Frontiers in PACS: DICOM Structured Reporting

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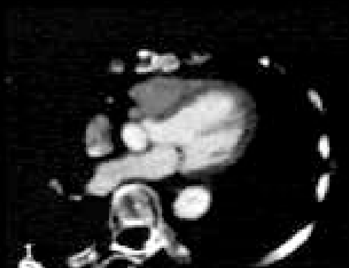
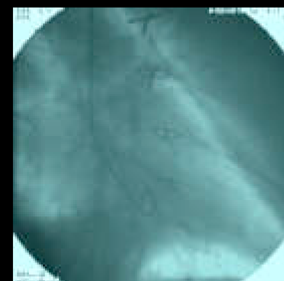
RadPharm

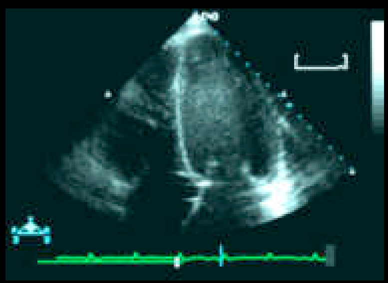
Outline

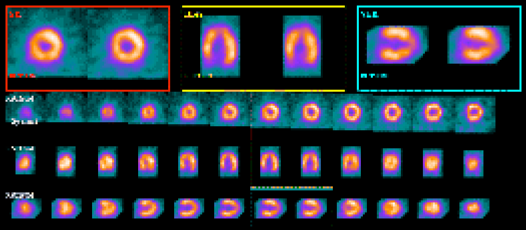
- Scope of DICOM
- Why use DICOM for reporting ?
- What is DICOM Structured Reporting ?
- Content encoding
- Templates
- Implementation
- Examples

DICOM Structured Reporting









Scope of DICOM

- Images
  - Radiology and cardiology
  - Nuclear Medicine
  - Ultrasound
  - Others …
    - Endoscopy
    - External photography
    - Microscopy

Scope of DICOM

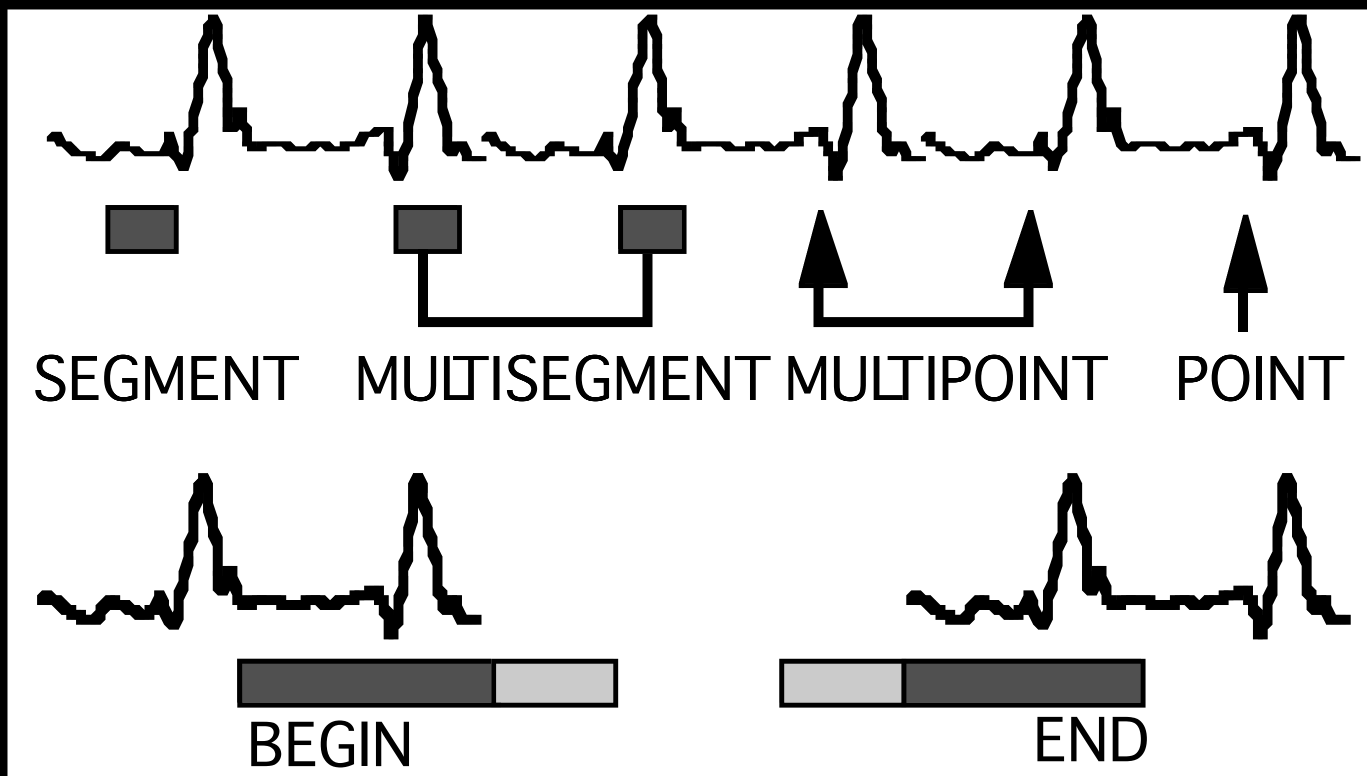
- Images
- Radiotherapy
  - Plan
  - Dose
  - Structure Set
  - Image
  - Treatment Record

Scope of DICOM

- Images
- Radiotherapy
- Waveforms
  - ECG (12-lead, continuous, Holter)
  - Hemodynamic (pressure)
  - Voice Audio
  - Others …

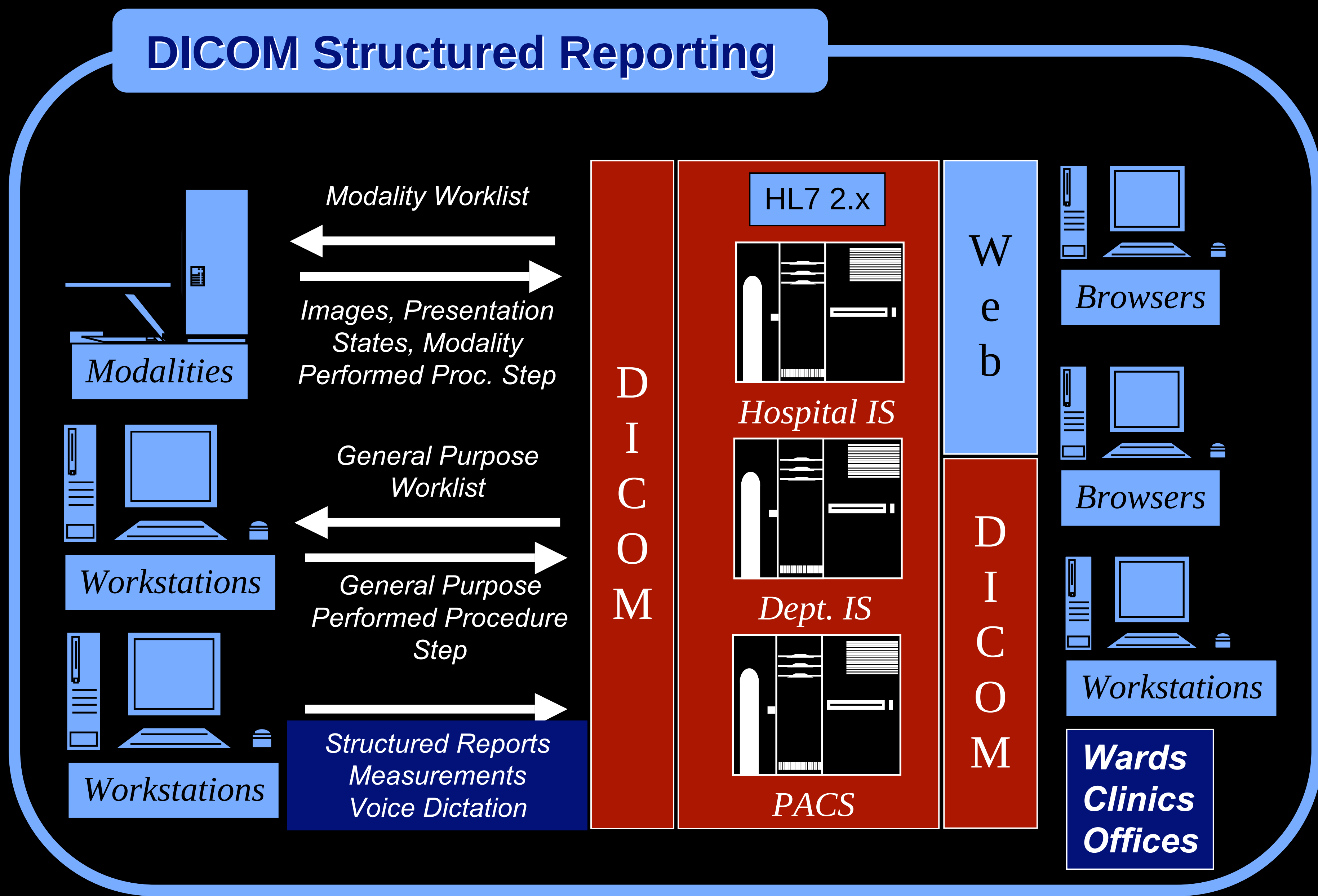
DICOM Structured Reporting

DICOM Time-based Waveforms



Scope of DICOM

- Images
- Radiotherapy
- Waveforms
- Workflow
  - Worklists (modality and general purpose)
  - Performed Procedure Step


DICOM Structured Reporting
Modality Worklist
Images, Presentation States, Modality Performed Proc. Step
Modalities
General Purpose Worklist
General Purpose Performed Procedure Step
Workstations
Workstations
Structured Reports
Measurements
Voice Dictation
DICOM
HL7 2.x
Hospital IS
Dept. IS
PACS
Web
DICOM
Browsers
Browsers
Workstations
Wards
Clinics
Offices

What about Reports ?

