits

• Minimize the risk and the effort
  – A standards-based approach
  – Incremental evolution from current workflow
  – Leverage the work of IHE (Integrating the Healthcare Enterprise)
Figure. Diagram illustrates how information technology initiatives in radiology can add service value (italicized concepts) and content or knowledge value (underlined concepts) to the process of care. Integration into the information system infrastructure of the enterprise will be a prerequisite for success in most if not all cases.

RadioGraphics,
http://pubs.rsna.org/doi/abs/10.1148/radiographics.21.4.g01j1371015

Published in: Ramin Khorasani; RadioGraphics 2001, 21, 1015-1018.
DOI: 10.1148/radiographics.21.4.g01j1371015
Admitting Diagnosis: NEUTROPENIC FEVER; HYPERBILIRUBEMIA

Clinical data:
Biliary tube check.

Carl M. Gompers, MD

Change Perc Biliary Drainage Cath Proced -- Exam #46 on 01/08/96

COMPARISON: 07/23/95 and 06/27/95

FINDINGS: After the procedure was explained to the patient and informed

Int -- Exam #47 on 02/05/96

FINDINGS: As above.

IMPRESSION: Successful biliary tube change, and findings consistent with interval tumor growth.

Simon A. Templar, MD  / Richard Nixon, MD  (R19)

Signed 02/9/96 at 8:48 AM
DICOM and Reporting

• Then
  – Supplement 23 Structured Reporting began in 1995
  – established place in the encoding of image analysis results, or “evidence documents”, it has seen only limited use for clinical reports

• Now
  – reporting based on CDA, an XML document format specified by HL7
SUPP 155: Introduction

• Nature of radiology reporting is evolving from purely text based reports to incorporate more discrete data elements

• New mechanism for specifying templates for imaging reports, as well as a set of specific templates for radiology diagnostic and screening reports
DICOM Supp 155: Imaging Reports using HL7 Clinical Document Architecture
DICOM is a Standards Development Organization whose domain is biomedical imaging.
DICOM Structured Reporting

- The scope of DICOM SR is the *standardization of documents in the imaging environment*

- SR documents record observations made for an imaging-based diagnostic or interventional procedure, particularly those that describe or reference images, waveforms, or specific regions of interest
DICOM SR Use

• DICOM SR is used in key subspecialty areas that produce structured data in the course of image acquisition or post-processing, where:
  – Leveraging the DICOM infrastructure is easy and desirable
  – Results should be managed with other study evidence

• Examples
  – Sonographer measurements
  – Computer-aided detection results
  – QC notes about images
  – Radiation dose reports
  – Image exchange manifests
Key Aspects of DICOM SR

• SR documents are encoded using DICOM standard data elements and leverage DICOM network services (storage, query/retrieve)

• SR uses DICOM Patient/Study/Series information model (header), plus hierarchical tree of “Content Items”

• Extensive mandatory use of coded content
  – Allows use of vocabulary/codes from non-DICOM sources

• Templates define content constraints for specific types of documents / reports
SR Content Item Tree

Arrows are parent-child relationships
- Contains, Has properties, Inferred from, etc.
Content Items are units of meaning
- Text, Numeric, Code, Image, Spatial coordinates, etc.
DICOM SR Object Classes

- **Enhanced** and **Comprehensive** - Text, coded content, numeric measurements, spatial and temporal ROI references
  - Templates for ultrasound, cardiac imaging
- **CAD** - Automated analysis results (mammo, chest, colon)
- **Key Object Selection (KO)** - Flags one or more images
  - Purpose (for referring physician, for surgery ...) and textual note
  - Used for key image notes and image manifests (in IHE profiles)
- **Procedure Log** - For extended duration procedures (e.g., cath)
- **Radiation Dose Report** - Projection X-ray; CT
HL7 is a Standards Development Organization whose domain is clinical and administrative data.
Clinical Document Characteristics

• Persistence
  – Documents exist over time and can be used in many contexts

• Stewardship
  – Documents must be managed, shared by the steward

• Potential for authentication
  – Intended use as medico-legal documentation

• Wholeness
  – Document includes its relevant context

• Human readability
  – Essential for human authentication
CDA Use Cases

• Diagnostic and therapeutic procedure reports
• Encounter / discharge summaries
• Patient history & physical
• Referrals
• Claims attachments

• Consistent format for all clinical documents
Key Aspects of the CDA

• CDA documents are encoded in Extensible Markup Language (XML)

• CDA documents derive their meaning from the HL7 v3 Reference Information Model (RIM) and use HL7 v3 Data Types

• A CDA document consists of a header and a body
  – Header is consistent across all clinical documents - identifies and classifies the document, provides information on patient, provider, encounter, and authentication
  – Body contains narrative text / multimedia content (level 1), optionally augmented by coded equivalents (levels 2 & 3)
CDA Structured Body

