National Diagnostic Reference Levels in Japan (2020)

- Japan DRLs 2020-

Japan Network for Research and Information on Medical Exposure (J-RIME)

Japan Association on Radiological Protection in Medicine

Japan Health Physics Society

Japan Pediatric Cardiac CT Alliance

Japan Radiological Society

Japan Society of Medical Physics

Japanese Society for Oral and Maxillofacial Radiology

Japanese Society for Radiation Oncology

Japanese Society of Interventional Radiology

Japanese Society of Nuclear Medicine

Japanese Society of Pediatric Radiology

Japanese Society of Radiological Technology

The Japan Association of Radiological Technologists

The Japan Central Organization on Quality Assurance of Breast Cancer Screening

The Japanese College of Medical Physics

The Japanese Radiation Research Society

The Japanese Society for Neuroendovascular Therapy

The Japanese Society of Nuclear Medicine Technology

In cooperation with the

Japan Medical Imaging and Radiological Systems Industries Association

National Institutes for Quantum and Radiological Science and Technology

Preface

Five years have passed since the Diagnostic Reference Levels (DRLs) were first published in Japan in June 2015. With this revision of "Diagnostic Reference Levels in Japan (2020 edition)" report (commonly referred to as the Japan DRLs 2020 or DRLs 2020), seven modalities are being released. This revision was prepared as per the results of a fact-finding survey conducted by the Japan Network for Research and Information on Medical Exposure (J-RIME) in cooperation with related academic societies.

Japan DRLs 2015 was established for six modalities as a compiled "Setting of DRLs based on the results of the latest domestic fact-finding survey" report in cooperation with related academic societies under the activities of J-RIME. Multiple experts, including physicians, clinical radiologists, and medical physicists, discussed the data, and expert advice was obtained from international organizations, including the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO). The establishment of national DRLs in Japan is ground-breaking, and has had a major impact on radiation protection in medicine in Japan and has been reported on by the media.

When initially published, the DRLs 2015 had not been included in laws and ordinances and were positioned as one set by the academic societies in the framework of the J-RIME, but were recognized and implemented in domestic radiation practice through the educational activities of academic societies. With the revision of the Medical Law Enforcement Regulations in March 2019, safety management systems for medical radiation have become an important part of the "Guidelines from relevant academic societies" in the dose management of medical exposure, and the DRLs 2015 has been, in effect, incorporated into laws and ordinances.

Based on these circumstances, the DRLs 2020 have been developed in a timely manner with the cooperation of relevant academic societies in a similar manner as that of the DRLs 2015.

Radiation medicine has come into wide use in modern times and become an essential part of medical care. Continuous advances have been made by introducing new methods and devices. While radiation medicine has brought great benefits to the general public, the medical exposure of patients has been increasing. Note that medical exposure accounts for a considerable part of the radiation exposure of the population in developed countries when combining natural and artificial radiations. Thus, it has been recognized domestically and internationally that radiation protection efforts are crucial to allow patients to enjoy safe and effective radiation therapy. ‘Justification’, ‘Optimization’, and ‘Dose Limits’ are three principles in the protection against various radiation exposures. However, unlike occupational and public exposure, dose limits have not been defined for protecting patients from medical exposure. The medical exposure of

patients differ from other types of exposure in that patients are exposed to radiation intentionally and in that patients themselves receive benefits; thus, a uniform dose limit may limit medical care and lead to disadvantages to patients. Therefore, the principles of justification and optimization must be followed for the medical exposure of patients and, for optimization, the DRLs are an important tool for optimizing radiological diagnosis and interventional radiology (IVR). Currently, the international standard is to establish and implement DRLs for each individual country. In 2017, the ICRP released Publication 135, which comprehensively discusses DRLs. This document provides historical information on the 20 years after the first introduction of the term diagnostic reference level by the ICRP and guidance. During the establishment of the current DRLs 2020, ICRP Publication 135 was used as a reference.