- Imaging studies are ordered to answer clinical ***questions***
- The primary product is the ***answer***, not the images themselves
- The answer is conveyed in the ***report***

Interoperability for reports as well

Why use DICOM for reporting ?

- Reports created in the imaging domain
- Relationship to images & waveforms
  - Image references (e.g. illustrate findings)
  - Spatial & temporal coordinates
- Mature persistent object paradigm
  - Installed base of archives adaptable
- Void to fill (few, if any, alternatives)

Traditionally …

- Films on a view box or alternator
- Text reports dictated and transcribed
- Interim reports hand-written

- Paper - creation and/or distribution
- If digital - proprietary systems

Evolution towards PACS

- Digital images, but reports still
  - Dictated
  - Transcribed (or speech recognition)
  - Separate equipment from image display
  - Proprietary entry/archive/distribution
- Best case: text for HL7 distribution
- Worse than before, e.g. no “wax pencil”

Doing better requires…

- Linking reports with images
- Integrating multiple vendors! systems
- Standards that preserve fidelity
- Leverage existing tools & standards …
  - DICOM
  - HL7
  - Web-based data entry & distribution

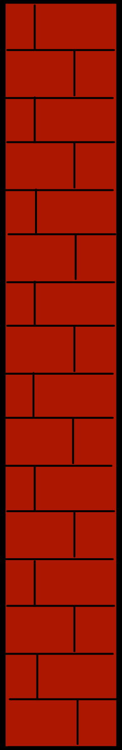
DICOM Structured Reporting

No link from Report to Images

Smith, M.

Tagged cardiac MRI reveals a focal dyskinetic segment located in the left ventricle anteriorly.

DAC. 2000/06/04



DICOM Structured Reporting

Multimedia: Report “+” Images

Smith, M.

Tagged cardiac MRI reveals a focal dyskinetic segment located in the left ventricle anteriorly.

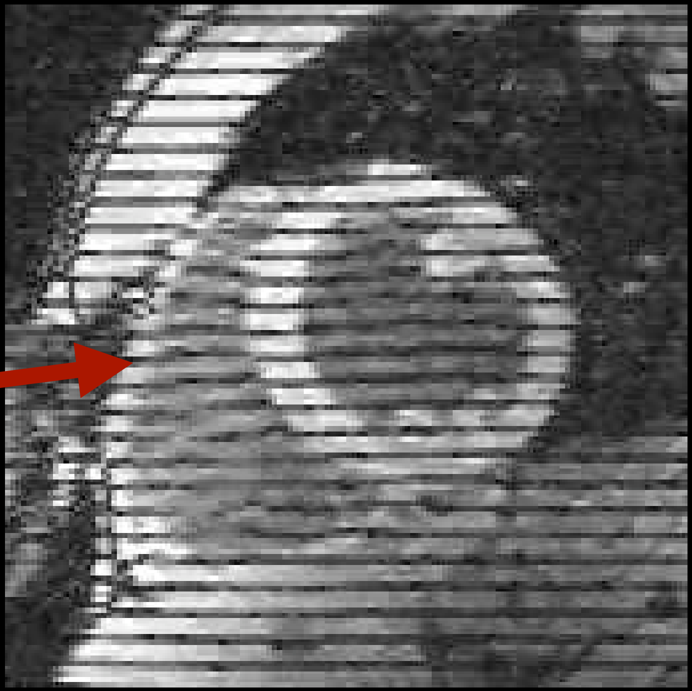
DAC. 2000/06/04

+

DICOM Structured Reporting

Structured Report *linked to* Images

Patient: Smith, M.
Procedure: tagged cardiac MRI
Finding: focal dyskinetic segment
  Anatomic Region: left ventricle
  Location: Anterior
  Spatial coordinates: Image:
Observer: DAC
Verification date: 2000/06/04



What is a Structured Report ?

- A document with structure
  - headings, codes, measurements + text
- Contains a “tree” of information
- Looks complicated internally
- “Flattened out” for simple display to users

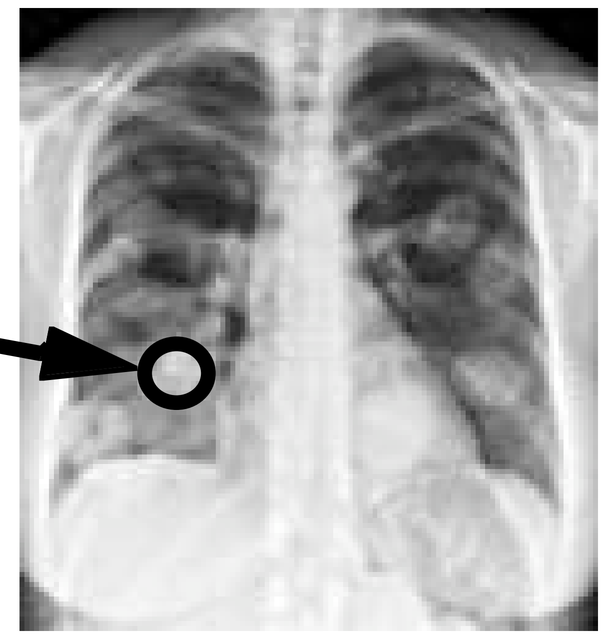
DICOM Structured Reporting

Headings, Findings, Images, Codes

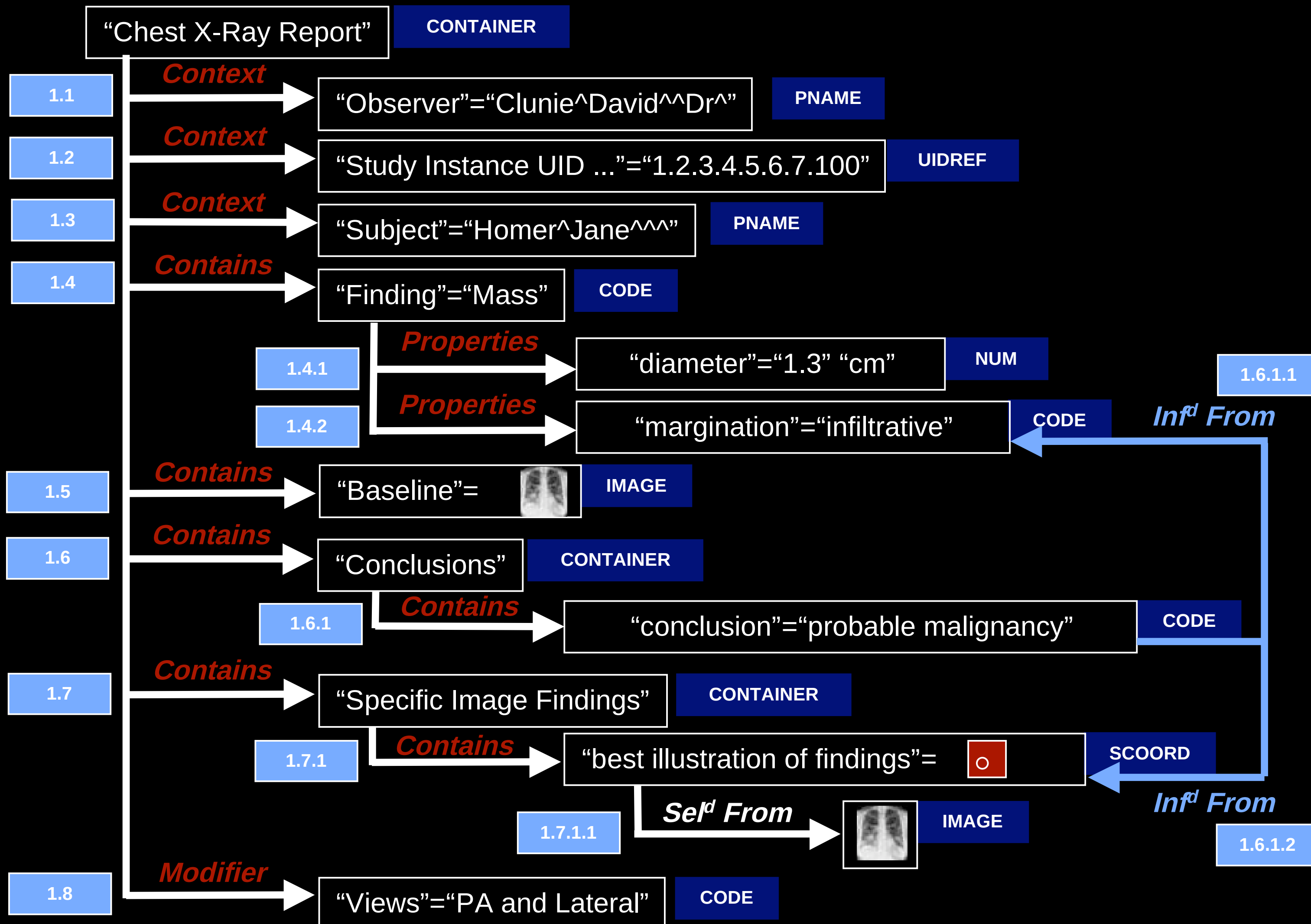
Chest X-ray Report:
Recording Observer: Clunie^David^A^Dr
History: malignant melanoma excised 1Y
Findings:
- finding: multiple masses in the lung fields
- best illustration of findings:

Conclusions:
- conclusion: cannon-ball metastases
- conclusion: recurrent malignant melanoma

Diagnosis Codes:
- diagnosis: 172.9/ICD9
- diagnosis: 197.0/ICD9



DICOM Structured Reporting



DICOM Structured Reporting

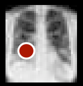
Report of <u>Chest X-Ray</u> (<u>PA and LateralViews</u>)

Patient <u>Jane Homer</u>
Study # 123456
Recorded by <u> Dr. John Smith</u>

The <u>finding</u> is a <u>mass</u> measuring <u>1.3</u> <u>cm</u> in <u>diameter</u> with an <u>infiltrative</u> <u>margin</u>.

