Patient Exposure Doses for CT examination in Japan 2011

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Abstract
We have investigated changes in exposure dose in Japan. Investigation of CT examination was started in 1997. In CT examination, doses were assessed in terms of CTDIvol. CTDIvol was calculated by determining CTDIw as defined by the International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA) and other organizations using PMMA cylinders 16 cm and 32 cm in diameter, and dividing it by BP. The trends from 1997 to 2011 in the doses in adult cranial and abdominal CT examinations, the doses increased slightly until 2007, with further increases to 21% for cranial CT and 33% for abdominal CT in 2011, compared with the 2007 levels. On the histogram for 2007 and 2011, the mean dose increased by 25% from 64 mGy to 79 mGy. Although the histograms are similar in shape, 2.4% of the institutions had mean doses exceeding 120 mGy. In 2007, the 4-row system was the most prevalent type, accounting for 24%. In 2011, the 64-row system accounted for 38%. Another noteworthy finding for 2011 was that systems with more than 64 rows, which were not available in 2007, were being used clinically at some institutions, although they accounted for only 0.01%. In 2011, CTDIvol in non-helical adult and child cranial were 82.3 ±29 mGy and 42.2 ±19.5 mGy. Chest adult and child were 14.6 ±10.0 mGy and 7.2 ±4.7 mGy. Abdomen adult and child were 18.7 ±9.3 mGy and 6.6 ±3.2mGy. The doses in children ranged from 30% to 50% relative to the adult levels, although some variation existed depending on the portion examined.

Key Words: *CT examination, CTDIvol, patient dose, national survey*

1. Introduction

Published diagnostic reference levels (DRLs) for X-ray computed tomography (CT) examinations available in Japan include the target dose levels for medical settings involving radiography (scout and contrast-enhanced), interventional radiology, CT examination, and nuclear medicine examination as specified in the Guideline for Medical Exposure 2006[1)] by the Japan Association of Radiological Technologists (JART). Internationally, DRLs for adults and children are specified by the International Commission on Radiological Protection in its publications ICRP publ. 87[2)] and ICRP publ. 102[3)] (table 1. table 2).

Table 1. CTDIvol Adult guideline and DRL [mGy]

Examination	JART	ICRP.87
Head	65	60
Chest	–	30
Abdomen	20	35

※Head is Calculated values of CTDIvol relate to the 16cm diameter dosimetry phantom
※JART's Abdomen Calculated values of CTDIvol relate to the 30cm diameter dosimetry phantom
※ICRP.87's Chest and Abdomen Calculated values of CTDIvol relate to the 32cm diameter dosimetry phantom

Table 2. CTDIvol Child DRL [mGy]

Examination	ICRP.102
Head	43
Chest	13

※ Calculated values of CTDIvol relate to the 16cm diameter dosimetry phantom

According to OECD Health Data 2011[4)], which contains a wide variety of comparative data from 34 countries, the number of X-ray CT systems available per million population has been increasing(Fig. 1). It is notable that Japan, which reported 14.4 systems per million population in 1981, had increased this rate to 97.3 by 2008, significantly higher than even the second-ranking country, Australia, which reported a rate of 42.5 in 2010. In Japan, 350.37 X-ray CT examinations per thousand population were undertaken in 2011 (Fig. 2).

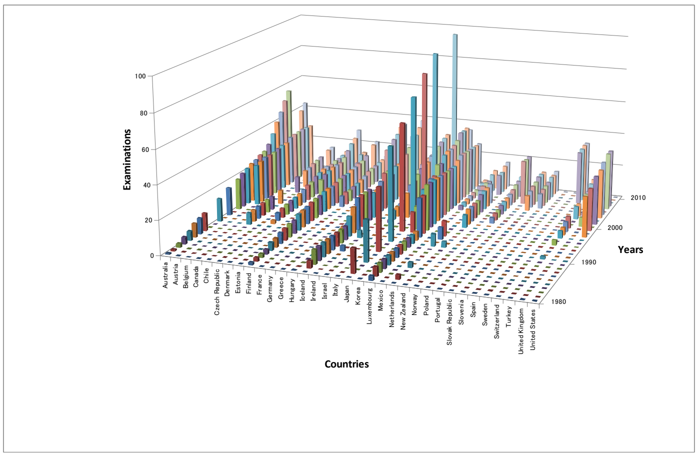

Fig. 1 The possession number of CT examination equipment of each country

The objective of this study was to acquire basic data for generating DRLs and for assessing the currently available exposure doses in X-ray CT examinations in Japan.