While Japan has considerably contributed to the development of radiation medicine over the years, knowledge about medical exposure has been accumulated but has not been systematized for protection against medical exposure. Therefore, it was recognized that there was a requirement to gather and share domestic and overseas research information on medical exposure with the cooperation of numerous experts in collaboration with academic societies and to establish a medical exposure protection system that is appropriate for the situation in Japan. In 2010, J-RIME was established as a parent organization for these activities in cooperation with related academic societies. The J-RIME's objectives are to collect data on medical exposure such as exposure dose and risk assessment in radiation medicine to gain an understanding of the actual status of medical exposure in Japan and create an appropriate protection system for medical exposure in Japan based on international trends. As of 2020, J-RIME has expanded the scale of its organization and activities with the participation and cooperation of academic societies, institutions, universities, professional organizations, medical facilities, governmental agencies, and associated industries related to radiation therapy and protection, and is also functioning as an all-Japan network.

Finally, I would like to express its sincere gratitude to all of the relevant parties for their tremendous efforts and support and for being accommodating during this revision of the DRLs.

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Japan Network for Research and Information on Medical Exposure (J-RIME)

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1. Background of Establishment of Diagnostic Reference Levels (DRLs 2020)

International guidelines on international basic safety standards, such as the International Commission on Radiological Protection (ICRP) and International Atomic Energy Agency (IAEA), state that Diagnostic Reference Levels (DRLs) are tools for optimizing medical radiation protection in the diagnostic field. DRLs include determining which dose is defined as the dose to be used for DRL, how this dose is to be measured, how this accumulates and how these are to be implemented. Moreover, DRLs are closely related to the quality assurance of equipment and methods and play an important role in optimization. Overseas, the European Union (EU) Council Directive 97/43/Euratom (June 1997) established a medical radiation protection framework in Europe, in which the establishment of DRLs in the diagnostic field was required in EU member countries and, in response, DRLs have been incorporated in various countries. Moreover, in the United States, DRLs from the American College of Radiology (ACR), American Association of Physicists in Medicine (AAPM), and National Council on Radiation Protection and Measurements (NCRP) are considered to be the de facto standard.

In Japan, at first, various organizations, academic societies, organizations, and researchers conducted a survey on diagnostic doses and proposed standard diagnostic doses. However, these were not necessarily conducted with sufficient cooperation of numerous related parties; therefore, there were no widely accepted DRLs available. Therefore, as part of its activities, the Japan Network for Research and Information on Medical Exposure (J-RIME), which was established as an organization to share and collaborate on medical exposure research information, set up a DRL working group of members assigned from each organization in August 2014 to create DRLs. After defining diagnostic doses, the survey method were jointly evaluated in detail by constituent organizations on one platform, a large-scale national survey was conducted, the results were tabulated and analyzed, and the work was performed with repeated discussions between committee members considering comments from domestic and overseas experts. Consideration was given to maintain transparency and objectivity during the process. In this manner, the first national DRLs were established for Japan (Japan DRLs 2015) and became widely recognized as a standard tool for promoting optimization in radiation protection within the country.

ICRP Publication 135, which defines the use of DRL in radiological diagnosis, recommends DRL revisions at least every 3-5 years. This is necessary to drive broader optimization by implementing DRLs and to respond to changes in technical progress and clinical demands. The DRL Working Group of J-RIME set 2020, which is five years from the initial version, as the time of revision, and a decision was made to establish the DRLs 2020 after a series of joint investigations and discussions by the constituent organizations. By enforcing the partial revision of the Enforcement Regulations of the Medical Care Law that includes the safety

management of radiation for medical use in April 2020, the optimization at each institution is expected to be promoted using these new DRLs.

2. Objective of Establishing new Diagnostic Reference Levels

2.1. Features of diagnostic reference levels (DRLs)

The DRLs are a tool for institutions to become aware of using higher doses than other institutions and to facilitate the process of dosing optimization. The ICRP defines DRLs as "a form of investigation level used as a tool to aid in optimisation of protection in the medical exposure of patients for diagnostic and Interventional procedures" [1]. The appropriate DRLs (a common and easily measured or determined measure of the amount of ionizing radiation) for the modalities will be determined by referring to the distribution of the DRL (e.g., 75th percentile) obtained from such methods as dosimetry.

