Giornate Siciliane di Radioprotezione "M.Bellia"

Radio protezione nelle attività interventistiche

dalla protezione passiva alla realtà aumentata

Sircacusa, 18-20 Aprile 2018

Diagnostic Reference Levels in Interventional Radiology

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Content

- Introduction
- History of DRL development
- DRLs in IR practice: complexity
- ICRP 135 recommendations
- ISS guidelines for the IR practice, including DRLs

Image Guided Interventions

- Imaging modalities
  - X-ray →
    - **Fluoroscopy images→ Angiography equipment**
    - Computed tomography images (CT and fluoroscopy CT)
  - PET/CT
  - Ultrasound
  - Visible light → endoscopic images → endoscopy devices
  - MRI

Fluoroscopy images: history and technology developments

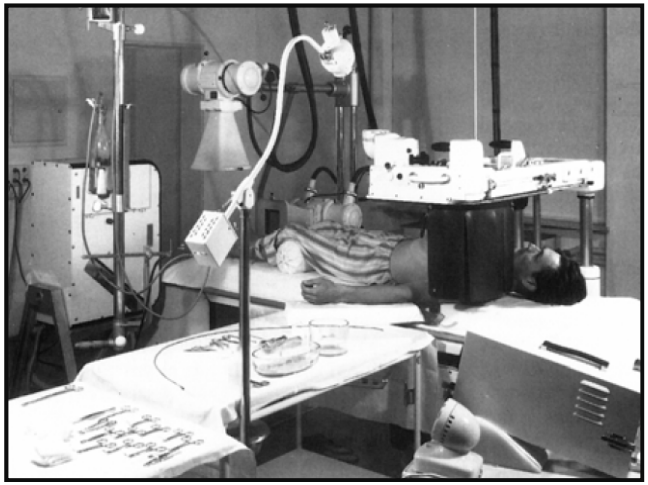


Table 1
Timetable of Developments in Digital Radiography

Year	Development
1977	Digital subtraction angiography
1980	Computed radiography (CR), storage phosphors
1987	Amorphous selenium–based image plates
1990	Charge-coupled device (CCD) slot-scan direct radiography (DR)
1994	Selenium drum DR
1995	Amorphous silicon–cesium iodide (scintillator) flat-panel detector
1995	Selenium-based flat-panel detector
1997	Gadolinium-based (scintillator) flat-panel detector
2001	Gadolinium-based (scintillator) portable flat-panel detector
2001	Dynamic flat-panel detector fluoroscopy–digital subtraction angiography

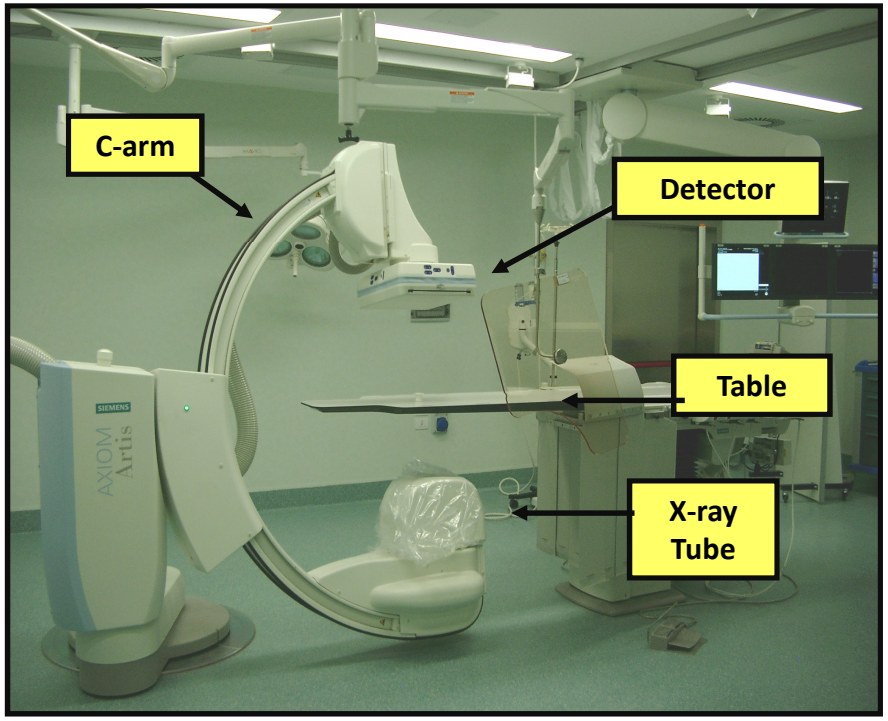
Fluoroscopy Guided Intervention: angiography system

- Imaging modes:
  - Pulsed fluoroscopy
  - Image acquisition (fluorography or cineangiography)
  - Digital subtraction angiography (DSA)
  - Conebeam CT (CBCT)

For each clinical task and imaging mode it is necessary to setup:

- Air kerma per image to the detector
- kV trajectory
- Added filtration
- Focal spot
- Image post-processing

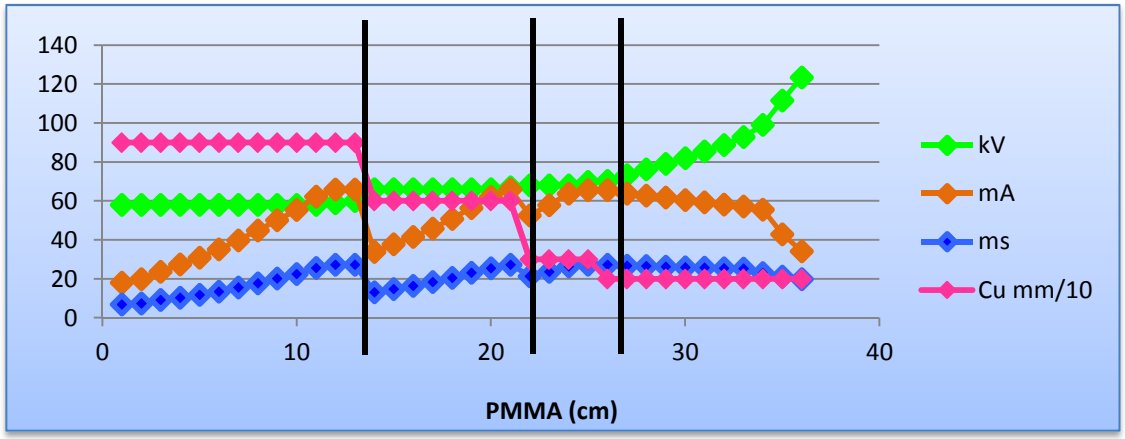
→ tens of programmed imaging techniques



Automatic Exposure Control

- Automatic exposure rate control maintains the radiation dose per image at the detector level at a predetermined level
  - adapting to the attenuation characteristics of the patient's anatomy
  - maintaining a consistent level of image quality

