Real Use of DICOM in the Domains

Radiology, Nuclear Medicine, Mammography and CAD

Peter Mildenberger
Johannes Gutenberg-Universität, Mainz

Insights from a DICOM-based PACS-Implementation

- Infrastructure (Hospital / Radiology)
- DICOM Services used
- Mammography
- Structured Reporting
- Teleradiology
- Conclusions

  – Experiences from a real implementation...

University Hospital Mainz and Department of Radiology

- 1500 beds, 104 wards
- 53.000 inpatients/year, 190.000 outpatients
- >30 examination rooms
- ~ 600 patients / d
- ~ 15 clinical conferences / d
- RIS since 1988
- PACS since 1996 (Radiology and Neurorad.)
  - with >30 modalities (e.g. 5 CTs, 5 MRs, 7 CRs, 2 DRs..)
  - ~ 20 -25 GB / d new data (incl. Cardiology)
  - ~ 30 TB online (around 50 million objects)

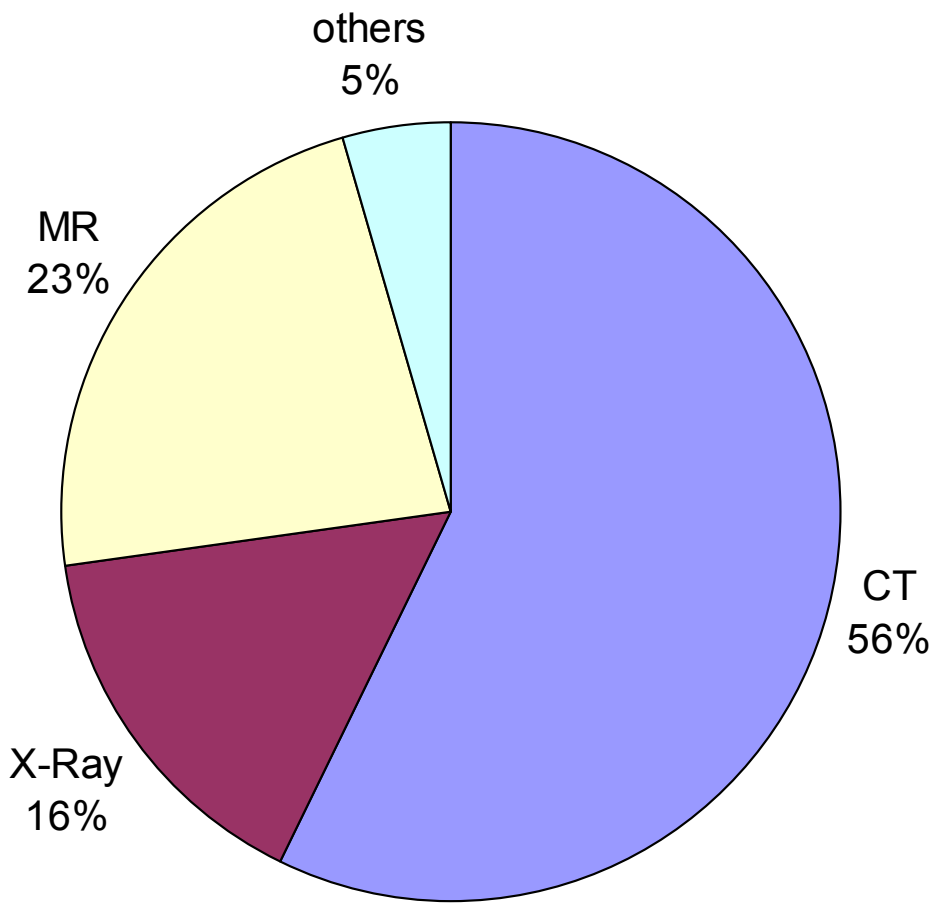
Data Load per Exam

Modality	Matrix	Depth	MB / image	Images / Exam.. (typical in Mz)	MB / Ex
CT	512*512	12 bit	0,5	250 (up to 2000)	125
MRT	256*256 - 512*512	12 bit	0,13 – 0,5	197	~50
DSA/DL	1024*1024	10 bit	2	18	36
CR	1500*2000 - 2000*2500	10 – 14 bit	6 - 10	4	24 - 40

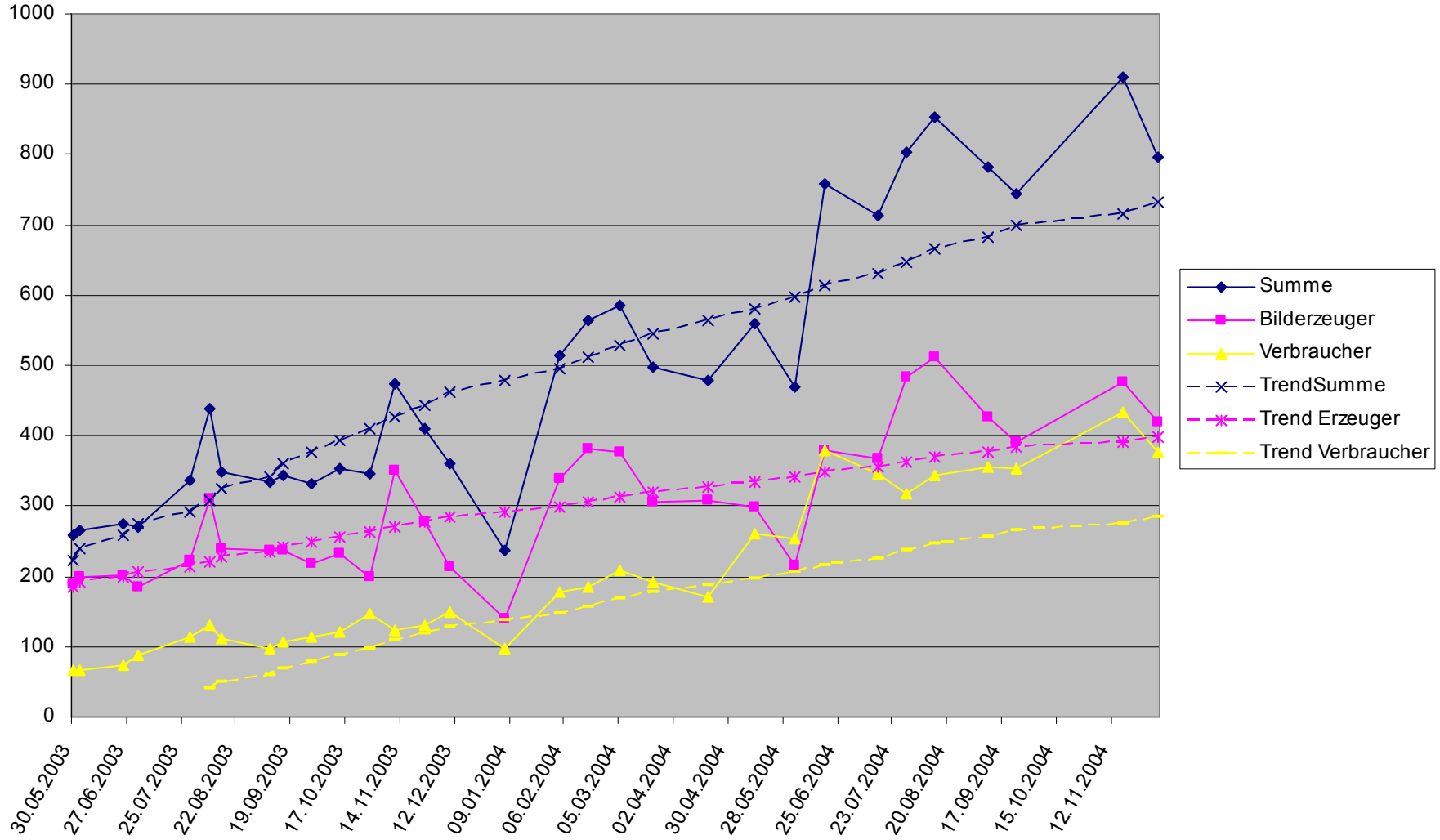
Data volume per Year in 2004 (without Cardiology)

