



Thai  
Medical  
Physicist  
Society

# Anatomical-Based VS Clinical Indication Diagnostic Reference Levels (DRL)

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# **National Diagnostic Reference Levels in Thailand 2023**

**ค่าปริมาณรังสีอ้างอิงในการถ่ายภาพรังสีวินิจฉัย  
ทางการแพทย์ของประเทศไทย 2566**

TECHNIQUE	(Pediatric)	ESAK (mGy)	KAP(mGy.cm <sup>2</sup> )
CHEST	1-4y	0.06	70
	5-9y	0.09	80
	10-14y	0.12	114
	15-18y	0.04	140
ABDOMEN	1-4y	0.12	123
	5-9y	0.71	29
	10-14y	0.69	439
	15-18y	1.59	667



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**NDRLs THAILAND 2023**

	TECHNIQUE	(Adult)	ESAK (mGy)	KAP(mGy.cm <sup>2</sup> )
	CHEST PA		0.40	219
	ABDOMEN AP		3.49	1442
	PELVIS AP		3.15	1261
	LUMBAR SPINE AP		3.40	2014
	LUMBAR SPINE LAT		9.18	3046
	SKULL		2.28	855
	CERVICAL SPINE		1.39	352
	THORACIC		1.36	469

## International and European recommendations for the establishment and use of DRLs

Organization		Publication
IAEA	International Atomic Energy Agency	Promoted approach of clinical DRLs
ICRP	International Commission on Radiological Protection	Report 135 : Clarification of terms and use of DRLs
European Union	European Commission	European BSS Directive
ESR	European Society of Radiology	Eurosafe Imaging Initiative European Study on Clinical DRLs (EUCLID), and pediatric DRLs (PDRLs)
ACR	American College of Radiology	ACR registry, DRLs according to patient size (Dw)



Radiation  
Protection

N° 195  
*European Study on  
Clinical Diagnostic Reference Levels  
for X-ray Medical Imaging*

EUROPEAN COMMISSION

**RADIATION PROTECTION N° 195**

**European Study on Clinical  
Diagnostic Reference Levels  
for X-ray Medical Imaging**

**EUCLID**

**@ European Union, 2021**

# ICRP\* publication 135

Clarified the need for Clinical DRLs\*\* (cDRL)



**DRLs**  
NATIONAL


ANATOMY-BASED

**LDRL**



**FASTER  
OPTIMIZATION**

**LcDRL**



**FASTER  
OPTIMIZATION**

**cDRL**  
NATIONAL



**CLINICAL  
INDICATION-BASED**

\*International Commission On Radiological Protection / \*\*Diagnostic Reference Levels / \*\*\*Local DRLs / \*\*\*\*Local Clinical DRLs

# Clinical relevance

Performance indicator

## For each examination:

- **Protect**

from unnecessary radiation exposure

- **The right dose for the right diagnosis,**  
delivered with an appropriate image quality

- **Track**

outliers and improve practice



# CLINICAL INDICATIONS

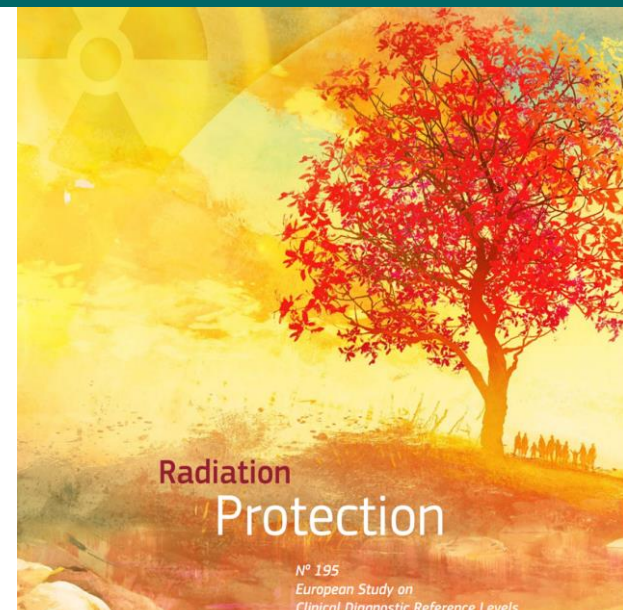
dictate the main parameters

- image quality
- scan length/collimation
- number of phases/projections/images that affect **patient dose**.
- Different image quality is needed for different clinical indications of the same anatomical location.
- **Kidney stone (high-contrast structures) evaluation, using lower radiation doses** than **appendicitis (low-contrast structures, high image noise)**.



	<b>Clinical Task (C)</b>	<b>Anatomical Location (A)</b>	<b>Procedure (P)</b>
CT 1	<u>Stroke</u> Detection or exclusion of a haemorrhage	Head	All Phases
CT 2	<u>Chronic sinusitis</u> Detection or exclusion of polyps	Neck	All Phases
CT 3	<u>Cervical spine trauma</u> Detection or exclusion of a lesion	Spine	All Phases
CT 4	<u>Pulmonary embolism</u> Detection or exclusion	Thorax	All Phases
CT 5	<u>Coronary calcium scoring</u> Risk stratification	Coronary Arteries	All Phases
CT 6	<u>Coronary angiography</u> Vessels assessment	Coronary Arteries	All Phases
CT 7	<u>Lung Cancer</u> Oncological staging First and F-up	Brain Thorax Liver	All Phases
CT 8	<u>Hepatocellular carcinoma</u> Oncological staging	Liver	All Phases
CT 9	<u>Colic /abdominal pain</u> Exclusion or detection of a stone	Abdomen	All Phases
CT 10	<u>Appendicitis</u> Detection or exclusion	Abdomen	All Phases

Table 25: Final CT clinical indications for the EUCLID project



EUROPEAN COMMISSION

**RADIATION PROTECTION N° 195**

**European Study on Clinical Diagnostic Reference Levels for X-ray Medical Imaging**

EUCLID

# Methodology for LcDRLs definition

## 10 steps for sustainable LcDRLs

1. **(Install** a Dose Management Software )
2. **Identify a project sponsor, set up** a Dose team and define the vision
3. **Assess your dose baseline and compare to NDRLs: picture of your status quo**
4. **Harmonize** protocols (parameters and clinical indication) across scanners and institutions
5. **After harmonization, estimate local Clinical DRLs; benchmark with literature**
6. **Optimize** protocols where needed (stepwise approach)
7. **Evaluate IQ** during each optimization phases
8. **Once protocol are optimized, recalculate your LcDRLS**
9. **Revise** LcDRLs periodically, and at each new system introduction
10. if dose tracking in place, continuous review

- National cDRLs values should be set as the 75th percentile of median values obtained in a sample of representative centres.