Example of AEC intervention on kV, mA, pulse width and filtration as a function of patient thickness

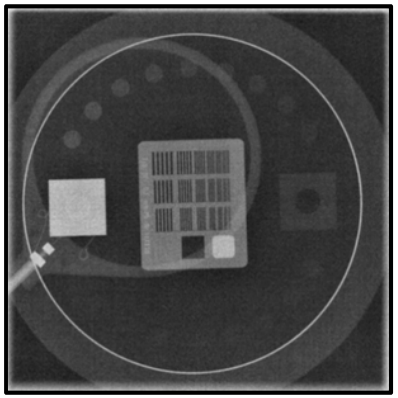


Diagnostic Reference Levels in Interventional Radiology, R. Padovani, 2018

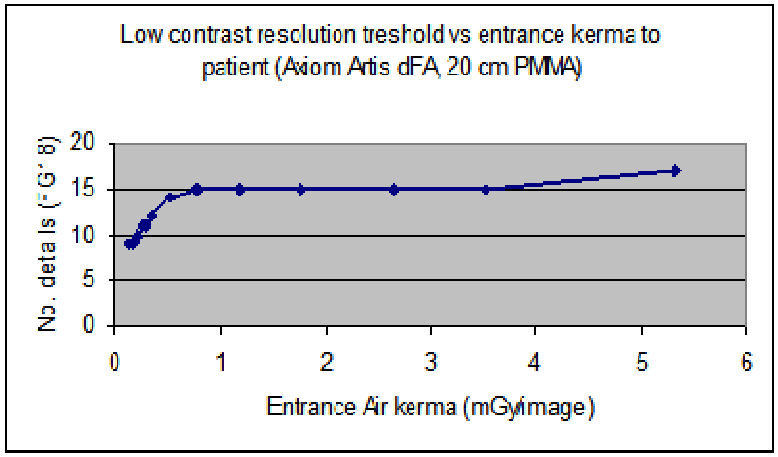
Equipment performance
Image quality: test object

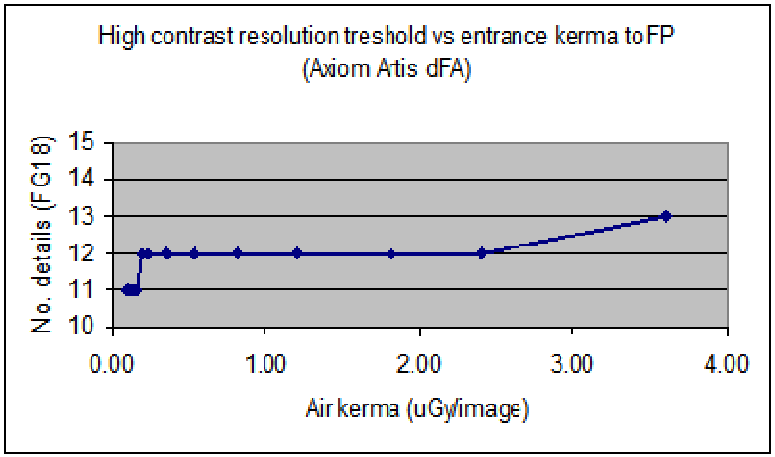
- Image quality vs. entrance air kerma to the detector:

→required entrance air kerma for each clinical task should be selected.



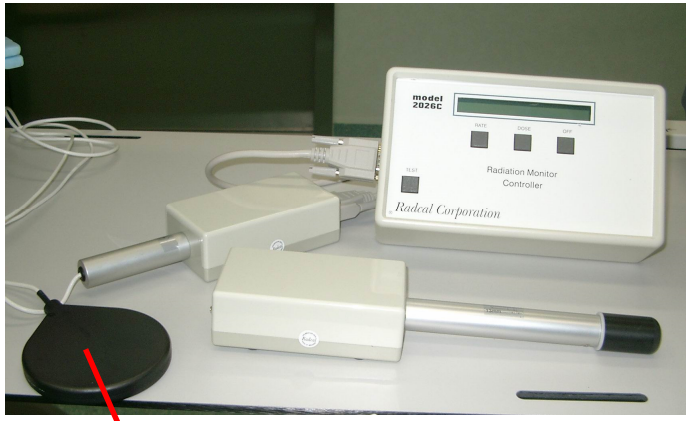
PMMA phantom to simulate the patient absorption and to drive the AEC and test object