• Studies / month	14400
• Images / month	745.000
• Gigabyte/month (uncompressed)	460 GB
• Images per Study	52
• MB per Study	32
• KB per Image	617
• Studies / year	173.000
• Images / year	8.940.000
• Gigabyte / year (uncompressed)	5.520 GB

Data Load per Modality (without Cardiology)



Inhouse Imagedistribution



Capacity and Costs for Archiving*

Medium	Capacity (GB)	Costs (ca. €)	Costs / GB (ca. €)
Film (35*43/20 images)	äq. 0,01	2	200
MOD	0,65	45	70
CD	0,65	3	4,6
DVD-Ram	2,6	20	8
DVD-R	4,7 bds.	12	1,3
CD-Jukebox	325	21000	65
DVD-Jukebox	1456	27500	19
DVD-Jukebox 2	5640	48000	8,5
RAID	1.000 – 80.000	5.000 – 500.000	5 – 6,25

*without compression or mirroring

Actual Use of the PACS in Mainz

- Radiography, CT, MRT, DSA
- Sonography
- Szintigraphy, PET
- Visible Light
  - Endoscopy, Ophthalmology, Digital Photography, Microscopic Slides)
- Cardiology

Image Sources

Radiology 505:
CT Siemens
CT Philips
MR Siemens
PCR Philips, CR Agfa
Flat-detektor Philips
Angio Philips
Ultrassoun GE L7
RF Philips
Filmscanner
CD-Import, JPEG Import
SecTelmed

Radiology 210:
CT Siemens
MR Siemens
Angio Siemens
Thoravision
CR Agfa
2 * PCR Philips
3 x Ultrasoundl
Mammography

Radiology 701:
2 x MR Siemens
CT Siemens
PCR Philips

Radiology 503:
PCR Philips
Flat-detektor Philips

Endoskopy :
SR-Generator
Endoskopy

Nuklear Medicine:
Gamma-Kameras
Ultrasound, PET,
SR_generatorr

Neuroradiology:
CT Picker
Angio Philips
MF-Platz (Myelo) Philips

Dental Clinic
Digital X-Ray
Sidicom

Urology:
Uroskop Siemens

Orthopedics:
OP-PCs with Arthro, RF

Child-Surgery:
RF

HTG:
RF

Neurosurgery:
OP-CT

Surgery:
Endoscopy

Angiology:
Capillar-mikroscop

Gynecology:
OP-Endoskop

Neurology:
Ultraschall

Pneumology:
Bronchoskopy

Cardiology:
Cathlab, Ultraschall

Ophthalmology:
Ultrasoundl

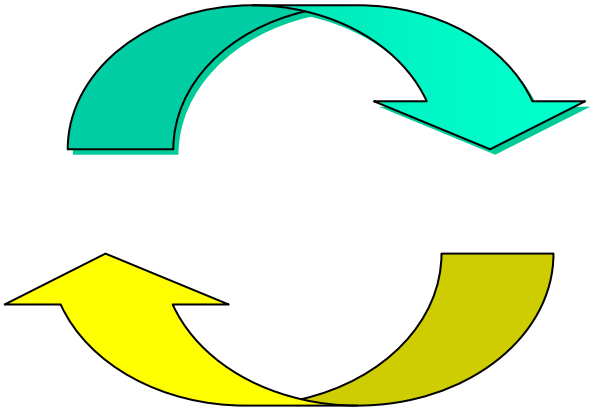
Workflow Support

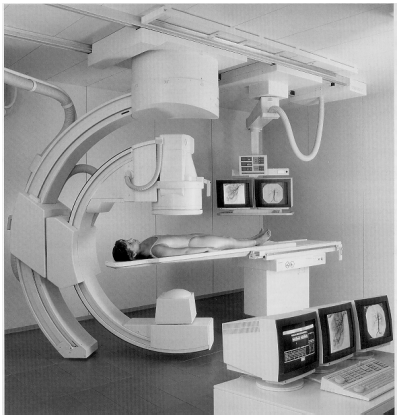
Modality Worklist / Performed Procedure Step

MWL:

Name, Birth date
Accession number
UIDs et al.

RIS





Acq. modality

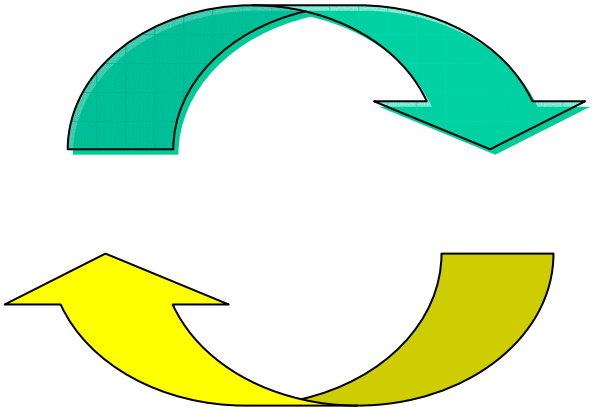
Conventional procedure:
manual entry in RIS
with different pitfalls

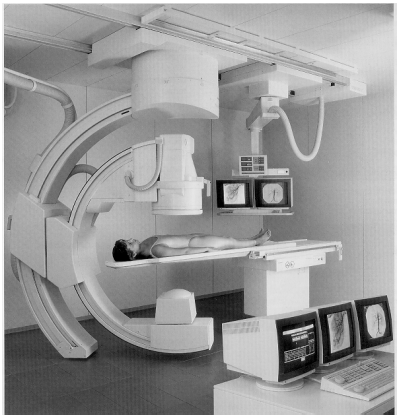
Modality Worklist / Performed Procedure Step

MWL:

Name, Date of Birth
Accession number
UIDs et al.