The <u>baseline</u> image is shown at  (Click to view)

<u>Conclusions</u>
The <u>conclusion</u> is a <u>probable malignancy</u>, *<u>inferred from</u>* the <u>infiltrative</u> <u>margin</u> of the <u>mass</u> and the appearance shown by the <u>best illustration of findings</u>.

<u>Specific Image Findings</u>
The <u>best illustration of findings</u> is  (Click to view)

Types of structured “documents”

- Traditional diagnostic imaging reports
- Procedure and event logs
- Measurements
- Quality Control reports
- Computer Assisted Diagnosis (CADx)
- Flagging images (key object selection)

Why use DICOM for Reporting ?

- Use of standard allows for interchange
- DICOM provides compatibility with image viewer and archive components
- Only reporting standard that combines
  - images, waveforms & measurements
  - structured documents
- Required by RSNA/HIMSS IHE

Relationship to Other Standards

- HL7 Clinical Document Architecture
  - CDA: Former Patient Record Architecture
  - Levels 1,2,3
  - XML encoding, V3 data types
- CORBAMed Clinical Observations Access Service (COAS)
- CEN TC 215 Electronic Healthcare Record Architecture

DICOM Structured Reporting

A few more details …

What is in a DICOM SR object ?

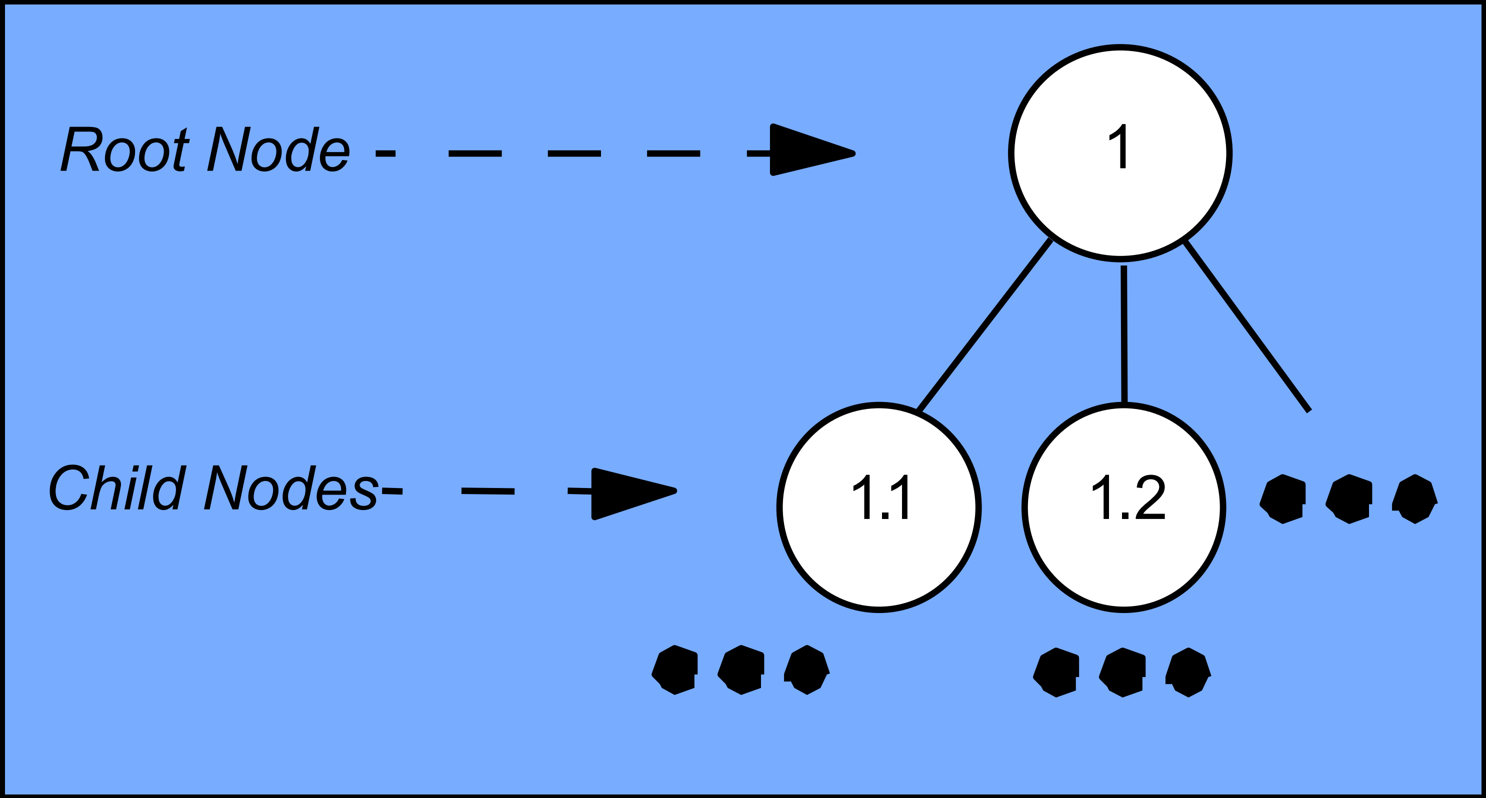
- “Header” of management information
  - Patient/Study/Series/Instance
  - State and status information
  - Source of “evidence” … to locate images
- “Tree” of “content”
  - Name-value pairs (e.g. “size” = “3” “cm”)
  - Relationships (e.g. “has properties”)

State and Status Information

- Complete or incomplete
- Verified or not; who & when
- List of evidence
  - Current
  - Relevant, e.g. prior reports
- Copies and versions
  - Rules for new UIDs for new versions

DICOM Structured Reporting

SR Content is a Tree



Each Node (Content Item)

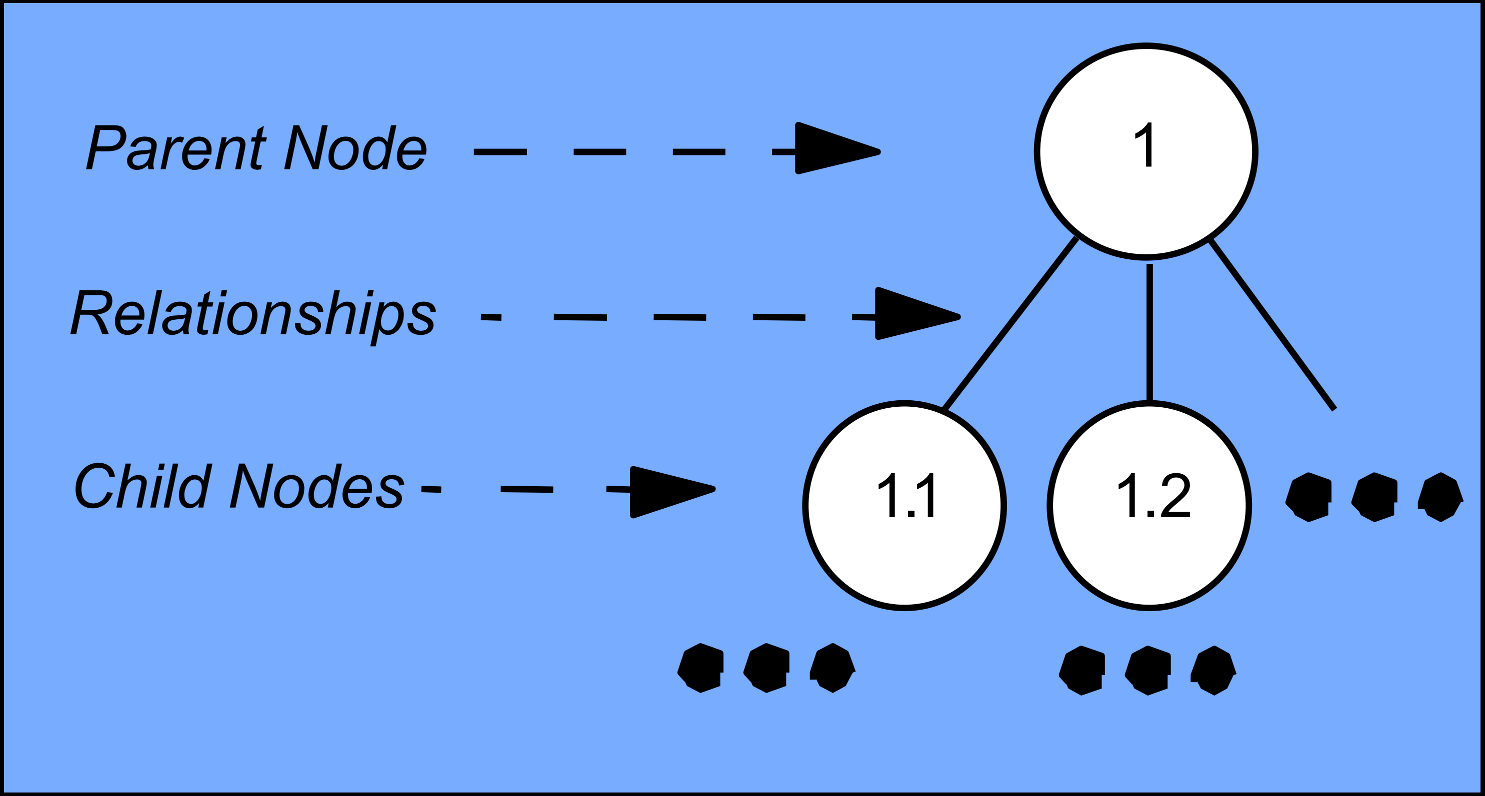
- Is a “name-value” pair
  - e.g. “finding” = “mass”
- The (concept) “name” is always coded
  - e.g. (27162,“99PMP”,“ Finding”)
- The “value” may be one of several “value types”

