


Radiation physics in radiology: daily practice and challenges



An De Crop
AZ Delta

Quality control

- “Part” of the job
- accuracy / reproducibility
- ALARA

► Samenvatting

	Limiet	Gemeten	Voldaan	Opmerkingen
Buisspanning				
nauwkeurigheid:	<10.0%	3.5%	JA	grote focus
	<10.0%	3.1%	JA	kleine focus
reproduceerbaarheid:	<5.0%	0.1%	JA	grote focus
	<5.0%	0.2%	JA	kleine focus
variatie met buisstroom:	<10.0%	4.1%	JA	grote focus
	<10.0%	3.9%	JA	kleine focus
variatie met exposie:	<10.0%	2.8%	JA	grote focus
	<10.0%	1.7%	JA	kleine focus

► Conclusie

Conform de vigerende wetgeving werd het apparaat gecontroleerd op basis van het besluit van het FANC d.d. 25/07/2011 houdende de aanvaardbaarheidscriteria voor röntgenapparatuur voor medisch diagnostische radiologie en op basis van het rapport van de Europese Commissie "Stralingsbescherming 91: Criteria voor de aanvaardbaarheid van apparatuur voor radiologie (inclusief radiotherapie) en nucleaire geneeskunde".

Al de gemeten parameters voldoen aan de normen hierin gespecificeerd, met uitzondering van de nauwkeurigheid van de opnametijd, alsook de resolutie van de beeldversterker.

De gemeten opnametijd mag voor 20ms en 50ms slechts 20%, respectievelijk 10% afwijken van de nominale tijdsinstelling. Bij selectie van de kleine focus is dit niet voldaan.

Merk ook op dat de golfvorm bij kleine focus geleidelijk wegzakt. Bovendien zijn de dosistempi bij kleine en grote focus sterk verschillend van elkaar.

De resolutie van de beeldversterker is niet meer voldoende. Respectievelijk voor norm, zoom1 en zoom2 dienen 1.6, 1.8 en 2.0 lp/mm te onderscheiden zijn.

Gelieve deze opmerkingen door te geven aan uw service engineer om de situatie te laten verbeteren.

afwijking links	<1.0%	-1.0%	JA	
afwijking rechts	<1.0%	-0.2%	JA	
afwijking hoofd	<1.0%	-0.2%	JA	
afwijking voeten	<1.0%	0.9%	JA	

Quality control

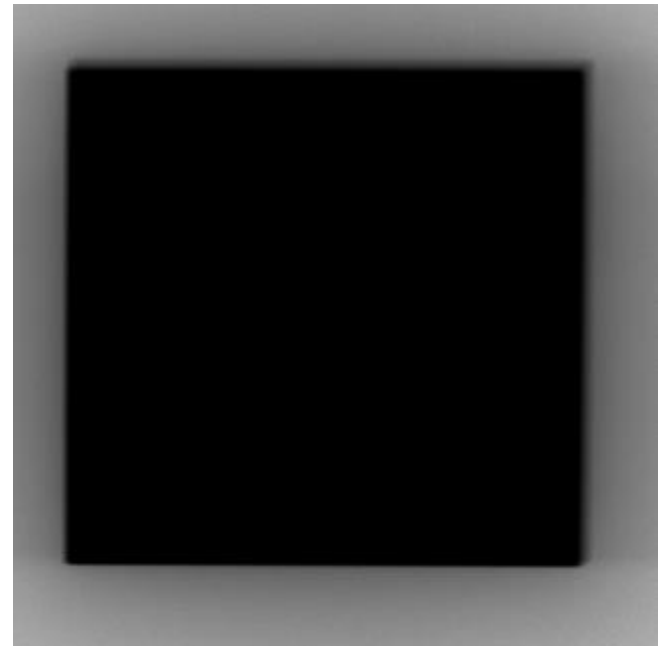
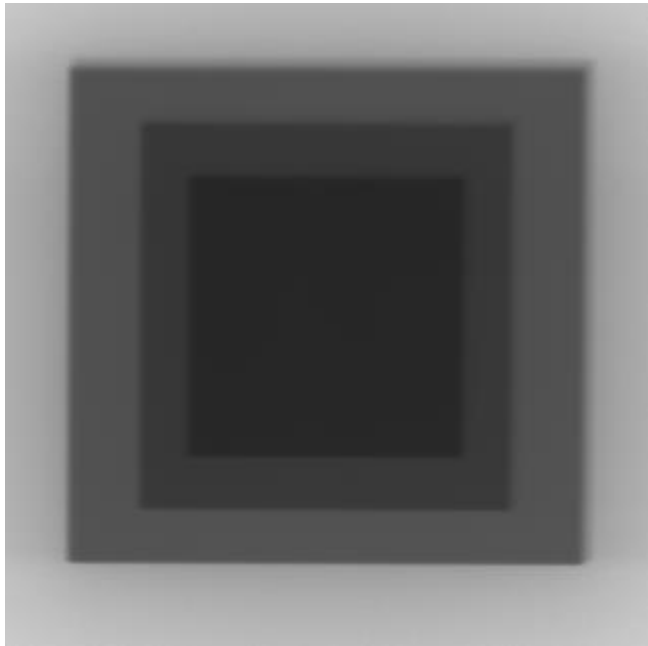
- Correction
 - Report to FANC
 - < 6 months
 - Before next control
- Contacting application or service engineer