- Regional (multi-national) cDRL values should be set as the median value of the national



# Radiation Dose Monitoring Software



2

## Set up a Dose team



Leading Change

*Creating a Shared Need*

*Shaping a Vision and Goals*

*Mobilizing Commitment*

*Making Change Last*

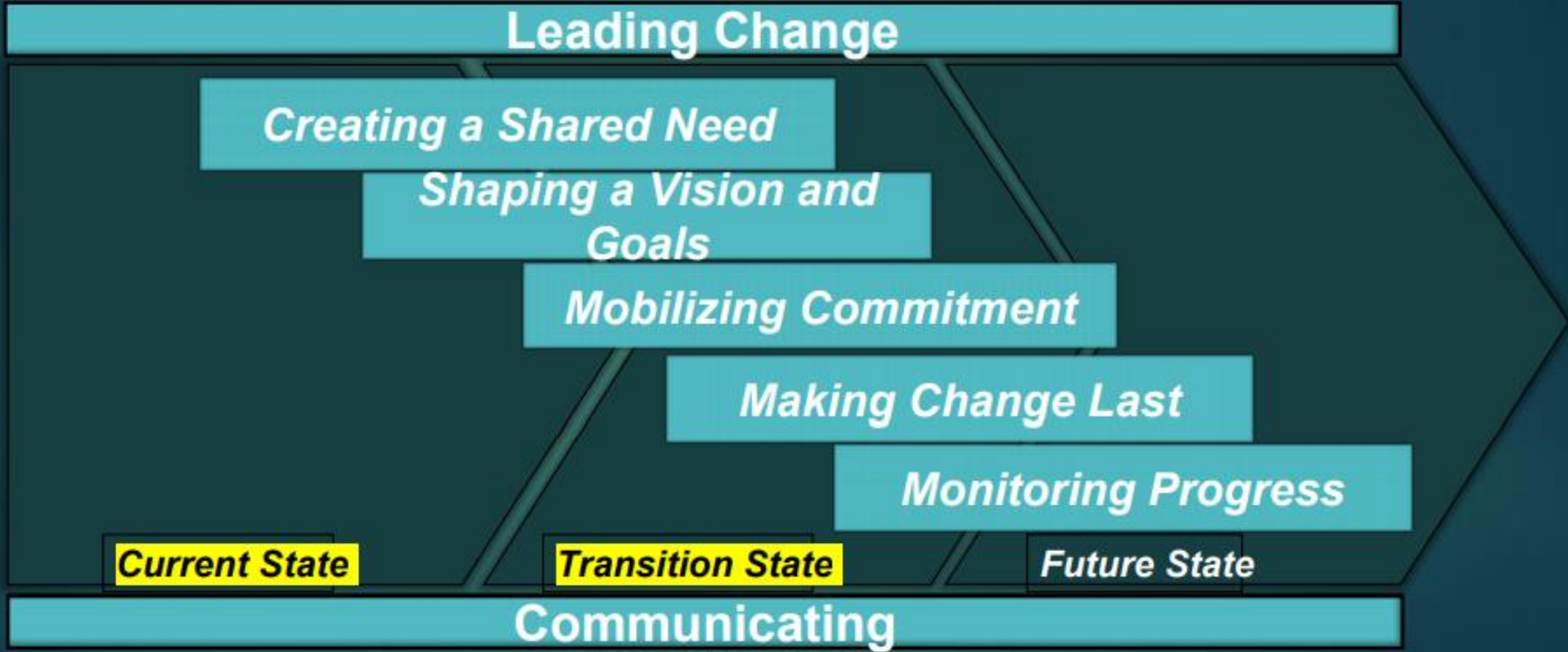
*Monitoring Progress*

**Current State**

**Transition State**

*Future State*

Communicating



# 10 steps for sustainable LcDRLs

## 2

### Set up a Dose team

- Steering committee
- Local dose-team (a radiologist, a physicist, a radiographer, a CT field engineer, and an application specialist dose tracking system)
- Organize workshops to define the vision and set achievable goals