RIS





Acq. modality

MPPS with automatic transfer of:

Exposure Time
Total dose
Exposure dose
Fluoro dose
Number frames
Fluoro time
Number series

Consistency and Completeness of Image Archiving

Klinikum und Poliklinik fuer Radiologie Mainz (DBMZ1)

Archive | Database | Transfer | Image Viewer | Workgroups | Rules Engine | Admin | Help

Database

Select machine
- dbmz1
- dbmz2

Report
- Daily report
- Summary report
- Database state
- Backup report

Patient editor
- Create new patient
- Edit patient
- Edit study relationship
- Merge unassigned studies
- Show modification history

Worklist
- Modality worklist management

Workflow
- Visit management
- Study management
- Study lock management

Daily Report

Yesterday | Today

Year 2001 Month November Day 06 Show

Equipment: SIEMENS, Sonata, Sonata

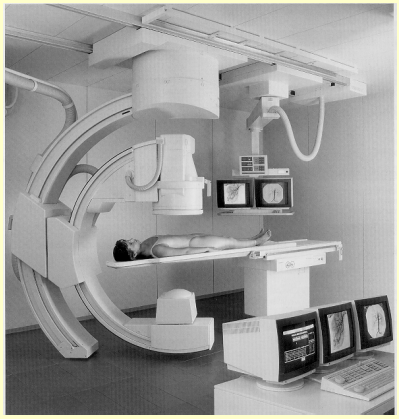
MR	, Miriam	337914	202
MR	, Radia	410367	343
MR	er, Richard	339145	341
MR	, Sylvia	300926	253
MR	Manfred	70222	506
MR	r, Lieselotte	272874	310
MR	, Johann	385278	671
MR	, Hans Joachim	408691	725
MR	, Simon Valentin	410879	151
Number of Images:			3502

Name: Thoravision 505
Equipment: Philips Medical Systems, Cassette Holder Type 9840 500 35201, THORAVISION

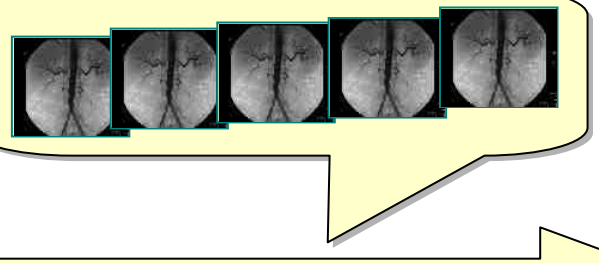
CR	, HELGA	272494	2
CR	ANTONIA	216387	2
CR	, Michael	410794	1
CR	, Willi	182978	2
CR	Manfred	260275	2
CR	, Peter	365918	2

- ~ 25000 images / d
- ~ 600 studies / d
- manual control takes 10 - 30 min / modality
- ~ 5h/d for the complete department

Storage Commitment



Acq modality



Please take responsibility for safekeeping of data

O.k., commitment for archiving images permanently

P A C S

DVD

PACS

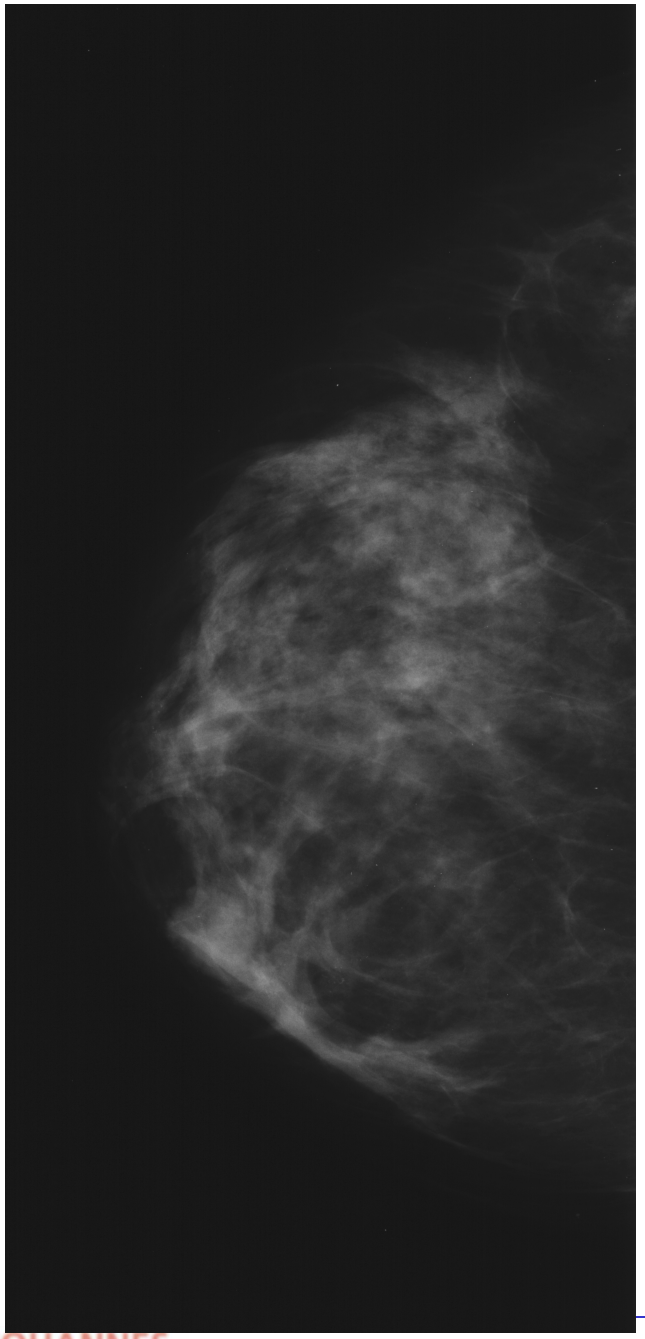
DICOM Print

- Standard for all new equipment
- Usable at modalities and workstations
- Easy way for backup-up solutions
  (configuration of two or more printers, e.g. laser film and paper printer)
- Avoids specific and costly interfaces
- Mainz: reduction of film print >90%, reduction of printers (8 of 14)