Quality Control

RAPPORT DES TRAVAUX EFFECTUES / VERSLAG UITGEVOERDE WERKEN						
testat frottime cellimaten en xopu rembleem. druer 2358 et regles verification et regles/cheke et xopu cheke test et xopu test = ok						
FOURNITURES PIECES / GELEVERDE ONDERDELEN						
Norm / Naam	Quant. / Hoev.	N° code N	Prix unit. Eenh. prijs	Prix total Totaalprijs	T.V.A. B.T.W.	Prix fact. Te factureren
OCI druer cellim: 2358	1					

Quality control

- Check if corrections are done correctly



Quality Control

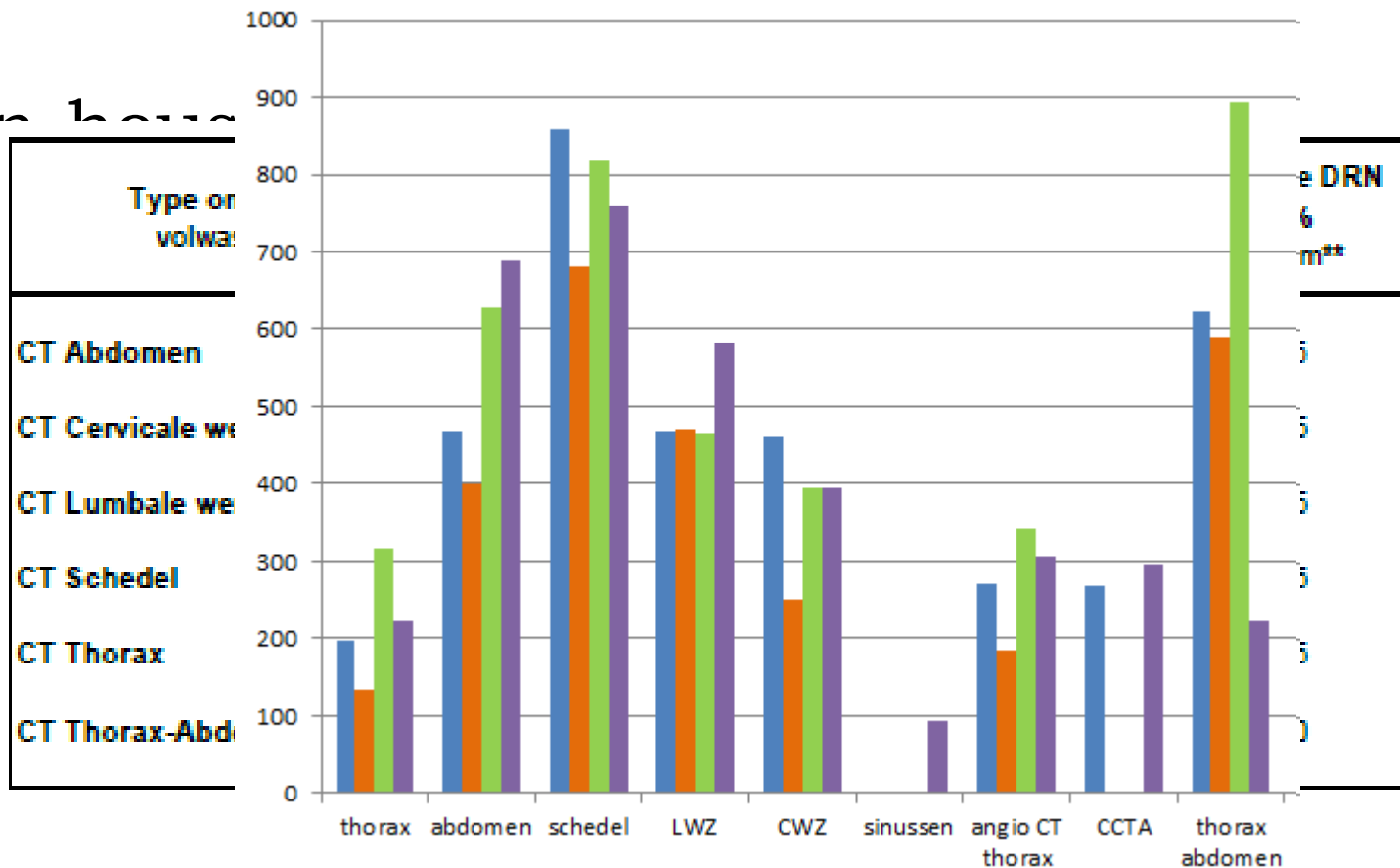
- ‘in-house’ MPE
 - Correct interpretation of the remarks
 - Direct communication with service engineer
 - Follow-up of modifications