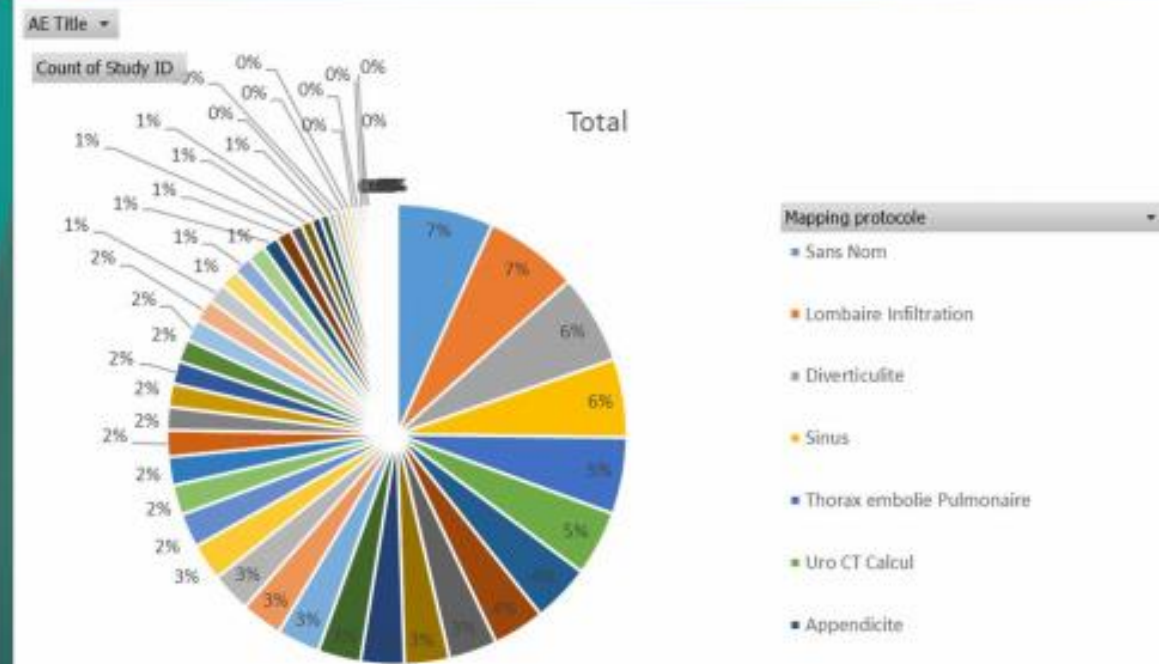


# 10 steps for sustainable LcDRLs

3

## Assess your dose baseline and compare to NDRLs

- List most frequent protocols (80% activity)
- Estimate your dose levels and compare to NDRLs
- Identify opportunity of improvements



# 10 steps for sustainable LcDRLs

## 4

### Harmonize protocols based on clinical indications

- Scanner parameters uniformization
- Design of a clinical indication-based protocol map
- Stratified by (2-3) BMI classes
- Protocol Radlex mapping
- Map each protocol to its RPID code in your dose management system



# Radlex

INDICATION-BASED MAPPING



**BMI**  
< 25



**BMI**  
> 25

# 5 CT Scanners

Division of Diagnostic Radiology, KCMH

Scanner parameters  
uniformization



GE Healthcare

**SIEMENS**

*Ingenuity for life*



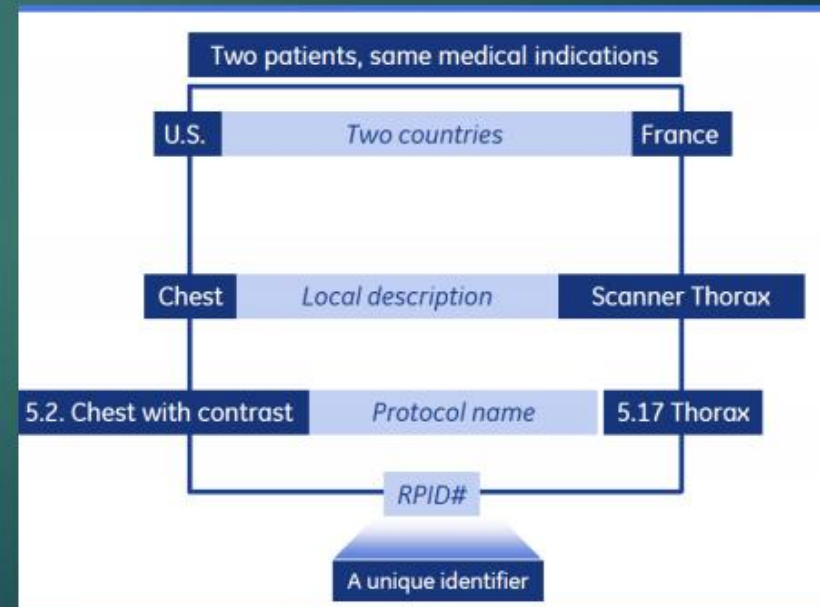
**PHILIPS**



# RadLex Definition

- ▶ The RadLex is a lexicon containing standard study descriptions, called RPID
- ▶ Every RPID is linked with precise clinical indications, which allows you to:
- ▶ Easily compare the practice between all your CTs.
- ▶ Compare the performance of your practice with other hospitals who use RadLex.

RPID	Long Description
RPID2	CT Abdomen Angio w and wo IV Contrast
RPID3	CT Abdomen wo IV Contrast
RPID4	CT Abdomen w and wo IV Contrast
RPID5	CT Abdomen w IV Contrast
RPID6	CT Chest Angio w and wo IV Contrast
RPID7	CT Head Angio w and wo IV Contrast
RPID10	CT Lower Extremity Angio w and wo IV Contrast
RPID11	CT Neck Angio w and wo IV Contrast
RPID12	CT Pelvis Angio w and wo IV Contrast
RPID16	CT Chest wo IV Contrast
RPID17	CT Chest w and wo IV Contrast
RPID18	CT Chest w IV Contrast

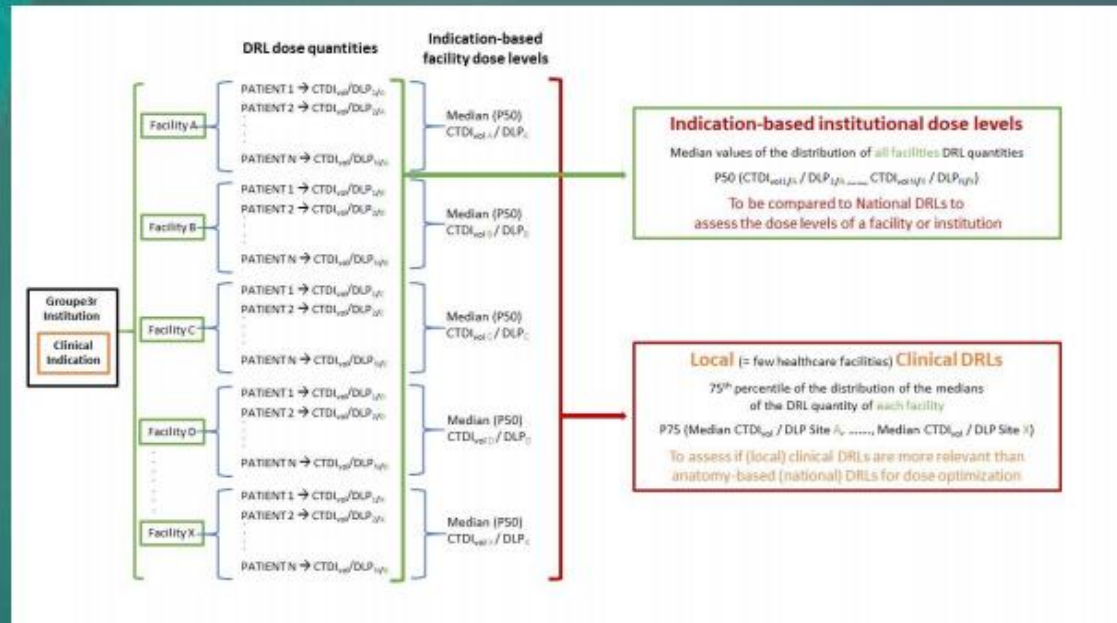


# 10 steps for sustainable LcDRLs

## 5

## Estimate LcDRLs

- Extract sufficient data from the dose management
- Calculate LcDRLs\*
- Compare to NDRLs and literature
- Identify opportunity of improvements