The most notable significance of this DRL is that it is not a dose limit and that it is not a boundary that separates right or wrong in terms of medical actions [1]. A dose limit is the dose that should not be exceeded. However, DRLs may be exceeded if clinically necessary [1]. Moreover, DRLs are used for patient groups or test groups and are not used to determine whether an individual patient or test dose is too high. Higher doses than those given to typical patients may be required depending on the patient's weight and body shape.

DRLs are set per country, per region, or locally. This is because equipment and procedural protocols may vary from country to country and from region to region. The DRLs 2020 represent national DRLs.

The DRLs are set in reference to the 75th percentile of the dose survey results and serve as an index to identify examinations, equipment, and institutions that use high doses. In addition to the DRLs, this report includes the 75th percentile and median value results from dose surveys for each modality included in the text of the report, as appropriate. If the median of the institution is higher than the median for the country, the median for the country may be a target for further optimization. However, if the median value at the institution is lower than the median value for the country, an assessment of whether the image quality or diagnostic capability is sufficient can be prioritized in the optimization process rather than dose [1].

2.2. Utilization of diagnostic reference levels in clinical settings

Typical doses used at the institution should be investigated and, if the median value exceeds the DRLs, a review should be performed to determine if doses have been optimized, unless there are clinical justifications. In general, the capacity of the equipment used and protocols (procedures) will be evaluated to identify the cause of any high doses and measures taken to use a more appropriate dose. After measures are implemented, the typical dose at the institution will be evaluated again and compared in relation to the DRLs. ICRP Publication 135[1] recommends annual dose surveys for computed tomography (CT) and IVR, and surveys every three years for other examinations unless there are changes in equipment. Protocols for new equipment should

be evaluated before these are used to test patients and should be reassessed within 1 year of introduction and when testing methods have been established. Note that throughout all of these procedures, rather than seeking the best image quality, physicians attempt to achieve the sufficient image quality required for each diagnosis.

The objective of DRLs is for optimization and not dose reduction. If the necessary diagnostic information cannot be obtained from a validated test, this will then result in unnecessary exposure. In particular, if the imaging conditions are changed, it is important to confirm that the change in dose and image quality and diagnostic capability are ensured.

To promote optimization in the clinical setting, there is a requirement to compare the dose at one's own institution with the DRLs. However, it is difficult to compare the dose at one's own institution with the DRLs if no dosimeter is available. As a countermeasure for the time being, numerical values calculated using the numerical dose determination (NDD) method [2)] or the use of existing software that can calculate the exposure dose or use of display values on the equipment can be substituted. Moreover, for dosimeters and phantoms, it may be useful to create a mechanism by which the dosimeters and phantoms of affiliated organizations and other institutions that own them can be used.

References:

1) International Commission on Radiological Protection, 2017. Diagnostic Reference Levels in Medical Imaging. ICRP Publication 135. Ann. ICRP 46 (1)
2) Mori T, Suzuki M, Sato H, et al. 1997 A Study of Creating Guidance Level in Medical Exposure [in Japanese]. Research reports of Suzuka University of Medical Science and Technology 4, 109-129.

3. National Diagnostic Reference Levels Established in 2020 (Japan DRLs 2020)

The following are recommended as national DRLs in Japan.

3.1. Japan DRLs 2020 for Computed Tomography

3.1.1. Japan DRLs 2020 for Adult CT

Protocol	**$CTDI_{vol}$ [mGy]**	**DLP [mGy·cm]**
Routine brain	77	1350
Routine chest	13	510
Chest to pelvis	16	1200
Abdomen and pelvis	18	880
Liver, multi-phase	17	2100
Coronary CTA	66	1300
Acute pulmonary thromboembolism and deep vein thrombosis	14	2600
Whole body CT for trauma	n/a	5800

Note 1) Standard body weight is 50-70 kg
Note 2) Liver, multiphase does not include the chest or pelvis. CTDI and DLP are based on the average of all phases and the whole examinations, respectively.
Note 3) The CTDI and DLP of the coronary artery are based on a CTA scan and whole examinations, respectively.
Note 4) The CTDI and DLP for acute pulmonary thromboembolism and deep vein thrombosis are based on the first phase and whole examinations, respectively.