Patient dosimetry

Nr	Datum dd/mm/jjjj	Patient		kVp (kV)	TCM (JA of NEE)	Iteratieve reconstructie (JA of NEE)	Low dose (JA of NEE)	Contrast- injectie (JA of NEE)	CTDI _w * ○	DLP	Aantal scans	Initialen
		Geslacht (M of V)	Leeft. (j)						CTDI _{vol} ● (mGy)	(mGy.cm)		
1	02/07/2015	M	67	120	JA	JA			27.14	434.05	1	
2	03/07/2015	F	61	120	JA	JA			18.76	336.41	1	
3	07/07/2015	F	48	120	JA	JA			24.22	444.95	1	
4	07/07/2015	M	45	120	JA	JA			28.10	579.52	1	
5	07/07/2015	M	59	120	JA	JA			32.48	641.28	1	
6	08/07/2015	M	57	120	JA	JA			26.47	454.83	1	
7	08/07/2015	F	39	120	JA	JA			19.81	306.93	1	
8	09/07/2015	F	37	120	JA	JA			15.45	273.20	1	
9	09/07/2015	F	69	120	JA	JA			30.51	583.43	1	
10	09/07/2015	F	38	120	JA	JA			20.23	345.06	1	
11	10/07/2015	M	34	120	JA	JA			21.24	400.86	1	
12	10/07/2015	M	58	120	JA	JA			25.26	396.20	1	
13	13/07/2015	F	68	120	JA	JA			18.68	321.05	1	
14	14/07/2015	F	75	120	JA	JA			38.25	805.37	1	
15	15/07/2015	F	37	120	JA	JA			16.01	338.11	1	
16	15/07/2015	F	71	120	JA	JA			16.63	297.10	1	
17	15/07/2015	M	47	120	JA	JA			22.26	436.69	1	
18	17/07/2015	F	47	120	JA	JA			24.03	405.32	1	
19	20/07/2015	F	38	120	JA	JA			23.67	300.19	1	
20	23/07/2015	F	64	120	JA	JA			22.26	346.29	1	

Patient dosimetry

- 'in house'



Dose optimisation

- Which protocols need optimisation
 - based on results of FANC patient dosimetry
 - based on dose monitoring software
 - Hugh amount of data / information
 - Configuration of reports / tables/ graphs
 - Analysis of the data

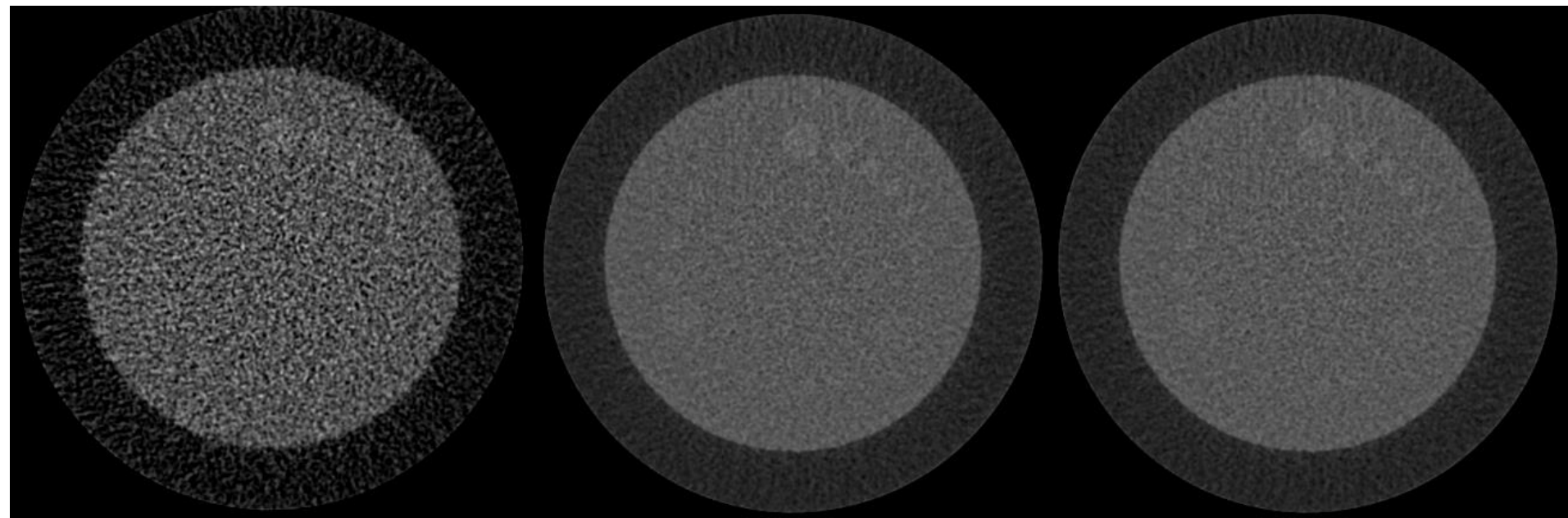
Dose optimisation

- Protocol modification
 - Comparison of acquisition/recon settings
 - Changing parameters