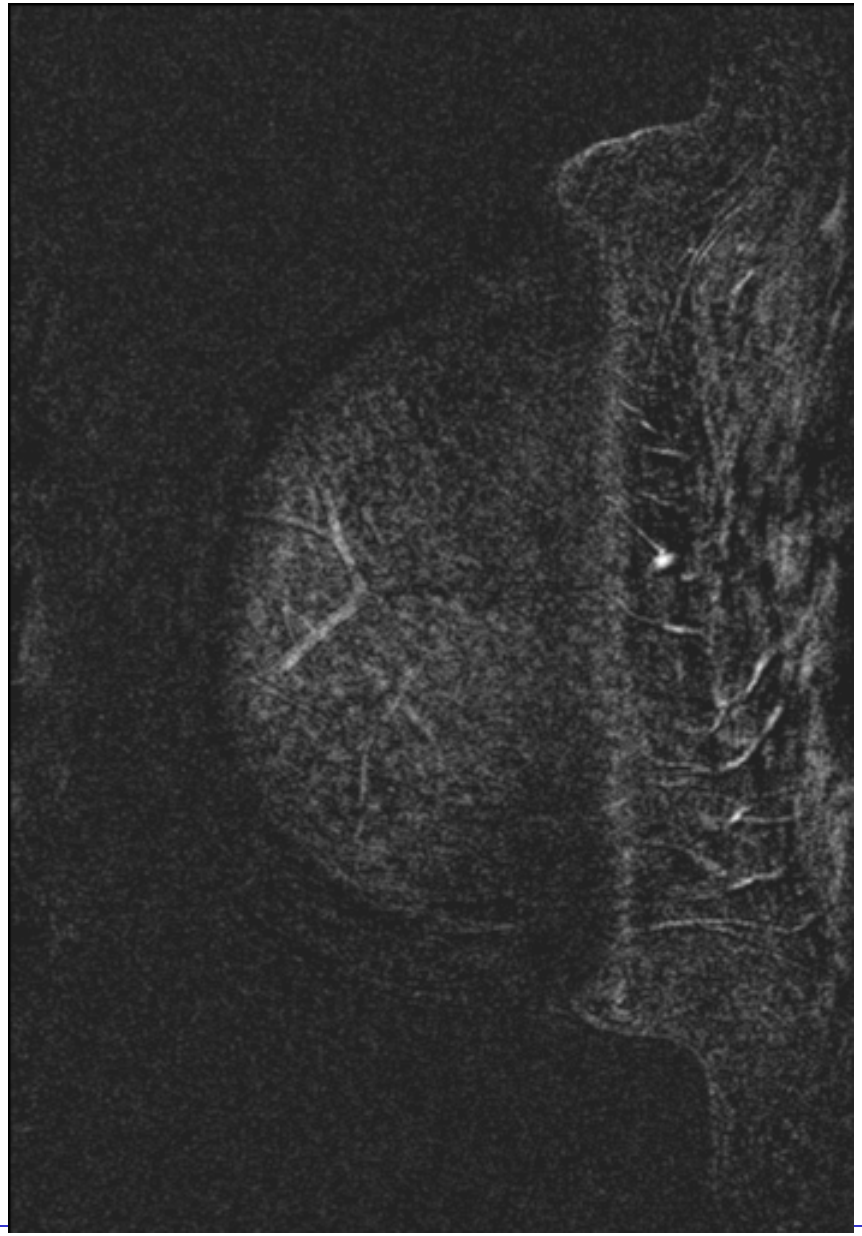
Mammography

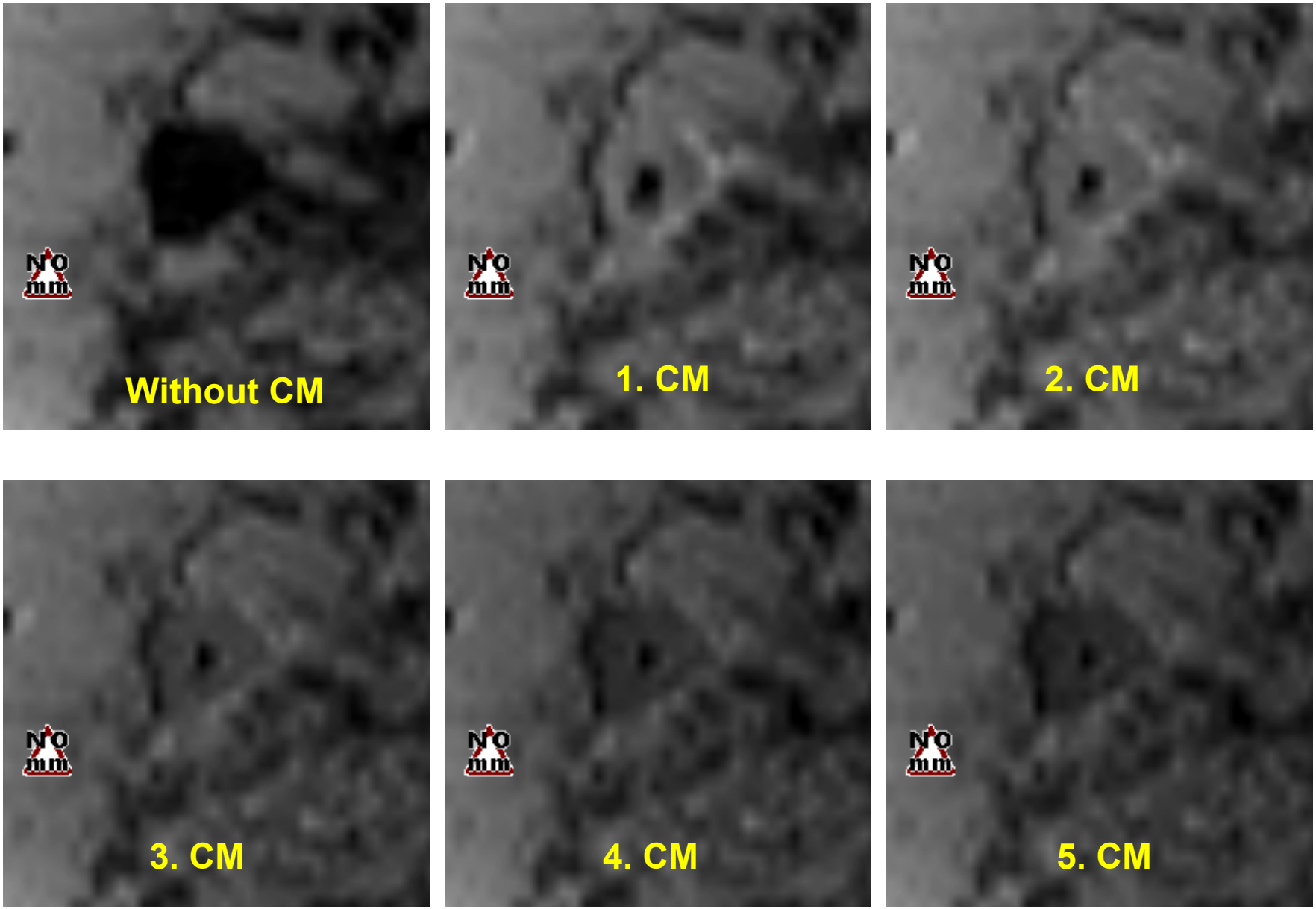
Mammography

- X-ray Mammography (3000/year)
- Preoperative marking (90% <1 cm)
- Ultrasound
- Biopsy (>100/year, Treffer >90%)
- Digital Stereotaxie
- MRT