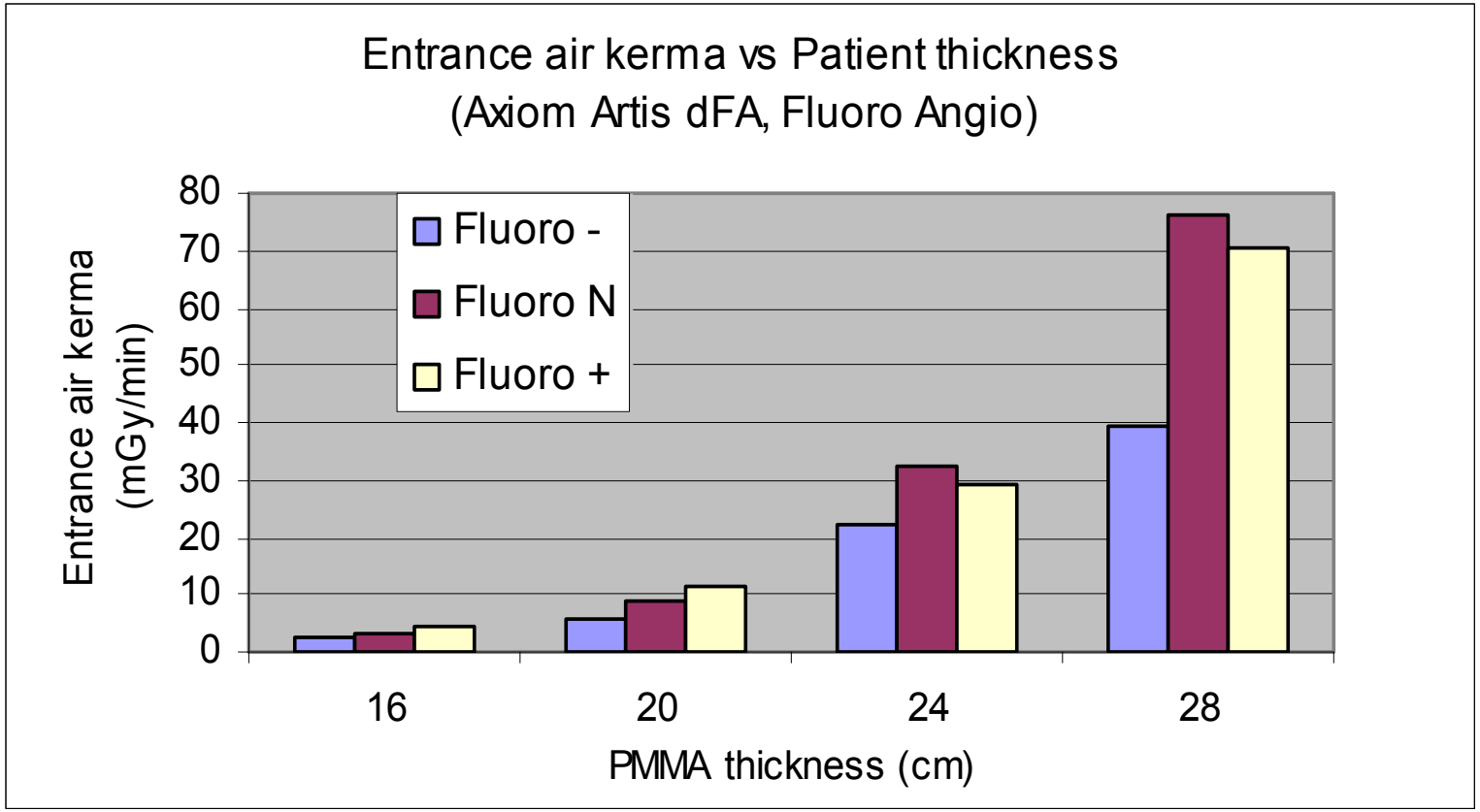


Equipment performance
Patient skin dose rates: Entrance Surface Air Kerma rate (ESAK) measurement

- PMMA phantom to simulate different patient thicknesses



Example ESAK rate



(Udine data, 2010)

ESAK rates in the real world

- Different equipment setups provide very different dose rate levels

Radiation Protection Dosimetry (2008), Vol. 129, No. 1–3, pp. 39–45
Advance Access publication 20 February 2008

doi:10.1093/rpd/ncn024

INVITED PAPER

PATIENT DOSE IN INTERVENTIONAL RADIOLOGY: A EUROPEAN SURVEY

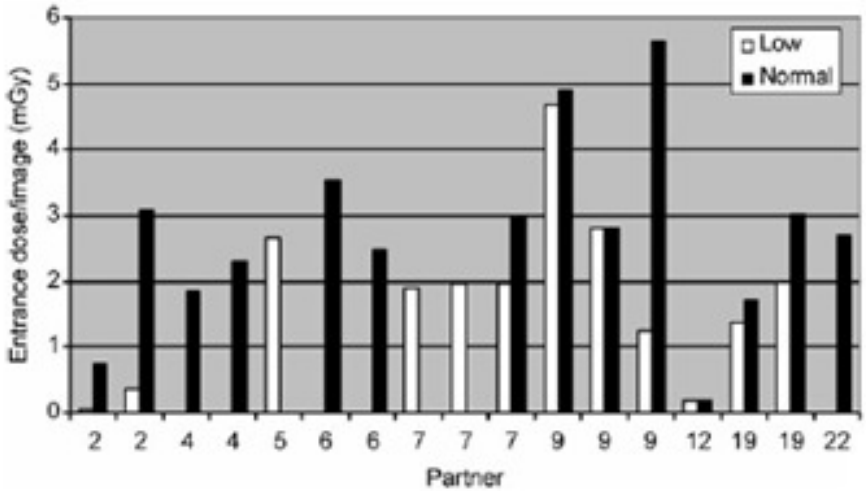


Figure 5. Entrance dose in different image acquisition modes (low and normal) for the IR units considered in this study.

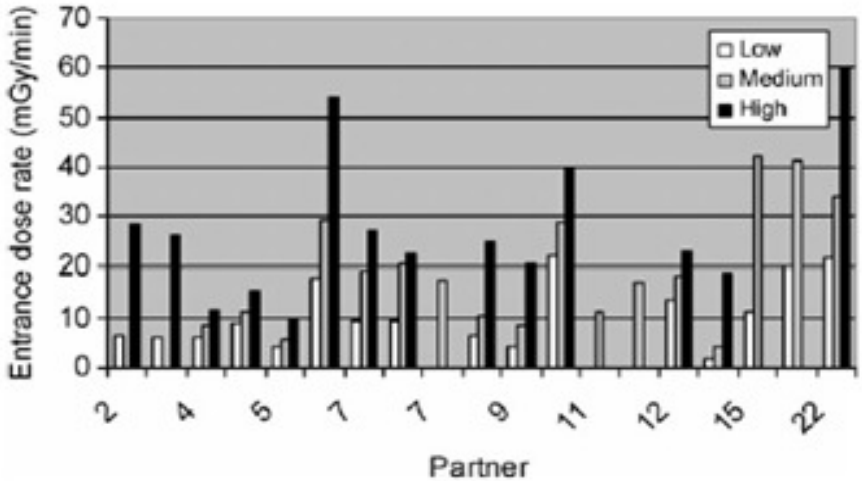


Figure 4. Entrance dose rate in different fluoro modes (low, medium and high) for the IR units considered in this study.

Limiting values: detector entrance air kerma rate

Evaluation criteria
FLUOROSCOPY

Reference	Parameter	Limit / value of threshold
EU 162 – IPEM 2005	Kerma rate at the entrance of the detector "NORMAL" mode	< 1 µGy/s

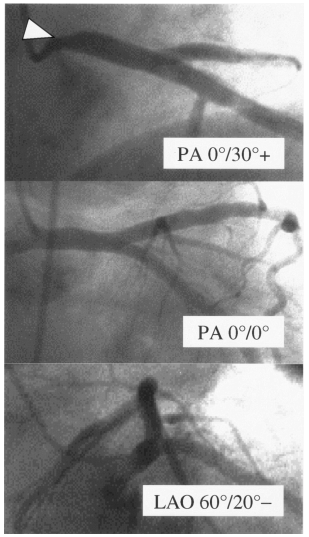
Evaluation criteria
FLUOROGRAPHY

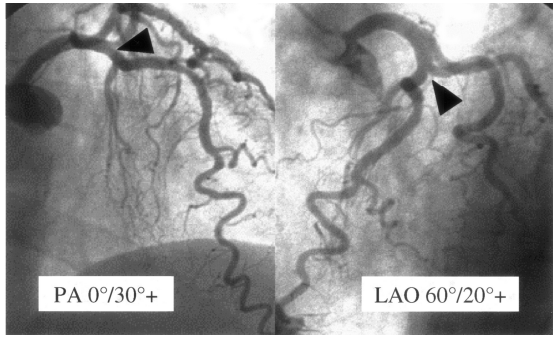
Reference	Parameter	Limit / value of threshold
EU 162 – IPEM 2005	Kerma rate at the entrance of the detector "NORMAL" mode	**Angiographic** > 5 µGy/frame **cardiac** > 0.5 µGy/frame