Value Types

- TEXT
- CODE
- NUM
- PNAME
- DATE
- TIME
- DATETIME
- CONTAINER
- UIDREF
- COMPOSITE
- IMAGE
- WAVEFORM
- SCOORD
- TCOORD

DICOM Structured Reporting

Nodes linked by Relationships



Relationships

- Contains
- Has Properties
- Inferred From
- Has Observation Context
- Has Acquisition Context
- Has Concept Modifier
- Selected From

Value Types

- TEXT
- CODE
- NUM
- PNAME
- DATE
- TIME
- DATETIME
- CONTAINER
- UIDREF
- COMPOSITE
- IMAGE
- WAVEFORM
- SCOORD
- TCOORD

DICOM Structured Reporting

Structured Report *linked to* Images

Patient: Smith, M.
Procedure: tagged cardiac MRI
Finding: focal dyskinetic segment
  Anatomic Region: left ventricle
  Location: Anterior
  Spatial coordinates: Image:
Observer: DAC
Verification date: 2000/06/04

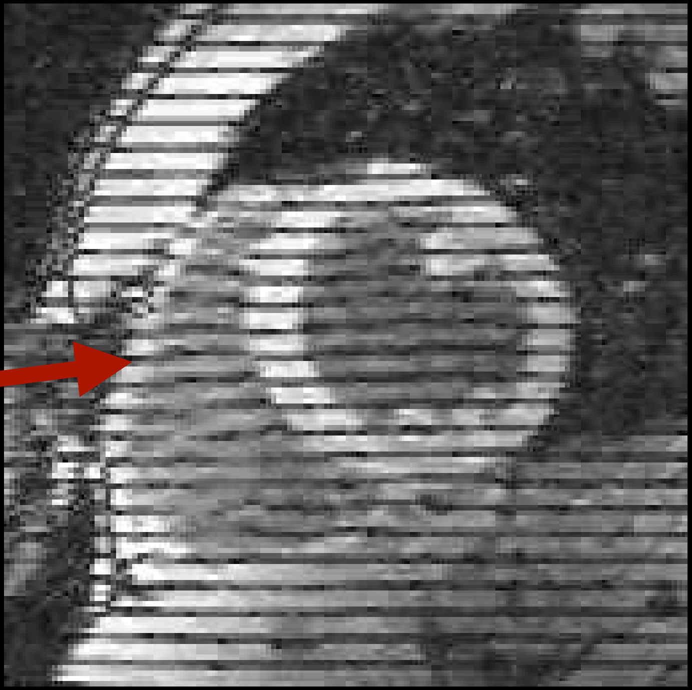


Image Reference

- Identify Image: SOP Instance UID
- Type of Image: SOP Class UID
- [Frame Number]
- [Presentation State]
  - Contrast transformations
  - Standard grayscale space
  - Spatial transformations

