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DICOM STRUCTURED REPORTS

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Disclosures

- Editor of the DICOM Standard (NEMA Contract)
- Owner of PixelMed Publishing, LLC
- Author of book on DICOM Structured Reporting
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I felt able to concurrently experience my proprioceptive awareness combined with other elements, such as a sense of narrative! Wow!
A Picture Is Worth A Thousand Words: Needs Assessment for Multimedia Radiology Reports in a Large Tertiary Care Medical Center

Lina Nayak, MD, Christopher F. Beaulieu, MD, PhD, Daniel L. Rubin, MD, MS, Jafi A. Lipson, MD

Rationale and Objectives: Radiology reports are the major, and often only, means of communication between radiologists and their referring clinicians. The purposes of this study are to identify referring physicians’ preferences about radiology reports and to quantify their perceived value of multimedia reports (with embedded images) compared with narrative text reports.

Materials and Methods: We contacted 1800 attending physicians from a range of specialties at large tertiary care medical center via e-mail and a hospital newsletter linking to a 24-question electronic survey between July and November 2012. One hundred sixty physicians responded, yielding a response rate of 8.9%. Survey results were analyzed using Statistical Analysis Software (SAS Institute Inc, Cary, NC).

Results: Of the 160 referring physicians respondents, 142 (89%) indicated a general interest in reports with embedded images and completed the remainder of the survey questions. Of 142 respondents, 103 (73%) agreed or strongly agreed that reports with embedded images could improve the quality of interactions with radiologists; 129 respondents (91%) agreed or strongly agreed that having access to significant images enhances understanding of a text-based report; 110 respondents (77%) agreed or strongly agreed that multimedia reports would significantly improve referring physician satisfaction; and 85 respondents (60%) felt strongly or very strongly that multimedia reports would significantly improve patient care and outcomes.

Conclusions: Creating accessible, readable, and automatic multimedia reports should be a high priority to enhance the practice and satisfaction of referring physicians, improve patient care, and emphasize the critical role radiology plays in current medical care.

Key Words: Multimedia reports; radiology reporting; digital images; communication; radiology practice.

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Structured Radiology Reporting: Are We There Yet?¹

Givrn the prominent role that information technology will play in the future of health care delivery, the potential benefits of structured reporting systems now seem more relevant than ever. These systems may lead to rapid cohort design. The same 25 brain magnetic resonance (MR) imaging cases were reviewed in two distinct phases by two separate groups of residents: a control group and an intervention group. The MR imaging cases contained a representative
What is a “Structured Report”?

- **Human perspective (radiologist, cardiologist, pathologist, referring physician …)**
  - Not a massive blob of prose (narrative)
  - Organized
  - Hierarchical
  - Sections and sub-sections
  - Bullet lists
  - Question and answer rather than single sentence

- **Machine perspective**
  - coded section headings
  - coded questions with answers:
    - coded answer
    - text answer
    - numeric answer (with coded units)
  - links to images, regions of interest, coordinates (spatial & temporal)
Machine Readable Reports
AI CHANGES THE GAME
DICOM Structured Reports

- A machine-readable structured report that satisfies humans too
- Added to DICOM circa 2000
- Primary use-cases circa 2018
  - Ultrasound cart output – echocardiography, obstetric measurements
  - Mammography CAD output
  - Radiation Dose from CT and projection X-Ray devices (RDSR)
  - Key Object Selection (KOS)
  - limited use for human-generated narrative reports with section structuring
- Major new use-cases in the quantitative/machine learning era
  - tumor/lesion region of interest encoding
  - quantitative measurements and categorical classification
    - created by humans or machines
    - consumed by humans or machines
DICOM Non-Image Objects

- Current DICOM Images from Modality
- Previous DICOM Images from PACS

Analysis Workstation

Previous DICOM SR etc

DICOM SR

- DICOM Segmentation
- DICOM Registration
- DICOM Real World Value
- DICOM Parametric Map Images

PACS Store, Distribute and Review
DICOM SR organizes them ...
CONTAINER: Imaging Measurement Report [SEPARATE] (DCMR,1500)