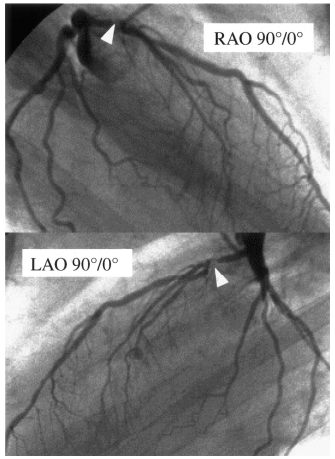
→ We don't have optimal/achievable ESAK rates and image quality recommended for the different clinical tasks

An interventional procedure

- usually requires many fluoroscopy and image acquisition runs with many projections according to patient anatomy and pathology







→ A pragmatic approach for the QA of IR procedures is to adopt quantities and tools to assess the outcomes (at the end of the imaging chain or at the ned of the procedure)

How to monitor the outcomes of a IR procedure

- Clinical information content (not only the quality of a single image)

- Cumulative patient doses or patient dose indicators:
  - Fluoroscopy time
  - No. of acquired images or DSA or CBCT
  - Cumulative air kerma –area product P_{KA} (KAP or DAP)
  - Cumulative air kerma at a reference point
  - (for CT: CTDI and DLP; for PET: administered activity)

  → DICOM Radiation Dose Structured Report (RDSR) provides these information

Clinical information content: The role of quality criteria

RAPPORTI ISTISAN 15|41
ISSN: 1123-3117 (cartaceo) • 2384-8936 (online)

Indicazioni operative per l'ottimizzazione della radioprotezione nelle procedure di radiologia interventistica

- Aim: to assess the overall quality of the procedure in term of clinical information content (grade of visibility of anatomical features)

Tabella A2.3. Criteri clinici e tecnici di qualità delle immagini di angiografia coronarica sviluppati e impiegati dal progetto SENTINEL

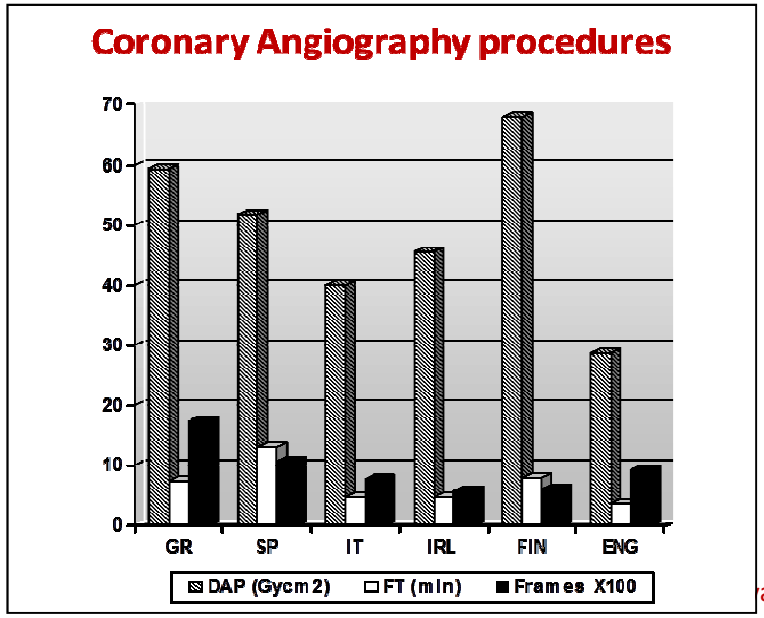
Criteri	Specifiche/azioni
Clinici	Riproduzione visualmente netta dell'origine, delle porzioni prossimale, media e distale dell'arteria coronaria destra, del tronco comune della coronaria sinistra, della discendente anteriore e della circonflessa, in almeno due proiezioni ortogonali, con minima sovrapposizione e accorciamento
	Riproduzione visualmente netta dei rami di divisione >1,5 mm delle arterie coronaria destra, discendente anteriore e circonflessa in almeno due proiezioni ortogonali, con minima sovrapposizione e accorciamento. L'origine dei vasi deve essere visibile in almeno una proiezione.
	Riproduzione visualmente netta delle lesioni in arterie >1,5 mm in almeno due proiezioni ortogonali, con minima sovrapposizione e accorciamento
	Visualizzazione della circolazione collaterale quando presente
Tecnici	Eseguire in inspirazione profonda, se necessario ad evitare la sovrapposizione del diaframma o per modificare le relazioni anatomiche (in apnea in ogni caso).
	Le braccia devono rimanere al di fuori del campo angiografico
	Quando possibile, evitare la sovrapposizione della colonna nel campo angiografico
	L'incannulazione del catetere angiografico deve essere selettiva e coassiale
	L'opacizzazione del lume dell'arteria deve essere simultanea e completa almeno fino alla prima lesione limitante il flusso, se presente (in genere > 95% da stima visiva)
	Limitare il movimento del lettino angiografico. Se necessario, eseguire movimenti a gradini piuttosto che continui, o eseguire serie successive per visualizzare strutture troppo distanti
	Utilizzare i collimatori del fascio
	Utilizzare i filtri semitrasparenti sulle aree chiare periferiche
	Quando i criteri clinici sono soddisfatti, evitare proiezioni ulteriori (principalmente LAO semiassiali)
	Eseguire 3-5 sequenze (eccetto per dettagli anatomici difficili) per l'angiografia della coronaria sinistra
	Eseguire 2-3 sequenze (eccetto per dettagli anatomici difficili) per l'angiografia della coronaria destra
	Utilizzare una cadenza 7,5- 12,5-15 immagini/s (25-30 solo in caso di frequenza cardiaca elevata o in pazienti pediatrici)
	Limitarsi a 60 immagini in media per sequenza, eccetto nel caso che debba essere visualizzato il circolo collaterale o sia presente flusso lento