Importance of Presentation State

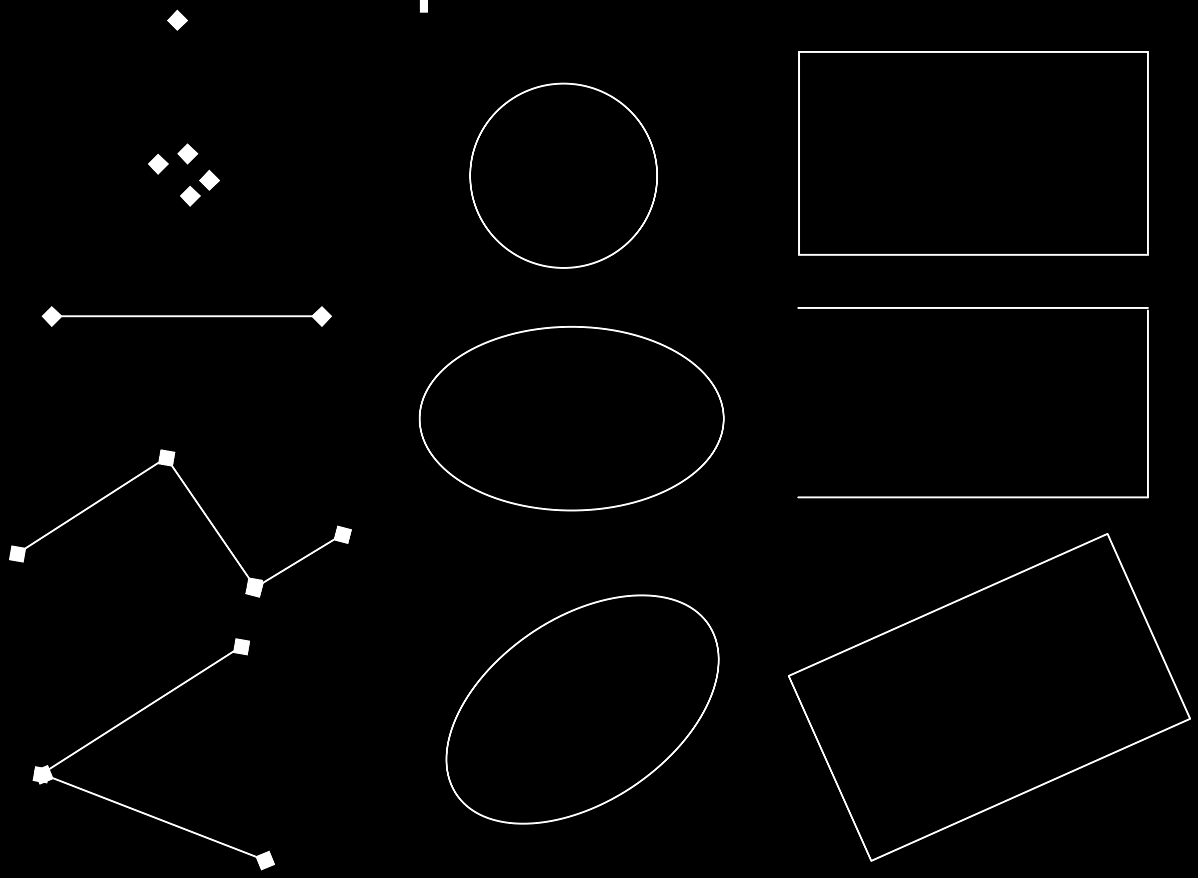
Importance of Presentation State

Original is wrong way around

Apply horizontal flip to correct orientation

Show retrocardiac mass by zoom/crop/adjust contrast

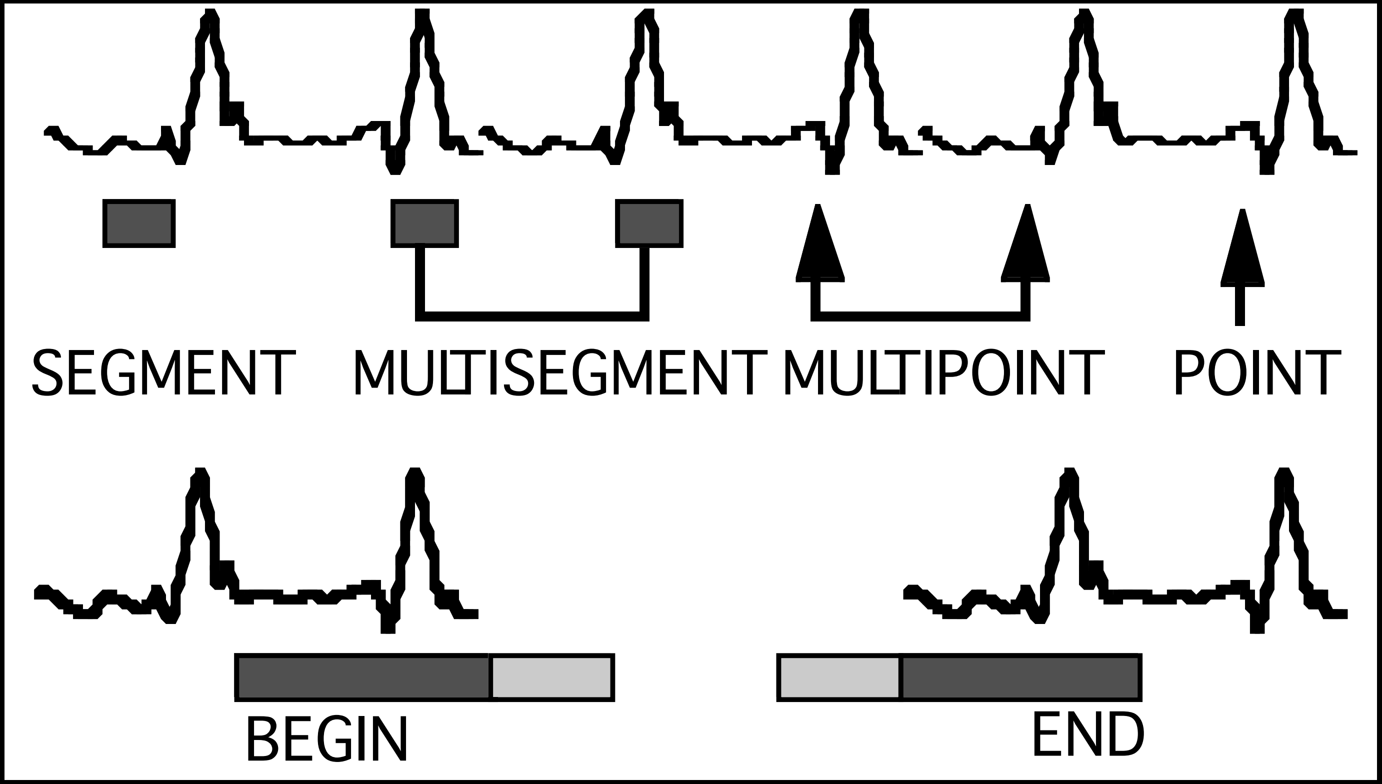
Spatial Coordinates



POINT
MULTIPOINT
POLYLINE
CIRCLE
ELLIPSE

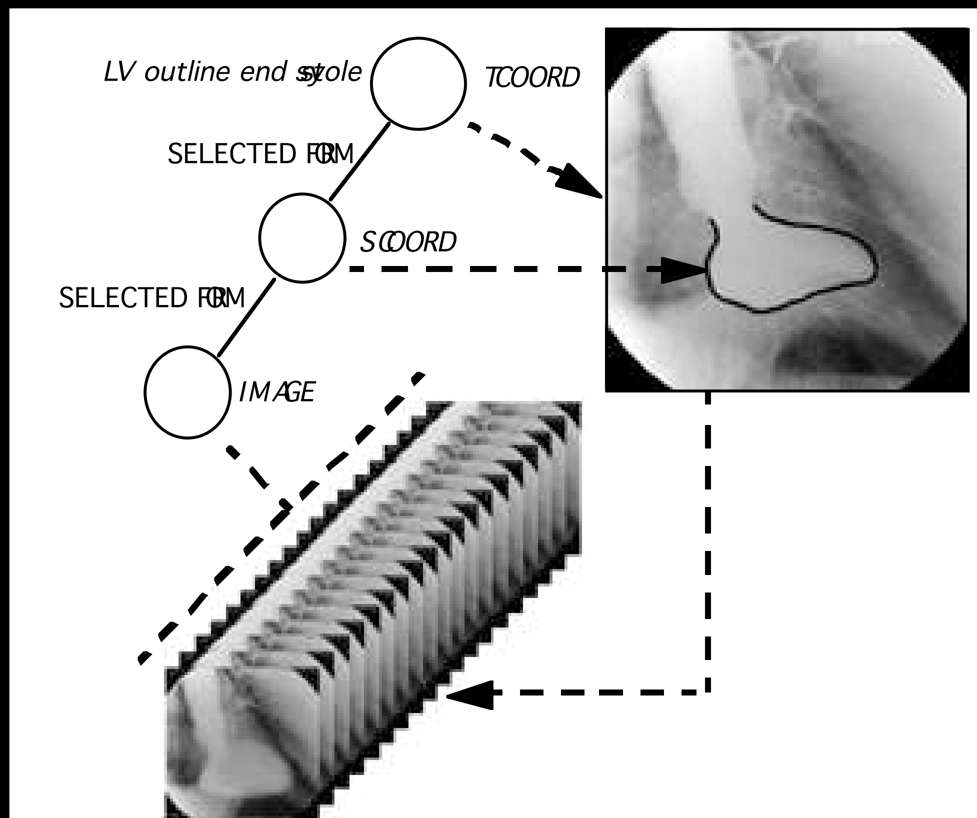
DICOM Structured Reporting

Temporal Coordinates

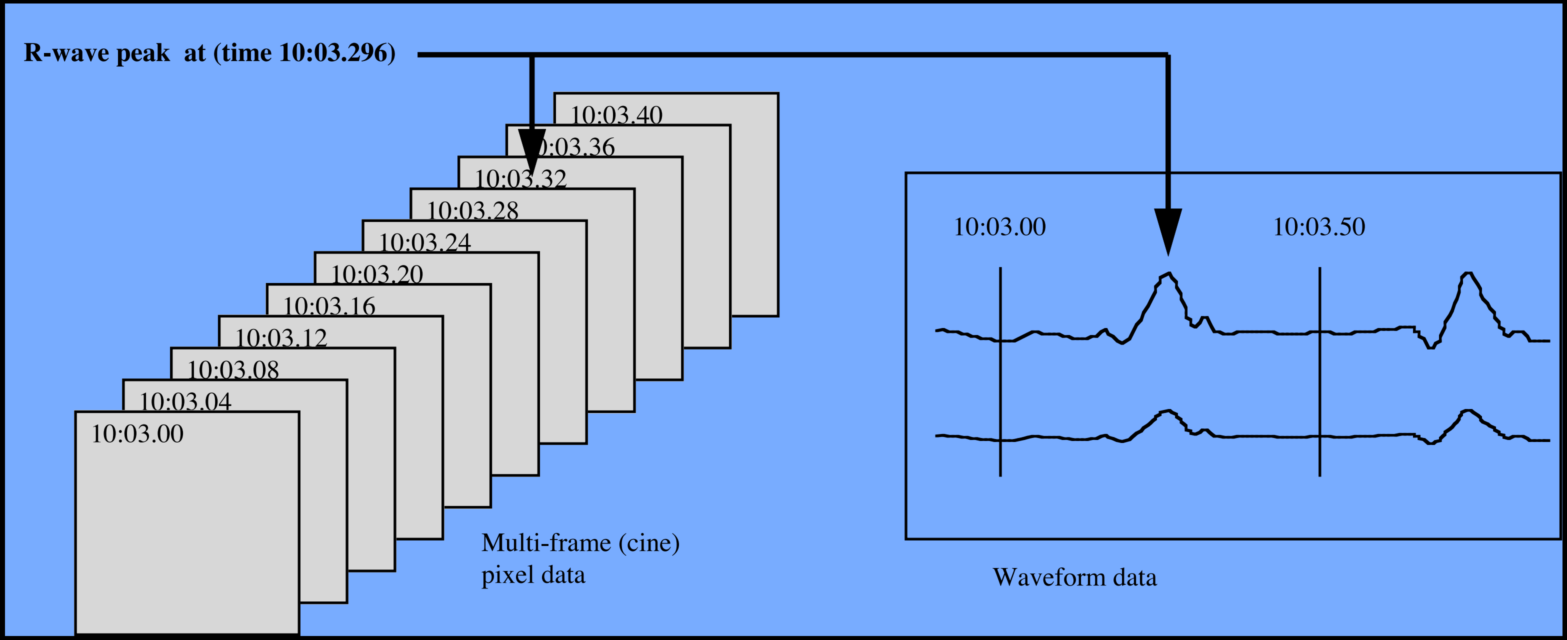


DICOM Structured Reporting

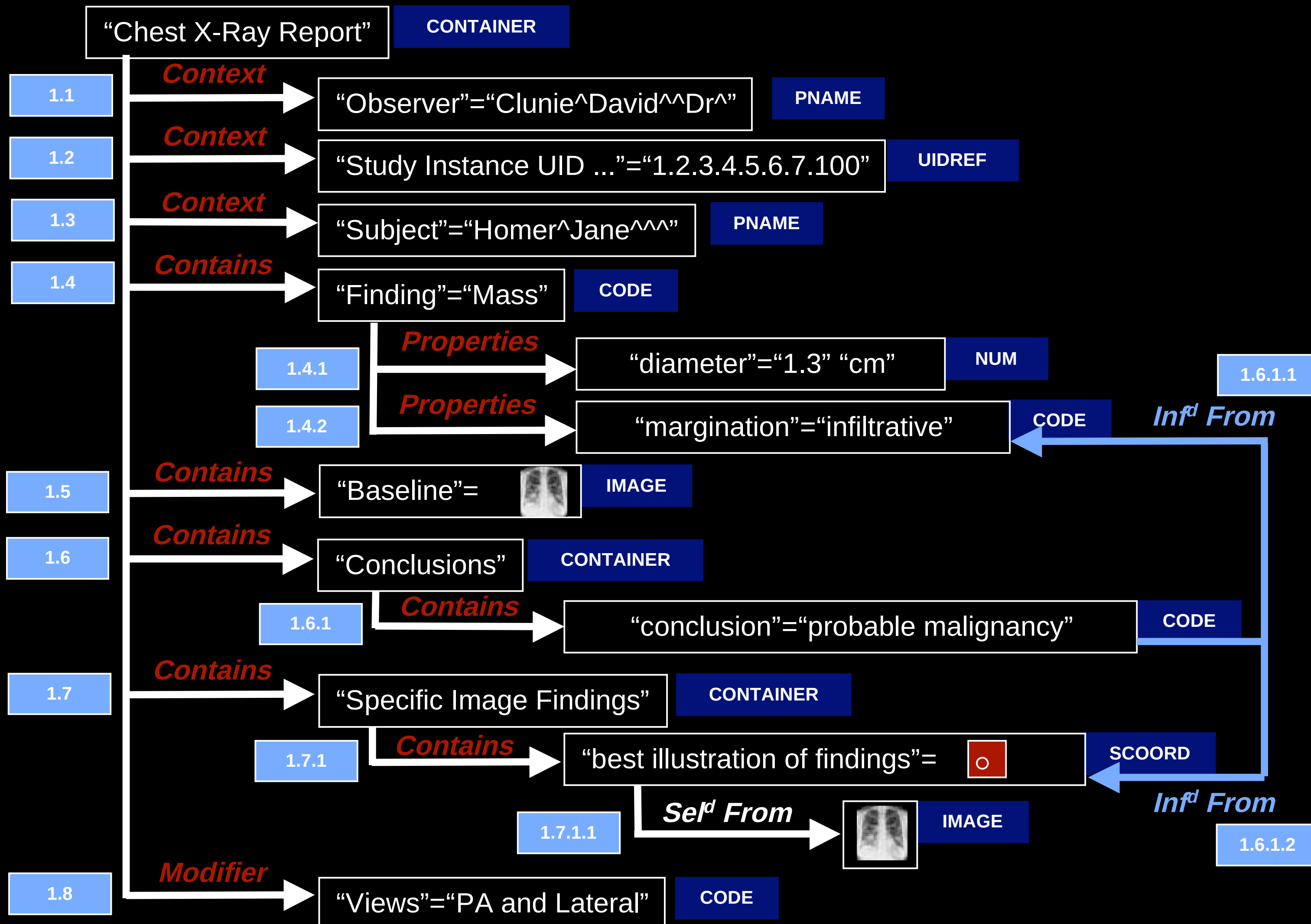
Temporal & Spatial Coordinates



Temporal Coordinates applied to both Images and Waveforms



DICOM Structured Reporting



Simplest SR is a Title + Text

- Legacy support
- Importation of foreign data (e.g. lab)

<CONTAINER:(29715,99PMP,“Chest X-ray Report”)>
<TEXT:(29716,99PMP,“Description”)=
“Reason for exam: Shortness of breath, history of CCF
Description of procedure: PA, lateral views were obtained followed by a left lateral decubitus
Findings: Blunting of the left costo-phrenic angle, cardiomegaly and interstitial lines. Subsequently pleural fluid was seen on the left in the decubitus view
Conclusions: Pulmonary oedema and pleural effusion”>

Order from chaos … Templates

- Trees of arbitrary complexity
- Unconstrained choice of code sets

-> risk of interoperability problems