Image quality

Image quality versus dose



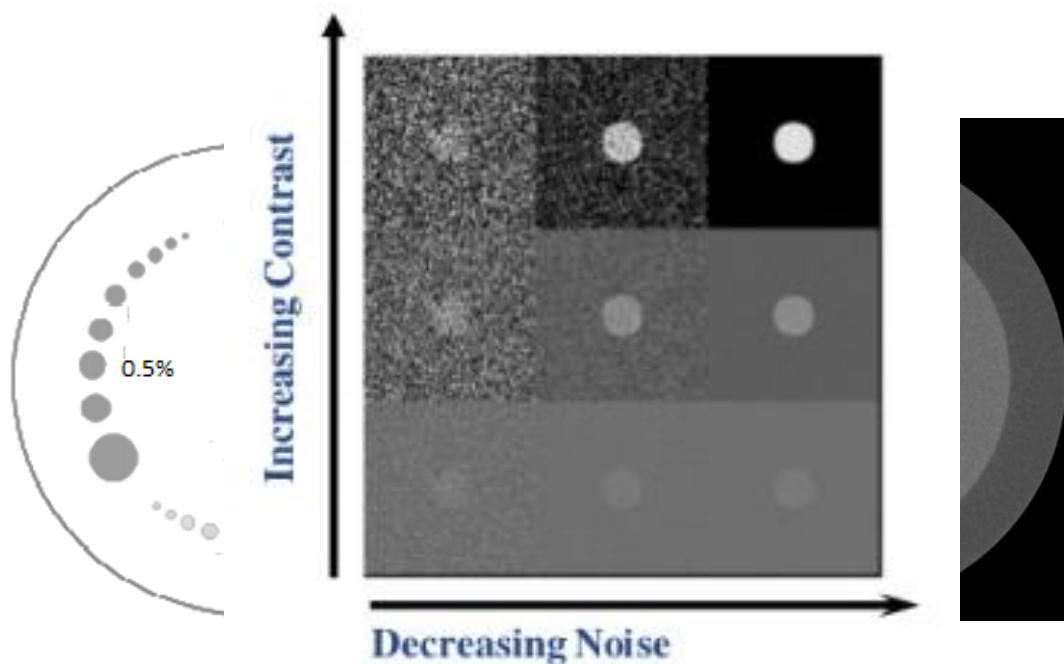
12 mAs

67 mAs

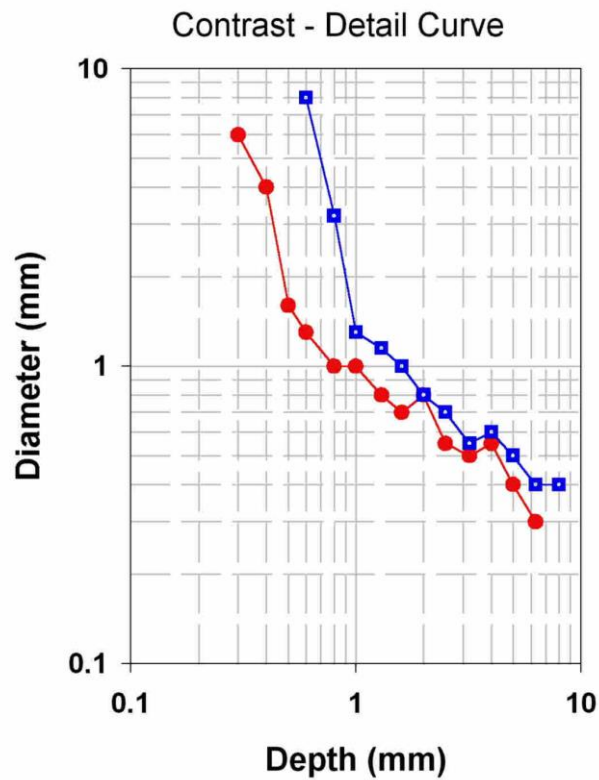
152 mAs

Physical technical IQ assessment

- Phantom images
- Assessment by **MPE**
- Noise / Contrast / Resolution
- CNR
- Contrast-detail

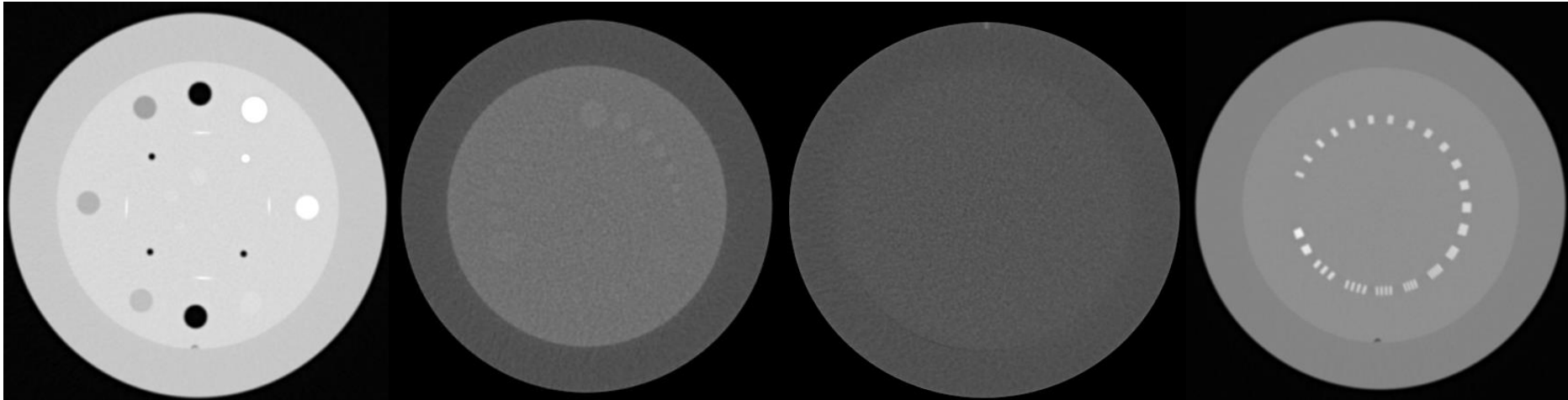


Physical technical IQ assessment



$$IQF_{inv} = \frac{100}{\sum_{i=1}^n C_i D_{i,th}}$$

Physical technical IQ assessment



Clinical image quality assessment

- Clinical anatomical images
- Assessment by radiologists
- Visual Grading Analysis (**VGA**)
 - normal anatomical structures
 - overall assessment of the image quality