Arrows are Act Relationships
- Has component, Derived from, etc.
Entries are coded clinical statements
- Observation, Procedure, Substance administration, etc.
Principle of *Human Readability*: Narrative and Coded Information

*• CDA structured body *requires* human-readable “Narrative Block”, all that is needed to reproduce the legally attested clinical content*

*• CDA allows *optional* machine-readable coded “Entries”, which drive automated processes*

*• By starting with a base of text, CDA allows incremental improvement to amount of coded data without breaking the model*
CDA Structures defined by Templates in Supplement 155

• The header contains structured data that allows management and exchange of clinical documents by generic document handling systems and interfaces, e.g., as specified in the IHE Cross-Enterprise Document Sharing (XDS) Profile

• RSNA RadReport initiative has specified five canonical top level narrative sections, which are supported by specific templates: Procedure Description, Clinical Information, Comparison Study, Findings, and Impression
Diagnostic Imaging Report Implementation Guide

- Header
- Structured Body
  - Section DICOM Object Catalog
  - Section Reason for Study
  - Section Patient History
  - Section Procedure Description
  - Section Comparison Study
  - Section Findings
  - Section Impressions
  - Section Recommendations
  - Section Key Images
- Entries (Annotated) Image References

References to DICOM objects in hierarchical context using native DICOM or WADO access
“Evidence” and “Reports”

• Evidence Documents
  – Includes measurements, procedure logs, CAD results, etc., created in the imaging context, and together with images are interpreted by a radiologist to produce a report
  – The radiologist may quote or copy parts of Evidence Documents into the report, but doing so is part of the interpretation process at his discretion
  – Appropriate to be stored in PACS as DICOM SR objects, with same (legal/distribution) status as images

• Reports
  – Become part of the patient’s medical record, with potentially wide distribution
  – Good match to HL7 CDA
CDA and Implementation Guides

• Industry consensus standard for the formatting of clinical reports across all medical disciplines
• Native (unencapsulated) and encapsulated CDA documents may be managed on DICOM exchange media
• Generic CDA format is typically constrained for specific document types by implementation guides in support of specific use cases
CDA and Implementation Guides

• Multiple layers of constraint and implementation guidance that go into a CDA imaging report
• Supplement 155 defines several report document structures that further constrain CDA
• Professional societies or healthcare providers may define even more detailed constraints and guidance for use in reporting on specific sub-specialty procedures
<table>
<thead>
<tr>
<th>Report Section</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative information</td>
<td>Imaging facility</td>
</tr>
<tr>
<td></td>
<td>Referring provider</td>
</tr>
<tr>
<td></td>
<td>Date of service</td>
</tr>
<tr>
<td></td>
<td>Time of service</td>
</tr>
<tr>
<td>Patient identification</td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Identifier (e.g., medical record number or Social Security number)</td>
</tr>
<tr>
<td></td>
<td>Date of birth</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
</tr>
<tr>
<td>Clinical history</td>
<td>Medical history</td>
</tr>
<tr>
<td></td>
<td>Risk factors</td>
</tr>
<tr>
<td></td>
<td>Allergies, if relevant</td>
</tr>
<tr>
<td></td>
<td>Reason for examination, including medical necessity</td>
</tr>
<tr>
<td>Imaging technique</td>
<td>Time of image acquisition</td>
</tr>
<tr>
<td></td>
<td>Imaging device</td>
</tr>
<tr>
<td></td>
<td>Image acquisition parameters, such as device settings, patient positioning, interventions (e.g., Valsalva maneuver)</td>
</tr>
<tr>
<td></td>
<td>Contrast materials and other medications administered (including name, dose, route, and time of administration)</td>
</tr>
<tr>
<td></td>
<td>Radiation dose</td>
</tr>
<tr>
<td>Comparison</td>
<td>Date and type of previous examinations reviewed, if applicable</td>
</tr>
<tr>
<td>Observations</td>
<td>Narrative description or itemization of findings, including measurements, image annotations, and identification of key images</td>
</tr>
<tr>
<td>Summary or impression</td>
<td>Key observations, inferences, and conclusions, including any recommendations</td>
</tr>
<tr>
<td>Signature</td>
<td>The date and time of electronic signature for each responsible provider, including attestation statement for physicians supervising trainees, if applicable</td>
</tr>
</tbody>
</table>

Templates

• Constraints specified in implementation guides
• Describe patterns that specify the structure and content of a document
  – Structure ➔ relationships among portions of the document
  – Content ➔ concepts and vocabularies used for a particular application
• mandatory or optional
Template: Purposes

