

DOSE TRACKING IN DIAGNOSTIC RADIOLOGY

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DOSE TRACKING IN RADIODIAGNOSTIC

- Why track?
- What to track?
- How to track?
- How to use the information available from tracking?

WHY TRACK

Over the years, radiodiagnostic imaging has benefited from huge technological and scientific developments, specifically in the field of CT. The undesired effect was a **notable increase in the exposure of patients**.

A systematic dose tracking that implies **recording of dosimetric data for each radiological investigation** has been identified as a fundamental support to ensure patient radioprotection.

Two different approaches have been suggested:

- Tracking of radiation doses of a group of patients
- Tracking of radiological procedures and doses of an individual patient

TRACKING OF RADIATION DOSES OF A GROUP OF PATIENT



Dose Index Registry

The Dose Index Registry (DIR) is a data registry that allows facilities to compare their CT dose indices to regional and national values. Information related to dose indices for all CT exams is collected, anonymized, transmitted to the ACR, and stored in a database. Institutions are then provided with periodic feedback reports comparing their results by body part and exam type to aggregate results.

TRACKING OF RADIATION DOSES OF A GROUP OF PATIENT



U.S. Food and Drug Administration
Protecting and Promoting *Your* Health

Tracking Radiation Safety Metrics

FDA promotes tracking of radiation safety metrics (e.g. dose data and adverse events) by advocating the development of national registries and databases.

Equipment Features

The FDA is working with imaging device manufacturers to ensure their equipment is capable of automatically recording dose, protocol data, and patient information in standardized formats.

Dose Registries

Dose registries would enable facilities to compare their radiation doses to those delivered in other facilities for the same exam, and such comparisons over time could assist in optimizing patient radiation doses for medical imaging. The goals of tracking imaging exams and the associated radiation exposure include: (1) providing information at the point-of-care for the referring practitioner (i.e. supporting justification); (2) promoting development and use of diagnostic reference levels (DRLs) (i.e. supporting optimization); (3) providing information for assessment of radiation risks; and (4) establishing a tool for use in research and epidemiology.

TRACKING OF RADIOLOGICAL PROCEDURES AND DOSE OF AN INDIVIDUAL PATIENT

An IAEA Project, useful for **individual patient protection**.



The scope of patient radiation exposure tracking is to cover all imaging modalities which use ionizing radiation for interventional procedures and radiographic, fluoroscopic, computed tomography (CT), and nuclear diagnostic examinations.

The scope also includes radiation dose recording, reporting and tracking.

<https://www.iaea.org/resources/rpop/resources/smart-card>

REGULATORY INDICATIONS

Regulatory indications emphasize the need for justification of medical exposure and for strengthening the requirements concerning the recording and reporting of doses from medical procedures.

First case

Effective July 1, 2012, CT dose reporting became mandatory in California (Law codified in California Senate Bill 1237)



Directive 2013/59/Euratom - protection against ionising radiation, implemented by the European Union member states

(28)

In the medical area, important technological and scientific developments have led to a notable increase in the exposure of patients. In this respect, this Directive should emphasise the need for justification of medical exposure, including the exposure of asymptomatic individuals and should strengthen the requirements concerning information to be provided to patients, **the recording and reporting of doses from medical procedures**, the use of diagnostic reference levels and the availability of dose-indicating devices. It should be noted that according to the World Health Organisation the concept of health is understood to cover the physical, mental and social well-being of an individual and not merely the absence of disease or infirmity.

DOSE TRACKING

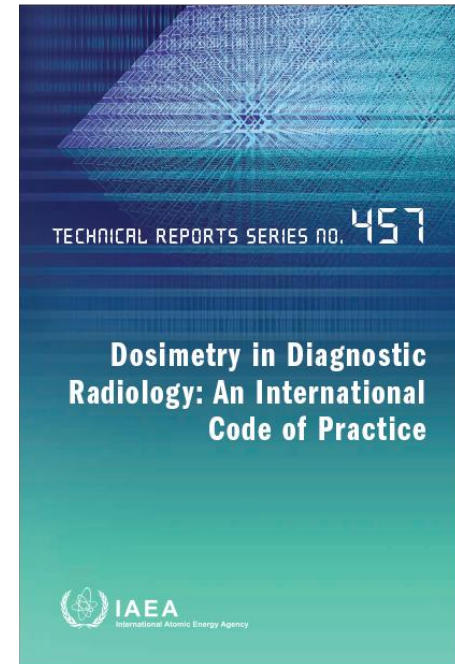
- Why track?
- What to track?
- How to track?
- How to use the information available from tracking?

References



ICRU Report 74

“Patient Dosimetry for X Rays Used in Medical Imaging” (2005)



IAEA TRS n.457

“Dosimetry in Diagnostic Radiology: an International Code of Practice” (2007)

Dosimetric indices

Modality	Dosimetric Indices
Conventional diagnostic	KAP
Mammography	KERMA in air Mean glandular dose
CT	CTDI DLP
Equipment for Interventional procedures	KAP KERMA at I.R.P.

DOSE TRACKING IN RADIODIAGNOSTIC

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- How to track?
 - How to record?
 - How to collect ‘
- How to use the information available from tracking?

FROM DISPLAYING TO RECORDING

Are all the equipments able of automatically recording dose data, protocol data, and patient information in standardized formats?

The answer is..... **it depends!!**

The aspects to be taken in account are modality, age of the equipment, manufacturer, but the possible solutions are:

- Dose display / proprietary Report
- DICOM Header (DICOM object)
- MPPS (DICOM object)
- RDSR (DICOM object)

DOSE DISPLAY and «not standard» REPORT

CTDIw on the console
for each scan



Patient Name (Country) : |

Patient Name (Multi-byte) : |

Patient ID : 15686

Study ID : 627

Sex : M

Patient's Birth Date : 1934.01.05

Patient's Age : 78Y

Image Comment :

Study Date : 2012.08.07

Body Part :

Contrast Enhance : CE

Contrast/Bolus Volume :

Contrast density :

Requesting Service :

Referring Physician's Name :

Name of Physician Reading Study :

Operators Name :

Total mAs in Study : 4749

Total Scan time in Study : 47.03

Total DLP mGycm : 1487.90

Total slice : 52

Scanning Sequence : HELICAL_CT

DOSE DISPLAY and «not standard» REPORT

Exam Information

Study ID: 28209

Time: Sep 14, 2018, 12:50:28

Total DLP: 2519.2 mGy*cm

Dose

DPL totale

[illegible]

Parametri per singola scansione

DICOM HEADER

The DICOM is an universal format which allows to exchange, view and analyse medical images independently of manufacturers.

Each medical image is associated with a DICOM Header. It is a block of data that contains specific information that complements the image, called DICOM tags. DICOM Tags can vary depending on modality, imaging detector and manufacturer, but generally include:

- data on patient
- data on exposure protocol
- data on geometrical set-up
- dosimetric indices

```
0008,1090 Manufacturer's Model Name: GIOTTO CLASS
0008,1111 Referenced Study Component Sequence:
0008,1150 Referenced SOP Class UID: 1.2.840.10008.3.1.2.3.3
0008,1155 Referenced SOP Instance UID: 2.16.840.1.113669.632.25.1.108802
0008,0100 Code Value: T-04000
0008,0102 Coding Scheme Designator: SRT
0008,0104 Code Meaning: Breast
0008,3010 ---: 2.16.840.1.113669.632.25.1.108802.20220331152739325.8
0010,0010 Patient's Name: ANONYMLN^ANONYMFN
0010,0020 Patient ID: 887766
0010,0030 Patient's Birth Date: 19500101
0010,0040 Patient's Sex: F
0010,1010 Patient's Age: 072Y
0018,0015 Body Part Examined: BREAST
0018,0060 kVp: 27
0018,1000 Device Serial Number: 108802
0018,1020 Software Versions(s): Raffaello 4.12.17.0 - IMSProc 4.12.16.0
0018,1030 Protocol Name: Mammography
0018,1110 Distance Source to Detector: 683.0
0018,1111 Distance Source to Patient: 666.0
0018,1114 ---: 1.0
0018,1147 Field of View Shape: RECTANGLE
0018,1149 Field of View Dimensions(s): 297\233
0018,1150 Exposure Time: 600
0018,1151 X-ray Tube Current: 134
0018,1152 Exposure: 80
0018,1153 Exposure in uAs: 80760
0018,1160 Filter Type: STRIP
0018,1164 Imager Pixel Spacing: 0.0829\0.0829
0018,1166 Grid: RECIPROCATING\FOCUSED
0018,1190 Focal Spot(s): 0.3
0018,1191 Anode Target Material: TUNGSTEN
0018,11A0 Body Part Thickness: 40
0018,11A2 Compression Force: 166.6
0018,11A4 ---: 24x30
0018,1405 Relative X-ray Exposure: 584
0018,1508 Positioner Type: MAMMOGRAPHIC
0018,1510 Positioner Primary Angle: 0
0018,1511 Positioner Secondary Angle: 3
0018,1530 Detector Primary Angle: 0
0018,1531 Detector Secondary Angle: 0
```

MPPS

Modality Performed Procedure Step

A DICOM service used to communicate the examination status, the number of images generated, and performed procedure information from the imaging modality to both the RIS and the PACS.

Although it was not originally designed to record dosimetric information, MPPS can also include radiation dose data. In the absence of other solutions, it can be used to extract dosimetric quantities, although the information available are often incomplete.

