Japanese structure survey of radiation oncology in 2009 based on institutional stratification of the Patterns of Care Study

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The ongoing structure of radiation oncology in Japan in terms of equipment, personnel, patient load and geographic distribution was evaluated in order to radiation identify and improve any deficiencies. A questionnaire-based national structure survey was conducted from March 2010 to January 2011 by the Japanese Society for Therapeutic Radiology and Oncology (JASTRO). These data were analyzed in terms of the institutional stratification of the Patterns of Care Study (PCS). The total numbers of new cancer patients and total of cancer patients (new and repeat) treated with radiation in 2009 were estimated at 201,000 and 240,000, respectively. The type and numbers of systems in actual use consisted of Linac (816), telecobalt (9), Gamma Knife (46), 60Co remote afterloading system (RALS) (29) and 192Ir RALS systems (130). The Linac systems used dual energy function for 586 (71.8%), 3DCRT for 663 (81.3%) and IMRT for 337 units (41.3%). There were 529 JASTRO-certified radiation oncologists (ROs), 939.4 full-time equivalent (FTE) ROs, 113.1 FTE medical physicists and 1836 FTE radiation therapists. The frequency of interstitial radiation therapy use for prostate and of intensity-modulated radiotherapy increased significantly. PCS stratification can clearly identify the maturity of structures based on their academic nature and caseload. Geographically, the more JASTRO-certified physicians there were in a given area, the more radiation therapy tended to be used for cancer patients. In conclusion, the Japanese structure has clearly improved during the past 19 years in terms of equipment and its use, although a shortage of manpower and variations in maturity disclosed by PCS stratification remained problematic in 2009.

Keywords: Structure survey; radiotherapy facility; radiotherapy personnel; radiotherapy equipment; caseload

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INTRODUCTION

The medical care systems of the USA and Japan have very different backgrounds. In 1990, the Patterns of Care Study (PCS) conducted a survey of the structure of radiation oncology facilities in 1989 for the entire census of facilities in the USA [1]. In 1991, the Japanese Society for Therapeutic Radiation Oncology (JASTRO) conducted the first national survey of the structure of radiation therapy facilities in Japan based on their status in 1990, and the results were reported by Tsunemoto et al. [2]. The first comparison of these two national structure surveys to illustrate and identify similarities and differences in 1989–90 was conducted by the author and reported in 1996 [3]. The resultant international exchange of information proved especially valuable for Japan, where the structure of radiation oncology could be improved on the basis of those data.

The Japanese structure has gradually changed since a greater number of cancer patients are treated with radiation and public awareness of the importance of radiotherapy (RT) has grown. JASTRO has conducted national structure surveys every two years since 1990 [2] and every year since 2011. Furthermore, in 2006 the Cancer Control Act was approved in Japan, which strongly advocates the promotion of RT and an increase in the number of radiation oncologists (ROs) and medical physicists. The Japanese Ministry of Education, Sciences and Sports is supporting the education of these specialists at university medical hospitals. The findings of international comparisons and the consequent structural data gathered and published by JASTRO have been useful for an understanding of our current position and future direction [4–7]. In this report, the recent structure of radiation oncology in Japan is analyzed and compared with the data of 2007 [6].