- “Local clinical diagnostic reference levels for chest and abdomen CT examinations in adults as a function of body mass index and clinical indication: a prospective multicenter study<sup>3</sup>, Eur Rad 2019

Hugues Brat, Federica Zanca Stéphane Montandon Damien Racine Benoit Rizk Eric Meicher Dominique Fournier

# 10 steps for sustainable **LcDRLs**

6

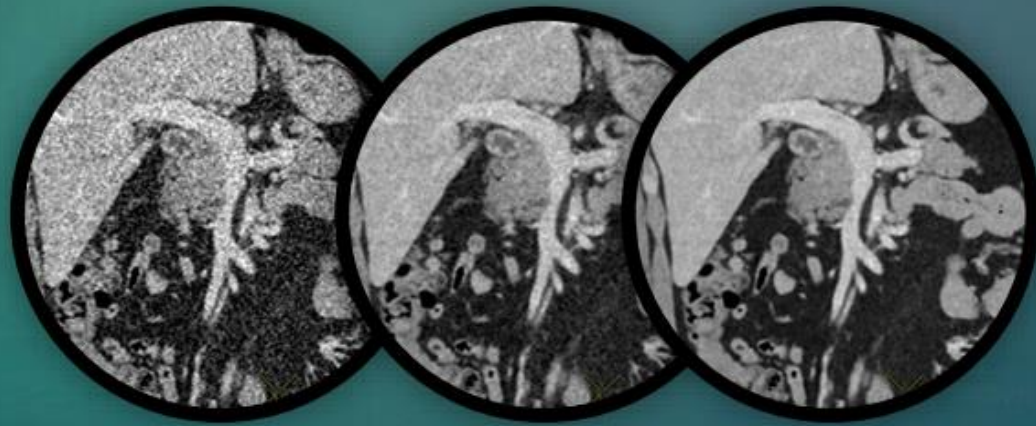
## Optimize your protocols

- Stepwise method for dose reduction (example CTDIvol -10%)

Finally, the right dose for the right diagnosis



**LcDRL**



# 10 steps for sustainable LcDRLs

7

## Evaluate Image Quality



- Contextual call in the PACS

OPTIMIZATION



14



3R  
RÉSEAU  
RADIOLOGIQUE  
ROMAND

# 10 steps for sustainable LcDRLs

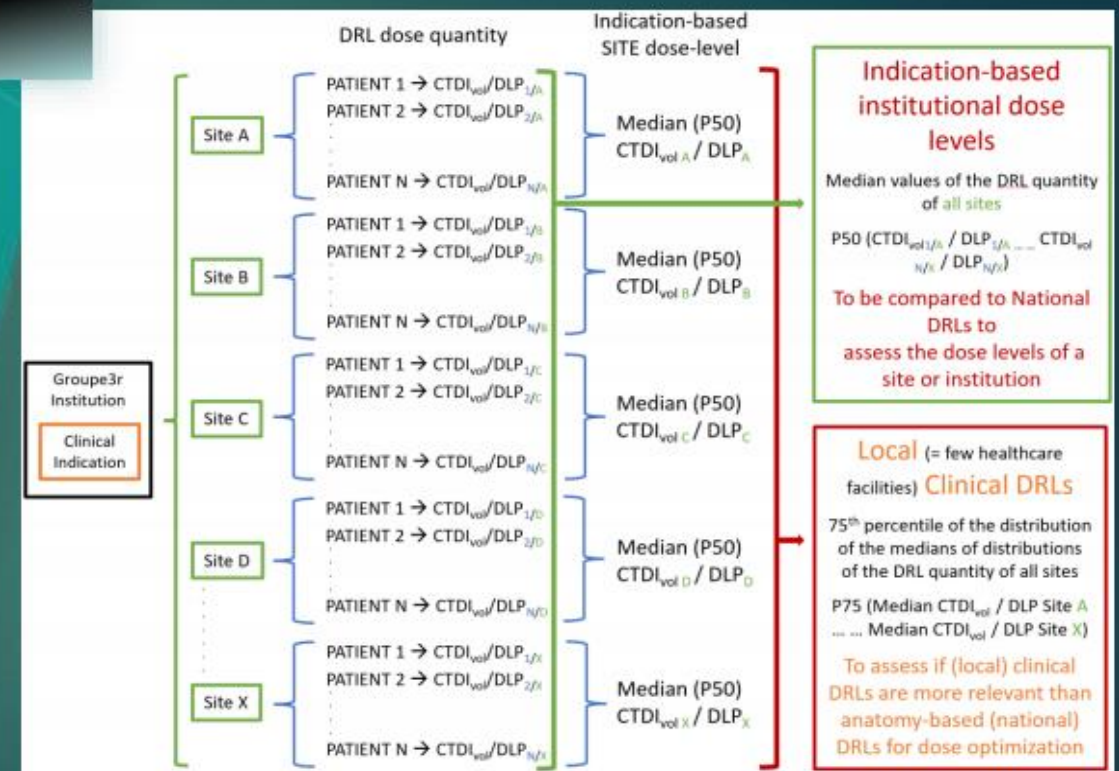
8

## Re-Calculate your LcDRLs

**LcDRLs**

**third quartile of the median dose values**

(CTDI<sub>vol</sub>, DLP) of each CT scanner



© Hugues Brat, Federica Zanca et al. Local clinical diagnostic reference levels for chest and abdomen CT examinations in adults as a function of body mass index and clinical indication: a prospective multicenter study. Eur Radiol. 2019 Dec;29(12):6794-6804.