RDSR

(Radiation Dose Structured Report)

DICOM object, created for recording informations related to dosimetric aspects

- It exists for:
 - Conventional radiography
 - mammography
 - Fluoroscopy e fluorography
 - CT
- Mandatory fields
- Available in PACS

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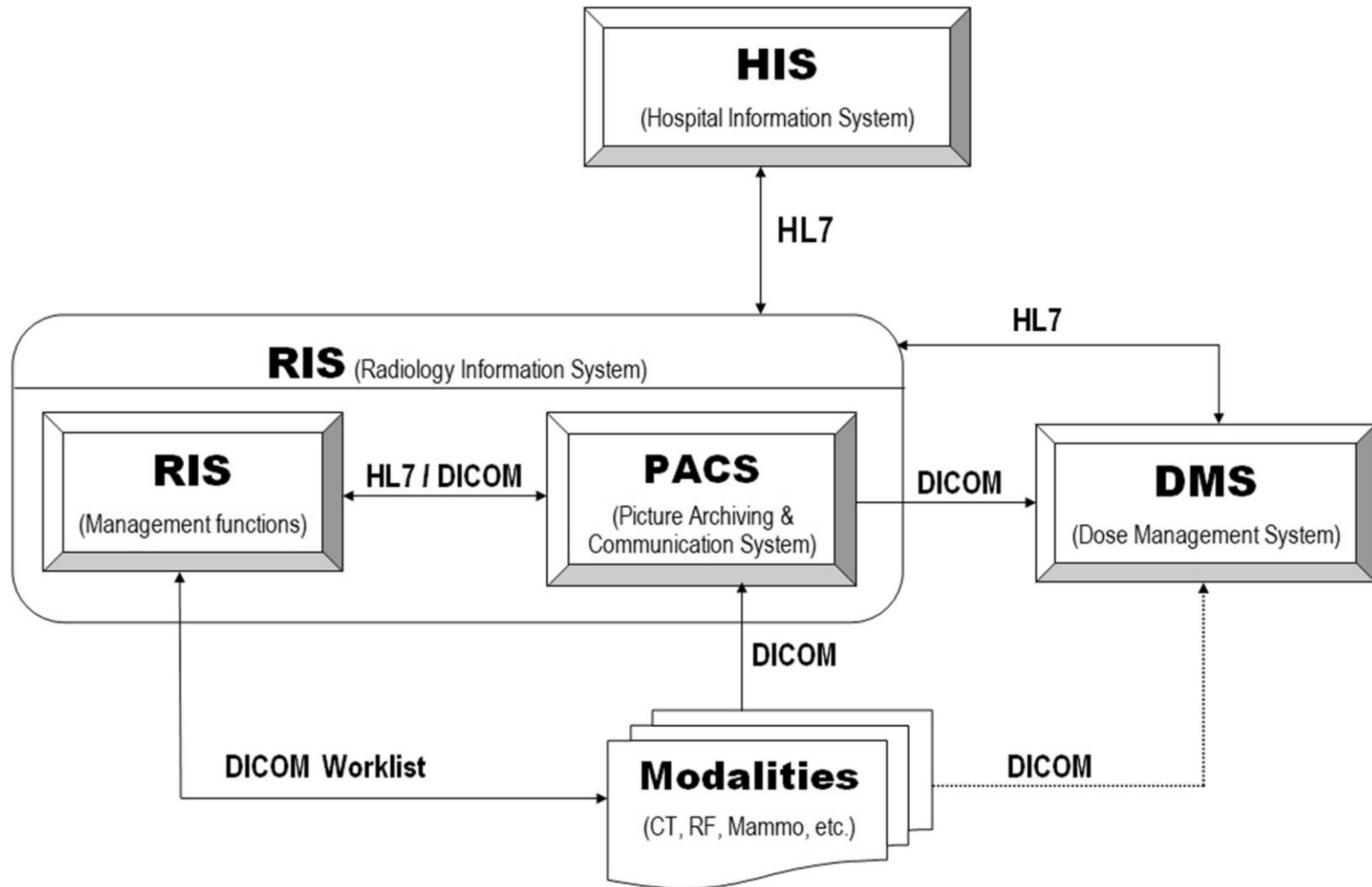
DOSE TRACKING SOFTWARE

Dose tracking software [more precisely RDIM (Radiation Dose Index Monitoring)] can automatically collect and store digital data related to patient radiation exposure (dosimetric indices) and other examination parameters in diagnostic imaging (exposure parameters, exposure geometrical conditions, information on the patient).

Although open-source programme are available and usable, generally commercial products are installed to create the dosimetric database.

All these software are multi-vendor, multimodality and able to collect dosimetric data as available.

RADIOLOGICAL WORKFLOW



COMMERCIAL RDIM



Product	Manufacturer
Dose Monitor	PACSHealth
DoseWatch	GE
Gray Detector	EL.CO.
Physico	EmmeEsse
Radiometric	BAYER
Synapse	FujiFilm
.....	



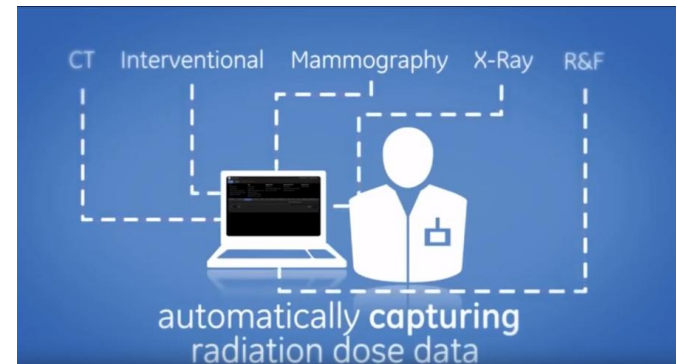
Not an exhaustive list, only some examples (more then 15 products are commercially available) Almost equivalent...

THE POWERFUL OF DOSE TRACKING SOFTWARE

Dose tracking software provide huge dosimetric database, including **thousands of investigations.**

Different modalities:

- **CT systems**
- Contrast injection systems
- Interventional Radiology (IR) systems
- Cardio-Vascular (CV) systems
- Mammography systems
- Radiography systems
- Surgical/mobile C-arms
- Nuclear Medicine and Molecular Imaging systems



DOSE TRACKING SOFTWARE: TOOLS

- Chronological trends for different parameters
- Statistical analysis, automatically provided
- Alert setting
- Effective dose estimation

CRONOLOGICAL TRENDS

The screenshot shows a medical imaging software interface with various filters and a list of parameters. Annotations highlight specific features:

- Age Range:** An arrow points from the 'Anni' dropdown menu (set to 'da 0 a 130') to a box labeled 'Age Range'.
- Period of interest:** An arrow points from the 'Data dello studio' dropdown menu (set to 'Tutto') to a box labeled 'Period of interest'.
- Parameter:** An arrow points from the 'Parametro' dropdown menu (set to 'STDlvol (mGy) | S') to a box containing a list of parameters and a 'CT' label.

Parameter:

- $CTDI_{vol}$
- collimation
- current
- DLP_{Tot}
- $DLP_{Tot} 16$
- $DLP_{Tot} 32$
- Effective Dose VP
- mAs
- Scan lenght
- SSDE.....

CT

CRONOLOGICAL TRENDS

Serie 1

Sede
OSPEDALE DI CATTINARA ▼

Apparecchiatura
MG ▼ Mammografo - ▼

Anni
da 20 a 51 ▼

Operatori
Seleziona ▼

Data dello studio
01-01-2025 28-05-2025 Oggi ▼

Descrizione Studio
Tutte ▼

Eta' all'esame
Range slider

Classificazione Dosimetrica
Tutte ▼

Parametri
Compression Force SR (N) ▼

Distretto Anatomico
Tutti ▼

Sesso
Tutti ▼

Range
0 0 0

Protocollo di Acquisizione
Tutti ▼

Filtri Avanzati: 0 Filtri Applicati

Period of interest

Age Range

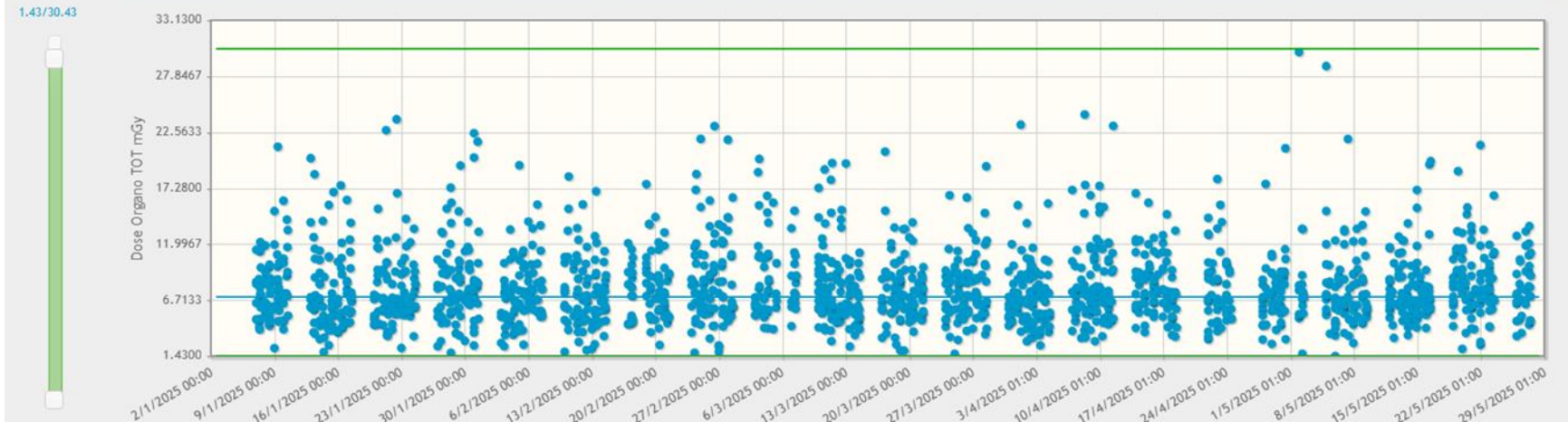
Parameter:

- Focal spot,
- kV,
- filter,
- HVL,
- mAs,
- Organ Dose,
- Total Organ Dose,
- Total Organ Dose Right;
- Total Organ Dose Left ,
- Air kerma,