- Use pre-defined templates
  - constrain structure of tree
  - constrain choice of codes
- Templates for part of or whole object

Template examples

- Whole document:
  - Basic imaging report
  - Key object selection
  - Mammography CAD report
- Part of tree:
  - Linear measurements
  - Individual findings

What about implementation ?

Typical Design Goals

- Re-use existing components
- DICOM toolkit/image viewer/archive
- Consumer/open-source tools
- Web browser windows
- Java Server Page (JSP) engine
- XML tools (SAX/DOM parse, XSL-T)

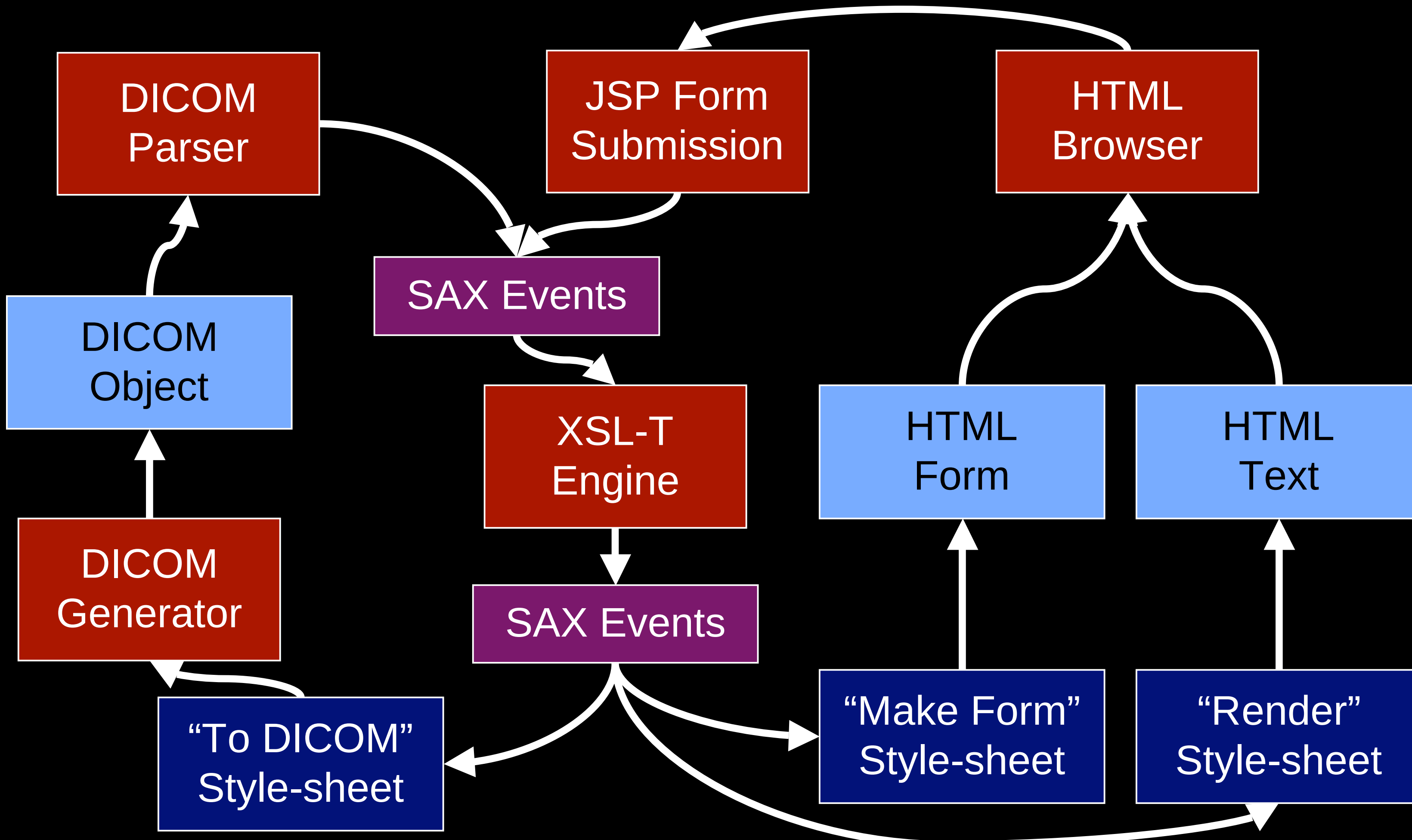
Design Alternatives

- Hard-coded SR-specific application
- Literal XML instantiation & conversion
  - DOM (slow, flexible) or SAX (fast, XSL-T)
- SR-specific Object Model
  - Limited reusability; support for XSL-T ?
- Virtual XML - simulate SAX events
  - Both DICOM parse & DICOM generate

Architecture: “round-trip”

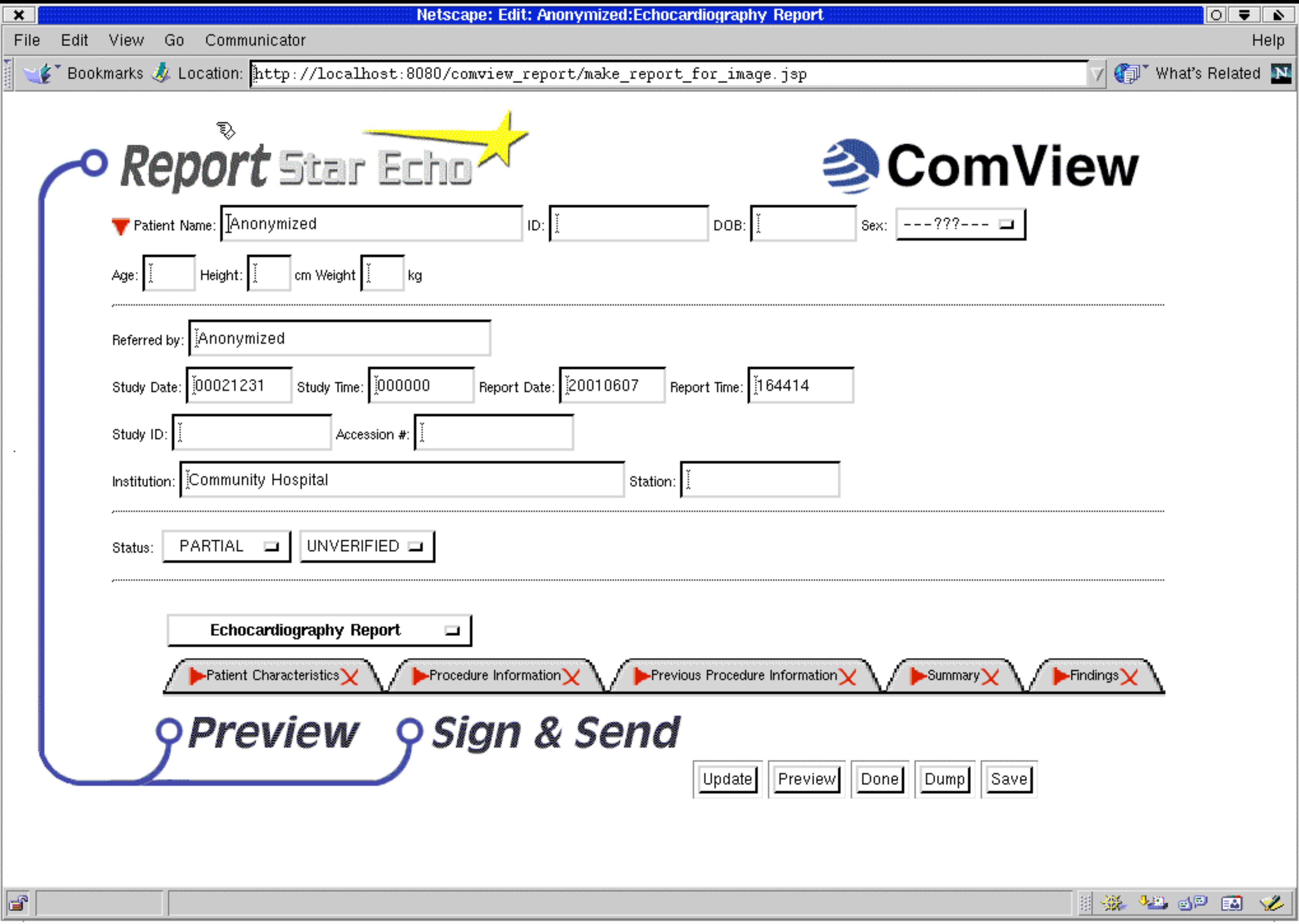
- Only persistent object is binary DICOM
- DICOM parser returns SAX events
  - i.e. implicit virtual XML conversion
- SAX events drive XSL-T stylesheet
  - produces HTML form (+CSS for prettiness)
- Web browser renders form which user fills in
- Submit -> JSP makes SAX events from form
  - i.e. another implicit virtual XML conversion
- Either: cycle revised form or DICOM C-Store