# 10 steps for sustainable LcDRLs

9

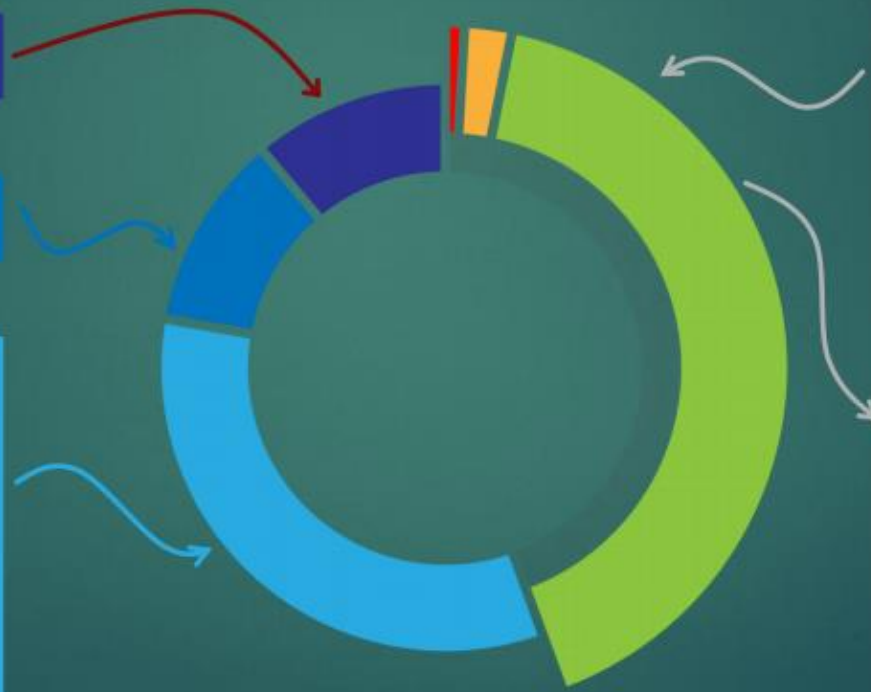
**Continuously improve your practice:  
track outliers / malpractice / feed-back**

**PRODUCTION**  
Most used protocols

**STANDARDIZATION**  
Number of acquisition phases

**OPTIMIZATION**  
Dose levels comparison (CTDI, DLP)  
▪ National DRLs  
▪ Local CDRLs

Clinical indication	BMI category	CT	Acquisition series	Dose (CTDIvol, mGy)	Dose (DLP, mGy.cm)	Flag
Diverticulitis - LCDRL	<25	7	Portal	5.2 (LCDRL : 4.4)	240 (LCDRL : 195.5)	
Diverticulitis - NDRL	<25	7	Portal	5.2 (P50 NDRL : 8)	240 (P50 NDRL : 470)	
Diverticulitis - LCDRL	<25	2	Portal	8.0 (LCDRL : 4.4)	406 (LCDRL : 195.5)	
Diverticulitis - NDRL	<25	2	Portal	8.0 (P50 NDRL : 8)	406 (P50 NDRL : 470)	



**JUSTIFICATION**

Target 100%

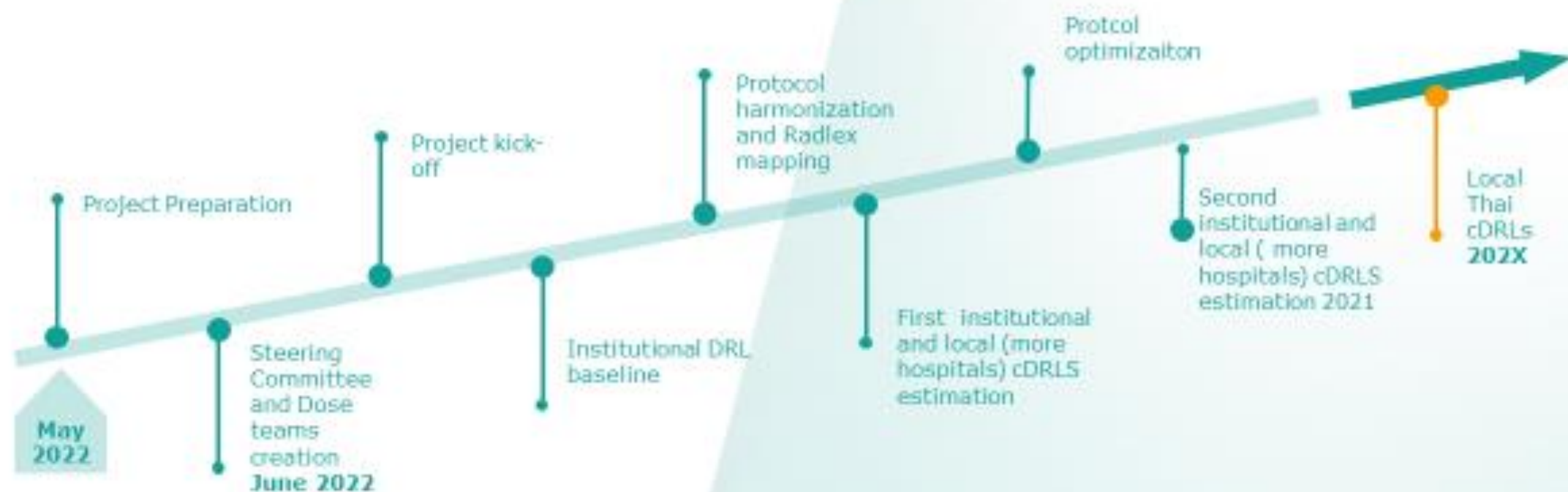
Alert-based examination distribution

- Unjustified alert
- Justified Alert
- No Alert

**QUALITY OF JUSTIFICATION**

- Centering
- Acquisition length
- Additional phase
- BMI
- Patient Movement
- Injection issue