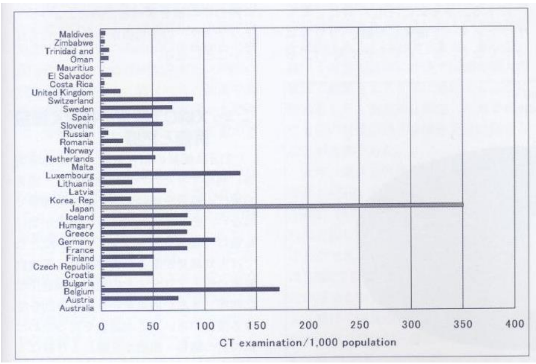

Fig. 2 The number of CT exaninations of each country

2. Method

2.1. Questionnaire-based survey

Data on CT examination systems and imaging conditions were obtained from a questionnaire-based survey undertaken at 3,000 medical institutions throughout Japan. Questionnaires were sent to 3,000 randomly selected institutions. The survey focused on the names of radiographic systems, tube voltage, tube amperage, pitch factor, rotating time, monitor-displayed CT dose index volume (CTDIvol), and other items. Target parts of the body were child/adult heads, child/adult chests, and child/adult abdomens.

2.2. Dose assessments

Doses were assessed in terms of CTDIvol as calculated with the ImPACT dose estimation program. CTDIvol values for the head, chest, and abdomen of children and adults were calculated from the imaging condition data obtained from the questionnaire-based survey.

2.3. Doses by irradiation site at the same institution

Doses at various irradiation sites were calculated from the imaging conditions used at a selected representative institution (institution-A) and compared with the results of the nationwide survey.

3. Results

3.1. Questionnaires were recovered from 1,306 institutions, the recovery rate being 43.6% among the 3,000 institutions in Japan. The number of institutions providing calculable data was 291 for child heads with non-helical scans, 140 for child heads with helical scans, 178 for child chests, and 182 for child abdomens. Regarding adult data, the number of institutions was 544 for adult heads with non-helical scans, 331 for adult heads with helical scans, 353 for adult chests, and 392 for adult abdomens.

The mean, standard deviation, textile/quartile dose (75% dose), maximum values, and minimum values of CTDIvol as calculated with the ImPACT program were tabulated by irradiation site for both children and adults(Table 3 and 4).

Table 3. CTDIvol of each part in a Child [mGy]

Examination	Average	Standard deviation	Maximum	Minimum	75%dose
Head (Non-Helical scan)	42.2	19.5	161.3	4.3	50.3
Head (Helical scan)	45.4	29.1	231.9	0.5	50.9
Chest	7.2	4.7	28.0	0.2	9.8
Abdomen	6.6	3.2	14.2	1.1	13.9

Table 4. CTDIvol of each part in a Adult [mGy]

Examination	Average	Standard deviation	Maximum	Minimum	75%dose
Head (Non-Helical scan)	82.3	29.0	250.3	11.1	97.2
Head (Helical scan)	74.1	36.3	207.7	1.1	101.6
Chest	14.6	10.0	111.2	0.5	19.3
Abdomen	18.7	9.3	69.8	3.6	23.7

CTDIvol values calculated with the ImPACT program from cranial CT data are shown in histograms(Fig.3). The mean for cranial non-helical scans was 82.3 mGy for adults and 42.2 mGy for children. The mean for cranial helical scans was 74.1 mGy for adults and 45.4 mGy for children. The helical values were lower than the non-helical values. CTDIvol values calculated from thoracic and abdominal CT data are also shown in histograms(Fig.4). The mean for thoracic scans was 14.6

mGy for adults and 7.2 mGy for children. The mean for abdominal scans was 18.6 mGy for adults and 6.6 mGy for children. A comparison of these national means with the guideline values for adult CT examinations specified in the JART Guideline 2006 reveals that the cranial CTDIvol was 1.14 times for helical scans and 1.27 times for non-helical scans; the abdominal CTDIvol was 0.93 times. Meanwhile, a comparison of the national means with the DRLs specified in the international standard ICRP Publ. 87, 102 reveals the cranial CTDIvol in children was 1.05 times for helical scans and 0.98 times for non-helical scans; and the thoracic CTDIvol for children was 0.55 times. For adults, the cranial CTDIvol was 1.37 times for helical scans and 1.23 times for non-helical scans; the thoracic CTDIvol was 0.49 times and the abdominal CTDIvol 0.53 times.