DICOM Structured Reporting



Results of Experience

- Existing DICOM toolkit re-use:
  - No tag ordering or sequence building problems
  - Service/SOP Class/IOD support
- Existing application re-use:
  - No need to re-implement archive/database
  - Image viewer integration (shared context)
- Web/XML/XSL-T tool re-use:
  - Off-the-shelf browsers/parsers/stylesheet engine



Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_report_for_image.jsp
What's Related
Report Star Echo
ComView
Patient Name: Anonymized
ID:
DOB:
Sex: ---???---
Age: Height: cm Weight kg
Referred by: Anonymized
Study Date: 00021231
Study Time: 000000
Report Date: 20010607
Report Time: 164414
Study ID:
Accession #:
Institution: Community Hospital
Station:
Status: PARTIAL UNVERIFIED
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Preview
Sign & Send
Update
Preview
Done
Dump
Save


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
What's Related
Report Star Echo
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Preview
Sign & Send
Update
Preview
Done
Dump
Save

Netscape: Edit: Anonymized:Echocardiography Report

File Edit View Go Communicator Help

Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp What's Related

Report Star Echo

ComView

Patient Anonymized, ; Study (00021231:000000)

Echocardiography Report

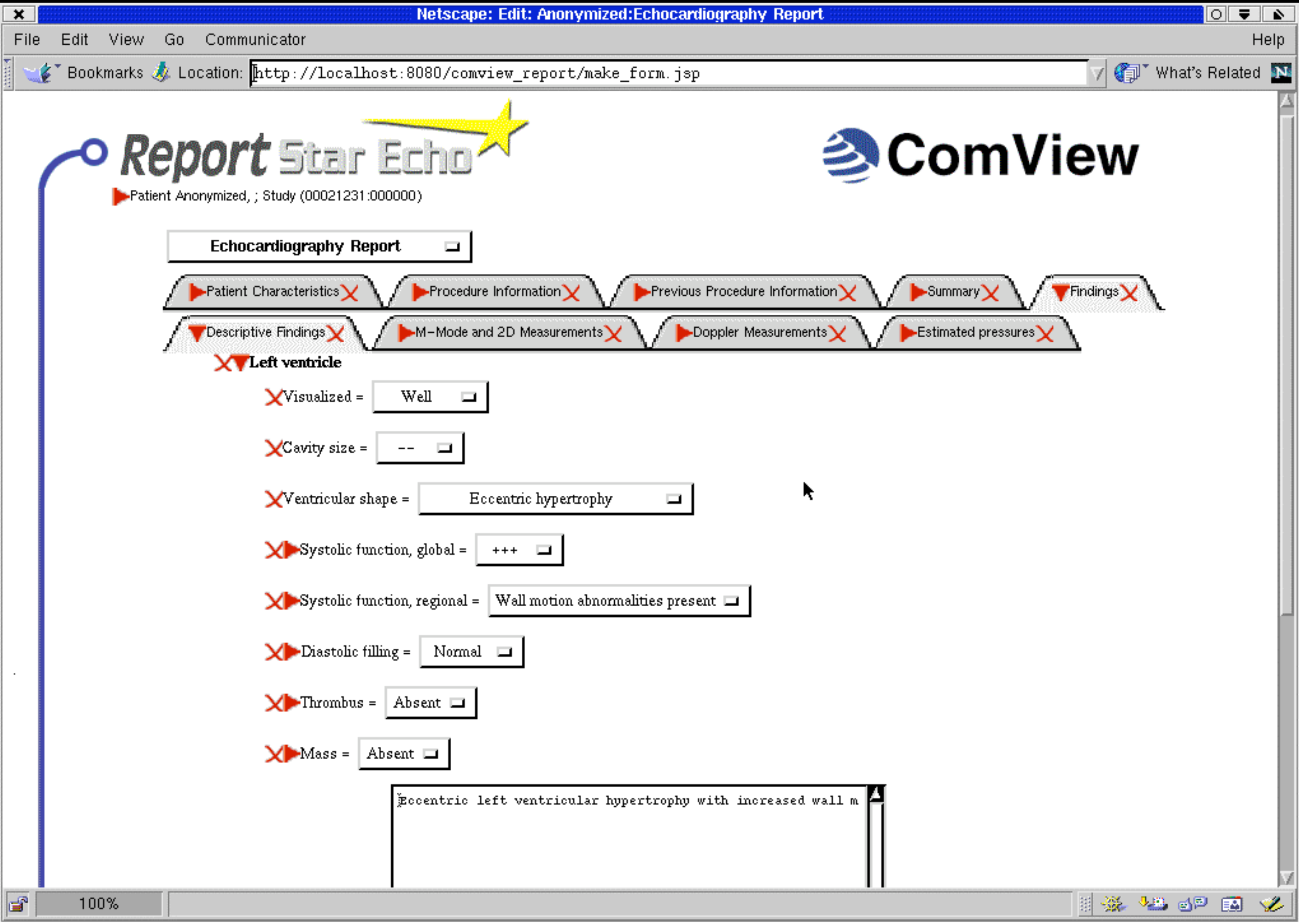
Patient Characteristics | Procedure Information | Previous Procedure Information | Summary | Findings

Descriptive Findings | M-Mode and 2D Measurements | Doppler Measurements | Estimated pressures

Preview

Sign & Send

Update | Preview | Done | Dump | Save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What's Related
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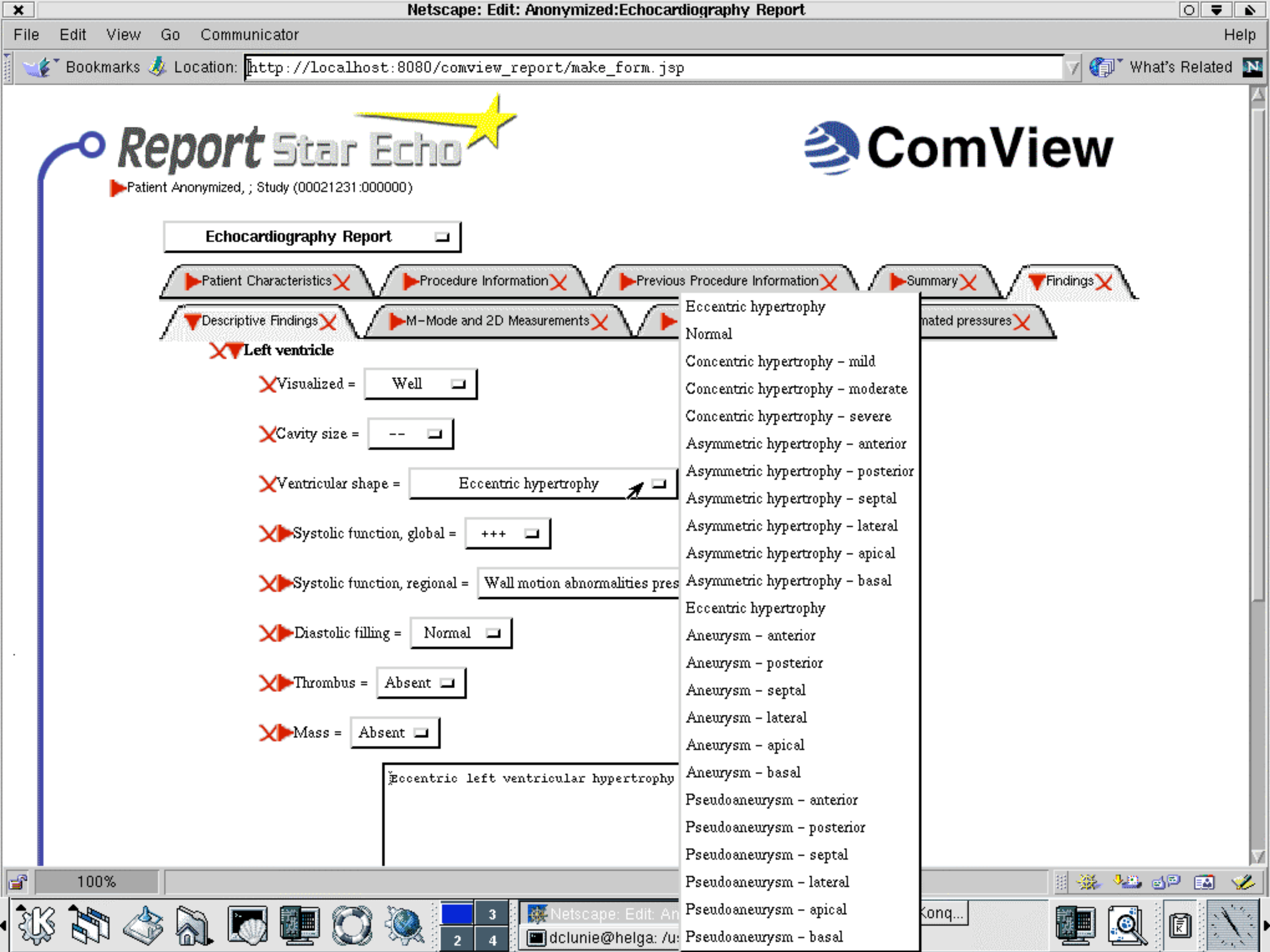
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Descriptive Findings
M-Mode and 2D Measurements
Doppler Measurements
Estimated pressures
Left ventricle
Visualized = Well
Cavity size = --
Ventricular shape = Eccentric hypertrophy
Systolic function, global = +++
Systolic function, regional = Wall motion abnormalities present
Diastolic filling = Normal
Thrombus = Absent
Mass = Absent
Eccentric left ventricular hypertrophy with increased wall m
100%