## 10 steps for sustainable LcDRLs



# LcDRLs in Thailand



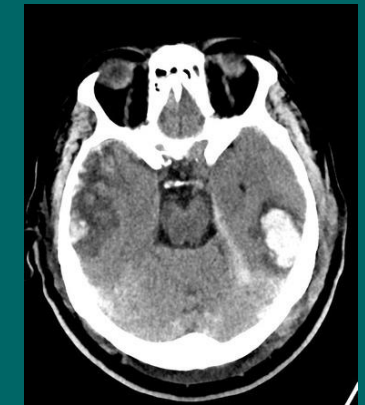


## Standard Protocol List and Radlex Mapping

ANATOMIC AREA	PROTOCOL NAME = CLINICAL INDICATION	EXISTING PROTOCOL NAME	MAIN CLINICAL INDICATION	SCANNING MODE	EXAM DESCRIPTION	NUMBER OF SERIES	RPID	Tai National DRL p75 CTDIvol (mGy)	Tai National DRL p75 DLP (mGy.cm)
HEAD	General Head helical		Unclear symptoms	helical	1 phase without contrast	1	22	62	1028
HEAD	Head space occupying lesion - inflammation, helical		Tumors, Infection, Metastasis, inflammation	helical	2 phases without and with contrast	2	23	52	935
SINUS	Sinusitis, facial trauma		Sinusitis	helical	without contrast	1	324		
Cervical Spine	Cervical Spine Trauma, Herniation		C-spine trauma, herniation, degenerative disease	helical	without contrast	1	21		
CHEST	General Chest		Unclear chest symptoms	helical	without contrast	1	16		
CHEST	General Chest		F/U examination (Metastasis detection, Staging, Tumor evaluation, Dyspnea, Unclear chest symptoms)	helical	with t contrast	1	18	18	417
CHEST	General Chest		Metastasis detection, Staging, Tumor evaluation, Dyspnea, Unclear chest symptoms, First examination	helical	with and without contrast	2	17	18	665
CHEST	Pulmonary Embolism		Thrombus detection	helical	(DE) 1 phase with contrast	1	147		
CHEST	Lung Parenchyma		Interstitial lung disease, bronchiectasis	helical	scan performed always without contrast. 1 phase in inspiratory apnea; or 2 phases: inspiratory, expiratory apnea or prone position	max 3	6001		
CARDIAC	Calcium score		Detect calcified plaques and coronary vessels	helical	without contrast	1	979		
ABDOMEN	Abdomen focal liver lesion max 4 phases		Detection, follow up of HCC, Cholangiocarcinoma,	helical	without and with in arterial and portal venous and/or delayed phase (>3 min)	max 4	953		
ABDOMEN/PELVIS	Renal stone		Detection of stones	helical	without contrast (DE)	1	344(v.1)	18	717

# 1. HEAD (Trauma, Stroke, Infarction) 1 Phase

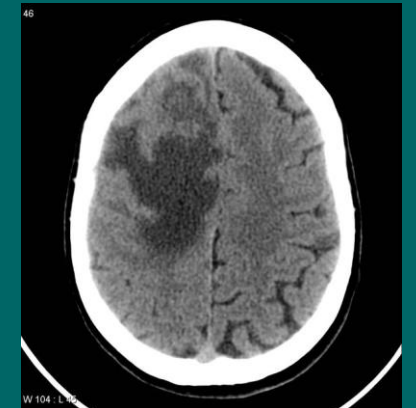
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	41	47	48	51	56	51
DLP(mGy.cm)	764	1,011	1,042	983	1,048	1,042
DLPt (mGy.cm)	764	1,011	1,044	983	1,048	1,042
Scan length (cm)	19	22	21	20	19	21



Brain non contrast

## 2. HEAD (Tumors, Infection, Metastasis) 2 Phases

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	42	47	48	51	56	51
DLP(mGy.cm)	768	1,033	1,054	967	1,157	1,054
DLPt (mGy.cm)	1,535	2,066	2,103	1,942	2,314	2,103
Scan length (cm)	19	22	21	19	20	21



Brain non contrast



Brain with contrast

### 3. SINUS (Sinusitis) 1 Phase

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	6	30	35	21	23	30
DLP(mGy.cm)	97	457	650	282	507	507
DLPt (mGy.cm)	97	457	652	282	507	507
Scan length (cm)	17	16	18	13	23	18



Sinus non contrast

## 4. CERVICAL SPINE (Trauma) 1 Phase

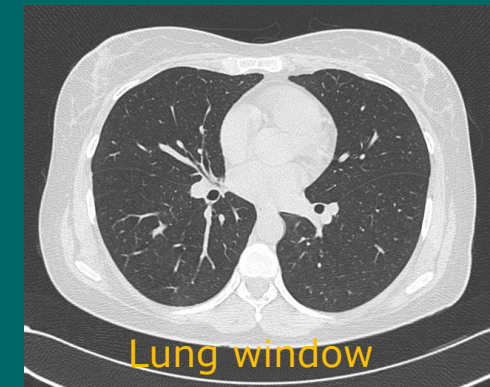
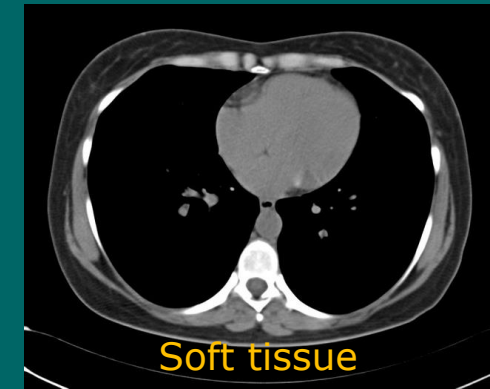
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	15	18	21	13	12	18
DLP(mGy.cm)	346	496	609	336	292	496
DLPt (mGy.cm)	346	496	609	336	292	496
Scan length (cm)	22	27	27	22	25	26



C-Spine non contrast

## 5. CHEST (Unclear chest symptoms) 1 Phase

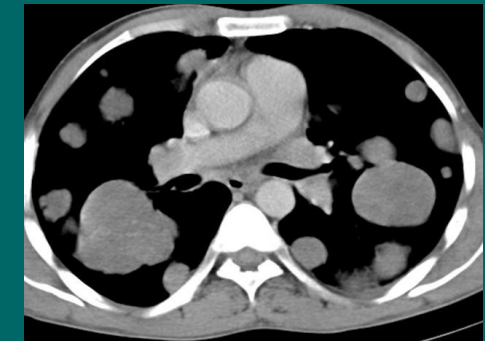
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	9	9	7	7	10	9
DLP(mGy.cm)	324	373	293	260	298	324
DLPt (mGy.cm)	324	373	306	260	298	324
Scan length (cm)	37	40	40	39	35	40