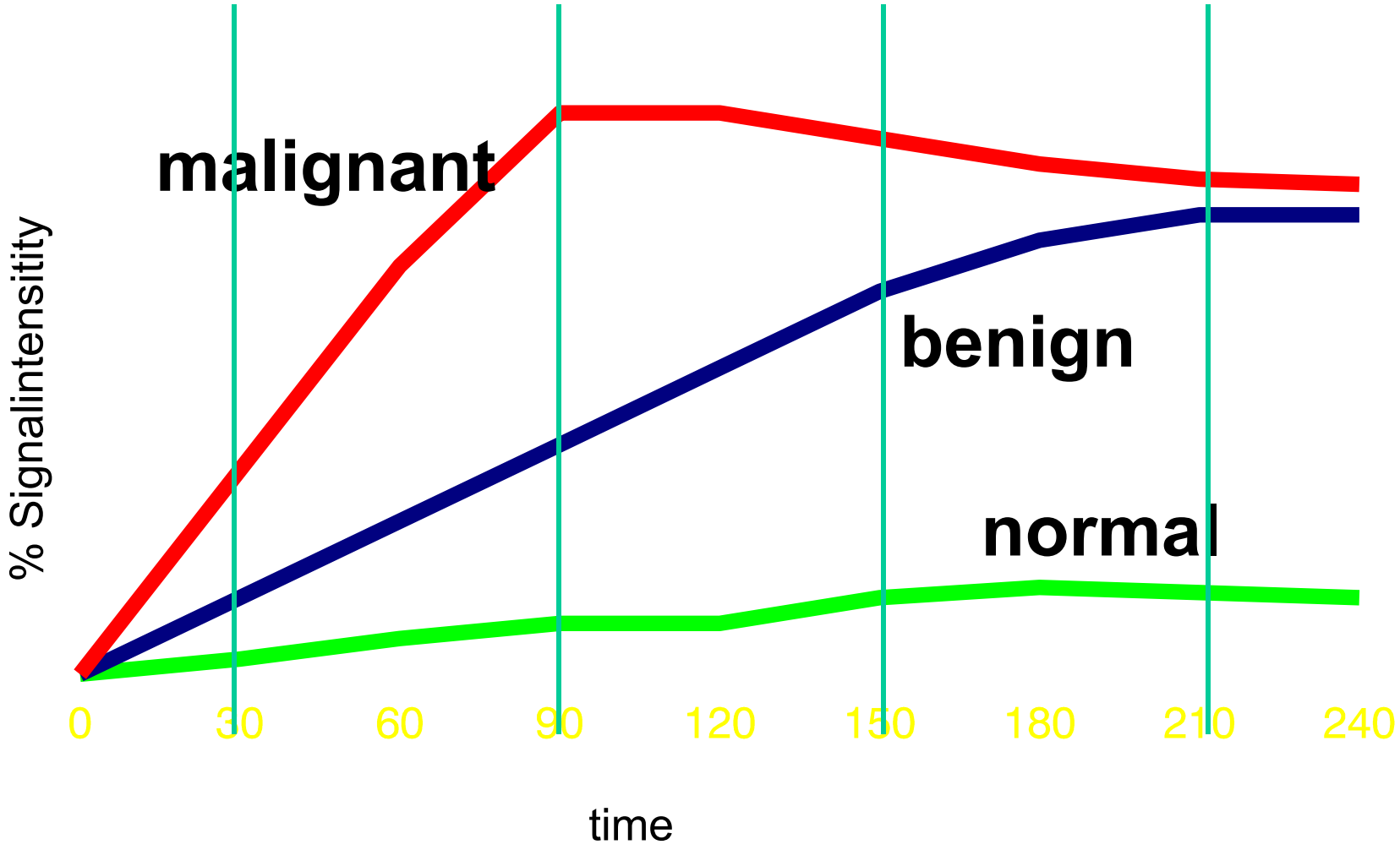



1
D 16.0MM 12.1MM




Without CM
1. CM
2. CM
3. CM
4. CM
5. CM

Dynamic contrast imaging



Digital Mammography

- Flat detector and CR-based available
- Higher dynamic of images (1:4000 vs. 1:200)
- Constant and consistent image quality
- Increased productivity
- Image postprocessing
- Evolving and new functionality:
  - CAD, Tomosynthese, Energy subtracted imaging, mammography with contrast media , Telemammography

DICOM SR in Breast Care

- Supplement 50 Mammography CAD is official part of the standard since 2001
- CAD-Systems providing SR are available
- part of the European Screen Trial (Mevis, R2...)
- Further developements
  - Patient Clinical History (Supp 75)
  - Breast Imaging Report (Supp 79)

Nuclear Medicine

Nuclear Medicine

- Integrated since the beginning
- Use for Scintigraphy, SPECT, PET
- Image fusion

STRUCTURED REPORTING

Conventional Radiological Reporting

Characteristics

- Different types
  - Prose without images
  - Structured reports without images
  - Prose with embedded images
  - Structured reports with embedded images
- "Good" report (Hall, AJR 2000)
  - Brief statement on exam indication, concise description of findings, no defensive posturing, accepted terminology and acronyms, summarize observations and assessment of clinical significance

Conventional Radiological Reporting

"Reality"

- Rapid technological improvement in imaging technology (display, processing, storage, 3D-acquisition..)
- But:
- Reports not transmitted in timely fashion
- contain ambiguous terms
  - opacity, density, infiltrate, consolidation…
  - tumor, lesion, focus, neoplasm…
- do not address the key clinical question
- contain clinically important errors

Expectations to Radiological Reporting

- Shortage of turnaround time
  - 19% same day, 42% 1 – 2 days (Naik, AJR, 2001)
- Design of reports
  - 86% clinicians prefer computer-generated itemized reports
  - Only 12% prefer prose
  - Also 64% of radiologists using PACS prefer computer-generated reports due to ease of reading, ease of extracting information, focused and organized nature..
- Structured reports with images (Reiner et al., 2004)
  - content, clarity, completeness, consistency, confidence

Reasons for Structured Reporting (SR)

- Ease of reading and extracting relevant informations included in hospital information systems
- Documentation of quantitative measurements
  - e.g. US, CT, MRT; CAD-Tools
- Comparability for follow-up studies
- Teaching and scientific research
  - automatically index and retrieve reports for online teaching
- measure and improve the performance of radiologists
  - e.g. number of recommended additional tests
- with realtime use, decision support would become available
  - diagnostic suggestions for unusual cases

Different ways to Structured Reports

Computer supported / generated

- manual measurement, e.g. Ultrasound
- computer assisted measurements
  - Calcium Scoring
  - Functional analysis
  - Quantification of stenosis, organ volumes...
- CAD
  - Breast, Chest, Colon...