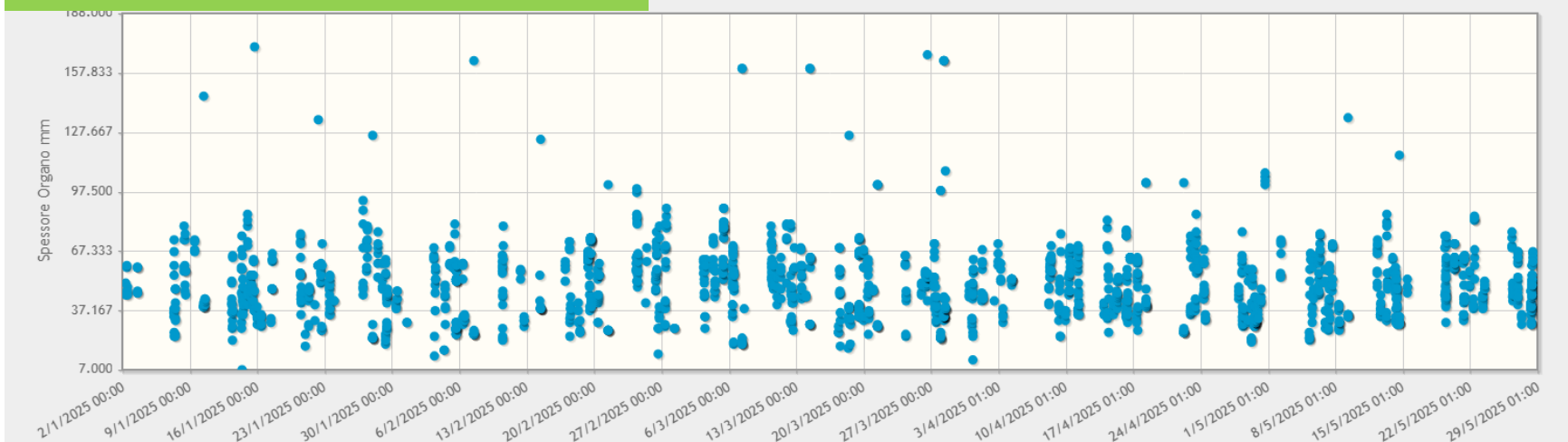
MAMMO

CRONOLOGICAL TRENDS

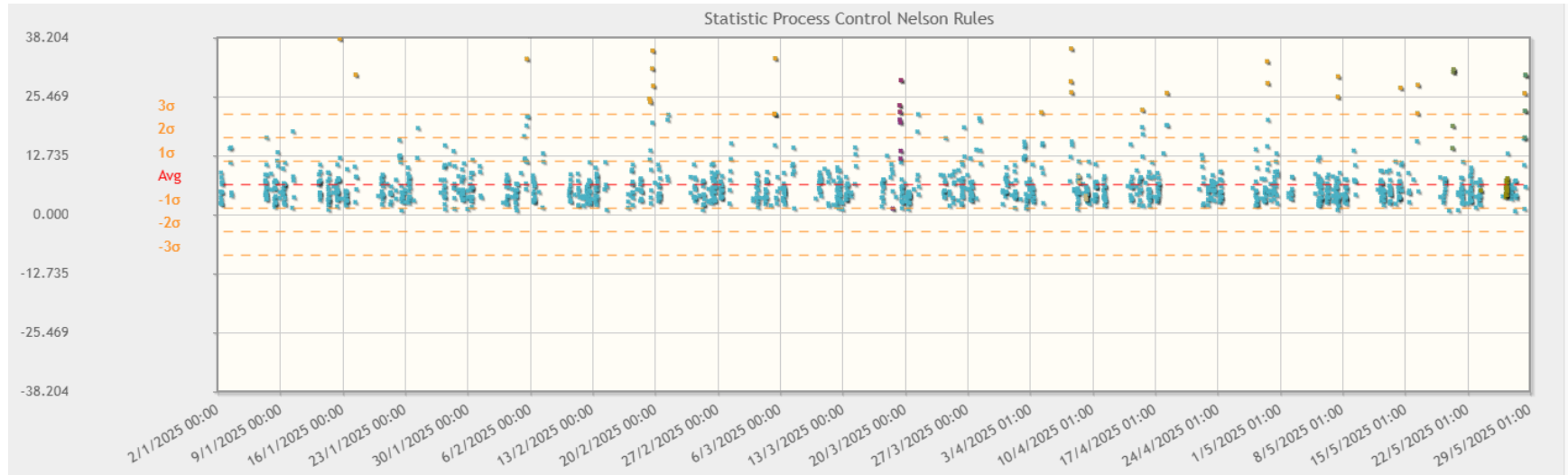
TOTAL Organ Dose – 1802 Records



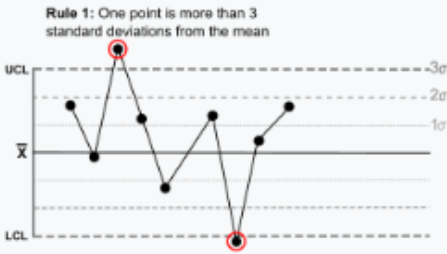
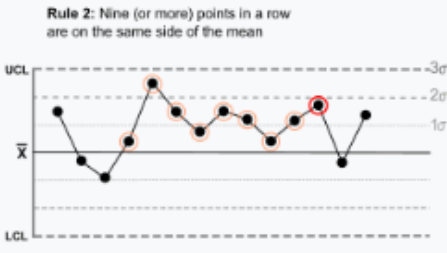
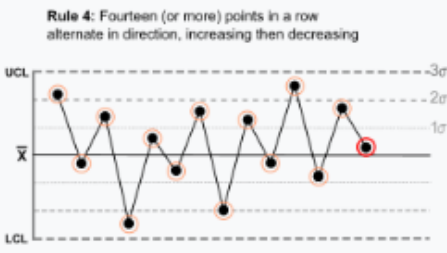
Organ Thickness – 1802 Records



STASTIC PROCESS CONTROL NELSON RULES



The rules are applied to a control chart on which the magnitude of some variable is plotted against time. The rules are based on the mean value and the standard deviation of the samples.

Rule	Description	Chart Example	Problem Indicated
Rule 1	One point is more than 3 standard deviations from the mean.	Rule 1: One point is more than 3 standard deviations from the mean 	One sample (two shown in this case) is grossly out of control.
Rule 2	Nine (or more) points in a row are on the same side of the mean.	Rule 2: Nine (or more) points in a row are on the same side of the mean 	Some prolonged bias exists.
Rule 3	Six (or more) points in a row are continually increasing (or decreasing).		A trend exists.
Rule 4	Fourteen (or more) points in a row alternate in direction, increasing then decreasing.	Rule 4: Fourteen (or more) points in a row alternate in direction, increasing then decreasing 	This much oscillation is beyond noise. Note that the rule is concerned with directionality only. The position of the mean and the size of the standard deviation have no bearing.

Rule 5	Two (or three) out of three points in a row are more than 2 standard deviations from the mean in the same direction.	Rule 5: Two (or three) out of three points in a row are more than 2 standard deviations from the mean in the same direction	There is a medium tendency for samples to be mediumly out of control. The side of the mean for the third point is unspecified.
Rule 6	Four (or five) out of five points in a row are more than 1 standard deviation from the mean in the same direction.	Rule 6: Four (or five) out of five points in a row are more than 1 standard deviation from the mean in the same direction	There is a strong tendency for samples to be slightly out of control. The side of the mean for the fifth point is unspecified.
Rule 7	Fifteen points in a row are all within 1 standard deviation of the mean on either side of the mean.	Rule 7: Fifteen points in a row are all within 1 standard deviation of the mean on either side of the mean	With 1 standard deviation, greater variation would be expected.
Rule 8	Eight points in a row exist, but none within 1 standard deviation of the mean, and the points are in both directions from the mean.	Rule 8: Eight points in a row exist with none within 1 standard deviation of the mean and the points are in both directions from the mean	Jumping from above to below while missing the first standard deviation band is rarely random.

STATIC PROCESS CONTROL NELSON RULES

Each violation is stored and the specific situation can be investigated.

Study Date

Dataset Regola 1

Legend: Data Series (blue), Rule 1 (orange), Rule 3 (yellow), Rule 5 (green), Rule 6 (dark green), Rule 7 (olive), Rule 8 (purple)

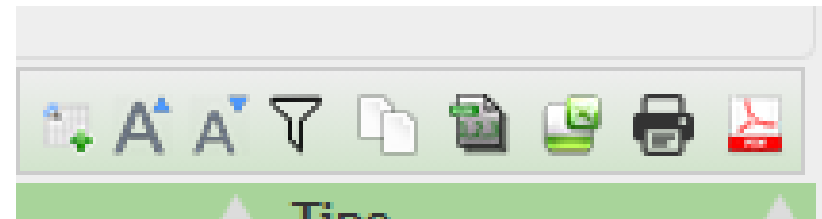
Actions: [Copy] [Print] [Export] [PDF] [Excel]

Data Ora	▲ Valore	▲ Azioni
5-3-2025 8:59	21.66	[Icon]
5-3-2025 9:35	21.74	[Icon]
7-4-2025 14:52	28.73	[Icon]
7-4-2025 15:50	35.81	[Icon]
7-4-2025 16:23	26.38	[Icon]
7-5-2025 12:35	25.4	[Icon]
7-5-2025 13:16	29.8	[Icon]

Showing 31 to 37 of 37 entries

Navigation: Previous | 1 | 2 | 3 | 4 | Next

MASSIVE EXPORT OF DATABASE



Id	Alias	Ambito	Tipo
821	Verifica Distretti (service)	Dose Paziente	
822	Verifica Nomenclatore (service)	Dose Paziente	
823	Inserimento Classi di Dose (service)	Dose Paziente	
824	Valori Serie Evento	Dose Paziente	
825	Valori Studio	Dose Paziente	
826	Valori Cumulativi	Dose Paziente	