Chest non contrast

## 6. CHEST F/U exam (Metastasis, Staging) 1 Phase

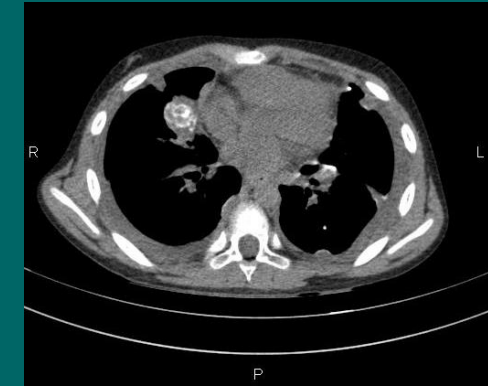
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	7	9	9	8	8	9
DLP(mGy.cm)	254	381	385	316	344	381
DLPt (mGy.cm)	254	381	385	316	344	381
Scan length (cm)	36	41	41	39	41	41



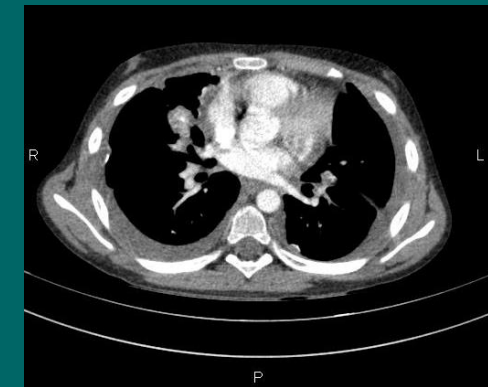
Chest **with** contrast

# 7. CHEST (Metastasis, Staging, 1st Exam) 2 Phase

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	7	9	9	6	-	9
DLP(mGy.cm)	268	367	391	228	-	373
DLPt (mGy.cm)	268	745	781	465	-	754
Scan length (cm)	37	40	37	38	-	39



Chest non contrast

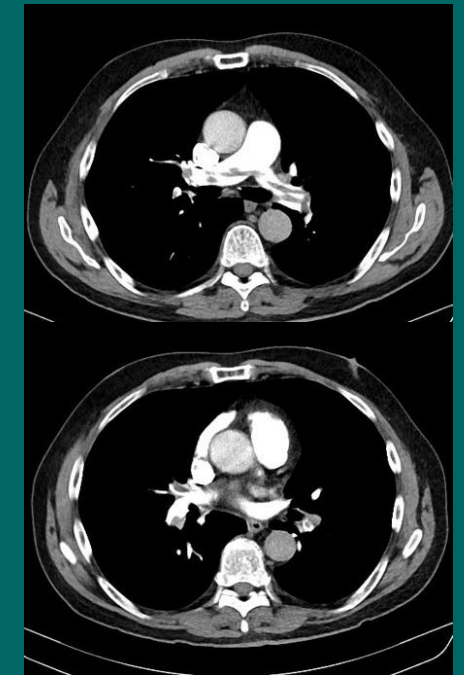


Chest **with** contrast



## 8. CHEST (Thrombus detection) 1 Phase

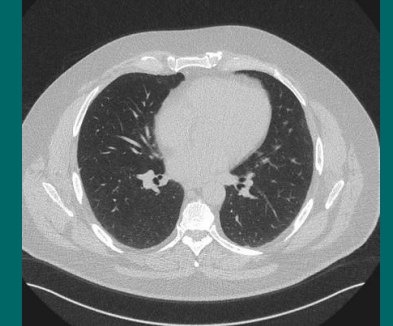
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	8	12	14	7	7	12
DLP(mGy.cm)	267	389	593	231	398	398
DLPt (mGy.cm)	267	389	593	231	398	398
Scan length (cm)	38	34	40	34	63	40



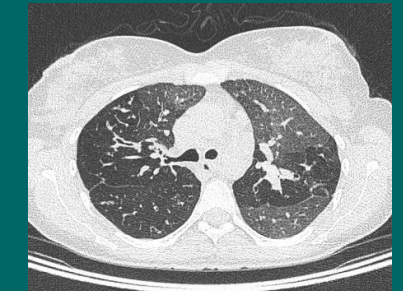
CTA Chest with contrast

# 9. CHEST(Interstitial lung disease) max 3 Phases

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
<b>All Phase : DLPT (mGy.cm)</b>	366	305	2,682*	245	144	366
Axial Inspiration HRCT						
CTDI <sub>vol</sub> (mGy)		1				
DLP(mGy.cm)		29				
DLPT (mGy.cm)		-				
Scan length (cm)		30				
Helical Inspiration Chest						
CTDI <sub>vol</sub> (mGy)	10	7	22*	7	4	
DLP(mGy.cm)	328	259	894	215	125	
DLPT (mGy.cm)	-	-	894	-	125	
Scan length (cm)	37	40	38	34	-	
Axial Expiration HRCT (Supine)						
CTDI <sub>vol</sub> (mGy)	0.3	0.6	22	0.4	2	
DLP(mGy.cm)	8	17	894	8	19	
DLPT (mGy.cm)	-	-	894	-	19	
Scan length (cm)	24	28	38	21	-	
Axial Inspiration HRCT (prone)						
CTDI <sub>vol</sub> (mGy)	1			1		
DLP(mGy.cm)	30			22		
DLPT (mGy.cm)	-			-		
Scan length (cm)	27			28		
Helical Forced Expiration						
CTDI <sub>vol</sub> (mGy)			22			
DLP(mGy.cm)			894			
DLPT (mGy.cm)			894			
Scan length (cm)			38			



Inspiration



Expiration



Prone /Inspiration

\* Helical scan mode

# 10.CARDIAC (Calcium score NC) 1 Phase

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	2	3	7	4	5	5
DLP(mGy.cm)	35	43	90	59	103	90
DLPt (mGy.cm)	35	43	94	59	103	90
Scan length (cm)	15	16	11	14	16	16