3.1.2. Japan DRLs 2020 for Pediatric CT

Age grouping

	<1 y		1- <5 y		5- <10 y		10- <15 y	
	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]
Head	30	480	40	660	55	850	60	1000
Chest	6 (3)	140 (70)	8 (4)	190 (95)	13 (6.5)	350 (175)	13 (6.5)	460 (230)
Abdomen	10 (5)	220 (110)	12 (6)	380 (190)	15 (7.5)	530 (265)	18 (9)	900 (450)

Weight grouping

	<5 kg		5 - <15 kg		15 - <30 kg		30 - <50 kg	
	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]	$CTDI_{vol}$ [mGy]	DLP [mGy cm]
Chest	5 (2.5)	76 (38)	9 (4.5)	122 (61)	11 (5.5)	310 (155)	13 (6.5)	450 (225)
Abdomen	5 (2.5)	130 (65)	12 (6)	330 (165)	13 (6.5)	610 (305)	16 (8)	720 (360)

Note 1) Doses refer to the 16 cm standard CT dosimetry phantom along with that refer to the 32 cm standard CT dosimetry phantom in parentheses.
Note 2) The scan range for the abdomen is from the upper abdomen to the pelvis.

3.2. Japan DRLs 2020 for General Radiography

Examination	Entrance-surface air kerma [mGy]
Chest PA (<100 kV)	0.4
Chest PA (≥ 100 kV)	0.3
Chest PA (medical checkup) (≥ 100 kV)	0.2
Abdomen (AP supine)	2.5
Infant hip joint (0-1y)	0.2
Infant chest (0-1 y)	0.2
Child chest (5 y)	0.2
Skull	2.5
Cervical spine	0.8
Thoracic spine	3.0
Thoracic spine LAT	5.0
Lumbar spine	3.5
Lumbar spine LAT	9.0
Pelvis	2.5

3.3. Japan DRLs 2020 for Mammography

Mean glandular dose at 40 mm polymethylmethacrylate (PMMA) [mGy]	2.4
2D mammography mean glandular dose based on clinical data [mGy]	1.4
Digital breast tomosynthesis (DBT) mean glandular dose based on clinical data [mGy]	1.5

3.4. Japan DRLs 2020 for Dental Radiography

3.4.1. Japan DRLs 2020 for Intraoral Radiography

Examination site	Incident air kerma ($K_{a,i}$) [mGy][a)]	
	Adults[b)]	Pediatric[c)]
Maxilla		
Incisor	1.1	0.9
Canine	1.3	0.9
Premolar	1.6	1.0
Molar	2.0	1.2
Mandible		
Incisor	1.0	0.7
Canine	1.1	0.8
Premolar	1.1	0.9
Molar	1.5	1.0

As with DRLs2015, DRLs were set for the standard intraoral radiography using the bisecting or paralleling technique and did not include other oral procedures such as bite-wing or occlusal techniques (bisection, axial projection).
a) Incident air kerma ($K_{a,i}$): Air kerma at the one-tip without patient backscatter[1, 3, 4)]
b) Adult patients with standard body size
c) Ten-year-old pediatric patients

3.4.2. Japan DRLs 2020 for Panoramic Radiography

Air kerma-area product (P_{KA}) [mGy cm^2]	134
Dose-width product (DWP) [mGy mm]	89

3.4.3. Japan DRLs 2020 for Dental Cone Beam CT

FOV	Air kerma-area product (P_{KA}) [mGy cm^2]	Air kerma at the isocenter (K_{iso}) [mGy]
<40 cm^2	841	24
40-100 cm^2	1670	29
>100 cm^2	1960	16