HAS CONCEPT MOD: CODE: Language of Content Item and Descendants = English

HAS CONCEPT MOD: CODE: Country of Language = United States

HAS OBS CONTEXT: PNAME: Person Observer Name = accomplished_peafowl

HAS CONCEPT MOD: CODE: Procedure reported = CT Abdomen

CONTAINS: CONTAINER: Image Library [SEPARATE]

CONTAINS: CONTAINER: Image Library Group [SEPARATE]

CONTAINS: IMAGE: = 1.2.840.10008.5.1.4.1.1.2 : 1.3.6.1.4.1.14519.5.2.1.9203.4004.26801842228881857322651602376

HAS ACQ CONTEXT: CODE: Modality = Computed Tomography

HAS ACQ CONTEXT: DATE: Study Date = 19870620

HAS ACQ CONTEXT: TIME: Study Time = 135823

CONTAINS: CONTAINER: Imaging Measurements [SEPARATE]

CONTAINS: CONTAINER: Measurement Group [SEPARATE]

HAS OBS CONTEXT: TEXT: Tracking Identifier = 5b6eb4301d3175942d29985a3d0fbb00

HAS OBS CONTEXT: UIDREF: Tracking Unique Identifier = 1.3.6.1.4.1.5962.1.1.0.0.0.1535644357.22655.1

HAS CONCEPT MOD: CODE: Finding Site = Kidney

CONTAINS: NUM: Length = 66.43856134 mm

INFERRRED FROM: SCOORD: = POLYLINE (172.835357666016,270.084086914062,133.798889160156,343.04531866,270.084086914062,172.835357666016)

SELECTED FROM: IMAGE: = 1.2.840.10008.5.1.4.1.1.2 : 1.3.6.1.4.1.14519.5.2.1.9203.4004.26801842228881857322651602376

Measurement Group Length = 66.43856134 mm
CONTAINER: Imaging Measurement Report [SEPARATE] (DCMR,1500)

HAS CONCEPT MOD: CODE: Language of Content Item and Descendants = English
  HAS CONCEPT MOD: CODE: Country of Language = United States

HAS OBS CONTEXT: PNAME: Person Observer Name = accomplished_peafowl

HAS CONCEPT MOD: CODE: Procedure reported = CT Abdomen

CONTAINS: CONTAINER: Image Library [SEPARATE]
  CONTAINS: CONTAINER: Image Library Group [SEPARATE]
    CONTAINS: IMAGE: = 1.2.840.10008.5.1.4.1.1.2 : 1.3.6.1.4.1.14519.5.2.1.9203.4004.26801842228881857322651601
      HAS ACQ CONTEXT: CODE: Modality = Computed Tomography
      HAS ACQ CONTEXT: DATE: Study Date = 19870620
      HAS ACQ CONTEXT: TIME: Study Time = 135823

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  CONTAINS: CONTAINER: Measurement Group [SEPARATE]
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    HAS CONCEPT MOD: CODE: Finding Site = Kidney

CONTAINS: NUM: Length = 66.43856134 mm

INFERRED FROM: SCOORD: = POLYLINE (172.835357666016,270.064086914062,133.798889160156,343.045162929687,100.047020289062,200.052001953125,250.059033203125,300.059033203125,350.059033203125,400.059033203125)