Single acquisition

Entire procedure

STATISTICAL ANALYSIS

MAMMO

STATIONARY ACQUISITION / cranio-caudal

Spessore di PMMA (mm)	Spessore compresso (mm)	Range spessore considerato (mm)	Media DGM (mGy)	Mediana DGM (mGy)	75° percentile (mGy)	LDR (mGy)	LDR Screening Acc./Ragg. (mGy)	Range (mGy)	Numerosità del campione
20	21	[0 - 25]	1.07	1.04	1.2	< 1.2	< 1.2 / 0.8	[0.24 - 3.16]	138
30	32	[26 - 37]	1.31	1.26	1.46	< 1.5	< 1.5 / 1.0	[0.68 - 3.18]	554
40	45	[38 - 48]	1.6	1.5	1.79	< 2.0	< 2.0 / 1.6	[1.01 - 3.7]	644
45	53	[49 - 54]	1.83	1.71	1.96	< 2.5	< 2.5 / 2.0	[1.27 - 4.11]	377
50	60	[55 - 64]	2.16	1.96	2.35	< 3.0	< 3.0 / 2.4	[1.43 - 4.96]	377
60	75	[65 - 81]	2.75	2.57	3.01	< 4.5	< 4.5 / 3.6	[1.89 - 6.4]	211
70	90	[82 - 1000]	4.61	4.54	4.97	< 6.5	< 6.5 / 5.1	[2.73 - 5.29]	30

Media ESD (mGy)	Mediana ESD (mGy)	75° percentile (mGy)	LDR (mGy)	Range (mGy)	Numerosità del campione
5.49	4.81	6.45	< 10.0	[0.51 - 26.91]	2331

DRL values

The values are «reference depending»

- Mean value
- 50% Percentile
- 75 %Percentile
- Range
- Sample size



STATISTICAL ANALYSIS

Bilateral mammography

Opzioni di ricerca

Data (da)

2023-01-01

Data (a)

2023-12-31

Modalità

MG

Apparecchiatura

Mammografo - Radiologia

Parametro di Studio

Dose Organo TOT

Parametro di Serie

Dose Organo

Parametro di Aggregazione

LDR Group 1 (Proiezione...

Genere

Tutti

Range età all'esame (anni)

Da 0 A 150

Download dati grezzi

Ambito Studio

Ambito Evento (RDSR)

Ambito Serie (DICOM)

Elenco studi RIS

☐ Agoaspirato in stereotassi mammella-Destro/a || 26239537

☐ Agoaspirato in stereotassi mammella-Sinistro/a || 26239538

☐ Biopsia ecoguidata mammella-Sinistro/a || 18952

☐ Biopsia ecoguidata tru-cut mammella-Sinistro/a || 18852

☐ Biopsia guidata stereotassica vacuum assisted mammella || 210

☐ Biopsia guidata stereotassica vacuum assisted mammella-Sinistro/a || 4006352

☐ Diagnosi dipartimentale di screening della mammella || 5127

☐ Ecografia mammella bilaterale || 88.73.1 || 423

☐ Ecografia mammella monolaterale sx || 88.73.2 || 424538

☐ Posizionamento ecoguidato mammo-repere monolaterale dx || 88.73.2 || 672537

☐ Radiografia di pezzo operatorio di mammella - R5024 || 3121

☒ Rx mammografia bilaterale || 87.37.1 || 846

☐ Rx mammografia monolaterale dx || 87.37.2 || 847537

☐ Rx mammografia monolaterale sx || 87.37.2 || 847538

☐ Visita radiologica || 3708

Elenco studi PACS

☐ Ecografia mammella bilaterale

☒ Rx mammografia bilaterale

☐ Rx mammografia monolaterale dx

☐ Rx mammografia monolaterale sx

☐ Visita radiologica

Elenco serie

☐ cranio-caudal Rotational Acquisition

☒ cranio-caudal Stationary Acquisition

☐ latero-medial Rotational Acquisition

☐ latero-medial Stationary Acquisition

☐ medio-lateral oblique Rotational Acquisition

☐ medio-lateral oblique Stationary Acquisition

☐ medio-lateral Rotational Acquisition

☐ medio-lateral Stationary Acquisition

Analysis on Total MGD (mGg)

Media	5.26
Mediana	4.66
P05 - P95	[2.53,9.16]
P25 - P75	[3.54,6.02]
Min - Max	[0.7,52.06]
Campione considerato (studi)	3871 su 3873 eseguiti
Studi/bimestre	265

Only C-C Stationary Acq. [2]

Media	2.46
Mediana	2.25
P05 - P95	[1.26,4.31]
P25 - P75	[1.71,2.90]
Min - Max	[0.52,15.70]
Campione	3442
Studi/bimestre	235

Only a single CC Stationary Acq

Media	1.18
Mediana	1.09
P05 - P95	[0.59,2.07]
P25 - P75	[0.82,1.41]
Min - Max	[0.21,8.62]
Campione	7167
Serie/bimestre	490

Export
DCM

EQUIPMENT 1

EQUIPMENT 2

Elenco studi PACS

☐ Ecografia mammella bilaterale

☒ Rx mammografia bilaterale

☐ Rx mammografia monolaterale dx

☐ Rx mammografia monolaterale sx

☐ Visita radiologica

Elenco serie

☒ cranio-caudal Rotational Acquisition

☐ cranio-caudal Stationary Acquisition

☐ latero-medial Rotational Acquisition

☐ latero-medial Stationary Acquisition

☐ medio-lateral oblique Rotational Acquisition

☐ medio-lateral oblique Stationary Acquisition

☐ medio-lateral Rotational Acquisition

☐ medio-lateral Stationary Acquisition

Analysis on Total MGD (mGg)

Media	5.26
Mediana	4.66
P05 - P95	[2.53,9.15]
P25 - P75	[3.54,6.02]
Min - Max	[0.7,52.06]
Campione considerato (studi)	3871 su 3873 eseguiti
Studi/bimestre	265

Only C-C Rotational Acq. [2]

Media	3.01
Mediana	2.69
P05 - P95	[1.22,5.53]
P25 - P75	[2.09,3.65]
Min - Max	[0.78,12.63]
Campione	509
Studi/bimestre	35

Only a single CC Rotational Acq

Media	1.56
Mediana	1.36
P05 - P95	[0.88,2.79]
P25 - P75	[1.10,1.87]
Min - Max	[0.78,6.71]
Campione	981
Serie/bimestre	67

Analysis on Total MGD (mGg)

Media	4.79
Mediana	4.42
P05 - P95	[2.70,8.22]
P25 - P75	[3.66,5.53]
Min - Max	[0.06,20.66]
Campione considerato (studi)	2860 su 2866 eseguiti
Studi/bimestre	195

Only C-C Rotational Acq. [2]

Media	0.13
Mediana	0.13
P05 - P95	[0.06,0.22]
P25 - P75	[0.10,0.16]
Min - Max	[0.05,0.42]
Campione	627
Studi/bimestre	43

Only a single CC Rotational Acq

Media	0.07
Mediana	0.07
P05 - P95	[0.05,0.11]
P25 - P75	[0.06,0.08]
Min - Max	[0,0.22]
Campione	1128
Serie/bimestre	77

RDSR of equipment 2 seems to record only the MGD of a single projection of the rotational acquisition

STATISTICAL ANALYSIS

CT

Analysis on $CTDI_{vol}$ and DLP per a **single CT scan**

CT scans by **anatomical region/protocol** (*Head, Chest, Abdomen....*)

Valori per evento radiante: $CTDI_{vol}$ e DLP

Distribuzione dei parametri di singoli eventi radianti raggruppati per protocolli come codificati nelle impostazioni.