MATERIALS AND METHODS

From March 2010 to January 2011, JASTRO conducted a questionnaire based on the national structure survey of radiation oncology in 2009. The questionnaire dealt with the number of treatment systems by type, number of personnel by category and number of patients by type, site and treatment modality. To measure variables over a longer period of time, data for the calendar year 2009 were also requested. The response rate was 700 out of 770 (90.6%) of active facilities. The use of image-guided radiation therapy (IMRT) for 337 units (41.3%), the IMRT function (3DCRT) for 663 (81.3%) and intensity-modulated radiation therapy (IMRT) for 337 units (41.3%) were employed more frequently for the equipment of academic institutions (A1: 73.4% and A2: 49.5%) than that of non-academic institutions (B1: 42.3% and B2: 18.1%). However, 3DCRT functions were disseminated widely in both academic and non-academic institutions, with 69% even in B2 institutions. The use of image-guided radiation
therapy (IGRT) has been steadily expanding from A1 institutions (30.4% to 33.5%) to the other types of institutions (14.0% to 35.5%). The annual numbers of patients/Linac were 393.2 for A1, 244.3 for A2, 339.1 for B1 and 118 for B2 institutions and showed a 9.8% increase compared with the data from 2007. The number of institutions with telecobalt in actual use showed a major decrease to 9 and became stable compared with 2007. Gamma Knife was installed more frequently in B1 and B2 institutions. A significant replacement of 60Co RALS with 192Ir RALS was observed especially in academic institutions, while the number of new 60Co RALS-type systems in use did not increase. Six particle machines were registered in this survey, two with carbon-beam and five with proton-beam irradiation. One machine in Hyogo Prefecture can deliver either carbon or proton beams. Although the HIMAC in Chiba Prefecture has two synchrotrons, it was registered as one machine in the 2009 survey. The total number of new cancer patients treated at these six institutions was estimated at 2038 (1.19% of all new patients in Japan). Twenty-seven advanced institutions were included in the A1 category and treated more than 800 patients per year. They were equipped with Linacs with dual energy (75.3% of the institutions), 3DCRT (97.2%) and IMRT function (82.2%), as well as with 192Ir RALS (92.6%) and a computed tomography (CT) simulator (96.3%).

Table 3 shows an overview of RT planning and other equipment. X-ray simulators were installed in 51.6% of all institutions, and CT simulators in 82.1%, with the latter exceeding the former for the first time in 2007. There was a significant difference in the rate of CT simulators installed by institutional stratification, from 95.7% in A1 to 69.3% in B2 institutions. Very few institutions (16 institutions) used magnetic resonance imaging (MRI) for RT only, while computers were widely used for RT recording.

**Staffing patterns and patient loads**

Table 4 shows the staffing patterns and patient loads by institutional stratification. ‘Full-time or part-time’ refers to the style of employment. Since even full-time ROs must share the diagnosis in a week at smaller institutions such as found in the B2 category, we felt that these numbers were not adequate for an accurate evaluation of man power. Therefore, data for full-time equivalent (FTE: 40 h/week for radiation oncology service only) were assessed in terms of the clinical working hours in RT of each individual. This is thus a method to determine actual man power at each institution. The total number of FTE ROs in Japan stood at 939.4, while the average numbers were 4.6 for A1, 1.6 for A2, 1.3 for B1 and 0.6 for B2 institutions. The number in B1 improved by 30% compared with 2007 [6]. The overall patient load per FTE RO in Japan was 231.9, and for A1, A2, B1 and B2 institutions the loads were 193.5, 205.2, 290.6 and 198.4, respectively, with the patient load for B1 institutions being far the highest. The increase in the overall patient load per
| Radiotherapy equipment and its function | A1 (n = 70) | A2 (n = 70) | B1 (n = 280) | B2 (n = 280) | Total (n = 700) | Comparison with data of 2007 (%) |
|----------------------------------------|-------------|-------------|-------------|-------------|----------------|-------------------------------|
| Linear accelerator                     | 158 93      | 300 265     | 816 1.1     |
| with dual energy function              | 122 77.2b   | 70 75.3b    | 235 78.3b   | 159 60.0b    | 586 71.8b       | 5.0c                          |
| with 3DCRT function (MLC width ≥1.0 cm)| 150 94.9b   | 81 87.1b    | 247 82.3b   | 185 69.8b    | 663 81.3b       | 12.5c                         |
| with IMRT function                     | 116 73.4b   | 46 49.3b    | 127 42.3b   | 48 18.1b     | 337 41.3b       | 12.2c                         |
| with cone beam CT or CT on rail        | 48 30.4b    | 33 35.5b    | 73 24.3b    | 41 15.5b     | 195 23.9b       |                               |
| with treatment position verification system | 51 32.3b   | 31 33.3b    | 85 28.3b    | 37 14.0b     | 204 25.0b       |                               |
| (X-ray perspective image)              | 53 33.5b    | 18 19.4b    | 77 25.7b    | 55 20.8b     | 203 24.9b       |                               |
| Annual no. patients/Linac              | 393.2d      | 244.3d      | 339.1d      | 118.0d       | 266.9d          | 9.8a                          |
| Particle                               | 3 0         | 3 0         | 3 0         | 0 0          | 6 0             |                               |
| Microtronon                            | 6 2         | 2 3         | 4 9         | 15           | 15              |                               |
| Telecobalt (actual use)                | 2 (0)       | 2 (0)       | 3 (1)       | 8 (7)        | 15 (9)          |                               |
| Gamma knife                            | 3 2         | 32 9        | 46          |              |                 |                               |
| Other accelerator                      | 2 1         | 1 1         | 5           |              |                 |                               |
| Other external irradiation device      | 4 2         | 1 0         | 6           |              |                 |                               |
| New type^{60}Co RALS (actual use)      | 4 (4) 5.7e  | 1 (1) 1.4e  | 9 (9)       | 2 (1) 0.7e   | 16 (15)         | 2.3e (2.1)                   |
| Old type^{60}Co RALS (actual use)      | 2 (2) 2.9e  | 2 (1) 2.9e  | 14 (11)     | 4 (0) 1.4e   | 22 (14)         | 3.1e (2.0)                   |
| 192Ir RALS (actual use)                | 60 (60) 85.7e | 32 (31) 45.7e | 37 (37) 13.2e | 4 (2) 1.4e   | 133 (130)       | 19.0e (18.6)                 |
| 137Cs RALS (actual use)                | 1 (0) 0     | 1 (1) 0     | 2 (2)       |              |                 |                               |