3.5. Japan DRLs 2020 for IVR

Head/neck

Diagnosis Angiography (pre-op)	**$K_{a,r}$ [mGy]**	**P_{KA} [Gy cm^2]**
Saccular aneurysm	590	89
Cerebral arteriovenous malformation	770	160
Cerebral dural arteriovenous fistula	1100	190
Cervical carotid artery stenosis/occlusion	560	120
Acute cerebral artery stenosis/occlusion	480	83
Intracranial tumor	720	140
Diagnosis Angiography (post-op)	**$K_{a,r}$ [mGy]**	**P_{KA} [Gy cm^2]**
Saccular aneurysm	510	57
Cerebral arteriovenous malformation	470	77
Cerebral dural arteriovenous fistula	820	150
Cervical carotid artery stenosis/occlusion	390	72
Acute cerebral artery stenosis/occlusion	500	83
Intracranial tumor	(1000)*	(77)*
Endovascular treatment (IVR)	**$K_{a,r}$ [mGy]**	**P_{KA} [Gy cm^2]**
Saccular aneurysm	3100	210
Cerebral arteriovenous malformation	4100	410
Cerebral dural arteriovenous fistula	4700	430
Cervical carotid artery stenosis/occlusion	820	150
Acute cerebral artery stenosis/occlusion	1400	230
Intracranial tumor	2500	320

Note 1) $K_{a,r}$: Incident air kerma at the patient entrance reference point (mGy) displayed on the equipment
Note 2) P_{KA}: Air kerma-area product (Gy cm^2) displayed on the equipment
Note 3) Cervical carotid artery stenosis/occlusion was in an elective case.
Note 4) *: Reference only because only few data are available

Cardiac Regions (Adult)

	$K_{a,r}$ [mGy]	P_{KA} [Gy cm^2]
Diagnostic catheterization	700	59
Non-CTO PCI	1800	130
CTO PCI	3900	280
Non-PVI RFCA	560	57
PVI RFCA	645	89

Note 1) PCI: Percutaneous Coronary Intervention
Note 2) CTO: Chronic Total Occlusion
Note3) RFCA: Radiofrequency Catheter Ablation
Note 4) PVI: Pulmonary Vein Isolation

Cardiac Regions (Pediatric, age grouping)

Diagnostic catheterization	$K_{a,r}$ [mGy]	P_{KA} [Gy cm^2]
<1 y	100	7
1 - < 5 y	130	12
5 - < 10 y	190	14
10 - < 15 y	350	47
Interventional radiography		
<1 y	150	8
1 - < 5 y	210	16
5 - < 10 y	210	16
10 - < 15 y	500	46

Interventional radiography for chest and abdomen

	$K_{a,r}$ [mGy]	P_{KA} [Gy cm^2]
TACE	1400	270
TEVAR	830	200
EVAR	1000	210

Note 1) TACE: Transcatheter Arterial ChemoEmbolization
Note 2) TEVAR: Thoracic Endovascular Aortic Repair
Note 3) EVAR: Endovascular Aortic Repair

Entrance-surface air kerma rate in fluoroscopy

Entrance-surface air kerma rate in fluoroscopy (mGy min^{-1})	17

Note 1) Phantom incident surface dose rate at the patient irradiation reference point (Entrance surface dose rate: Incident surface dose rate including backscattered radiation from a phantom)

3.6. DRLs for Diagnostic Fluoroscopy

	$K_{a,r}$ [mGy]	P_{KA} [Gy cm^2]	Fluoroscopic time [min]	No. of images per exam
Barium swallow	30	17	5	5
Upper gastrointestinal fluoroscopy with contrast	110	45	6	27
Upper gastrointestinal fluoroscopy with contrast (detailed examination)	230	61	13	45
Upper gastrointestinal fluoroscopy with contrast (medical checkup)	89	29	6	21
Ileus tube insertion	150	47	28	6
Barium enema	130	46	11	27
ERCP (diagnostic)	93	26	14	12
ERCP (treatment)	170	36	17	13
Bronchoscopy	38	8	8	1
Total parenteral nutrition catheterization (CV catheter-port insertion)	8	3	3	2
Lumbar nerve root block	49	9	3	2
Lumbar myelography	69	26	4	11