Distretto / Protocollo	Grandezza	Media	Mediana	75° percentile	LDR	Range interquartile	Range	Numerosità del campione	Frequenza bimestrale media nel periodo selezionato (365 giorni)
Addome	$CTDI_{vol}$ (mGy) DLP (mGycm)	8.59 421.29	8.2 393.55	10.73 532.38	18 550	5.15 269.86	[1.48 - 41.56] [51.48 - 2753.34]	2396 2396	393.6 393.6
Arti Inferiori	$CTDI_{vol}$ (mGy) DLP (mGycm)	9.7 485.63	10.37 330.31	10.37 681.67	n/d n/d	2.75 460.27	[2.69 - 25.99] [98.23 - 1360.13]	207 207	34.2 34.2
Arti Superiori	$CTDI_{vol}$ (mGy) DLP (mGycm)	15.55 331.16	14.89 281.14	21.53 459.26	n/d n/d	13.23 303.73	[2.03 - 38.26] [26.08 - 1158.96]	154 154	25.2 25.2
Collo	$CTDI_{vol}$ (mGy) DLP (mGycm)	10.51 315.21	10.48 305.15	11.22 356.47	n/d n/d	1.7 90.71	[4.01 - 19.38] [93.87 - 729.5]	165 165	27.0 27.0
Collo-Torace	$CTDI_{vol}$ (mGy) DLP (mGycm)	8.74 408.94	8.53 449.26	12.15 509.98	n/d n/d	7 255.5	[3.99 - 14.26] [188.57 - 650.42]	10 10	1.8 1.8
Colo-TC	$CTDI_{vol}$ (mGy) DLP (mGycm)	2.06 100.45	1.72 103.51	2.42 115.75	11 n/d	0.49 30.25	[0.03 - 2.42] [1.59 - 143.27]	134 134	22.2 22.2
Colonna cervicale	$CTDI_{vol}$ (mGy) DLP (mGycm)	5.07 89.79	5.07 89.79	5.07 89.79	n/d n/d	0 n/d	[5.07 - 5.07] [89.79 - 89.79]	1 1	0.0 0.0
Coronaro-TC	$CTDI_{vol}$ (mGy) DLP (mGycm)	16.89 286.54	15.41 246.85	26.32 376.33	60 1200	21 307.38	[0.16 - 60.49] [1.3 - 3192.28]	245 245	40.2 40.2
Cranio	$CTDI_{vol}$ (mGy) DLP (mGycm)	49.34 1030.75	47.37 948.91	51.57 1075.02	70 1300	6.83 207.82	[22.49 - 99.44] [278.06 - 2777.7]	3129 3129	514.2 514.2
Cranio-Collo	$CTDI_{vol}$ (mGy) DLP (mGycm)	28.98 649.64	15.69 508.57	47.4 930.93	n/d n/d	35.96 618.34	[0.03 - 83.89] [1.14 - 2554.69]	801 801	131.4 131.4
orace, addome, pelvi	$CTDI_{vol}$ (mGy) DLP (mGycm)	8.45 457.3	8.51 393.58	10.49 630.78	n/d n/d	4.72 365.67	[1.24 - 35.02] [54.73 - 1823.73]	1755 1755	288.6 288.6
Pelvi	$CTDI_{vol}$ (mGy) DLP (mGycm)	18.18 569.56	16.91 695.72	21.36 695.72	n/d n/d	7.79 354.98	[7.53 - 39.5] [186.63 - 2088.09]	59 59	9.6 9.6
Rachide Cervicale	$CTDI_{vol}$ (mGy) DLP (mGycm)	11.87 246.37	11.7 245.09	13.84 327.46	n/d n/d	4.83 148.24	[5.53 - 24.9] [58.34 - 525.46]	56 56	9.0 9.0
Rachide Dorsale	$CTDI_{vol}$ (mGy) DLP (mGycm)	18.5 779.48	18.16 470.31	23.56 909.26	n/d n/d	10.04 546.27	[8.73 - 29.7] [191.17 - 2070.62]	19 19	3.0 3.0
Rachide Lo	$CTDI_{vol}$ (mGy) DLP (mGycm)	18 1.2	26.69 776.95	26.69 776.95	n/d n/d	14.1 473.21	[7.95 - 36.98] [99.61 - 2157.3]	89 89	14.4 14.4
Torace	$CTDI_{vol}$ (mGy) DLP (mGycm)	8.67 45	8.67 85	8.67 336.24	15 600	5.03 196.03	[1.16 - 39.16] [37.83 - 947.91]	1036 1036	170.4 170.4
Torace, addome, pelvi	$CTDI_{vol}$ (mGy) DLP (mGycm)	8.44 559.44	8.95 575.52	10.55 741.82	18 1200	4.63 356.25	[0.03 - 14.72] [2 - 1041.3]	120 120	19.8 19.8
Total Body	$CTDI_{vol}$ (mGy) DLP (mGycm)	26.9 702.92	10.74 698.04	52.76 1059.58	n/d n/d	46.06 726.73	[2.86 - 52.77] [14.02 - 4219.61]	935 935	153.6 153.6
Uro-TC	$CTDI_{vol}$ (mGy) DLP (mGycm)	7.21 348.16	7.22 347.9	8.23 425.53	n/d n/d	2.08 185.46	[2.7 - 13.07] [58.92 - 721.56]	422 422	69.6 69.6

STATISTICAL ANALYSIS

1. Selection from RIS studies list (for Example: Abdomen TC and Abdomen TC with contrast)

Elenco studi RIS

- ☐ Angio TC dell'aorta toracica | 88.44.1 | 26126
- ☐ Angio TC dell'aorta toraco addominale | 88.47.2 | 26200
- ☐ Angio TC dell'aorta toraco addominale | 88.47.2 | 26200
- ☐ Angio TC di aorta addominale e arti inferiori | 88.47.3 | 26201
- ☐ Angio TC distretto vascolare intracranico | 88.41.1 | 36
- ☐ Angio TC vasi collo | 88.41.2 | 38
- ☐ Drenaggio TC guidato addome | 54.91.1 | 356
- ☒ TC addome completo | 88.01.5 | 913
- ☒ TC addome completo con MDC | 88.01.6 | 914
- ☐ TC addome inferiore con MDC (e/o pelvi, colon e retto, vescica, utero ed annessi o prostata) | 88.01.4 | 916
- ☐ TC addome inferiore (e/o pelvi, colon e retto, vescica, utero, annessi, prostata) | 88.01.3 | 915
- ☐ TC addome superiore con e senza MDC | 88.01.2 | 918
- ☐ TC articolazione coxofemorale femore con MDC-Destroia | 88.39.A | 920 S1
- ☐ TC articolazione coxofemorale femore con MDC-Sinistroia | 88.39.A | 920 S2
- ☐ TC articolazione coxofemorale femore-Destroia | 88.39.2 | 919 S1
- ☐ TC articolazione coxofemorale femore-Sinistroia | 88.39.2 | 919 S2
- ☐ TC arto superiore-Destroia | 88.38.H | 923 S1
- ☐ TC bacino e articolazioni sacro-iliache | 88.38.5 | 925
- ☐ TC caviglia-Destroia | 88.39.6 | 40165 S1
- ☐ TC caviglia-Entrambi | 88.39.6 | 40165 S3
- ☐ TC caviglia e/o piede dx | 88.38.6 | 927 S1
- ☐ TC caviglia e/o piede-Entrambi | 88.38.6 | 927 S3
- ☐ TC caviglia e/o piede sx | 88.38.6 | 927 S2
- ☐ TC caviglia e/o piede ex con MDC | 88.38.7 | 928 S2
- ☐ TC caviglia-Non specificato | 88.39.6 | 40165 S1
- ☐ TC caviglia-Sinistroia | 88.39.6 | 40165 S2
- ☐ TC collo con MDC (e/o gh.salivari, tiroide, paratiroide, faringe,laringe, esofago cervicale) | 87.03.8 | 3453
- ☐ TC collo (e/o gh.salivari, tiroide, paratiroide, faringe,laringe, esofago cervicale) | 87.03.7 | 3452
- ☐ TC coronarografia | 87.42.6 | 26178
- ☐ TC cranio-encefalo | 87.03 | 3450
- ☐ TC cranio-encefalo senza e con MDC | 87.03.1 | 3451
- ☐ TC femore (coscia) con MDC-Destroia | 88.39.B | 40167 S1
- ☐ TC femore (coscia) con MDC-Sinistroia | 88.39.B | 40167 S2
- ☐ TC femore (coscia)-Sinistroia | 88.39.3 | 40163 S2
- ☐ TC ginocchio con MDC-Destroia | 88.39.C | 40168 S1
- ☐ TC ginocchio-Destroia | 88.39.4 | 40164 S1
- ☐ TC ginocchio e gamba con MDC-Destroia | 88.39.G | 931 S1
- ☐ TC ginocchio e gamba con MDC-Sinistroia | 931 S2
- ☐ TC ginocchio e gamba-Destroia | 88.39.8 | 930 S1
- ☐ TC ginocchio e gamba-Sinistroia | 930 S2
- ☐ TC ginocchio-Sinistroia | 88.39.4 | 40164 S2
- ☐ TC gomito-Destroia | 88.38.J | 40154 S1
- ☐ TC gomito e avambraccio-Destroia | 88.38.P | 932 S1
- ☐ TC gomito-Non specificato | 88.38.J | 40154 S2
- ☐ TC mano con MDC-Destroia | 88.38.V | 40162 S1
- ☐ TC mano-Destroia | 88.38.M | 40157 S1

Elenco studi PACS

- ☐ Angio TC del circolo polmonare
- ☐ Angio TC dell'aorta addominale
- ☐ Angio TC dell'aorta toraco addominale
- ☒ TC addome completo
- ☒ TC addome completo con MDC
- ☐ TC articolazione coxofemorale femore con MDC-Sinistroia
- ☐ TC cranio-encefalo
- ☐ TC cranio-encefalo senza e con MDC
- ☐ TC femore (coscia) con MDC-Destroia
- ☐ TC massiccio facciale (Include av. ricostruzione tridimensionale)
- ☐ TC rachide cervicale
- ☐ TC rachide lombosacrale e sacrococcigeo
- ☐ TC rachide toracico (dorsale)
- ☐ TC torace con MDC (e/o: polmoni, aorta toracica, trachea, esofago, sterno, coste, mediastino)
- ☐ TC torace (e/o: polmoni, aorta toracica, trachea, esofago, sterno, coste, mediastino)

Elenco serie

- ☐ Abdomen 1.8 POLITRAUMA
- ☐ Abdomen 5.17 TOR ADDOME MDC DIR + MDC
- ☐ Abdomen 5.6 TOR ADD MDC ART +VENOSA
- ☐ Abdomen 5.7 TOTAL BODY ONCOLOGICO
- ☐ Abdomen 6.13 BIOPSIA IDRENAGGIO -ADDOME
- ☐ Abdomen 6.17 ADDOME TRIFASICO ANGIO
- ☐ Abdomen 6.2 ADDOME SMDC LOW DOSE X CALCOLI
- ☒ Abdomen 6.3 ADDOME DIRETTA + MDC
- ☒ Abdomen 6.4 ADDOME TRIFASICO FEGATO
- ☒ Abdomen 6.5 ADDOME TRIFASICO FEGATO
- ☐ Abdomen 6.7 ANGIO AORTA ADD
- ☐ Abdomen 6.8 ARTI INFERIORI
- ☐ Abdomen and Pelvis 6.13 BIOPSIA IDRENAGGIO -ADDOME
- ☐ Abdomen and Pelvis 6.17 ADDOME TRIFASICO ANGIO
- ☐ Abdomen and Pelvis 6.2 ADDOME SMDC LOW DOSE X CALCOLI
- ☐ Abdomen and Pelvis 6.3 ADDOME DIRETTA + MDC
- ☐ Abdomen and Pelvis 6.4 ADDOME TRIFASICO FEGATO
- ☐ Abdomen and Pelvis 6.5 ADDOME TRIFASICO FEGATO
- ☐ Abdomen and Pelvis 6.7 ANGIO AORTA ADD
- ☐ Brain 1.17 ENCEFALO MDC
- ☐ Brain 1.2 ENCEFALO SMDC HELICAL
- ☐ Brain 1.8 POLITRAUMA