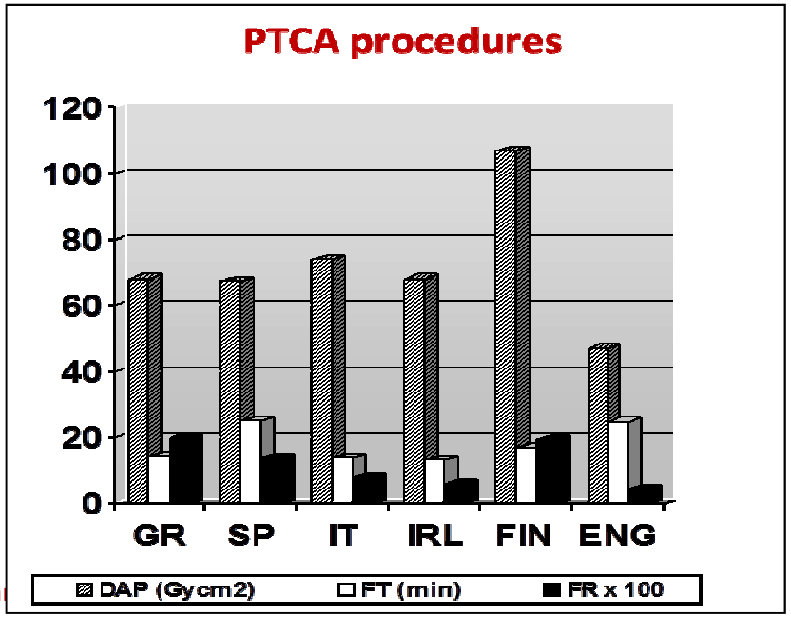
Cumulative patient dose indicators

- Fluoroscopy time
- No. of acquired images or DSA or CBCT
- Cumulative air kerma –area product P_{KA} (KAP or DAP)
- Cumulative air kerma at a reference point

→ several surveys have shown large variabilities

SENTINEL Europe 2007

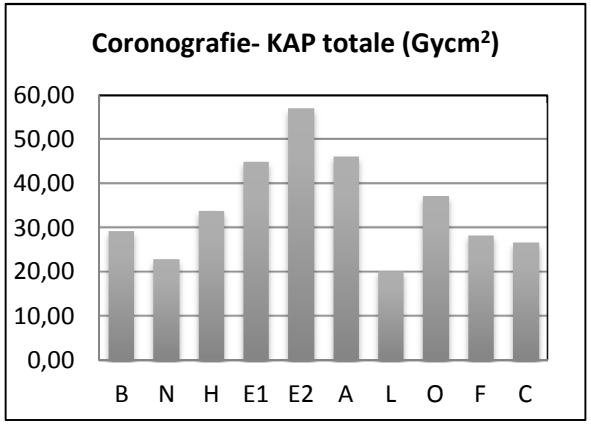


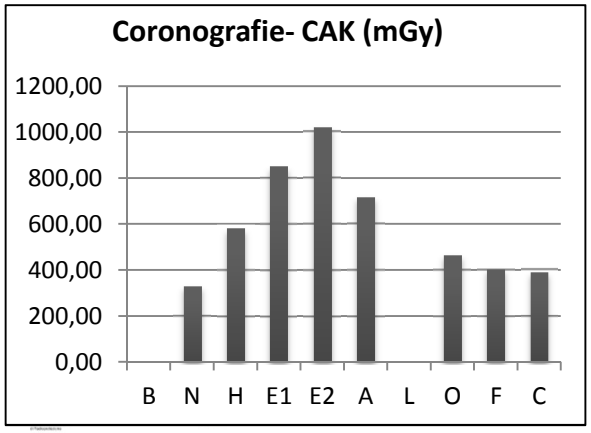


Radio protezione nelle attività interventistiche

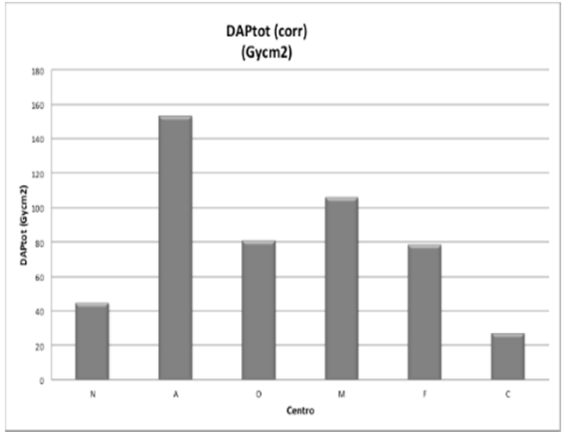
Cumulative patient doses or patient dose indicators (ISS study 2011)

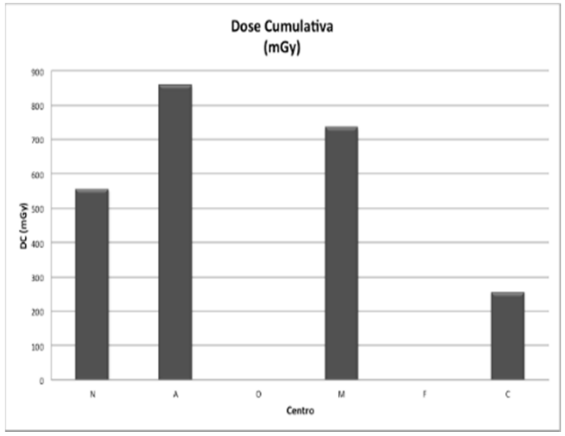
Coronary angiography



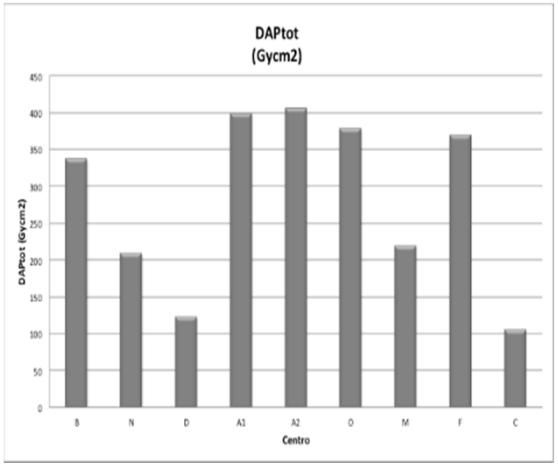


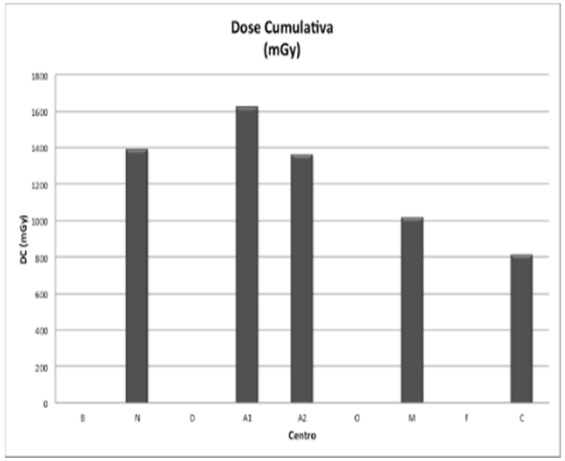
Carotid angioplasty





Liver embolization





→ large variabilities of the median doses between centres

Radio protezione nelle attività interventistiche

History of DRL concept

- Diagnostic reference levels were first mentioned by the International Commission on Radiological Protection (ICRP) in 1991 and subsequently recommended in more details in 1996.
- DRL introduced as Dose Constraints:

ICRP 60 (1991) (par. 180)

"..Considerations should be given to the use of dose constraints, or investigation levels, selected by appropriate or regulatory agency, for application in some common diagnostic procedures…"

History of DRL concept

ICRP 73 (1996): *Radiological Protection and Safety in Medicine*

- Introduced the term "diagnostic reference level"
- Explained its place in the broader ICRP concept of reference levels
- Expanded the ICRP Publication 60 recommendation

ICRP 73 (1996)

".. Dose limits/constraints are not applicable. To use diagnostic reference levels. A DRL is not a limit and dose not apply to a single patient…
It is a form of investigation level to identify unusually high levels, which calls for local review if consistently exceeded"

History of DRL concept

In Europe: Directive 97/43/EURATOM (1997)

Directive 97/43/EURATOM

Introduction of DRL concept

Dose Levels in medical radiodiagnostic practices to patients of standardized phantoms for typical examinations and broadly types of equipment. These levels should not be exceeded for standard procedures when good practice is applied, regarding diagnostic and technical practice.

Member States shall promote the establishment and the use of DRL as a strategy within optimization

History of DRL concept

ICRP 103 (2007)

Diagnostic reference level

Used in medical imaging with ionizing radiation to indicate whether, in routine conditions, the patient dose or administered activity from a specified procedure is unusually high or low for that procedure.

DRL in Interventional Radology

ICRP 105 (2007): *Radiological Protection in Medicine*

*"..For **fluoroscopically guided interventional procedures**, **DIAGNOSTIC REFERENCE LEVELS**, in principle, could be used to promote the management of patient doses with regard to avoiding unnecessary **stochastic** radiation risks…"*

More than one quantity (i.e., multiple diagnostic reference levels) may be needed to evaluate patient dose and stochastic risk adequately.

DRL in Interventional Radology

European Directive 2013/59/EURATOM

European Directive 2013/59/EURATOM

”… regular review and use of diagnostic reference levels for radiodiagnostic examinations, having regard to the recommended European diagnostic reference levels where available, and where appropriate, **for interventional radiology procedures**, and the availability of guidance for this purpose.”

Appropriate local reviews are undertaken whenever diagnostic reference levels are consistently exceeded and that **appropriate corrective action is taken without undue delay**

The role of the Diagnostic Reference Levels (DRL) in monitoring patient exposures

ICRP 135 (2017):

- *The DRL has been proven to be an effective tool that aids in optimisation of protection in the medical exposure of patients for diagnostic and interventional procedures*
- *It provides information on the use of DRLs for* ***interventional procedures***
- *It suggests modifications in the conduct of DRL surveys that take advantage of automated reporting of radiation dose*
- *It highlights the importance of including information on DRLs in training programmes for healthcare workers.*

DRL in Interventional Radiology

- Potential approach: taking into account also the **complexity of the procedure** → more aspects that the usual dose-related value
- The observed distribution of patient doses is very wide, even for a specified protocol, because the duration and complexity of the fluoroscopic exposure is strongly dependent on the individual clinical circumstances
- Many papers published since 2000 proposing different levels for some interventional procedures

DRL in cardiac IR procedures: no just a dose quantity

- First approach to account for the complexity of IR procedures: **more quantities to express DRLs**
- This approach is **recommended by ICRP 135** and by the **ISS guidelines**

- More quantities provide more information on the technique and give indication of the causes that can bring to an unacceptable level of patient exposures.
- e.g., a high mean FT can indicate a mix of complex cases or poor operator skill; a higher KAP and low CK can indicate a non necessary larger x-ray beam size.

Dose or dose analogue	Procedures		
	CA	*PTCA*	*EFO*
KAP ($Gycm^2$)	45	85	35
Effective dose (mSv)	8	15	6
CD at IRP (mGy)	650	1500	-
Fluoroscopy time (min)	6.5	15.5	21
No. of cine images	700	1000	-
Entrance surface air kerma rate	Fluoroscopy low: 13 (mGy/min) Image acquisition: 100 (µGy/frame)		

(SENTINEL Europe, 2008)

DRL – Switzerland (2008)

- DRLs expressed with multiple quantities adopted in some countries.

Esame	TF (min)	KAP (Gy cm^2)	Immagini (n.)
Esami diagnostici			
Angiografia cerebrale	15	150	400
Angiografia carotidea (vasi)	10	100	250
Angiografia delle estremità superiori	15	150	150
Angiografia polmonare	15	150	150
Angiografia addominale selettiva	20	300	150
Angiografia mesenteriale	20	300	150
Angiografia renale	20	300	150
Angiografia dei vasi aorto-iliaci	20	300	150
Arteriografia del cingolo del bacino	20	300	150
Arteriografia delle anche	20	300	150
Angiografia delle estremità inferiori	10	200	150
Angiografia coronarica	7	70	1300
Esami terapeutici			
TIPS	40	350	250
Drenaggio e dilatazione biliari	30	250	50
Embolizzazione epatica	20	300	200
Embolizzazione delle estremità superiori	30	150	300
Embolizzazione delle arterie bronchiali	30	150	300
Embolizzazione delle arterie del bacino	30	300	300
Embolizzazione delle arterie cerebrali	50	350	1000
PTA cerebrale	50	350	1000
PTA renale	20	200	150
PTA iliacale	20	200	250
PTA delle estremità inferiori	14	350	200
PTCA	20	100	1500
Vertebroplastica	15	80	75
Nefrostomia	20	50	10
ERCP	10	30	0

DRL in cardiac IR – Italian studies

- DRLs expressed with multiple quantities

Procedure	TF (min)	KAP (Gycm^2)	CK all'IRP (mGy)
Coronarography			
Studio INAIL (6 centri italiani, 2012) (57)*	8,1	58,7	-
Studio GISE (27 centri italiani, 2013) (58)	7,1	67,8	988
Studio ISS (12 centri italiani, 2013) (48)	7	53	826
Studio EU (Neofotistou e al.2003) (31)	6	57	-
Studio IAEA (Balter e al.2008) (29)	9	50	-
PCI			
Studio INAIL (6 centri italiani, 2012) (57)*	16,9	128,6	-
Studio GISE (27 centri italiani, 2013) (58)	18,8	160	2934
Studio ISS (12 centri italiani, 2013) (48)	17,5	125	2155
Studio EU (Neofotistou e al, 2003) (31)	16	94	-
Studio IAEA (Balter e al.2008) (29)	22	125	-