PCS = Patterns of Care Study; RT = radiotherapy; 3DCRT = three-dimensional conformal radiotherapy; MLC = multileaf collimator; IMRT = intensity-modulated radiotherapy; RALS = remote-controlled after-loading system.

aRate of increase compared with the data of 2007. Calculating formula: \( \frac{data\ of\ 2009\ (n) - data\ of\ 2007\ (n)}{data\ of\ 2007\ (n)} \times 100\ (%) \)

bPercentage calculated from the number of systems using this function and the total number of linear accelerator systems.

cComparison with the data of 2007. Calculating formula: \( \frac{data\ of\ 2009\ (\%) - data\ of\ 2007\ (\%)}{data\ of\ 2007\ (\%)} \)

dThe number of patients over the number of linear accelerators; institutions without linear accelerators excluded from calculation.

eRate of institutions that have this equipment (≥2 pieces of equipment per institution).
FTE RO was 13.7% compared with 2007 (6). In Japan, 42.6% of the institutions providing RT have their own designated beds, where ROs must also take care of their in-patients. The percentage distribution of institutions by patient load per FTE RO shown in Fig. 1a indicates that the largest number of facilities featured a patient/FTE staff level in the 101–150 range, and in the 151–200 range for the second largest number. The blue areas of the bars show that 47.7% of the institutions (334/700) had less than one FTE RO. Compared with 2007 [6], the patient load has increased even more.

A similar trend was observed for RT technologists and their patient load by institutional stratification with the percentage distribution of institutions by patient load per radiation technologist displayed in Fig. 1b. The largest number of facilities had a patient-per-radiotherapy technologist level in the 101–120 range, with the second largest number showing a range of 81–100 and the third largest a range of 121–140.

Table 3. Radiotherapy planning and other equipments by PCS institutional stratification

| CT = computed tomography; RTP = radiotherapy planning; MRI = magnetic resonance imaging; other abbreviations as in Table 2. |
|---|---|---|---|---|---|
| Table 5 shows the distribution of primary sites by institutional stratification. The most common disease site was the breast, followed by the lung/bronchus/mediastinum and genito-urinary region. In Japan, the number of patients with prostate cancer undergoing RT was 17,919 in 2009, showing an increase of 10.4% over 2007 [6]. By disease site, the rate of increase compared with 2007 was the highest for prostate cancer at 10.4%, the second highest for breast cancer at 9.6% and the third highest for head and neck cancer at 9.3%. The stratification of institutions indicates that the rate of increase for lung cancer was notable for A1 institutions and the rates for prostate cancer were high for all categories, ranging from 8.0–20.3%. On the other hand, the rate for breast cancer was the lowest (–0.7%) for A2, while those for B1 and B2 ranged from 11.8–18.8%, and the rates for head and neck cancer were high for A2 (17.7%) and B1 (21.4%).