2. Selection from PACS studies list

Statistica LDR DLP Totale (mGycm)

Media	1074.26
Mediana	825.53
P05 - P95	[325.26,3033.16]
P25 - P75	[542.88,1221.00]
Min - Max	[132.19,6137.85]
Campione considerato (studi)	242 su 271 eseguiti
Studi/bimestre	173

Statistica LDR aggregata DLP (mGycm)

Media	423.25
Mediana	432.91
P05 - P95	[2.94,1014.62]
P25 - P75	[3.45,607.85]
Min - Max	[2.90,1695.91]
Campione	176
Studi/bimestre	126

3. Only studies with protocols for abdomen

ALERT

Thresold is settable from the user

Trigger Manager

Ricerca trigger | **Impostazioni trigger** | Impostazioni trigger TAG

Modalità
MG ▼ Mammo - Radio ▼

Trigger	Parametro	Protocollo	Distretto
2	Dose Organo TOT (St) ▼	Tutti ▼	BREAST ▼

Parameter:

- Organ Dose,
- Total Organ Dose,
- Total Organ Dose Right;
- Total Organ Dose Left ,
- Air kerma,

Operatore	Valore Soglia	Età	Invia Mail	Alert	Non pubblicare
<= ▼			☐	☐	☐

Thresold Value

Age range

Action

EFFECTIVE DOSE

MAMMO

Effective dose is estimated from the Total MGD, using the Tissue weighing factors w_T for the breast, equal to 0.12 (ICRP 103).

Dose Efficace Totale (mSv)	1.29
Dose Organo TOT DX (mGy)	5.22
Dose Organo TOT SX (mGy)	5.45
Dose Organo TOT (mGy)	10.67
Numero Totale Eventi Radianti (num)	12

EFFECTIVE DOSE

CT

Effective dose is estimated using VP (Virtual Phantom)

Alert	▲ Etichetta	◆ Valore
✓	Numero Totale Eventi Radianti (num)	5
✓	Dose Efficace VP Totale (mSv)	22.56
✓	DLP Totale (mGycm)	1591.45
✓	DLP Totale 32 (mGycm)	1591.45
Alert	Etichetta	Valore

DOSE TRACKING IN RADIODIAGNOSTIC

- Why track?
- What to track?
- How to track?
 - How to record?
 - How to collect ?
- How to use the information available from tracking?

HOW TO USE THE INFORMATION AVAILABLE FROM TRACKING

Some examples:

- Support to optimization
- DRL verification
- Comparison among facilities
- Information for patients
-

OPTIMIZATION PROCESS

Dose tracking is an invaluable support in optimizing radiological procedures **but** all the analysis on the database (usually responsibility of the medical physicist) are only the starting point in the optimization process.

The results of the analysis should promote remedial actions, but the medical physicist can not work alone.

A synergic collaboration among radiologist, radiographer and physicist is a focal point.

A working group (**DOSE TEAM**) is required for monitoring over time the optimization process.

LEVEL OF STANDARDIZATION

The first, crucial problem: verify the level of standardization

Opzioni di ricerca

Data (da)

2025-01-01

Data (a)

2025-05-27

Modalità

CT

Apparecchiatura

TC - Sezione 15 - Radiol...

Parametro di Studio

DLP Totale

Parametro di Serie

DLP

Parametro di Aggregazione

LDR Group 1 (Distretto+...

Genere

Tutti

Range età all'esame (anni)

Da

0

A

150

Download dati grezzi

Ambito Studio

↓

Ambito Evento (RDSR)

↓

Ambito Serie (DICOM)

↓

Elenco studi RIS

☐ Ablazione tumorale con radiofrequenza - R5014 || 3111

☐ Angio TC arti inferiori || 40171

☐ Angio TC arti superiori bilaterale || 40174

☐ AngioTC arto inferiore | 88.48.1 | 33

☐ Angio TC dei vasi intracranici e del collo | 88.41.3 | 26194

☐ Angio TC dell'aorta addominale | 88.47.1 | 26199

☐ Angio TC dell'aorta toraco addominale | 88.47.2 | 26200

☐ Angio TC di aorta addominale e arti inferiori | 88.47.3 | 26201

☐ AngioTC distretto toracico | 88.9221 | 35

☐ AngioTC distretto vascolare intracranico | 88.41.1 | 36

☐ AngioTC vasi addominali | 88.9571 | 37

☐ AngioTC vasi collo | 88.41.2 | 38

☐ Biopsia agobiopsia TC guidata ossea || 156

☐ Drenaggio TC guidato addome | | 356

☐ TC addome completo | 88.01.5 | 913

☒ TC addome completo con MdC | 88.01.6 | 914

☐ TC addome inferiore con MdC (e/o pelvi, colon e retto, vescica, utero ed annessi o prostata) | 88.01.4 | 916

☐ TC addome inferiore (e/o pelvi, colon e retto, vescica, utero, annessi, prostata) | 88.01.3 | 915

☐ TC addome superiore con MdC (e/o fegato vie bil. pancreas, milza, retroperit, stomaco, duodeno, tenue, grossi vasi | 88.01.2 | 918

☐ TC addome superiore (e/o fegato vie biliari, pancreas, milza, retrop, stomaco, duodeno, tenue, grossi vasi add. | 88.01.1 | 917

☐ TC articolazione coxofemorale femore dx | 88.38.6 | 919S1

☐ TC articolazione coxofemorale femore sx | 88.38.6 | 919S2

☐ TC arto inferiore dx | 88.38.6 | 921S1

☐ TC bacino | 88.38.5 | 925

☐ TC capo con MdC (e/o encefalo, cranio, sella turcica, orbite) | 87.03.1 | 3451

☐ TC capo (e/o encefalo, cranio, sella turcica, orbite) | 87.03 | 3450

☐ TC caviglia e/o piede dx | 88.38.6 | 927S1

☐ TC caviglia e/o piede sx | 88.38.6 | 927S2

☐ TC collo con MdC (e/o gh. salivari, tiroide, paratiroide, faringe, laringe, esofago cervicale) | 87.03.8 | 3453

☐ TC collo (e/o gh. salivari, tiroide, paratiroide, faringe, laringe, esofago cervicale) | 87.03.7 | 3452

☐ TC coronarografia | 87.42.6 | 26178

☐ TC ginocchio-Destro/a || 40164S1

☐ TC ginocchio-Sinistro/a || 40164S2

☐ TC gomito-Destro/a || 40154S1

☐ TC mano-Destro/a || 40157S1

☐ TC massiccio facciale con MdC (e/o mascellare, seni paranasali, etmoide...

Elenco studi PACS

☐ AngioTC distretto toracico

☐ AngioTC vasi addominali

☒ TC addome completo con MdC

☐ TC capo con MdC (e/o encefalo, cranio, sella turcica, orbite)

☐ TC capo (e/o encefalo, cranio, sella turcica, orbite)

☐ TC collo con MdC (e/o gh. salivari, tiroide, paratiroide, faringe, laringe, esofago cervicale)

☐ TC rachide cervicale

☐ TC rachide lombosacrale

☐ TC rachide toracico (dorsale)

☐ TC torace con MdC (e/o: polmoni, aorta toracica, trachea, esofago, sterno, coste, mediastino)

☐ TC torace (e/o: polmoni, aorta toracica, trachea, esofago, sterno, coste, mediastino)

Elenco serie

☐ Abdomen 16.1.3 CT ABDOMEN 20-30 KG

☐ Abdomen 5.17 TOR ADDOME MDC DIR + MDC

☐ Abdomen 5.6 TOR ADD MDC ART + VENOSA

☐ Abdomen 5.7 TOTAL BODY ONCOLOGICO

☐ Abdomen 6.13 BIOPSIA /DRENAGGIO -ADDOME

☐ Abdomen 6.17 ADDOME TRIFASICO ANGIO

☐ Abdomen 6.19 URO - TC

☐ Abdomen 6.3 ADDOME DIRETTA + MDC

☐ Abdomen 6.4 ADDOME TRIFASICO FEGATO

☐ Abdomen 6.5 ADDOME TRIFASICO 40/80

☐ Abdomen 6.7 ANGIO AORTA ADD

☐ Abdomen and Pelvis 6.13 BIOPSIA /DRENAGGIO -ADDOME

☐ Abdomen and Pelvis 6.17 ADDOME TRIFASICO ANGIO

☐ Abdomen and Pelvis 6.19 URO - TC

☐ Abdomen and Pelvis 6.2 ADDOME SMDC LOW DOSE X CALCOLI

☐ Abdomen and Pelvis 6.3 ADDOME DIRETTA + MDC

☐ Abdomen and Pelvis 6.4 ADDOME TRIFASICO FEGATO

☐ Abdomen and Pelvis 6.5 ADDOME TRIFASICO 40/80

☐ Abdomen and Pelvis 6.7 ANGIO AORTA ADD

☐ Brain 1.8 POLITRAUMA

☐ Brain 1.9 ENCEFALO +MASS +CERV.

