8. Nakamura K, Shioyama Y, Tokumaru S, Hayashi N, Oya N, Hiraki Y, et al. Variation of clinical target volume definition among Japanese radiation oncologists in external beam radiotherapy for prostate cancer. *Jpn J Clin Oncol* 2008;38:275–80.
9. O'Neill L, Armstrong J, Buckney S, Assiri M, Cannon M, Holmberg O. A phase II trial for the optimisation of treatment position in the radiation therapy of prostate cancer. *Radiother Oncol* 2008;88:61–6.
10. Weber DC, Nouet P, Rouzaud M, Miralbell R. Patient positioning in prostate radiotherapy: is prone better than supine? *Int J Radiat Oncol Biol Phys* 2000;47:365–71.
11. Fiorino C, Reni M, Bolognesi A, Bonini A, Cattaneo GM, Calandrino R. Set-up error in supine-positioned patients immobilized with two different modalities during conformal radiotherapy of prostate cancer. *Radiother Oncol* 1998;49:133–41.
12. Leal A, Sánchez-Doblado F, Arráns R, Capote R, Lagares JI, Pavón EC, et al. MLC leaf width impact on the clinical dose distribution: a Monte Carlo approach. *Int J Radiat Oncol Biol Phys* 2004;59: 1548–59.
13. Wang L, Hoban P, Paskalev K, Yang J, Li J, Chen L, et al. Dosimetric advantage and clinical implication of a micro-multileaf collimator in the treatment of prostate with intensity-modulated radiotherapy. *Med Dosim* 2005;30:97–103.
14. Jereczek-Fossa BA, Orecchia R. Evidence-based radiation oncology: definitive, adjuvant and salvage radiotherapy for non-metastatic prostate cancer. *Radiother Oncol* 2007;84:197–215.
15. National Comprehensive Cancer Network. NCCN Clinical Practice Guidelines in Oncology: Prostate Cancer V2. 2009. http://www.nccn.org/.

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Postoperative Radiotherapy for Localized Prostate Cancer: Clinical Significance of Nadir Prostate-specific Antigen Value within 12 Months

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Abstract. *Aim: To analyze retrospectively the results of postoperative radiotherapy for localized prostate cancer and to investigate the clinical significance of nadir prostate-specific antigen (PSA) value within 12 months (nPSA12) as an early estimate of clinical outcome after radiotherapy. Patients and Methods: Seventy-six patients with localized prostate cancer treated with postoperative radiotherapy were retrospectively reviewed. Total radiation doses ranged from 50 to 70 Gy (median: 60 Gy), and the median follow-up period for all 76 patients was 47.9 months (range, 12.4-101.3 months). Results: The 5-year actuarial overall survival, progression-free survival, biochemical relapse-free survival (BRFS) and local control rates in all 76 patients after radiotherapy were 86.1%, 77.8%, 80.0% and 92.2%, respectively. Distant metastases and/or regional lymph node metastases developed in 11 patients (14%) after radiotherapy, while local progression was observed in only 5 patients (7%). Of all 76 patients, the median nPSA12 in patients with biochemical failure and that in patients without biochemical failure were 1.16 ng/ml and 0.05 ng/ml, respectively. The 5-year BRFS rates in patients with low nPSA12 (<0.5 ng/ml) and those with high nPSA12 (≥0.5 ng/ml) were 92.7% and 42.2%, respectively (p<0.0001). In univariate analysis, nPSA12, pre-radiotherapy PSA, Karnofsky performance status and the use of chemotherapy had a significant impact on BRFS, and in multivariate analysis, nPSA12 alone was an independent prognostic factor for BRFS. Conclusion: Postoperative radiotherapy results in an excellent local control rate for localized prostate cancer and nPSA12 is predictive of biochemical failure after postoperative radiotherapy.*

Radical prostatectomy has been established as the primary curative procedure for the treatment of localized prostate cancer. However, despite a marked downward stage shift due to widespread serum prostate-specific antigen (PSA) screening and improvement in surgical techniques, approximately one-third of patients who undergo radical prostatectomy for their prostate cancer will experience biochemical recurrence after surgery (1-3). Many reports have indicated that the most significant risk factors for biochemical recurrence after prostatectomy are high Gleason score, extraprostatic extension, seminal vesicle invasion and a positive surgical margin (1, 4-8). Rising PSA levels following radical prostatectomy may be due to a local recurrence in the prostatic bed, occult distant metastases or a combination of both.