SELECTED FROM: IMAGE: = 1.2.840.10008.5.1.4.1.1.2 : 1.3.6.1.4.1.14519.5.2.1.9203.4004.26801842228881857322651601
Report") [SEPARATE] (DCMR, 1500) "Language of Content Item and Descendants"") = (eng, RFC5646, "English") 121046, DCM, "Country of Language") = (US, ISO3166_1, "United States") "Person Observer Name") = "accomplished_peafowl" "Procedure reported") = (41806-1, LN, "CT Abdomen") Image Library") [SEPARATE] 6200, DCM, "Image Library Group") [SEPARATE] GE: = (1.2.840.10008.5.1.4.1.1.2, 1.3.6.1.4.1.14519.5.2.1.9203.40 S ACQ CONTEXT: CODE: (121139, DCM, "Modality") = (CT, DCM, "Computed S ACQ CONTEXT: DATE: (111060, DCM, "Study Date") = "19870620" S ACQ CONTEXT: TIME: (111061, DCM, "Study Time") = "135823" S ACQ CONTEXT: "Imaging Measurements") [SEPARATE] 5007, DCM, "Measurement Group") [SEPARATE] XT: TEXT: (112039, DCM, "Tracking Identifier") = "5b6eb4301d317594 XT: UIDREF: (112040, DCM, "Tracking Unique Identifier") = "1.3.6.1.4 OD: CODE: (G-C0E3, SRT, "Finding Site") = (T-71000, SRT, "Kidney") : (G-D7FE, SRT, "Length") = 66.43856134 (mm, UCUM, "mm") REFERRED FROM: SCOORD: = POLYLINE {172.835357666016, 270.0640869140 1.4.1.1: SELECTED FROM: IMAGE: = (1.2.840.10008.5.1.4.1.1.2, 1.3
SR Content is a Tree

Root Node

Child Nodes
Each Node (Content Item)

- Is a “name-value” pair
  - e.g. “finding” = “mass”

- Concept “name” is always coded
  - e.g. (121071, DCM, “Finding”)

- “Value” may be one of several “value types”

- “Value” may be coded too
  - e.g. (M-37000, SRT, “Hemorrhage”)
  - e.g. 37.2 (mm2, UCUM, “square millimeters”)
Value Types

- TEXT
- CODE
- NUM
- PNAME
- DATE
- TIME
- DATETIME
- CONTAINER
- UIDREF
- COMPOSITE
- IMAGE
- WAVEFORM
- SCOORD(3D)
- TCOORD
NUM: Distance = 37.6 mm

SCCORD: Path = POLYLINE
(32,77), (210,93)

INFERRED FROM

SELECTED FROM

IMAGE: 1.2.840.276453....
Individual Impression/Recommendation

CONTAINS

CODE: "Single Image Finding" = "Mammography breast density"

HAS PROPERTIES

SCOORD: "Outline" = POLYLINE
{2531,2114,2537,2114,..,2525,2114,2531,2114}

SELECTED FROM

IMAGE: 1.2.840.276453....
Spatial Coordinates

- Point
- Multipoint
- Polyline
- Circle
- Ellipse
Temporal Coordinates

- SEGMENT
- MULTISEGMENT
- MULTIPOINT
- POINT

BEGIN

END
Image Temporal and Spatial Coordinates

- **LV outline end systole**
- **TCOORD**
- **SELECTED FROM**
- **SCOORD**
- **SELECTED FROM**
- **IMAGE**
Temporal Coordinates applied to both Images and Waveforms
What about Codes?

- DICOM uses external lexicons
  - SNOMED
  - LOINC
  - RADLEX
  - defines DCM codes & definitions if no other good scheme

- EHR push towards more reliable codes
  - e.g., EHR interoperability and common data elements
  - RIS, modalities and PACS implementations could do better
  - institutions need to standardize internal procedure codes
  - harmonize/bridge imaging/EHR codes
Codes for Structured Reports

- Codes needed for
  - entities, e.g., lesions, tumors, tissue types
  - location, e.g., anatomic site
  - characteristics, e.g., edges, enhancement
  - measurements, e.g., volume, sum of areas, mean
  - units, e.g., HU, mm

- Availability
  - many already - SNOMED, LOINC, RADLEX, DCM, NCI, UCUM
  - more being defined every day
  - vendors also use private codes
  - need to anticipate code evolution (configurable producer/consumer)
## Table CID 7150. Segmentation Property Categories