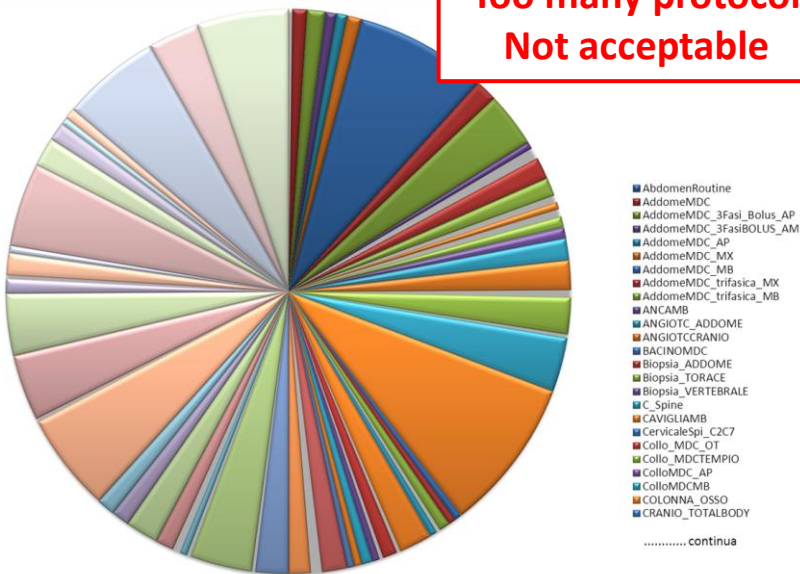
☐ Brain 5.18 TOTAL BODY POLITRAUMA

☐ Brain 5.7 TOTAL BODY ONCOLOGICO

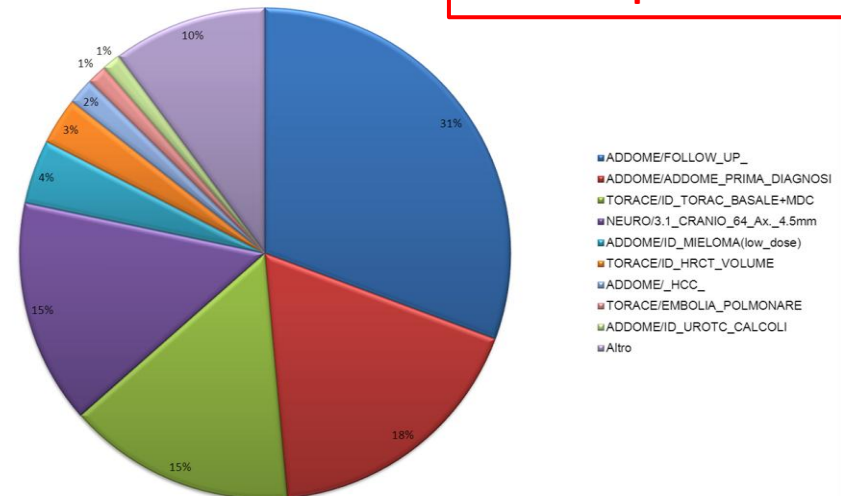
LEVEL OF STANDARDIZATION

Often, too many different protocols exist in the database, effect of a lack of standardization

**Too many protocol
Not acceptable**



Acceptable



MAMMOGRAPHY: NO PROBLEM AT ALL

Opzioni di ricerca

Data (da)

Data (a)

Modalità

Apparecchiatura

Parametro di Studio

Parametro di Serie

Parametro di Aggregazione

Genere

Range età all'esame (anni)

Da

A

Elenco studi RIS

- ☐ Ecografia mammella monolaterale dx | 88.73.2 | 424S37
- ☐ Radiografia di pezzo operatorio di mammella - R5024 | | 3121
- ☒ Rx mammografia bilaterale | 87.37.1 | 846
- ☐ Rx mammografia monolaterale dx | 87.37.2 | 847S37
- ☐ Rx mammografia monolaterale sx | 87.37.2 | 847S38
- ☐ Visione esami | | 4289

Elenco studi PACS

☒ Rx mammografia bilaterale

☐ Rx mammografia monolaterale dx

☐ Rx mammografia monolaterale sx

Elenco serie

- ☐ cranio-caudal Rotational Acquisition
- ☐ cranio-caudal Stationary Acquisition
- ☐ medio-lateral oblique Rotational Acquisition
- ☐ medio-lateral oblique Stationary Acquisition
- ☐ medio-lateral Rotational Acquisition
- ☐ medio-lateral Stationary Acquisition
- ☐ superolateral to inferomedial oblique Rotational Acquisition
- ☐ superolateral to inferomedial oblique Stationary Acquisition

DIAGNOSTIC REFERENCE LEVEL

Median values of distributions of DRL quantities at a facility should be compared with DRL values to support optimization process.

**To properly estimate the median values,
we need a “clean” database**

Critical problem in CT

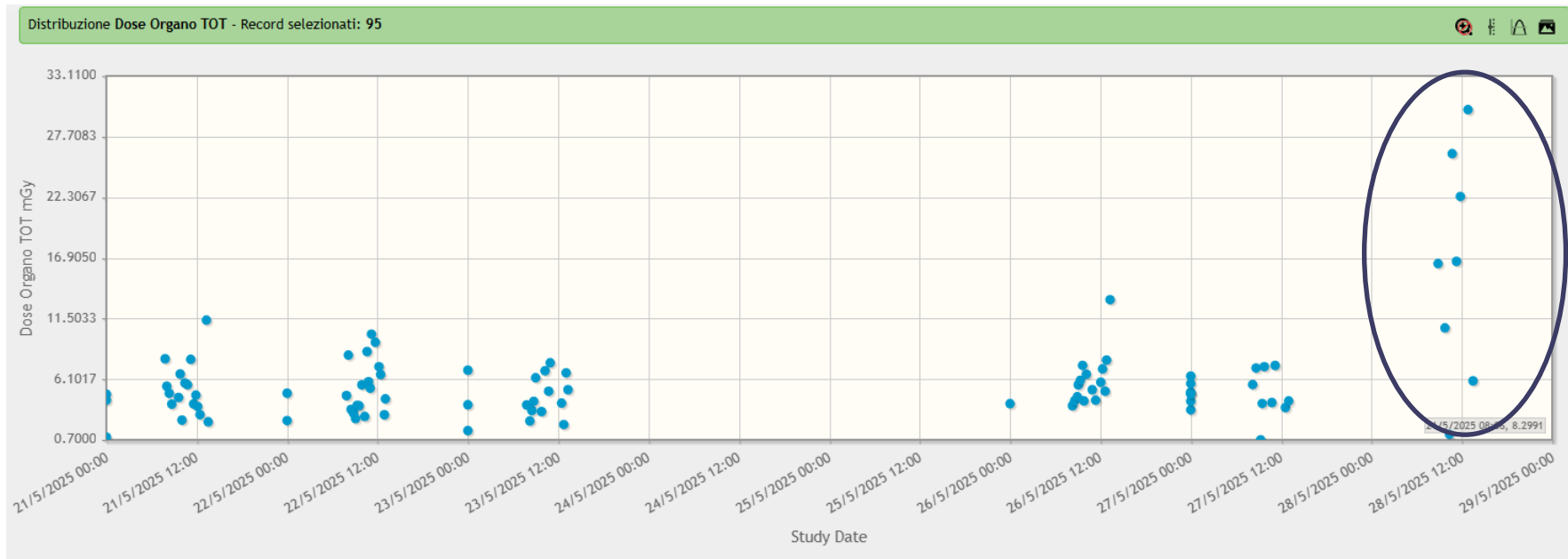
Acquisition protocol: Abdomen

Investigated district: abdomen + chest + head

Critical problem in mammography

Identify (CESM/CEDM/CEM)	Contrast	Enhanced	Spectral	Mammography
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CESM



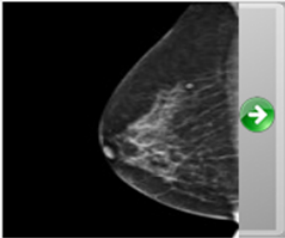
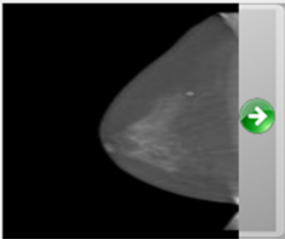
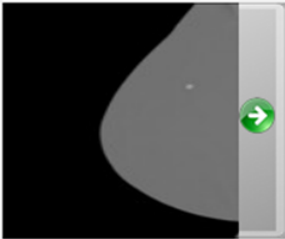
MAY 28th : 7 CESM procedures

DICOM HEADER

Dettaglio Studio

Informazioni Studio Valori **Rilievi DICOM HEADER** Rilievi DICOM SR

[Mostra tutti](#) - : 20 su



Descrizione Serie:	R CC DES
Identificativo Serie:	1.2.840.113681.168887139.1748417176.5080.55677
Numero di Oggetti:	1
Distretto:	BREAST
Protocollo:	R CC CEDM COMBO
Tipo di immagini:	DERIVED\PRIMARY\CONTRAST_IMAGE
Series Time:	104327
	

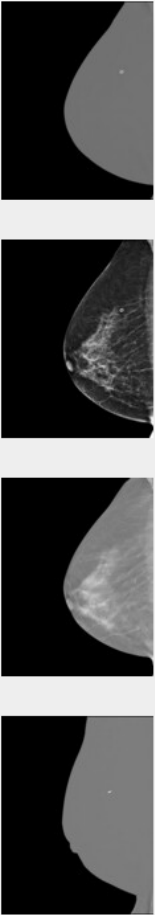
Descrizione Serie:	R CC Tomosynthesis Projection
Identificativo Serie:	1.2.840.113681.168887139.1748417176.5080.55683
Numero di Oggetti:	1
Distretto:	BREAST
Protocollo:	R CC CEDM COMBO
Tipo di immagini:	DERIVED\PRIMARY
Series Time:	104327
	

Descrizione Serie:	R CC LE
Identificativo Serie:	1.2.840.113681.168887139.1748417176.5080.55679
Numero di Oggetti:	1
Distretto:	BREAST
Protocollo:	R CC CEDM COMBO
Tipo di immagini:	DERIVED\PRIMARY\LOW_E_POST_CON
Series Time:	104327
	 