$$VGAS = \frac{\sum_{s=1}^S \sum_{i=1}^I G_{s,i}}{S * I}$$

Criterion number	Description
1	Medial border of the scapulae outside the lung fields
2	Reproduction of the whole rib cage above the diaphragm
3	Visually sharp reproduction of the vascular pattern in the whole lung, particularly the peripheral vessels
4	Visually sharp reproduction of the trachea and proximal bronchi
5	Visually sharp reproduction of the borders of the heart and aorta

Clinical phantoms

- Patient images
- Anthropomorphic phantoms

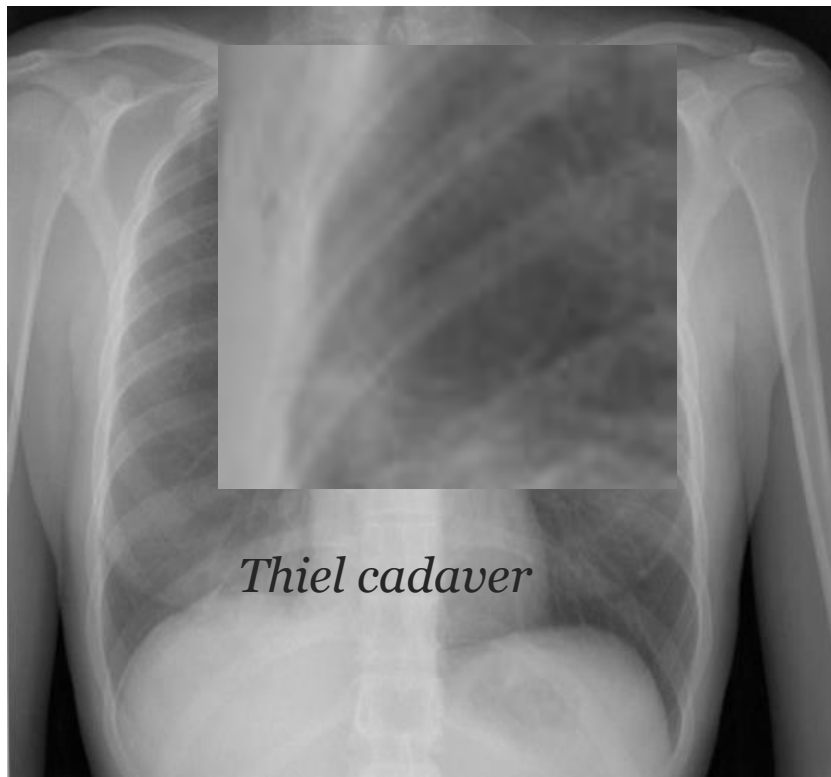


Kyoto Kagaku N1 Lungman fantoom

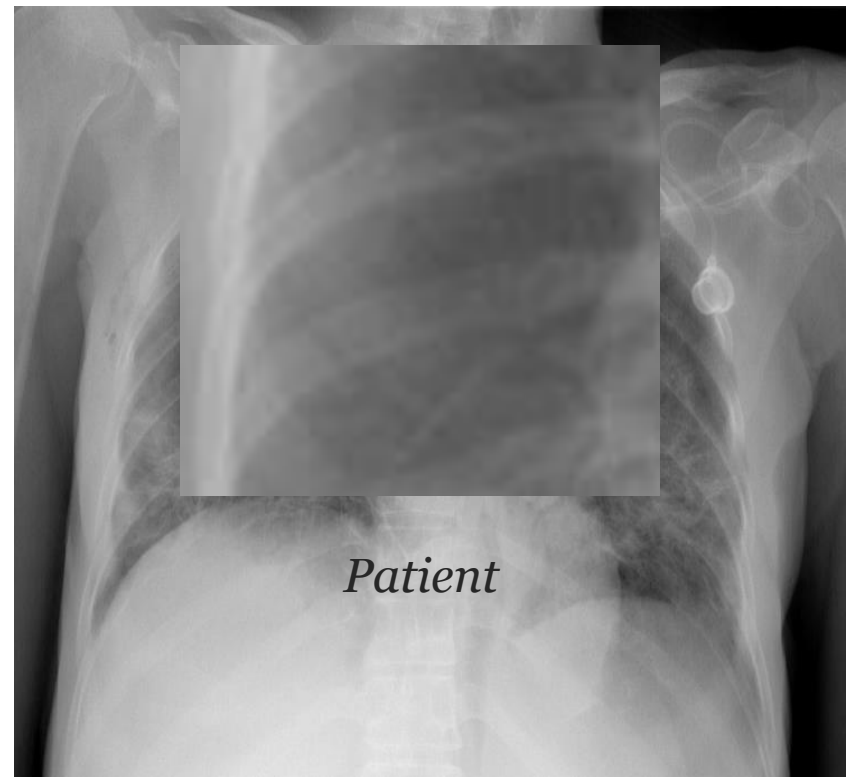
- Thiel embalmed cadavers



Thiel embalmed cadavers



Patient



Thiel cadaver

Image quality assessment

Clinical image quality



Physical technical image
quality

Complex

Time consuming

Clinical reality

Relatively easy

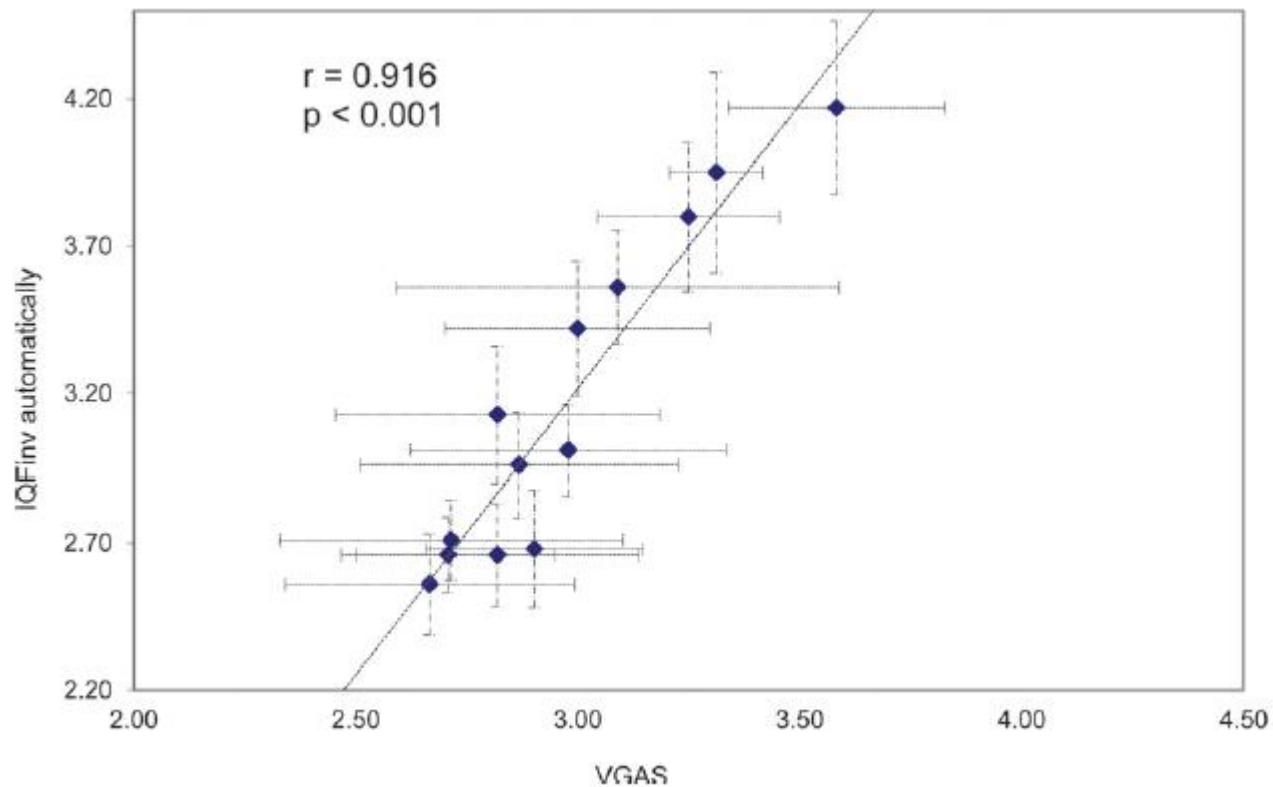
Automated analysis

Non anatomical phantoms

Correlation?