How to describe the complexity of IR procedures

Catheterization and Cardiovascular Interventions 51:1–9 (2000)

Clinical and Technical Determinants of the Complexity of Percutaneous Transluminal Coronary Angioplasty Procedures: Analysis in Relation to Radiation Exposure Parameters

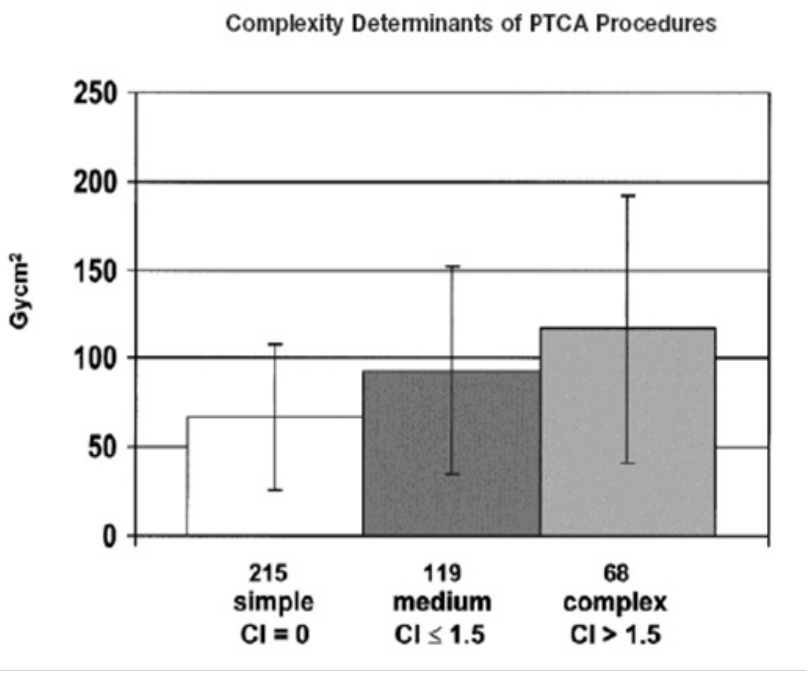
Guglielmo Bernardi,[1*] MD, Renato Padovani,[2] PhD, Giorgio Morocutti,[1] MD, Eliseo Vaño,[3] PhD, Maria Rosa Malisan,[2] PhD, Massimo Rinuncini,[1] MD, Leonardo Spedicato,[1] MD, and Paolo M. Fioretti,[1] MD

In therapeutic procedure the severity of the treated pathology influences the complexity of the procedure and the patient dose

- Pathology and technical factors (Complexity Factors) correlate with fluoroscopy time, KAP and CAK

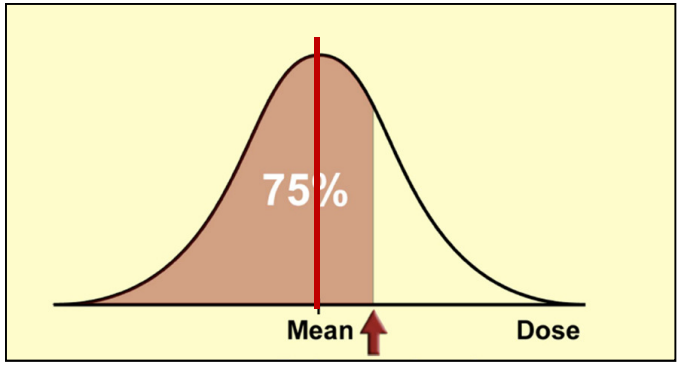
Example: Development of a ***complexity index (CI) for PTCA****:*
For a sample of PTCA procedures :

- *Complexity factors have been identified (vessel tortuosity, ostial stenting, etc.)*
- *A CI has been developed*
- *The sample of PTCI has been divided in 3 groups of increasing complexity*



What is new in the ICRP 135 (2017): How to assess DRL

- DRL are set at the 75th percentile of the **national distribution of the median doses** from a survey conducted across a number of installation in a country
  → *before the <u>mean values</u> were considered*



- **Optimisation of IR procedures**: The median value of the national distribution can serve as an additional tool to aid in optimisation, may be a desirable goal at which to aim and represents a situation closer to the optimum use of the applied radiation.

DRL in IR (ICRP 135): to account for complexity

- For interventional procedures, **complexity of the procedure may be considered in setting DRL values**, and a multiplying factor for the DRL value may be appropriate for more complex cases of a procedure.
- If possible, the **data from all** interventional procedures performed (not just from a limited sample) should be collated to derive local and national DRL values.

DRL in IR (ICRP 135): to account for complexity

- **Complexity index** is difficult to assess: it requires several information on the anatomy/pathology of each single procedure
- An **alternative approach** is recommended:
  - To compare the distribution of a large number of procedures performed in an installation with the distribution of all cases collected for the assessment of the DRL (called Advisory Data Set – ADS)
  - **to compare the median, 25th, and 75th percentile values of the facility data to the corresponding percentile values of the benchmark data** is recommended

DRL in IR (ICRP 135): How to use DRL in IR

- DRLs should be **flexible** (tolerances should be established: different patient sizes, different pathologies, etc).
- Values **ABOVE** DRLs require an investigation and optimization:
  - Equipment mulfunction
  - Equipment setup (e.g. too high image quality, wrong imaging protocol)
  - Operators (skills, RP training)
  - Procedure protocol
  - Complexity level of the group of procedures
- Values too **BELOW** DRLs may need optimization if the image quality is inadequate for the clinical task

In Italy: ISS guidelines (2015 and 2017)

- Two documents have been recently developed with reference to the IR practice, with the contribution of INAIL and professional societies:

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Indicazioni operative per l'ottimizzazione della radioprotezione nelle procedure di radiologia interventistica

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

- A document developed by a working group representing ISS, INAIL, SIRM and AIFM
- Aim: to provide a list of updated DRLs for diagnostic and interventional radiology to support the implementation of the EU Directive in Italy, including DRLs for IR procedures

- Nuclear medicine practice was outside the scope of the working group

Radio protezione nelle attività interventistiche

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali
per la radiologia diagnostica e interventistica