Cardiac CT  
Non contrast

Age: 66  
Sex: M  
Ethnicity:  
Weight:  
Height:  
Cholesterol:  
Blood Pressure:  
Diabetes: No  
Smoking: No  
Medications:  
Cardiac History: CALCIUM SCORE  
Previous Calcium Score:  
Family Cardiac History:  
Study Notes:  
Scored By:

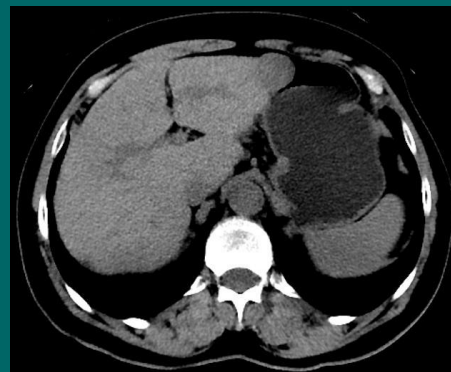
	LHA	LAD	LCA	RCA	PDA	A	B	C	Total
AJ-130	74	7	1	1	0	152	0	0	235
Volume130	55	10	4	4	0	124	0	0	197

# 11. ABDOMEN (Detection, F/U of HCC) max 4 Phases

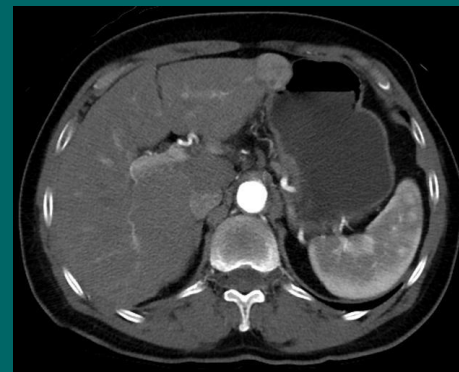
LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	9	11	11	8	9	11
DLP(mGy.cm)	259	333	392	302	440	392
DLPt (mGy.cm)	1,047	1,325	1,600	1,364	-	1,423
Scan length (cm)	29	31	35	32	-	32



Abdomen multi-phases



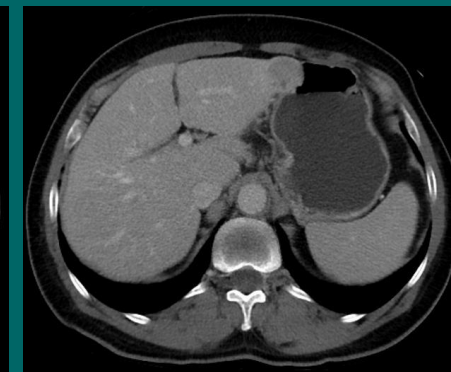
Non contrast



Arterial



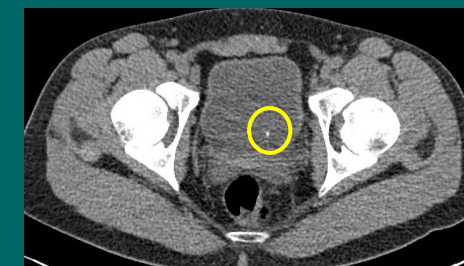
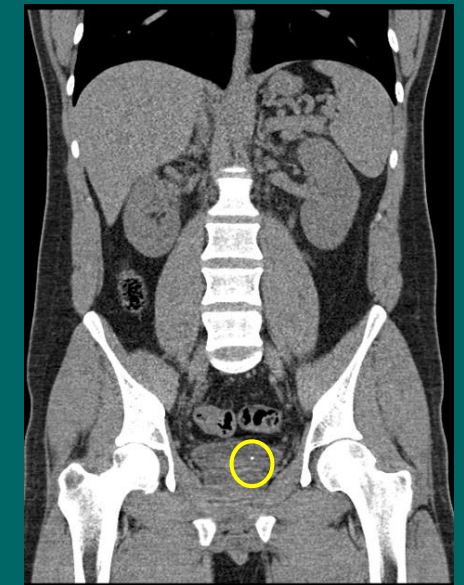
Porto-venous



Delayed

# 12. ABDOMEN/ PELVIS (Detection of Stones) 1 Phase

LcDRLs	Center					NcDRLs (Q3) THAILAND
	1	2	3	4	5	
CTDI <sub>vol</sub> (mGy)	9	7	10	10	9	10
DLP(mGy.cm)	368	359	477	440	286	440
DLPt (mGy.cm)	368	359	477	440	286	440
Scan length (cm)	43	49	44	38	47	47



Abdomen non contrast

Table 30 presents the CT DRLs for the ten clinical indications investigated in the survey.

CI	clinical indication	CTDI <sub>vol,p</sub> (mGy)*	DLP <sub>p</sub> (mGy.cm)	DLP <sub>t</sub> (mGy.cm)	scan length (cm)
1	Stroke - Detection or exclusion of a haemorrhage	48	807	1386	18
2	Chronic sinusitis - Detection or exclusion of polyps	11	188**	211	16
3	Cervical spine trauma - Detection or exclusion of a lesion	17	455	495	23
4	Pulmonary embolism - Detection or exclusion	9	307	364	35
5	Coronary calcium scoring - Risk stratification	4	72	81	17
6	Coronary angiography - Vessels assessment	25	415	459	17
7	Lung cancer - Oncological staging, First and F-up	8	348	628	47
8	Hepatocellular carcinoma - Oncological staging	9	354	1273	37
9	Colic / abdominal pain - Exclusion or detection of a stone	8	436	480	48
10	Appendicitis - Detection or exclusion	9	498	874	49

\*CTDI<sub>vol,p</sub> represents the mean CTDI<sub>vol</sub> of all phases

\*\* Chronic sinusitis DLP<sub>p</sub> reflects data coming from small number of patients (14 patients in total) with more than 1 phase and DLP values much higher than those with only 1-phase protocol

# Keys to success

Deliver The Right Dose for the Right Diagnosis

**Strong leadership**

**Collaboration between radiologists, radiographers, medical physics experts and industry**

**Dashboards to present results**

## Conclusion



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**THANK YOU FOR  
YOUR ATTENTION**