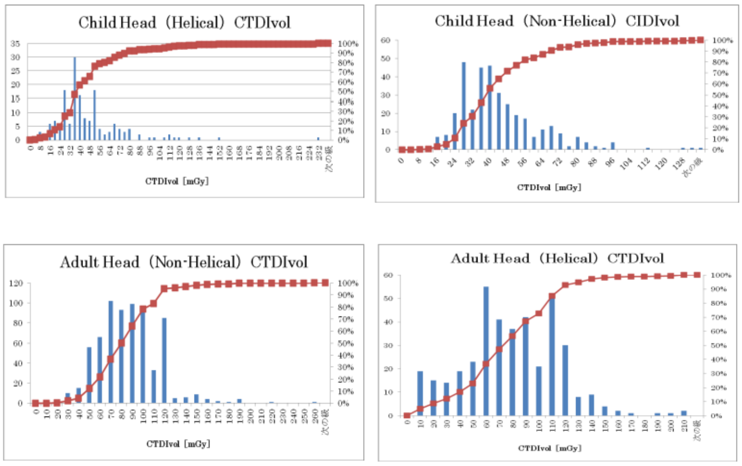

Fig. 3　The histogram of CTDIvol in a head X-rays CT examination

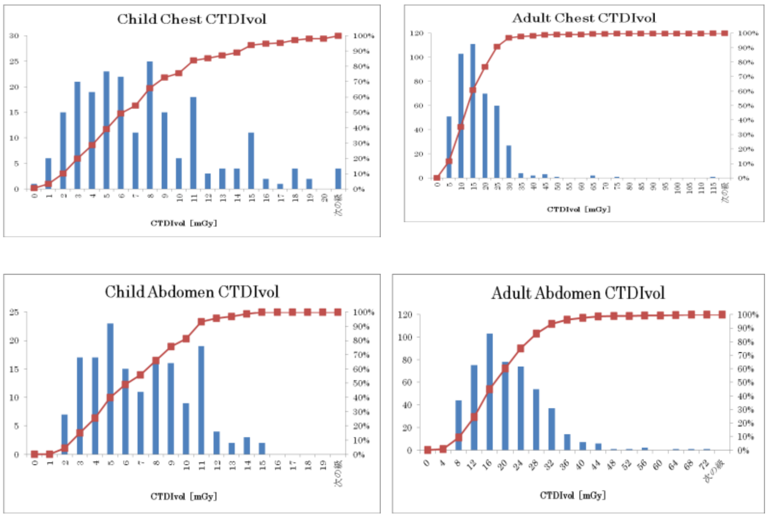

Fig. 4 The histogram of CTDIvol in a chest・Abdomen X-rays CT examination

3.2 Adult cranial, thoracic, and abdominal CTDIvol values obtained at representative institution-A were tabulated (Table.5).

Table5 CTDIvol of adult's head, a chest, and an abdomen in the institution A

	CTDIvol[mGy]
Head (Non-Helical scan)	215.7
Head (Helical scan)	133.7
Chest	11.7
Abdomen	9.3

The national means and the institution-A data for CTDIvol values were graphically represented(Fig.5). The thoracic and abdominal values were lower than the national means, whereas the cranial values exceeded the national means for both helical and non-helical scans. A comparison of our findings with the JART Guideline 2006 reveals that the cranial CTDIvol was 2.06 times for helical scans and 3.32 times for non-helical scans; the abdominal CTDIvol was 0.47 times. A comparison of the institution-A data and the DRLs specified in ICRP publ. 87 reveals that the cranial CTDIvol was 2.23 times for helical scans and 3.60 times for non-helical scans; the thoracic CTDIvol was 0.39 times, and the abdominal CTDIvol was 0.27 times.

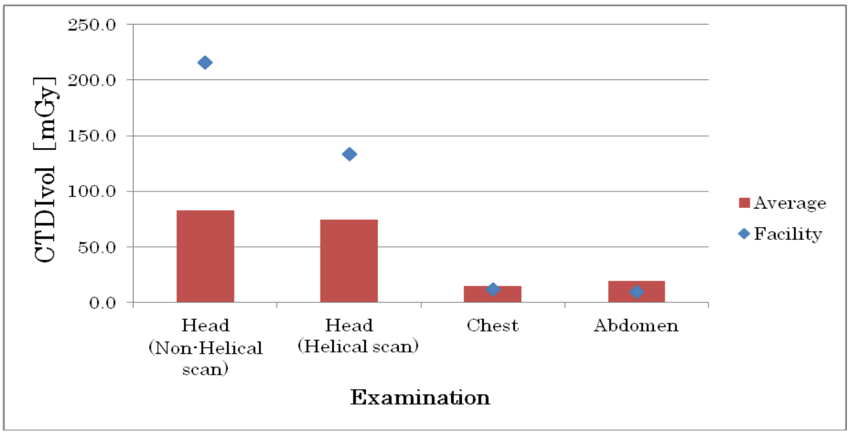

Fig. 5 CTDIvol of average value and the Facility A (adult)

4. Conclusion

The Japanese national mean CTDIvol values for adult chest and abdomen were lower than the DRLs specified in JART Guideline 2006 and ICRP publ. 87. However, the national mean CTDIvol value for adult head exceeded the DRLs specified in JART Guideline 2006 and ICRP publ. 87.

Many institutions in Japan have endeavored to reduce thoracic and abdominal exposures and have recognized the need to reduce cranial exposures. Child CTDIvol values — whether of the head, chest, or abdomen — were 30% to 50% of the corresponding adult doses. Furthermore, mean child CTDIvol values were lower than, or equivalent to, the DRLs specified in ICRP publ. 102. We attribute this to institutional efforts to reduce exposure doses in children.

The cranial (both helical and non-helical) CTDIvol values obtained at institution-A were higher than the DRLs specified in JART Guideline 2006 and ICRP pub. 87, as well as the national means. On the other hand, the thoracic CTDIvol value was lower than the national mean, and the abdominal CTDIvol was lower than both the national mean and the target value specified in the Guideline. It was therefore necessary to establish appropriate imaging conditions at each institution in order to optimize exposure doses in CT examinations.

The present study provides basic data for assessing exposure doses of patients undergoing CT examinations in Japan and for generating diagnostic reference levels (DRLs).

References

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