- Source of information to derive DRLs:
  - National or large surveys data performed in the last 10 years
    (adult radiography, CT adult and paediatric, adult IR)
  - European guidelines
    (paediatric radiography draft)
  - DoseDataMed 2 summary of European countries DRLs
    (mainly UK, Ireland, France)
  - Other published results from limited survey
- Comparisons between Italian and European DRLs to assure coherence

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

- DRLs for IR
  - Limited number of procedures
  - representing most common and frequent IR procedures in radiology, neuroradiology, cardiology (hemodynamic and electrophysiology) and gastroenterology

In Italy: ISS guidelines (2017)

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Livelli diagnostici di riferimento nazionali
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Tabella 4.5. Valori LDR per radiologia interventistica (corpo, neurologica, cardiologica, gastroenterologica) nell'adulto nella pratica radiologica italiana

Procedura	Valori LDR	
	KAP *Gycm²*	Tempo fluoroscopia *min*
Angiografia cerebrale	115	10
Embolizzazione aneurismi cerebrali	180	45
PTA e/o stenting carotideo	100	20
Embolizzazione o chemoembolizzazione epatica	400	20
CPRE	45	
Interventistica biliare percutanea	45	
TIPS	500	40
Vertebroplastica	80	15
Endoprotesi aorta addominale	158	18
Coronarografia	70	7
Angioplastica e/o stenting coronarico (CA+PCI)	160	19
Impianto di pacemaker	20	8
Ablazione cardiaca con radiofrequenza *	110	40

* I valori qui riportati si riferiscono a procedure eseguite integralmente con guida fluoroscopica.
In questa prima applicazione degli LDR per la radiologia interventistica e visti i limitati studi in merito, si ritiene di non proporre valori di LDR graduati per livello di complessità della procedura.

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

- DRLs for IR
  - Only 2 quantities (KAP and fluoroscopy time) are used to express DRLs due to the limited information available
  - Information on other quantities are found in the chapter 1 where all source of information adopted are compared

Tabella 3.5. Valori LDR per radiologia interventistica (corpo, neurologica, cardiologica, gastroenterologica) nell'adulto e riferimenti bibliografici (rif.)

Procedure	Valori LDR - indagini nazionali			Valori LDR - indagini altri Paesi (sigle)		
	KAP *Gycm²*	Tempo fluoroscopia *min*	Immagini *n.*	KAP *Gycm²*	Tempo fluoroscopia *min*	Immagini *n.*
Angiografia cerebrale	**112,3** (7)	**9,3** (7)		150 (14) 56 (12) 90 (27)	15 (14) 11 (27)	400 (14) 400 (27)
Embolizzazione aneurismi cerebrali	**178,9** (7)	**42,9** (7)		360 (28) 350 (14) 185 (27)	90 (28) 50 (14) 58 (27)	1350 (28) 1000 (14) 1050 (27)
PTA e/o stenting carotideo	**104,8** (7)	**20,1** (7)				

Radio protezione nelle attività interventistiche

Diagnostic Reference Levels in Interventional Radiology, R. Padovani, 2018

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

- DRLs for IR:
  - Complexity factors are also not provided in these set of DRLs
  - In the document some information are provided for some procedures, as useful guide to interpret local values

Tabella 3.6. Valori di LDR proposti in funzione del parametro clinico di complessità individuato o di un indice di complessità creato nel caso di più parametri clinici di complessità

Procedura	Valori LDR - indagini in altri Paesi europei			Rif.
	KAP *Gycm²*	Tempo fluoroscopia *min*	Immagini *n.*	
Angiografia cerebrale (tutte)	90	11	400	27
1 arteria cerebrale	30	4	305	
2 arterie cerebrali	75	7	320	
3 o più arterie cerebrali	105	13	460	
Interventistica biliare percutanea (tutte)	35	16	10	27
senza endoprotesi	30	15	3	
con endoprotesi	45	18	11	

In Italy: ISS guidelines (2017)

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Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

How to use DRLs for IR:

- *Numero minimo di esami o procedure che si propone di raccogliere per il confronto con gli LDR è:*
  - *Radiografia proiettiva: 20 pazienti*
  - *Mammografia: 50 pazienti a causa delle variazioni nello spessore della mammella compressa*
  - *Fluoroscopia: 30 pazienti*
  - *TC: 30 pazienti*
  - ***Radiologia interventistica: almeno 30 pazienti per procedura***

Radio protezione nelle attività interventistiche

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali
per la radiologia diagnostica e interventistica

How to use DRLs for IR:

- *Quando la presente raccomandazione indica più valori di LDR per una medesima procedura si ritiene che:*
- ***per le procedure fluoroscopiche e interventistiche**: il confronto deve essere fatto con il valore del KAP; il valore delle altre grandezze è utile per identificare possibili cause di superamento del valore di LDR*

(es. un valore elevato del tempo di fluoroscopia può indicare un mix di procedure particolarmente complesse o la presenza di un operatore in formazione e ciò può giustificare una maggiore dose media al paziente).

In Italy: ISS guidelines (2017)

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Livelli diagnostici di riferimento nazionali per la radiologia diagnostica e interventistica

How to use DRLs for IR:

- *.. se viene superato un valore di LDR la pratica radiologica di quella installazione deve essere esaminata senza ritardo. L' indagine deve servire ad identificare le cause del superamento del valore di LDR.*
- *Una prima analisi riguarda l'insieme dei dati del campione di procedure utilizzato per il confronto con i valori di DRL*

In Italy: ISS guidelines (2017)

RAPPORTI ISTISAN 17|33

Livelli diagnostici di riferimento nazionali
per la radiologia diagnostica e interventistica

How to use DRLs for IR:

- *In generale, i fattori che dovranno essere analizzati per individuare le cause di superamento sono:*
  - *il protocollo della procedura radiologica, relativamente ai fattori tecnici;*
  - *le prestazioni dell'apparecchiatura,*
  - *le competenze degli operatori medici o tecnici,*
  - *la complessità della casistica;*

How to manage the potential of skin reactions in IR

- In the QA of IR procedures we should know the potential to deliver high skin doses in single or repeated procedures
- In the 2015 ISS document:
  - Methods and recommendation to assess skin dose are provided
  - Adoption of trigger levels to identify and prevent high skin dose in a procedure is recommended
  - Clinical patient follow-up protocol is recommended in the case of high skin cases

Radio protezione nelle attività interventistiche

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Indicazioni operative per l'ottimizzazione della radioprotezione nelle procedure di radiologia interventistica

Summary

- Interventional radiology is a rapidly evolving practice, in term of type of procedures, complexity of pathology treated and technology (radiological equipment and devices)
- The QA process, addressing patient exposure, should be robust : DRLs can play an important role
- Education and training of all staff involved is a must to achieve optimised exposures