Table 6 shows the distribution of use of specific treatments and the number of patients treated with these modalities by PCS stratification of institutions. Use of interstitial irradiation, radioactive iodine therapy for prostate cancer, stereotactic body RT, IMRT and hyperthermia increased by 23.3%, 14.5%, 4.9%, 34.8% and 15%, respectively, compared with 2007 [6]. On the other hand, the use of intraoperative RT decreased significantly by –31.1%. Institutional stratification shows that there was a dramatic increase of 454.1% in the use of IMRT in B2 [5]. In 2009,
101 institutions (14.4%) actually utilized IMRT, which was significantly lower than the 337 Linacs with IMRT function (41.3%) as shown in Table 2. Figure 2 lists the numbers of patients treated with SRT and IMRT for each survey year. Approximately 12,000 patients were treated with SRT for the brain in each survey year and this number has remained stable. On the other hand, the number treated with SRT for the rest of the body has been increasing gradually and exceeded 2000 in 2009. The corresponding number of patients for IMRT has been increasing more rapidly and exceeds 4000, or about 2% of all RT-treated patients in 2009.

Table 7 shows the number of patients with brain or bone metastasis treated with radiation according to the same institutional stratification. More patients with brain metastasis (12.2% of all patients) were treated at B1 than at the other types of institutions, while use of radiation for bone...
metastasis ranged from 10.4% for A2 to 15.7% for B2. Overall, more patients with bone metastasis were treated with radiation at non-academic than at academic institutions. The number of patients with brain metastasis decreased slightly by \(-0.47\%\) compared with 2007 [6].

**Geographic patterns**

Figure 3 shows the geographic distributions for 47 prefectures of the annual number of patients (new plus repeat) per 1,000 population arranged in increasing order of the number of JASTRO-certified ROs per 1,000,000 population [20]. There were significant differences in the use of RT, from 1.1 patients per 1,000 population (Saitama) to 2.3 (Tokyo). The average number of cancer patients per 1,000 population per quarter ranged from 1.57 to 1.80 (P = 0.1585). The more JASTRO-certified physicians there were in a given area, the more RT tended to be used for cancer patients, although the correlation was of borderline significance. Similar trends were clearly observed in 2005 [5] and 2007 [6]. Compared with 2005 and 2007, the utilization rate of RT increased in every prefecture in 2009. However, the rates in 2007 and 2009 were not related to prefectural population density as was also observed in the data for 1990 [3].

**DISCUSSION**

In 1990, there were fewer facilities for radiation treatment and fewer patients treated with radiation in Japan than in the USA. Over the next 19 years, however, the number of patients in Japan increased significantly by a factor of 3.2 [3]. On the other hand, the utilization rate of radiation for new cancer patients remained at 27.6%, less than half that recorded in the USA and European countries, although the rate increased slightly by 0.75% per year between 2007 [6] and 2009. For implementation of the Cancer Control Act, comparative data of the structure of radiation oncology in Japan and in the USA as well as relevant PCS data proved to be very helpful.

Compared with 1990, the number of Linac systems increased significantly by a factor of 2.62 and increased by 1.1% over 2007 [6], while the number of systems using telecobalt decreased to only nine and remained stable. Furthermore, the use of various functions of Linac, such as dual energy, 3DCRT (MLC width <1 cm) and IMRT, improved significantly. The number of high dose rate (HDR) RALS in use has increased and \(^{60}\)Co RALS has been largely replaced with \(^{192}\)Ir RALS. In 2009, CT simulators had been installed in 82.1% of institutions throughout the country for a 15.7% increase over 2007 [6] and exceeded the number of X-ray simulators (51.6%). Radiotherapy planning systems (RTPs) were used at 96.0% of institutions for an increase in the number of RTPs of 6.59 times compared with 1990 [3]. Maturity of the functions of Linac and installation rates of CT simulators and systems using \(^{192}\)Ir RALS also improved further compared with 2007 [6], but were still closely correlated with the PCS institutional stratification, which could therefore aid accurate differentiation between structural maturity and immaturity and the identification of structural targets for improvement.