Computer supported / generated

manual measurement,

e.g. Ultrasound

Carotid Bulb

Concept Modifier: Topographical modifier = Distal (G-A119, SRT)

End Diastolic Velocity:
0.77708441 m/s

Peak Systolic Velocity:
1.2273264 m/s

Carotid Bulb

Concept Modifier: Topographical modifier = Mid-longitudinal (G-A188, SRT)

End Diastolic Velocity:
0.84378693 m/s

Peak Systolic Velocity:
1.294029 m/s

Carotid Bulb

Concept Modifier: Topographical modifier = Proximal (G-A118, SRT)

End Diastolic Velocity:
0.56030121 m/s

Peak Systolic Velocity:
1.1939752 m/s

Common Carotid Artery

Computer Assisted Measurements

Risk Factors

- [ ] Diabetes Mellitus
- [ ] Hypertension
- [ ] Hypercholesterolemia
- [ ] Smoker
  - ◇ Present
  - ◇ Former
- [ ] Positive Family History
- [ ] Obesity
- [ ] Sedentary Lifestyle

Clinical History

Symptoms

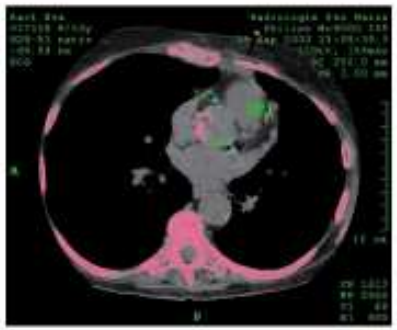
- ◇ Asymptomatic
- ◇ Unstable Angina Pectoris
- ◇ Stable Angina Pectoris
- ◇ Atypical Angina Pectoris
- ◇ Atypical Chest Pain
- ◇ Dyspnea
- ◇ Other

- [ ] Previous Myocardial Infarction
- [ ] Previous Coronary Revascularization
  - [ ] Bypass Surgery
  - [ ] Balloon Angioplasty
  - [ ] Coronary Stenting

Ok

Cancel

Computer Assisted Measurements



(Sep 15, 2008 1:06PM)

* Images are for reference use only

Nomenclature

LMAIN - Main left coronary artery.
LAD - Left anterior descending artery.
CRX - Left circumflex artery.
RCA - Right coronary artery.

Signature

Signed By: Date:

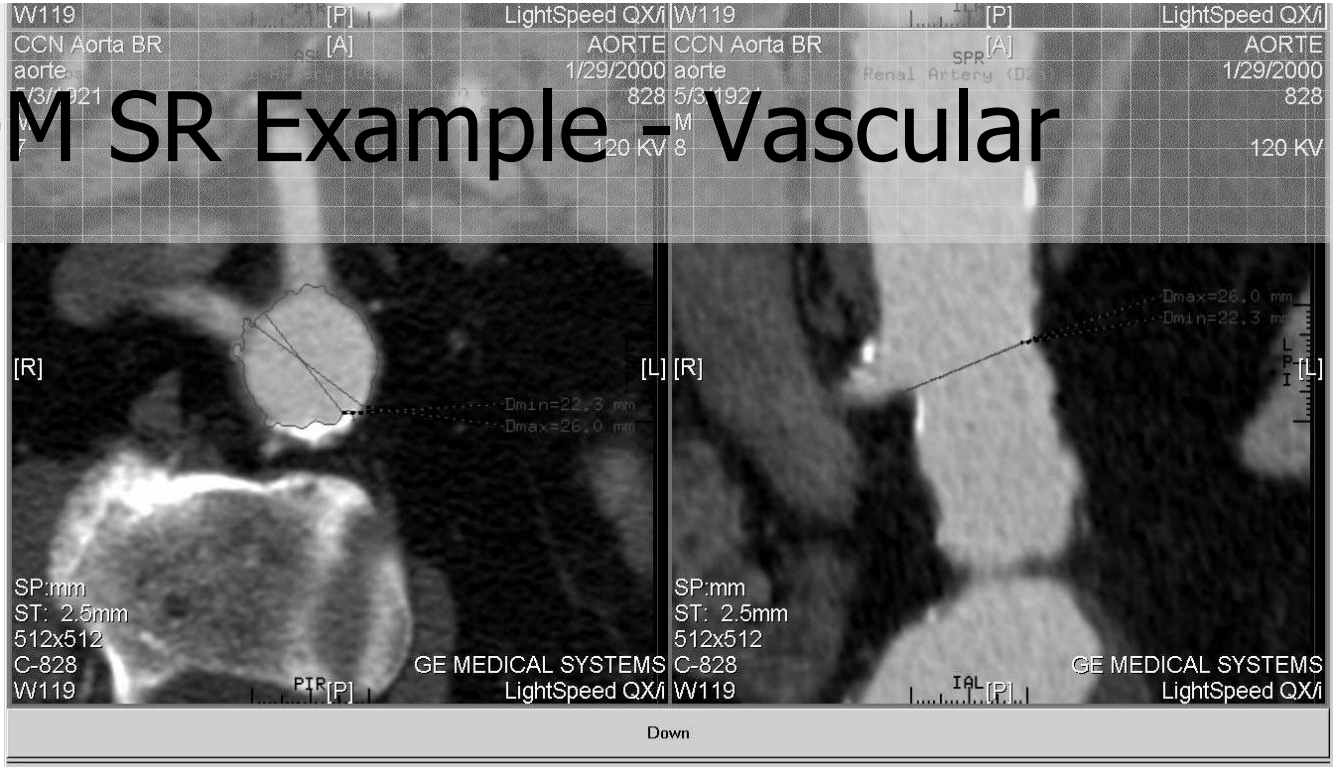
PD Dr. P. Mildenberger

Id: 317128
Eva Karl

Page 3 of 3

DICOM SR Example - Vascular

- CAD output for quantitation DSA, CTA, MRA
- Awaiting Suppl. 97



Down

Current Procedure Description : thickness: IV, spacing: 2.500000, kV: 1.250000, mA: 120