<table>
<thead>
<tr>
<th>Coding Scheme Designator</th>
<th>Code Value</th>
<th>Code Meaning</th>
<th>SNOMED-CT Concept ID</th>
<th>UMLS Concept Unique ID</th>
<th>Segmentation Property Type Context Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRT</td>
<td>T-D0050</td>
<td>Tissue</td>
<td>85756007</td>
<td>C0040300</td>
<td>CID 7191 “Tissue Segmentation Property Types”</td>
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<tr>
<td>SRT</td>
<td>T-D000A</td>
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<td>C1268086</td>
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<td>SRT</td>
<td>A-00004</td>
<td>Physical object</td>
<td>260787004</td>
<td>C0085089</td>
<td>CID 7193 “Physical Object Segmentation Property Types”</td>
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<td>SRT</td>
<td>M-01000</td>
<td>Morphological Abnormal Structure</td>
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<td>CID 7194 “Morphological Abnormal Structure Segmentation Property Types”</td>
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<td>SRT</td>
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<td>Function</td>
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<td>C0587374</td>
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<td>91720002</td>
<td>C0504082</td>
<td>CID 7197 “Body Substance Segmentation Property Types”</td>
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<td>105590001</td>
<td>C0439861</td>
<td>CID 7198 “Substance Segmentation Property Types”</td>
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<tr>
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<td>C2329633</td>
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<tr>
<td>SRT</td>
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<tr>
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<td>Brain cerebrospinal fluid pathway</td>
<td>280371009</td>
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<td>Brain stem</td>
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<td>C1268144</td>
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<tr>
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<td>T-A1600</td>
<td>Brain ventricle</td>
<td>35764002</td>
<td>C0007799</td>
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<td>C0007461</td>
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<td>Cerebellar white matter</td>
<td>33060004</td>
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<tr>
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<tr>
<td>SRT</td>
<td>T-A2020</td>
<td>Cerebral cortex</td>
<td>40146001</td>
<td>C0007776</td>
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</tr>
</tbody>
</table>
Constrained by Templates

- Generic tree of content items has unbounded complexity, so need constraints
- Templates for interoperability for specific use cases
  - e.g., Mammography CAD
- Templates for entire structure
  - “root level”
- Templates for parts of structure – re-usable
  - e.g., Volumetric ROI Measurements
- Defined in PS3.16, follow pattern similar to Module tables in PS3.3
  - (coded) name of content item
  - requirement type
  - multiplicity
  - conditions
  - value set for coded values
  - coded units for numeric values
Table TID 1411. Volumetric ROI Measurements

<table>
<thead>
<tr>
<th>NL</th>
<th>Rel with Parent</th>
<th>VT</th>
<th>Concept Name</th>
<th>VM</th>
<th>Req Type</th>
<th>Condition</th>
<th>Value Set Constraint</th>
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<td>CONTAINS</td>
<td>INCLUDE</td>
<td>DTID 1502 “Time Point Context”</td>
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<td>&gt;</td>
<td>CONTAINS</td>
<td>SCOORD</td>
<td>EV (111030, DCM, &quot;Image Region&quot;)</td>
<td>1-n</td>
<td>MC</td>
<td>XOR Rows 7, 10</td>
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<td>&gt;&gt;</td>
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<td>IMAGE</td>
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<td>XOR Rows 5, 10</td>
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<td>IMAGE</td>
<td>EV (121233, DCM, &quot;Source image for segmentation&quot;)</td>
<td>1-n</td>
<td>MC</td>
<td>XOR Row 9 and IFF Row 7</td>
</tr>
</tbody>
</table>
Key Object Selection Document

- Specialized form of DICOM Structured Report
  - SOP Class constrains to specific template
- Essentially
  - list of images and other DICOM objects ("manifest")
  - coded Document Title, e.g., “For Clinical Trial Export”
  - text description
- Used in IHE as
  - Key Image Note profile
  - manifest for XDS-I profile
Presentation States relatively useless

- DICOM Presentation States are great for capturing state of rendering to human
  - zoom/pan, window center/width, …
  - but limited text and graphic annotations
  - no semantics
  - not even linkage of graphics and text
  - can be referenced from SR to set appropriate viewing conditions for referenced images
- Unfortunately are very popular with PACS due to their simplicity
  - better than no DICOM capture of annotations at all of course
  - means product managers not motivated to add SR support
- Ideally, all PACS viewers would support displaying any kind of SR
  - not just tabulating/rendering hierarchical content as text
  - not just jumping to reference image
  - but also displaying all coordinates/SEG references overlaid on images
  - preferably with local context from the tree such as finding, measurements and units
DICOM SR Nirvana!