The staffing patterns in Japan also improved in terms of numbers. However, institutions with less than one FTE radiation oncologist on their staff still account for 47.7% nationwide, although this represents an 8% decrease...
| Primary site                                      | A1 (n = 69) | Comparison with data of 2007<sup>a</sup> (%) | A2 (n = 66) | Comparison with data of 2007<sup>a</sup> (%) | B1 (n = 256) | Comparison with data of 2007<sup>a</sup> (%) | B2 (n = 253) | Comparison with data of 2007<sup>a</sup> (%) | Total (n = 644) | Comparison with data of 2007<sup>a</sup> (%) |
|--------------------------------------------------|-------------|---------------------------------------------|-------------|---------------------------------------------|-------------|---------------------------------------------|-------------|---------------------------------------------|----------------|---------------------------------------------|
| Cerebrospinal                                    | 1906 3.8    | –5.7                                        | 994 5.4     | 38.1                                        | 4812 6.2    | –13.6                                       | 1349 5.4    | –3.4                                        | 9061 5.3       | –6.6                                        |
| Head and neck (including thyroid)               | 6444 12.8   | –1.2                                        | 2500 13.6   | 17.7                                        | 7601 9.8    | 21.4                                        | 1560 6.3    | –5.7                                        | 18 105 10.6   | 9.3                                        |
| Esophagus                                        | 3247 6.5    | –5.8                                        | 1196 6.5    | 1.4                                         | 3735 4.8    | –8.2                                        | 1416 5.7    | –3.9                                        | 9594 5.6       | –5.7                                        |
| Lung, trachea and mediastinum                   | 7880 15.7   | 5.6                                         | 2771 15.0   | –2.8                                        | 15 855 20.4 | –5.7                                        | 5801 23.3   | –0.7                                        | 32 307 18.9   | –2.0                                        |
| Lung                                             | 7335 14.6   | 8.0                                         | 2438 13.2   | –0.6                                        | 14 358 18.5 | –1.3                                        | 5060 20.4   | –6.2                                        | 29 191 17.0   | 0.0                                        |
| Breast                                           | 10 869 21.7 | 5.2                                         | 3637 19.7   | –0.7                                        | 19 373 24.9 | 11.8                                        | 5955 24.0   | 18.8                                        | 39 834 23.3   | 9.6                                        |
| Liver, biliary tract, pancreas                  | 1948 3.9    | 1.0                                         | 806 4.4     | 19.6                                        | 2907 3.7    | 3.6                                         | 980 3.9     | –4.2                                        | 6641 3.9       | 3.2                                        |
| Gastric, small intestine, colorectal            | 2167 4.3    | 4.4                                         | 945 5.1     | –6.9                                        | 3783 4.9    | –6.2                                        | 1384 5.6    | –7.6                                        | 8279 4.8       | –4.0                                        |
| Gynecologic                                     | 3430 6.8    | 3.5                                         | 1135 6.2    | 7.3                                         | 2914 3.7    | –4.7                                        | 737 3.0     | –5.6                                        | 8216 4.8       | 0.0                                        |
| Urogenital                                       | 7167 14.3   | 5.8                                         | 2470 13.4   | –1.1                                        | 10 019 12.9 | 2.8                                         | 3394 13.7   | 13.4                                        | 23 050 13.5   | 4.7                                        |
| Prostate                                         | 5926 11.8   | 9.9                                         | 1888 10.2   | 8.0                                         | 7618 9.8    | 8.6                                         | 2487 10.0   | 20.3                                        | 17 919 10.5   | 10.4                                        |
| Hematopoietic and lymphatic                     | 2639 5.3    | 1.9                                         | 963 5.2     | 7.0                                         | 3264 4.2    | –10.1                                       | 1083 4.4    | 15.8                                        | 7949 4.6       | –1.3                                        |
| Skin, bone and soft tissue                     | 1269 2.5    | –12.8                                       | 496 2.7     | 2.5                                         | 1590 2.0    | –15.4                                       | 738 3.0     | –1.7                                        | 4093 2.4       | –10.4                                       |
| Other (malignant)                               | 541 1.1     | –39.5                                       | 241 1.3     | 1.7                                         | 852 1.1     | –5.0                                        | 307 1.2     | 5.1                                         | 1941 1.1       | –16.3                                       |
| Benign tumors                                   | 675 1.3     | –31.7                                       | 278 1.5     | 4.5                                         | 1112 1.4    | –13.7                                       | 155 0.6     | –16.7                                       | 2220 1.3       | –18.6                                       |
| Pediatric <15 y (included in totals above)      | 461 0.9     | 4.8                                         | 145 0.8     | 25.0                                        | 349 0.4     | –6.7                                        | 137 0.6     | 8.7                                         | 1092 0.6       | 3.4                                        |
| Total                                           | 50 182 100  | 0.8                                         | 18 432 100  | 4.3                                         | 77 817 100  | 0.6                                         | 24 859 100  | 4.3                                         | 171 290 100   | 1.5                                        |