Vessel Section Diameters and Area Measurements

Measurement Name : Section above Renal Arteries

Measurement Abbreviation : D1

Mean Diameter : 28.829111 Millimeter

Short Axis : 27.914459 Millimeter

Long Axis : 29.661556 Millimeter

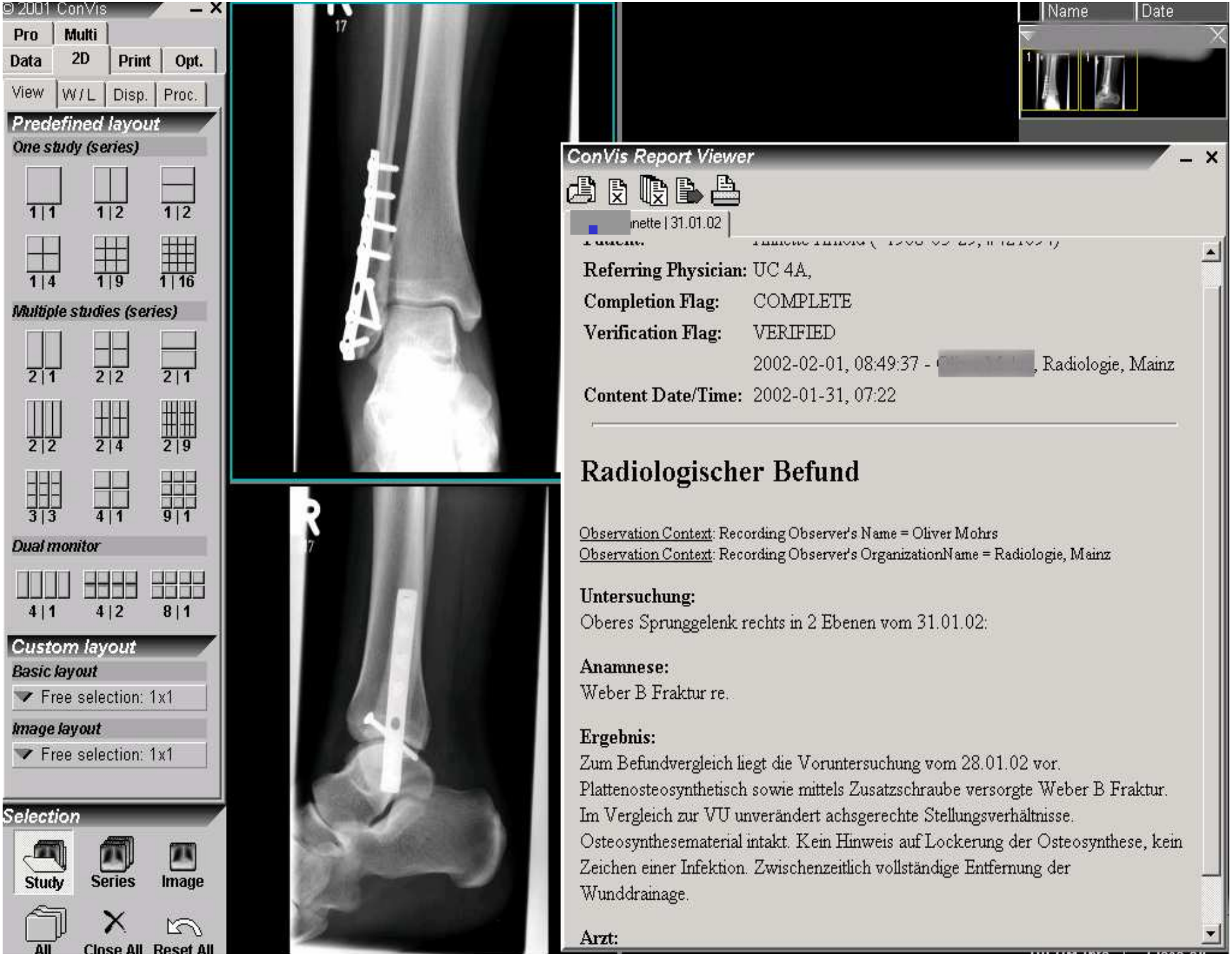
Area : 652.791565 Square Millimeter

Best Illustration of finding : 1.2.840.113619.2.80.2161049224.760.1002565988.7

Best Illustration of finding : 1.2.840.113619.2.80.2161049224.760.1002565988.8

Measurement Name : Most Inferior Renal Artery

Measurement Abbreviation : D2a


© 2001 ConVis
Pro
Multi
Data
2D
Print
Opt.
View
W / L
Disp.
Proc.
Predefined layout
One study (series)
1 | 1
1 | 2
1 | 2
1 | 4
1 | 9
1 | 16
Multiple studies (series)
2 | 1
2 | 2
2 | 1
2 | 2
2 | 4
2 | 9
3 | 3
4 | 1
9 | 1
Dual monitor
4 | 1
4 | 2
8 | 1
Custom layout
Basic layout
Free selection: 1x1
Image layout
Free selection: 1x1
Selection
Study
Series
Image
All
Close All
Reset All
Name
Date
ConVis Report Viewer
nette | 31.01.02
Referring Physician: UC 4A,
Completion Flag: COMPLETE
Verification Flag: VERIFIED
2002-02-01, 08:49:37 - , Radiologie, Mainz
Content Date/Time: 2002-01-31, 07:22
Radiologischer Befund
Observation Context: Recording Observer's Name = Oliver Mohrs
Observation Context: Recording Observer's OrganizationName = Radiologie, Mainz
Untersuchung:
Oberes Sprunggelenk rechts in 2 Ebenen vom 31.01.02:
Anamnese:
Weber B Fraktur re.
Ergebnis:
Zum Befundvergleich liegt die Voruntersuchung vom 28.01.02 vor.
Plattenosteosynthetisch sowie mittels Zusatzschraube versorgte Weber B Fraktur.
Im Vergleich zur VU unverändert achsgerechte Stellungsverhältnisse.
Osteosynthesematerial intakt. Kein Hinweis auf Lockerung der Osteosynthese, kein Zeichen einer Infektion. Zwischenzeitlich vollständige Entfernung der Wunddrainage.
Arzt:

DICOM SR Standardization Process

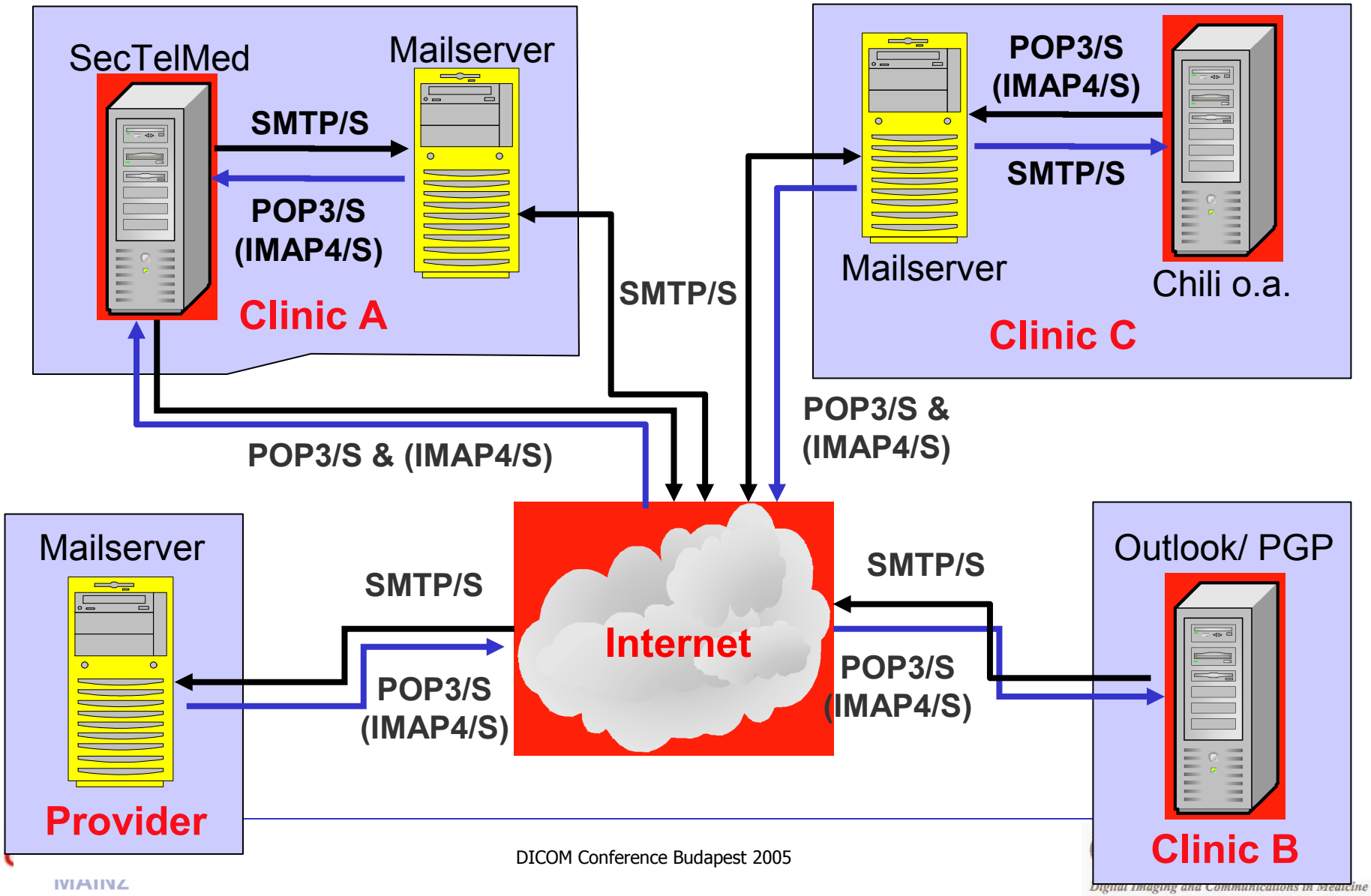
- Part 16 - Content Mapping Resource (2001)
- Supp 23 - Structured Reporting (2000)
- Supp 36 - Codes and Controlled Terminology (1999)
- Supp 50 - Mammography CAD (2001)
- Supp 65 - Chest CAD SR (2003)
- Supp 66 - Cath Lab SR (2004)
- Supp 71 - Vascular Ultrasound SR (2004)
- Supp 72 - Echocardiography SR (2004)
- Supp 75 - Patient History (2004)
- Supp 76 - Quant.Angiography and Ventriculography SR (2004)
- Supp 77 - Intravascular US SR (2004)
- Supp 78 - Fetal and Pediatric Echocardiography SR (preliminary)
- Supp 79 - Breast Imaging Report (2004)
- Supp 86 - Digital Signatures for Structured Reports (Early Draft)
- Supp 94 - Radiation Dose Report (Early Draft)
- Supp 97 - CT/MR Cardiovascular Analysis Report (Public comment)
- Supp 104 - DICOM Encapsulation of PDF Objects (Public comment)