Correlation in thorax radiography

IQF_{inv} en VGAS: $r = 0.916$, $p < 0.001$



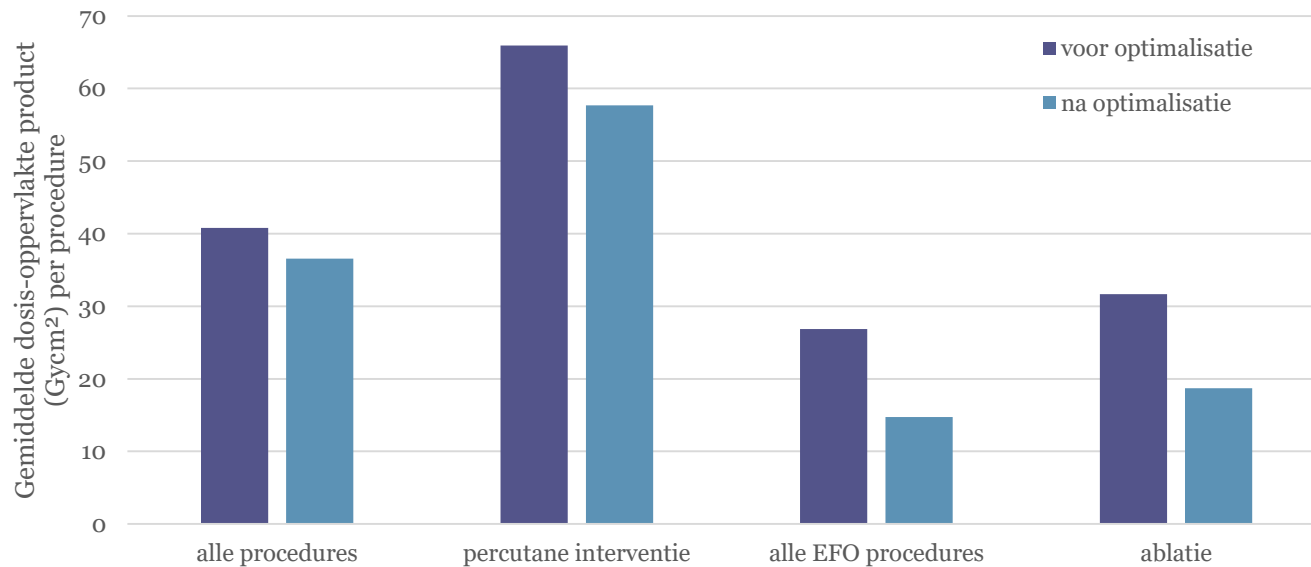
Dose optimisation

- Medical physics → direction
- **Collaboration** between radiologists and MPE
- Optimisation: not an easy task
- Trial and error
- Protocol dependent

Optimisation: Bobby thorax neonato



Optimisation: fluoroscopy guided procedures



Fetal Dose

The screenshot shows the 'FetDose: Main' application window. The menu bar includes 'File', 'Information', 'View DataBase', 'Print Report', and 'Calculation Forms'. The main area is divided into three tabs: 'Dose Calculation Selection', 'Medical Exposure', and 'Fetal Dose Calculations'. The 'Fetal Dose Calculations' tab is active, displaying two main sections: 'X-Ray Tube Output' and 'Patient Information'.

X-Ray Tube Output

Conventional Radiography

X-ray tube Output (free-in-air) mGy/mAs

Focus Skin Distance (FSD) cm

Tube Potential kV

[Click here for information](#)

Fluoroscopy

X-ray tube Output rate (free-in-air) mGy/mA/min

Focus Skin Distance (FSD) cm

Tube Potential kV

[Click here for information](#)

Patient Information

Gestational Age Information

Gestational Age (GA) weeks

Maternal Parameters

Height cm

Weight kg

AP Thickness cm

Fetal Parameter

Fetal Depth cm

Allow user input of AP thickness and fetal depth

Fetal Dose

FetDose: Main

File Information View DataBase Print Report Calculation Forms

Dose Calculation Selection | Medical Exposure | Fetal Dose Calculations

Examination Type

Single Exam

Examination/Projection

AP Pelvis/Colon

Dose-Area Product

DAP Rad
 Fluo

0.26 Gy-cm²

Entrance Surface Dose (ESD)#

Radiography

0.0 mGy Calculated Measured

Fluoroscopy

0.0 mGy Calculated Measured

Technique Factors Used for Examination

Tube Potential (kV) 80 Filtration (mmAl) 3.1

FSD (cm) 88 No. of Films Field Size 36 X 43 (cm²)

Radiography

Current* Time (mAs)

Fluoroscopy

Time (min) Current (mA)

Examination & Projection	Rad (R)/ Fluo (F)	No. of Films	mAs or mA-min	kVp	FSD	DAP	ESD	NUD	Fetal Dose
▶ AP Pelvis/Colon	R			80	88	0.26		0.5424	0.141
AP Pelvis/Colon	R			80	88	0.26		0.5424	0.141
AP Pelvis/Colon	R			80	88	0.26		0.5424	0.141

Calculated or measured ESD used MUST be without backscatter

Total Fetal Dose (mGy) 0.423

Fetal Dose

Dose to conceptus (mGy) above natural background	Probability of no malformation	Probability of no cancer (0-19 years)
0	97	99.7
1	97	99.7
5	97	99.7
10	97	99.6
50	97	99.4
100	97	99.1
>100	Possible, see text	Higher

Fetal Dose

The screenshot shows the 'FetDose: Main' application window with the 'Fetal Dose Calculations' tab selected. The main area is titled 'Comparison of the calculated fetal doses with values from the literature' and contains two side-by-side tables.

Calculated dose per Examination

Examination & Projection	Dose (mGy)
▶ AP Pelvis/Colon	0.141
AP Pelvis/Colon	0.141
AP Pelvis/Colon	0.141

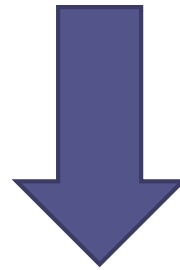
Doses per Examination from the literature

Examination & Projection	Mean Dose (mGy)	Dose Range (mGy)
AP Abdomen	1.90	0.16 - 9.20
PA Abdomen	0.53	0.35 - 0.82
---Abdomen	1.80	0.25 - 4.20
Barium Enema	6.80	1.70 - 16.90
Barium Meal	1.60	0.10 - 5.80
AP Chest	<0.01	<0.01 - 0.01
PA Chest	<0.01	<0.01
---Chest	<0.01	<0.01 - 0.01
Cholecystography	0.60	0.10 - 1.10
IVU/IVP	4.80	2.90 - 10.0
Hip joint	0.90	0.11 - 2.10
AP Lumbar Spine	1.90	0.20 - 15.0
LAT Lumbar Spine	0.41	0.09 - 3.50
---Lumbar Spine	1.70	0.11 - 10.0
LAT Lumbosacral joint	0.42	0.10 - 2.40
▶ Pelvis	3.40	1.40 - 15.0
AP Thoracic Spine	<0.01	<0.01 - 0.03
LAT Thoracic Spine	<0.01	0.10 - 0.01

At the bottom of the window, there are five buttons: Exit, Calculate Dose, Calculate Risks, Calculate Safety, and Calculate Equivalents.