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
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ComView
Patient Anonymized, ; Study (00021231:000000)
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Ventricular shape = Eccentric hypertrophy
Systolic function, global = +++
Systolic function, regional = Wall motion abnormalities pres
Diastolic filling = Normal
Thrombus = Absent
Mass = Absent
Eccentric left ventricular hypertrophy
Eccentric hypertrophy
Normal
Concentric hypertrophy - mild
Concentric hypertrophy - moderate
Concentric hypertrophy - severe
Asymmetric hypertrophy - anterior
Asymmetric hypertrophy - posterior
Asymmetric hypertrophy - septal
Asymmetric hypertrophy - lateral
Asymmetric hypertrophy - apical
Asymmetric hypertrophy - basal
Eccentric hypertrophy
Aneurysm - anterior
Aneurysm - posterior
Aneurysm - septal
Aneurysm - lateral
Aneurysm - apical
Aneurysm - basal
Pseudoaneurysm - anterior
Pseudoaneurysm - posterior
Pseudoaneurysm - septal
Pseudoaneurysm - lateral
Pseudoaneurysm - apical
Pseudoaneurysm - basal
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Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp What's Related

Report Star Echo

ComView

Patient Anonymized, ; Study (00021231:000000)

Echocardiography Report

Patient Characteristics | Procedure Information | Previous Procedure Information | Summary | Findings

Descriptive Findings | M-Mode and 2D Measurements | Doppler Measurements | Estimated pressures

Left Ventricular End-Diastolic Dimension	65.0	mm	(0.0	mm	- 0.0	mm)	~
Left Ventricular End-Systolic Dimension	50.0	mm	(0.0	mm	- 0.0	mm)	~
Inter-Ventricular Septal Diastolic Thickness	11.0	mm	(0.0	mm	- 0.0	mm)	~
Left Ventricular Posterior Wall Thickness	10.0	mm	(0.0	mm	- 0.0	mm)	~
Left Ventricular Fractional Shortening	23.0	%	(0.0	%	- 0.0	%)	~
Left Ventricular Ejection Fraction	23.0	%	(0.0	%	- 0.0	%)	~
Left Ventricular Circumferential Shortening	146.0	/	(0.0	/	- 0.0	/)	~
Left Ventricular Rate of Circumferential Shortening	146.0	/s	(0.0	/s	- 0.0	/s)	~
Left Ventricular Wall Mass	146.0	g	(0.0	g	- 0.0	g)	~
Left Ventricular Wall Mass Index	146.0	g/m	(0.0	g/m	- 0.0	g/m)	~

100%

Netscape: Edit: Anonymiz... | file:/home/dclunie - Konq... | dclunie@helga: /usr/local...

Netscape: Preview: Anonymized:Echocardiography Report

File Edit View Go Communicator Help

Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp What's Related

Patient Name: Anonymized ***ID:*** ***DOB:*** ***Sex:***
Age: ***Height:*** cm ***Weight:*** kg

Referred by:
Study Date: 00021231 ***Study Time:*** 000000 ***Report Date:*** 20010607 ***Report Time:*** 164414
Study ID: ***Accession #:***
Institution: Community Hospital ***Station:***

Status: PARTIAL UNVERIFIED

- ***Echocardiography Report.***
  - ***Patient Characteristics.***

Height	= 74.0 inch
Weight	= 74.0 pound
BSA	= 1.98 square meter
Heart Rate	= 73.0 per minute
Systolic Blood Pressure	= 123.0 mmHg
Diastolic Blood Pressure	= 123.0 mmHg

  - ***Procedure Information.***
    - ***Operator***=Harry
    - ***Study Type***=Transthoracic echocardiogram
    - ***Study Quality***=Technically adequate
    - ***Indication***=Assess LV function
  - ***Previous Procedure Information.***
    - ***Study Type***=None
  - ***Summary.***
    - ***Answer to question posed***=Left ventricular dimension was moderately increased with mildly to moderately reduced systolic performance. Anterior and septal hypokinesis was the main finding. Despite ECG changes, the inferior and posterior walls appeared to move well.
  - ***Findings.***
    - ***Descriptive Findings.***
      - ***Left ventricle.***
        - ***Visualized***=Well
        - ***Cavity size***=Mildly to moderately decreased
        - ***Ventricular shape***=Eccentric hypertrophy
        - ***Systolic function, global***=Moderately increased

inferred from ***Ejection fraction***	= 35.0 Percent
inferred from ***Fractional shortening***	= 45.0 Percent

        - ***Systolic function, regional***=Wall motion abnormalities present
          - ***Basal anterior segment***=Hypokinetic (ASE 2)
          - ***Basal lateral segment***=Normal (ASE 1)
          - ***Basal posterior segment***=Normal (ASE 1)
          - ***Basal inferior segment***=Normal (ASE 1)

- ☐ ***Right atrium.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=Right atrial size was normal.
- ☐ ***Vena cavae.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=The IVC was moderately dilated. Respirophasic change in IVC caliber was blunted, suggesting increased central venous pressure.
- ☐ ***Pulmonic valve.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=Normal.
- ☐ ***Pulmonary artery.***
  - ☐ ***Visualized***=Poorly
  - ☐ ***Narrative finding***=Pulmonary artery dimensions appeared to be normal.
- ☐ ***Pericardium.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=No pericardial effusion.

☐ ***M-Mode and 2D Measurements.***

Left Ventricular End-Diastolic Dimension	= 65.0 mm	*(0.0 mm - 0.0 mm) [Normal]*
Left Ventricular End-Systolic Dimension	= 50.0 mm	*(0.0 mm - 0.0 mm) [Normal]*
Inter-Ventricular Septal Diastolic Thickness	= 11.0 mm	*(0.0 mm - 0.0 mm) [Normal]*
Left Ventricular Posterior Wall Thickness	= 10.0 mm	*(0.0 mm - 0.0 mm) [Normal]*
Left Ventricular Fractional Shortening	= 23.0 %	*(0.0 % - 0.0 %) [Normal]*
Left Ventricular Ejection Fraction	= 23.0 %	*(0.0 % - 0.0 %) [Normal]*
Left Ventricular Circumferential Shortening	= 146.0 /	*(0.0 / - 0.0 /) [Normal]*
Left Ventricular Rate of Circumferential Shortening	= 146.0 /s	*(0.0 /s - 0.0 /s) [Normal]*
Left Ventricular Wall Mass	= 146.0 g	*(0.0 g - 0.0 g) [Normal]*
Left Ventricular Wall Mass Index	= 146.0 g/m	*(0.0 g/m - 0.0 g/m) [Normal]*
Left Atrial Systolic Dimension	= 32.0 mm	*(0.0 mm - 0.0 mm) [Normal]*
Aortic Root Diastolic Diameter	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Aortic Annulus Diameter	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Aortic Valve Cusp Separation	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Left Ventricular Outflow Tract Systolic Diameter	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Mitral Valve Diastolic E-F Slope	= 32.0 cm/s	*(28.0 cm/s - 34.0 cm/s) [Normal]*
Mitral Valve Excursion	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Mitral Valve E Septal Separation	= 32.0 mm	*(28.0 mm - 34.0 mm) [Normal]*
Right Ventricular End-Diastolic Dimension	= 65.0 mm	*(0.0 mm - 0.0 mm) [Normal]*

☐ ***Doppler Measurements.***

Aortic Valve Peak Systolic Velocity	= 0.0 cm/s	*(0.0 cm/s - 0.0 cm/s) [Normal]*
Aortic Valve Time Velocity Integral	= 0.0 cm	*(0.0 cm - 0.0 cm) [Normal]*
Aortic Valve Maximum Instantaneous Systolic Gradient	= 0.0 mmHg	*(0.0 mmHg - 0.0 mmHg) [Normal]*
Aortic Valve Mean Systolic Gradient	= 0.0 mmHg	*(0.0 mmHg - 0.0 mmHg) [Normal]*
Aortic Valve Area (by Velocity)	= 0.0 cm2	*(0.0 cm2 - 0.0 cm2) [Normal]*

Summary

- Reporting within the scope of DICOM
- Integration with DICOM archives
- DICOM SR provides a tree of content
- Encoded as name-value pairs
- Templates improve interoperability
- Implement using existing tools
  - DICOM toolkits and web technology

DICOM Structured Reporting