RDSR

Dettaglio Studio

Informazioni Studio Valori Rilievi DICOM HEADER **Rilievi DICOM SR**



Distretto:	BREAST
Protocollo:	--
Identificativo Evento Radiante:	1.2.840.113681.168887139.1748417176.5080.55881
Fantoccio:	--
Tipo di Evento:	STATIONARY ACQUISITION

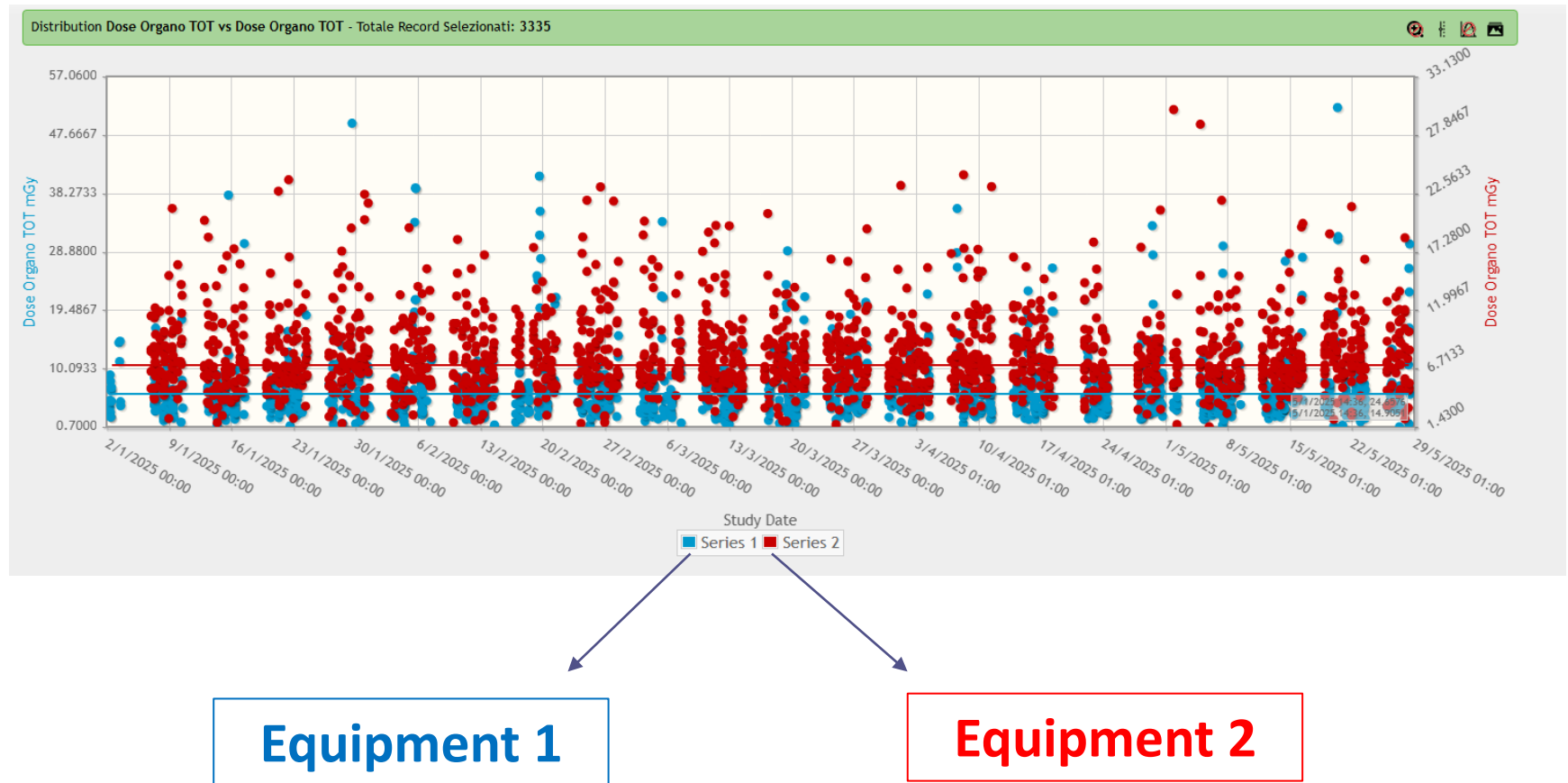
Distretto:	BREAST
Protocollo:	--
Identificativo Evento Radiante:	1.2.840.113681.168887139.1748417176.5080.55882
Fantoccio:	--
Tipo di Evento:	STATIONARY ACQUISITION

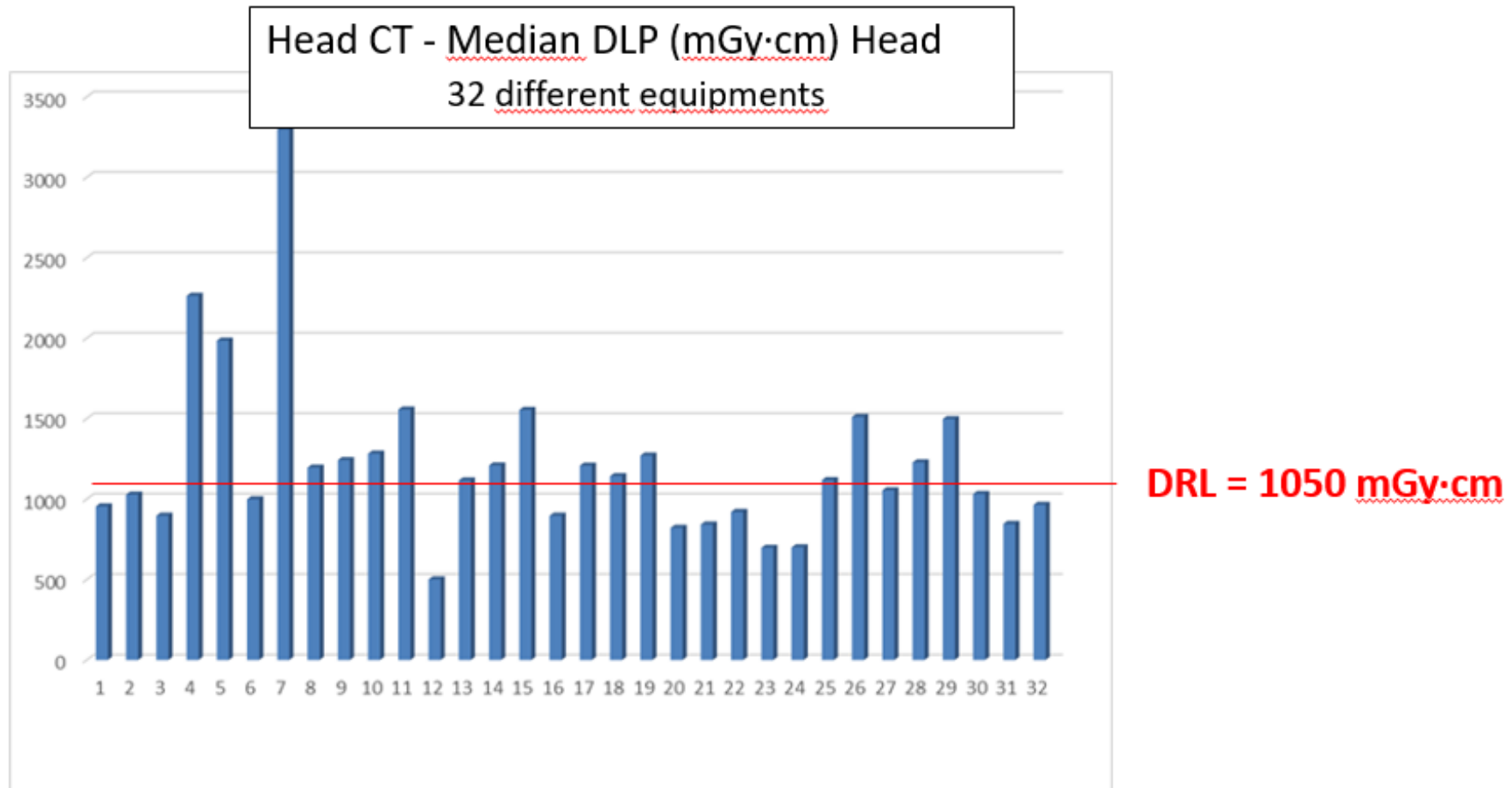
Distretto:	BREAST
Protocollo:	--
Identificativo Evento Radiante:	1.2.840.113681.168887139.1748417176.5080.55885
Fantoccio:	--
Tipo di Evento:	ROTATIONAL ACQUISITION

Distretto:	BREAST
Protocollo:	--
Identificativo Evento Radiante:	1.2.840.113681.168887139.1748417176.5080.55988
Fantoccio:	--
Tipo di Evento:	STATIONARY ACQUISITION

Two red arrows originate from the 'Rilievi DICOM SR' tab. One arrow points to the 'Identificativo Evento Radiante' field of the first table. The other arrow points to the 'Tipo di Evento' field of the third table.

COMPARISON AMONG FACILITIES





If the median DLP value exceeds the DRL... which is the problem?

Age of the equipment?, model? Iterative post-processing/AI-based algorithms used or not-used ? Incorrect selection of exposure parameter? Requirement of some special technique, for clinical needs?

INFORMATION FOR PATIENTS

Information relating to patient exposure should form part of the **report of the medical radiological procedure**

The RDIM software can communicate with RIS and dosimetric information can be sent write automatically in the report (which information.. depends on local regulatory indications)

Patient at risk of deterministic effect, automatically identified, could be included in follow-up programme.

CLASS OF EFFECTIVE DOSE

Effective Dose(E)	Class of Effective Dose
$E < 1 \text{ mSv}$	I
$1 \text{ mSv} \leq E < 5 \text{ mSv}$	II
$5 \text{ mSv} \leq E < 10 \text{ mSv}$	III
$E \geq 10 \text{ mSv}$	IV

The Class of effective dose can be automatically recorded in the clinical report