Abbreviations as in Table 2.

<sup>a</sup>Rate of increase compared with the data of 2007. Calculating formula: 
\[
\text{rate of increase} = \left( \frac{\text{data of 2009} \times n}{\text{data of 2007} \times n} \right) \times 100 \%
\]

<sup>b</sup>Total number of new patients different with these data, because no data on primary sites were reported by some institutions.
| Specific therapy | A1 \((n = 70)\) | A2 \((n = 70)\) | B1 \((n = 280)\) | B2 \((n = 280)\) | Total \((n = 700)\) | Comparison with data of 2007\(^a\) (%) |
|-----------------|---------------|---------------|-----------------|---------------|-----------------|-----------------------------|
| Intracavitary RT |               |               |                 |               |                 |                             |
| Treatment facilities | 64 91.4 | 28 40.0 | 58 20.7 | 1 0.4 | 151 21.6 |                             |
| Cases | 1864 | 421 | 848 | 6 | 3139 | –3.0 |
| Interstitial RT |               |               |                 |               |                 |                             |
| Treatment facilities | 55 78.6 | 20 28.6 | 32 11.4 | 2 0.7 | 109 15.6 | 23.3 |
| Cases | 2482 | 550 | 993 | 45 | 4070 |                             |
| Radioactive iodine therapy for prostate |               |               |                 |               |                 |                             |
| Treatment facilities | 50 71.4 | 16 22.9 | 29 10.4 | 1 0.4 | 96 13.7 |                             |
| Cases | 1842 | 360 | 856 | 22 | 3080 | 14.5 |
| Total body RT |               |               |                 |               |                 |                             |
| Treatment facilities | 63 90.0 | 31 44.3 | 65 23.2 | 21 7.5 | 180 25.7 |                             |
| Cases | 798 | 235 | 620 | 137 | 1790 | 4.9 |
| Intraoperative RT |               |               |                 |               |                 |                             |
| Treatment facilities | 15 21.4 | 6 8.6 | 4 1.4 | 3 1.1 | 28 4.0 | –31.1 |
| Cases | 135 | 21 | 9 | 8 | 173 |                             |
| Stereotactic brain RT |               |               |                 |               |                 |                             |
| Treatment facilities | 43 61.4 | 26 37.1 | 94 33.6 | 39 13.9 | 202 25.8 |                             |
| Cases | 1660 | 658 | 9671 | 1866 | 13 855 | 10.4 |
| Stereotactic body RT |               |               |                 |               |                 |                             |
| Treatment facilities | 51 72.9 | 26 37.1 | 71 25.4 | 17 6.1 | 165 23.6 |                             |
| Cases | 1087 | 185 | 1125 | 140 | 2537 | 1.9 |
| IMRT |               |               |                 |               |                 |                             |
| Treatment facilities | 47 67.1 | 10 14.3 | 36 12.9 | 8 2.9 | 101 14.4 |                             |
| Cases | 1855 | 94 | 1961 | 386 | 4296 | 34.8 |
| Thermoradiotherapy |               |               |                 |               |                 |                             |
| Treatment facilities | 7 10.0 | 5 7.1 | 4 1.4 | 4 1.4 | 20 2.9 |                             |
| Cases | 185 | 38 | 137 | 31 | 391 | 15.0 |

PCS = Patterns of Care Study; RT = radiotherapy; IMRT = intensity-modulated radiotherapy.