Translating

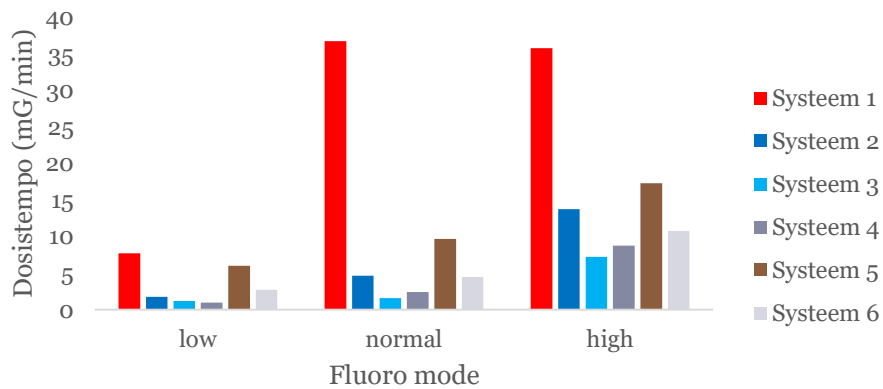
“I can’t see anything”



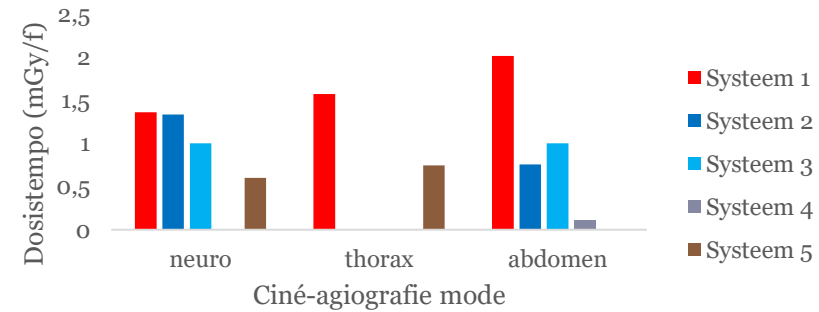
low contrast detectability
high contrast detectability
resolution
motion unsharpness

Translating

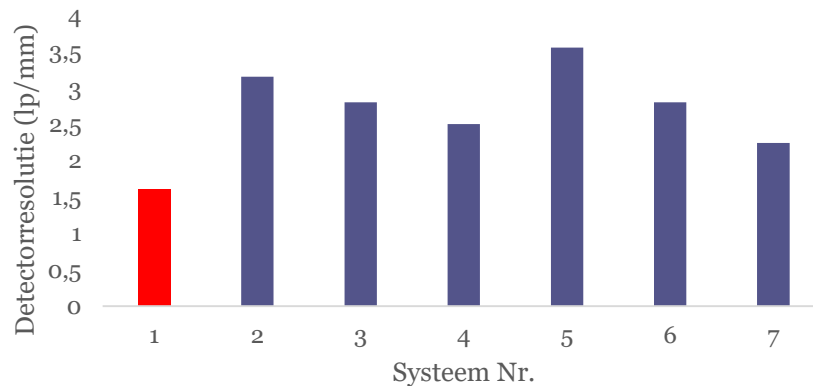
Vergelijking dosistempo patiënt bij fluoroscopie



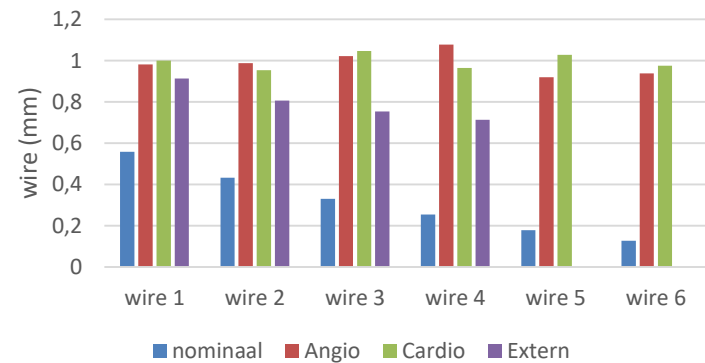
Vergelijking dosistempo patiënt bij ciné-angiografie



Hoogcontrastresolutie detector



Motion unsharpness



Education

- Continual education
- Refresher course: basic radioprotection
- Overview of optimisation procedures that were performed
- Specific new features of devices

Conclusion

- Quality control
- Patient Dosimetry
- Optimisation (dose and image quality)
- Fetal dose
- Communication
- Education

Conclusion

- Disagree
- Challenge to do it differently
- Optimisation of overall radiation protection
(both for physician and patient)