Note 1) KAP (Air kerma-area product) was expressed as P_{KA} in ICRP Publication 135 [1]. The conventional notation is DAP: Dose area product

Note 2) Incident air kerma at the patient entrance reference point ($K_{a,r}$) is the incident air kerma at the patient entrance reference point for fluoroscopes specified in JIS Z 4751-2-54 [2] (excluding backscatter)

3.7 Japan DRLs 2020 for Nuclear Medicine

3.7.1. Japan DRLs 2020 for SPECT radiopharmaceuticals

Radiopharmaceutical	Adult dose [MBq]
Bone: ^{99m}Tc-MDP	950
Bone: ^{99m}Tc-HMDP	950
Bone marrow: ^{111}In-chloride	80
Cerebral blood flow: ^{99m}Tc-HMPAO (rest or stress)	800
Cerebral blood flow: ^{99m}Tc-HMPAO (rest and stress)	1200
Cerebral blood flow: ^{99m}Tc-ECD (rest or stress)	800
Cerebral blood flow: ^{99m}Tc-ECD (rest and stress)	1100
Cerebral blood flow: ^{123}I-IMP (rest or stress)	200
Cerebral blood flow: ^{123}I-IMP (rest and stress)	270
Brain receptors: ^{123}I-iomazenil	200
Striatum: ^{123}I-ioflupane	190
Cisternography: ^{111}In-DTPA	40
Thyroid uptake: Na^{123}I	10
Thyroid: $^{99m}TcO_4^-$	240
Parathyroid: ^{201}Tl-chloride	120
Parathyroid: $^{99m}TcO_4^-$	300
Parathyroid: ^{99m}Tc-MIBI	800
Lung ventilation: ^{81m}Kr-gas	200
Pulmonary blood flow: ^{99m}Tc-MAA	260
Radionuclide venography: ^{99m}Tc-MAA	500
Liver/spleen: ^{99m}Tc-phytate	200
Hepatic function: ^{99m}Tc-GSA	260
Hepatobiliary: ^{99m}Tc-PMT	260
Liver and spleen: ^{99m}Tc-Sn colloid	180
Myocardial perfusion: ^{201}Tl-chloride	120
Myocardial perfusion: ^{99m}Tc-tetrofosmin (rest or stress)	840
Myocardial perfusion: ^{99m}Tc-tetrofosmin (rest and stress)	1200

Myocardial blood flow: ^{99m}Tc-MIBI (rest or stress)	880
Myocardial blood flow: ^{99m}Tc-MIBI (rest and stress)	1200
Myocardial fatty acid metabolism: ^{123}I-BMIPP	130
Cardiac sympathetic function: ^{123}I-MIBG	130
Cardiac blood pool: ^{99m}Tc-HSA-D	970
Myocardial infarction: ^{99m}Tc-PYP	800
Salivary gland: $^{99m}TcO_4^-$	370
Meckel's diverticulum: $^{99m}TcO_4^-$	440
Gastrointestinal bleeding: ^{99m}Tc-HSA-D	1040
Protein leakage: ^{99m}Tc-HSA-D	1040
Static renal imaging: ^{99m}Tc-DMSA	210
Dynamic renal imaging: ^{99m}Tc-MAG 3	380
Dynamic renal imaging: ^{99m}Tc-DTPA	390
Adrenal cortex: ^{131}I-adosterol	40
Adrenal medulla: ^{123}I-MIBG	130
Tumor: ^{201}Tl-chloride	120
Tumor and inflammation: ^{67}Ga-citrate	120
Somatostatin receptor: ^{111}In-pentetreotide	120
Lymphatic vessels: ^{99m}Tc-HSA-D	830
Sentinel lymph node (breast cancer): ^{99m}Tc-Sn colloid	120
Sentinel lymph node (breast cancer): ^{99m}Tc-phytate	120
Sentinel lymph node (melanoma): ^{99m}Tc-Sn colloid	120
Sentinel lymph node (melanoma): ^{99m}Tc-phytate	120
RI angiography: ^{99m}Tc-HSA-D	1000