\(^{a}\)Rate of increase compared with the data of 2007. Calculating formula: \(\frac{\text{data of 2009} \,(n) - \text{data of 2007} \,(n)}{\text{data of 2007} \,(n)} \times 100 \, (%)\)
compared with 2007 [6]. In other words, nearly half the institutions in Japan still rely on part-time radiation oncologists. There are two reasons for this. First, although the number of FTE radiation oncologists grew by 13.7% over the last 2 years, the number of cancer patients who require radiation has also increased by 10% over the same period. Second, specialist fees for radiation oncologists in academic institutions are not covered by the Japanese medical care insurance system, which is strictly controlled by the government. Therefore, most radiation or other oncologists at academic institutions must work part-time at affiliated hospitals in the B1 and B2 groups to earn a living. To reduce the number of institutions that rely on part-time radiation oncologists and thus may encounter problems with their quality of care, a reform of Japan’s current medical care system based on treatment outcome is required, especially as it applies to staff at academic institutions. However, great care is needed to ensure that the long-term success of radiation oncology in Japan and patient benefits are well balanced with costs. For this reason, personal identification of ROs in both A and B institutions was included and recorded in the 2007 and 2009 surveys for further detailed analysis of patient load and real cost [7]. There were

significant differences in the average practice index for patients between ROs working mainly in main university hospitals and in affiliated hospitals (1.07 vs 0.71: \( P < 0.0001 \)). Under the current Japanese national medical system, patterns of work by ROs at academic facilities appear to be problematic for fostering true specialization of ROs. On the other hand, according to the increase in the number of cancer patients who require RT, B1 institutions are gradually offering full-time positions for ROs. However, the speed of offers for second or third positions are slow in individual institutions due to tight budgets in most B1 institutions. Therefore, monitoring these structural data is necessary to convince local government to improve working environments for ROs. Even under these conditions, however, the number of FTE ROs increased by 2.57 times compared with 1990 [3], and by 13.7% over 2007 [6]. On the other hand, patient load per FTE RO also increased by 1.35 times to 231.9 during the same period 1990–2009, but registered a –0.67% decrease compared

**Table 7:** Brain metastasis or bone metastasis patients treated with RT in 2007 by PCS institutional stratification

| Metastasis | A1 (n = 70) | A2 (n = 70) | B1 (n = 280) | B2 (n = 280) | Total (n = 700) | Comparison with data of 2007\(^a\) (%) |
|------------|------------|------------|-------------|-------------|----------------|-----------------------------------|
| Brain      | 3534 5.2   | 1363 6.0   | 12394 12.2  | 3043 9.7    | 20334 9.3      | –4.3                              |
| Bone       | 6948 11.2  | 2419 10.6  | 12618 12.4  | 4921 15.7   | 26906 12.4     | –3.8                              |

Data presented as number of patients, with percentages in parentheses.

\(^a\)Rate of increase compared with the data of 2007. Calculating formula: \( \frac{\text{data of 2009} (n) - \text{data of 2007} (n)}{\text{data of 2007} (n)} \times 100 \) (%)
with 2007 [6]. This may reflect the growing popularity of RT due to an increase in the elderly population and recent advances in technology and improvement in clinical results. The caseload ratio in Japan has therefore already exceeded the limit of the Blue Book guidelines of 200 patients per radiation oncologist and improved only slightly in 2009 [21, 22]. The percentage distribution of institutions by patient load per RO showed a slightly high percentage for smaller patient load/RO than that in the USA in 1989 [3], but also showed a major shift to a larger size in 2009 compared with 1990. In Japan, the patterns are now becoming similar to those of the USA in 1989 [3], indicating that Japanese radiation oncology is catching up quickly with western systems and growing steadily in spite of limited resources. Furthermore, additional recruiting and education of ROs continue to be top priorities for JASTRO. The distribution of patient load per RT technologist shows that only 17.3% of institutions met the narrow guideline range (100–120 patient per RT technologist) and the rest showed a dense distribution around the peak level. Compared with the distribution in the USA in 1989, nearly 18% of institutions in Japan had a relatively low caseload of 10–60, because there are still a large number of smaller B2-type institutions, which account for nearly 40% of institutions that do not attain the range specified by the guidelines. As for medical physicists, an analysis of patient load for FTE staff similar to that for RT technologists remains difficult, because the number of the former was very small and they were working mainly in metropolitan areas. However, RT technologists in Japan have been acting partly as medical physicists. Their training duration has changed from 3 to 4 years over the last decade, and graduate and postgraduate courses have been introduced. Currently, RT technologists who have obtained a master’s degree or those with enough clinical experience can take the examination for qualification as a medical physicist, as can those with a master’s degree in science or engineering like in the USA or Europe. A unique, hybrid education system for medical physicists has thus been developed in Japan since the Cancer Control Act actively started to support improvement in quality assurance and quality control (QA/QC) specialization for RT. However, the validity of this education and training system remains to be proven, not only for QA/QC but also for unique research and developmental activities. The discrepancy between FTE medical physicists and the number of registered medical physicists in Japan reflects the fact that their role in the clinic is not recognized as a full-time position only for medical physics services.