Teleradiology

Request with / for Teleradiology

- Radiological consultation
- Radiological research
  - FTP or HTTP transfer possible,
    but uncomfortable and not user-friendly
- Normally teleradiology tools are not part of the various PAC-Systems
- Security, privacy aspects
- Interoparability with different vendors

Telemedicine via e-mail



Members of the Telemedicine-Initiative

Ärztliche Stelle Hessen

AGFA

Charité Berlin

Chili

ConVis

Curagita AG

DKFZ

FH Würzburg-Schweinfurt

GeSIT

GI Gesundheitsinformatik

Gesundheitsnetz-R

Image Devices

Medical Communications

OFFIS

Siemens

Steinhart Medizinsysteme

University Mainz

University Freiburg

University Mannheim

Limitations in Implementations

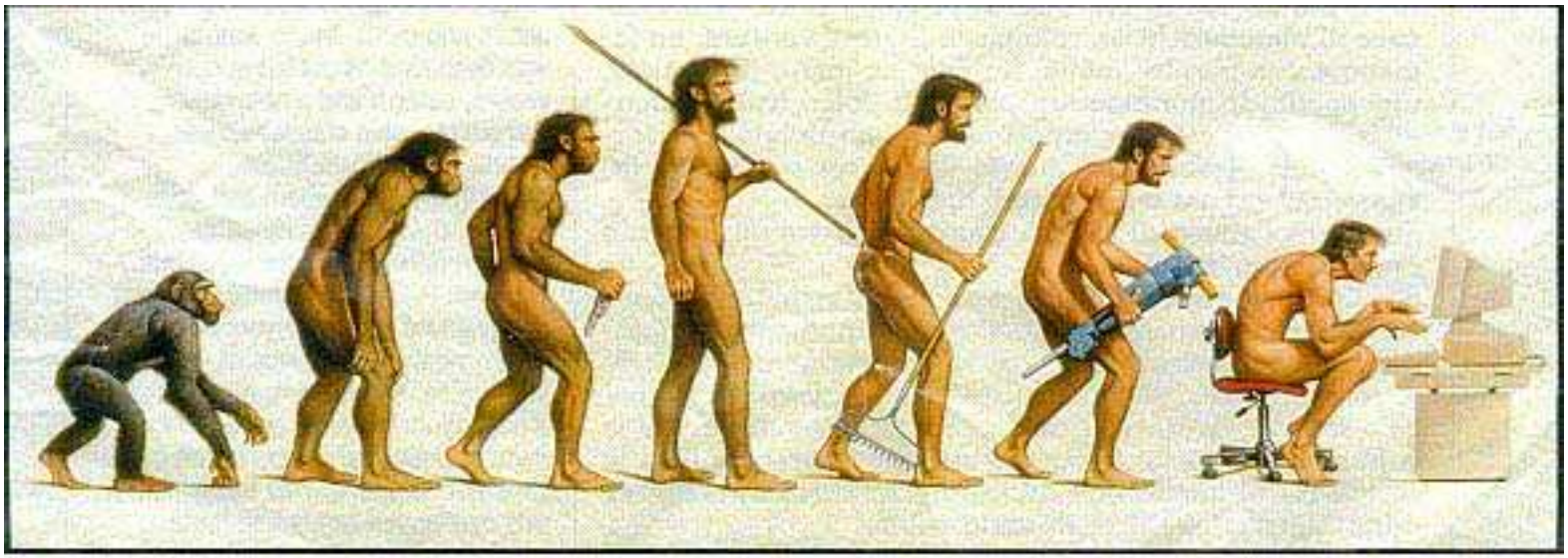
- Order / Entry
- Selection of relevant images (Key Objects)
- Access to images and reports
  - Compression
- Enterprise-wide patient identification
- GSDF
- DICOM-SR

National Recommendations in Germany

- DFG (German Science Foundation)
  - Image Management Systems to cover all imaging applications in hospitals
  - DICOM Services
    - DICOM Basic Services, MWL, MPPS, St.C.,
    - Print (opt.)
  - IHE – Profiles
    - For RFPs
- DRG (German Roentgen Society)
  - Teleradiology
    - DICOM eMail

Summary

- DICOM-based PACS opens many different opportunities to use optimal solutions for given requests (modalities, workstations, other domains…)
- Basic DICOM-services essential to improve the quality of data consistency, documentation, or workflow improvement
- DICOM-SR is evolving, used for quantified data and for report access through network or CDs
- DICOM eMail is a common approach for teleradiology between independant health care enterprises or PACS-solutions



Somewhere, something went terribly wrong

Thank you for your attention!

Peter.Mildenberger@web.de