3.7.2. DRLs for PET radiopharmaceuticals

Radiopharmaceutical	Adult dose [MBq]
Brain function: $C^{15}O_2$-gas (2D acquisition)	8000
Brain function: $^{15}O_2$-gas (2D acquisition)	6000
Brain function: $C^{15}O$ -gas (2D acquisition)	3000
Brain function: $C^{15}O_2$-gas (3D acquisition)	1800
Brain function: $^{15}O_2$-gas (3D acquisition)	4500
Brain function: $C^{15}O$-gas (3D acquisition)	3600
Amyloid: ^{18}F -flutemetamol (in-house preparation)	260 1)
Amyloid: ^{18}F -flutemetamol (delivery)	260 1)
Amyloid: ^{18}F -florbetapir (in-house preparation)	370 1)
Amyloid: ^{18}F -florbetapir (delivery)	370 1)
Amyloid: ^{18}F -florbetaben (in-house preparation)	300 1)
Cerebral glucose metabolism: ^{18}F -FDG (in-house preparation)	240
Cerebral glucose metabolism: ^{18}F -FDG (delivery)	240
Cerebral glucose metabolism: ^{18}F -FDG (dose per body weight)	4
Myocardial glucose metabolism: ^{18}F -FDG (in-house preparation)	240
Myocardial glucose metabolism: ^{18}F -FDG (delivery)	240
Myocardial glucose metabolism: ^{18}F -FDG (dose per body weight)	5
Myocardial blood flow: $^{13}NH_3$ (in-house preparation)	520
Tumor glucose metabolism: ^{18}F -FDG (in-house preparation)	240
Tumor glucose metabolism: ^{18}F -FDG (delivery)	240
Tumor glucose metabolism: ^{18}F -FDG (dose per body weight)	4
Inflammation: ^{18}F-FDG (in-house preparation)	240
Inflammation: ^{18}F-FDG (delivery)	240
Inflammation: ^{18}F-FDG (dose per body weight)	4

Note 1) This criterion was set for amyloid (^{18}F-flutemetamol, ^{18}F-florbetapir, ^{18}F-florbetaben) by referring to the package insert.

3.7.3. DRLs for SPECT/CT hybrid CT

SPECT/CT (Attenuation correction only)	$CTDI_{vol}$ [mGy]	DLP [mGy·cm]
Brain	13.0	330
Heart	4.1	85

SPECT/CT (Attenuation correction and image fusion)	$CTDI_{vol}$ [mGy]	DLP [mGy·cm]
Whole body	5.0	380
Brain	23.0	410
Head and neck	5.8	210
Chest	4.1	170
Heart	4.5	180
Abdomen, pelvis	5.0	210
Extremities	4.6	230

3.7.4. DRLs for PET/CT hybrid CT

PET/CT (Attenuation correction and image fusion)	$CTDI_{vol}$ [mGy]	DLP [mGy·cm]
Whole body (medical examination)	6.1	600
Whole body (medical checkup)	5.5	550
Brain (medical examination)	31.0	640
Heart (medical examination)	9.1	380

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OKUMURA, YASUHIKO
OHNO, KAZUKO
SAI, MASAHIRO
SAKAMOTO, HAJIME
SAKURAI, TAKASHI
SATO, KENJI
SHIRAGAMI, NOBUYUKI
SUGIHARA, YOSHITO
SUZUKI, SHOICHI
SUZUKI, YOSHIAKI
TAKEDA, KAZUYA
TAKEI, YASUTAKA
TAKESHITA, YOHEI
TANAMI, YUTAKA
TSUKAMOTO, ATSUKO
TSUSHIMA, HIROYUKI
UEMA, CHIAKI
WATANABE, HIROSHI
YOKOOKA, YUKI
YONAI, SHUNSUKE