Analysis of the distribution of primary sites for RT showed that the number of lung cancer patients at A1-type institutions increased by 8% compared with 2007. On the other hand, more head and neck cancer patients were treated at A1-, A2- or B1-type institutions, but the rates of increase compared with 2007 were high for A2 and B1 institutions. The increase in the number of lung cancer patients at A1 institutions in 2009 was noteworthy and the same goes for that of prostate cancer patients or breast cancer patients at A1-, A2-, B1- and B2-type institutions. This suggests that stereotactic body RT (SBRT) for lung cancer at A1 and 3DCRT for prostate cancer or breast-conserving therapy for breast cancer (BCT) at A1, A2, B1 and B2 were used more frequently in 2009. Especially in B2-type institutions, breast cancer patients (18.8%) and prostate cancer patients (20.3%) increased at two of the highest rates. This indicates that treatments such as 3DCRT and BCT were disseminated widely to B2-type institutions as a standard. The number of patients with brain or bone metastasis did not increase compared with 2007 [6]. The use of specific treatments and the number of patients treated with these modalities were significantly affected by institutional stratification, with more specific treatments being performed at academic institutions. These findings indicate that significant differences in patterns of care, as reflected in structure, process and possibly outcome for cancer patients continued to be prevalent in Japan in 2009. However, these differences point to opportunities for improvement. The Japanese PCS group published structural guidelines based on PCS data [22] and we are using the structural data obtained in 2009 to revise the Japanese structural guidelines for radiation oncology in the near future. The use of intraoperative RT decreased significantly from 2005 to 2007 and showed a similar rate of decrease (35%) between 2007 and 2009, while that of thermoradiotherapy increased slightly by 15% compared with 2007 [6]. These two modalities are thus not considered mainstay treatments in Japan. The numbers of patients with bone metastasis or brain metastasis in 2009 decreased, compared with those in 2007. Within the limited resources of departments of radiation oncology, more efforts may be made, focusing on radical treatment than palliative ones. Also general treatments such as bisphosphonates or narcotic drugs such as opioids for bone metastasis may relatively reduce the candidates for RT. The reason for the reduction in use of RT for brain metastasis is unknown.

Geographic patterns showed that there were significant differences among prefectures in the use of RT, and the number of JASTRO-certified physicians per population was associated with the utilization of RT in 2005 [5], 2007 [6] and 2009, so that a shortage of radiation oncologists or medical physicists on a regional basis will remain a major concern in Japan. Compared with 2005 [5] and 2007 [6], however, the utilization rate of radiation for new cancer patients in 2009 showed further increase. JASTRO has been making every effort to recruit and educate radiation oncologists and medical physicists through public relations, to establish and conduct training courses at academic
institutions, to become involved in the national examination for physicians and to seek an increase in the coverage of fees for ROs by the government-controlled insurance scheme.

In conclusion, the Japanese structure of radiation oncology has clearly and steadily improved over the past 19 years in terms of installation and use of equipment and its functions, but shortages of man power and differences in maturity depending on type of institution and caseload remain. Structural immaturity is an immediate target for improvement, while for improvements in process and outcome, the PCS or National Cancer Database (NCDB), which are currently operational and the subject of close examination, can be expected to perform an important function in the future of radiation oncology in Japan.

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