- improve interoperability by limiting the variability of unconstrained (idiosyncratic or arbitrary) structures and content
- allows a professional society or healthcare provider to normalize best practice for reports with content appropriate for their use cases, including foreseeable secondary uses such as research or quality improvement
- may be used operationally in the creation of reports
  - an application may use the template to guide authoring of the report, ensuring the entry or composition of essential reporting elements, and structuring that data into the target encoded format
- provide a conformance validation for instances of reports against the purposes (use case) of the template
Medical Terminologies

- ACR Index
  - Anatomic Taxonomy + Pathologic Taxonomy
  - Several thousand codes

- SNOMED (Systematized Nomenclature of Medicine)
  - As SNOP 1974 by CAP published, als SNOMED 1982
  - International Healthcare Terminology Standards Development Organization (IHTSDO)
    - Constitution of 14 countries (US, CA, AU, NZ, SG, UK, DK, NL, SE, LT, EE, CY, SK, ES)
    - 350,000 terms

- RadLex by RSNA
Library of Templates

- RSNA Reporting Initiative started about 2009
- IHE MRRT Template July 2014 published
- ESR has joined this effort through eHealth SC (O Ratib et al.)
Imaging Report Templates for CDA

• Supplement 155 defines the CDA format structures and technical constraints

• High level structures that can belie the details of implementation

• Facilitate report authoring templates
Schematics and Blue Prints

- IHE MRRT profile
- RSNA Reporting Initiative – radreport.org
- Literature – and many more...
RSNA RadReport and IHE MRRT

• RadReport is focused on developing best practice clinical content templates for authoring radiology reports

• Management of Radiology Report Templates (MRRT) Profile specifies an XML-based encoding for those report authoring templates that can be used by a report authoring application
Figure 33.1-1: MRRT Actor Diagram

- Report Template Creator
  - ↓ RAD-104 Store Imaging Report Template
  - ↓ RAD-105 Query Imaging Report Templates
  - ↓ RAD-103 Retrieve Imaging Report Template

- Report Template Manager
  - ↓ RAD-104 Store Imaging Report Template
  - ↑ RAD-103 Retrieve Imaging Report Template
  - ↑ RAD-105 Query Imaging Report Templates

- Report Creator
Supp 155 Summary

This standard forms the basis for encoding radiology reports as CDA documents, including the following features:

- Standard header allowing management using any CDA-based document management or exchange system, e.g., as used for meaningful use
- Narrative reporting in canonical report sections (Clinical Information, Procedure, Comparison, Findings, Impressions, Addendum)
- Available structures for lists or tabular report content
- Optional discrete data elements for numeric or qualitative observations, including flags for critical/actionable findings
- Computer-processable documentation for communication of actionable findings, for follow-up recommendations, and for radiation dose summary
- Linkage to key images and to complete DICOM study imaging evidence
- Support for subspecialty report content templates, e.g., RSNA RadReport
- Transcoding from DICOM SR imaging report instances
UNIVERSITY OF CHICAGO HOSPITALS
RADIOLOGY CONSULTATION
342 02/05/96
BHIS #: 1234567     INPATIENT                                         201-23-90
Hematology / Oncology                                         CHANDLER, CAROLYN
Mitchell-6NE                                                   49   FEMALE
Admitting Diagnosis:  NEUTROPENIC FEVER; HYPERBILIRUBEMIA

Clinical data:
Biliary

Carl M. Gompers
, MD

Change
Perc Biliary
Drainage
Cath Proced
--  Exam #46 on 01/08/96

COMPARISON: 07/23/95 and 06/27/95
FINDINGS: After the procedure was explained to the patient and informed
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Int
--  Exam #47 on 02/05/96
FINDINGS: As above.

IMPRESSION:
Successful
biliary
tube change, and findings consistent with interval tumor
growth.

Simon A. Templar
, MD  / Richard Nixon, MD  (R19)
Signed 02/9/96 at 8:48 AM

3

Image Viewing Application

Reporting Application

Image selection

Annotation

Dictated report

Verification

Transcribed narrative

Reporting System
Validation Functions

Reporting Integration
Functions

Reporting

DICOM
GSPS object
(annotations)

DICOM
KO object
“For Report”

DICOM Query/Retrieve for all
KO objects matching Accession
Number

DICOM
Encapsulated CDA object

CDA
Report

WADO
Server

Image Archive

WADO
URI references to
Images with GSPSs (JPEG rendering)
Open-Source Tools

- RadLex
- DICOM
  - Supplements 23, 76, 77, 86, 101, 128, 155
- IHE MRRT Library
- Web-based implementation with HTML5
- PHP / MySQL...
Acknowledgements

• Dean Bidgood, M.D.
• Fred Behlen, Ph.D
• Dave Clunie, M.D.
• Kevin O’Donnell
• Harry Solomon
• Peter Mildenberger, M.D.