Although the optimal postoperative management of patients with localized prostate cancer has not yet been established, postoperative radiotherapy may be considered the treatment of choice to achieve both biochemical and local control (9-13). Recent randomized trials have demonstrated that in men who had undergone radical prostatectomy for pathologically advanced prostate cancer, adjuvant radiotherapy resulted in a significantly reduced risk of biochemical recurrence and disease recurrence compared with observation alone (11, 14).

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Key Words: Surgery, prostate cancer, nPSA12, radiotherapy, biochemical failure, prognostic factor.

However, little information regarding clinically useful markers of recurrence risk exists for prostate cancer patients who undergo postoperative radiotherapy.

For patients with untreated prostate cancer, PSA has been utilized as an important marker for treatment response and disease recurrence for prostate cancer (15, 16). The nadir in PSA (nPSA) after radiotherapy has been shown to predict biochemical failure (17, 18), distant metastasis (19, 20), cause-specific mortality (21, 22) and overall mortality (22). However, the nPSA usually takes several years to occur, even as long as 8-10 years in some patients, and as a consequence, nPSA has little practical clinical value. It would be ideal to identify a surrogate nPSA that describes the lowest PSA achieved during a well-defined, relatively short time interval after completion of radiotherapy. Recently, time-limited survey of PSA, such as nPSA value within 12 months (nPSA12), has been reported to be an early predictor of biochemical failure, distant metastasis and mortality that is independent of radiotherapy dose and other determinants of outcome after radiotherapy for previously untreated localized prostate cancer (15, 16).

Because nPSA12 has been shown to be a useful predictor of treatment outcome for untreated localized prostate cancer treated with radical radiotherapy, we hypothesized that nPSA12 may also have potential applications in the monitoring of localized prostate cancer treated with postoperative radiotherapy. In the current study, we first analyzed the treatment results of postoperative radiotherapy for patients with localized prostate cancer. Next, we examined the nPSA12 level in patients with localized prostate cancer treated with postoperative radiotherapy and investigated whether nPSA12 could be a prognostic factor of clinical outcomes for these patients.

Patients and Methods

We used the detailed data from patients with localized prostate cancer who were included in the Japanese Patterns of Care Study (PCS). The PCS, which has been developed in the United States as a quality assurance program, was conducted in Japan in an attempt to obtain data on the national standards of radiotherapy for several diseases including prostate cancer (23). The Japanese PCS Working Subgroup of Prostate Cancer initiated a nationwide process survey for patients who underwent radiotherapy between 1996 and 1998. Subsequently, a second PCS of Japanese patients treated between 1999 and 2001 was conducted. We have previously reported the results of the first and second PCS surveys with respect to postoperative external beam radiotherapy for prostate cancer patients (24).

PCS methodology has been described previously (23, 25, 26). In brief, the PCS surveys were extramural audits that utilized a stratified two-stage cluster sampling design. The PCS surveyors consisted of 20 radiation oncologists from academic institutions, and each radiation oncologist collected data by reviewing patients' charts from their institution. Patients with a diagnosis of adenocarcinoma of the prostate were eligible for inclusion in the present study unless they had one or more of the following conditions: i) evidence of distant metastasis; ii) concurrent or prior diagnosis of any other malignancy; iii) prior radiotherapy. The PCS data used in the current study are from two Japanese national surveys conducted to evaluate prostate cancer patients treated with radiotherapy in the 1996-1998 and 1999-2001 PCS surveys. Of the 839 patients comprising the 1996-1998 and 1999-2001 PCS survey populations, a total of 169 patients who received postoperative radiotherapy after radical prostatectomy were identified. Of these, 93 patients with insufficient nPSA12 data and/or patients who received total doses of less than 50 Gy were excluded, and in total, 76 patients with measurable nPSA12 were subjected to this analysis. The disease characteristics of these 76 patients, such as the tumor stage and pre-treatment PSA levels, were not significantly different compared to those of 93 patients having insufficient data for nPSA12 and/or those who received total doses of less than 50 Gy. All 76 patients received surgical resection initially, followed by postoperative radiotherapy.

Table I shows the patient characteristics of all 76 patients. Postoperative radiotherapy was administered as an adjuvant therapy (undetectable PSA and postoperative radiotherapy in 3-12 months after surgery) to 42 patients and the remaining 34 patients received radiotherapy as salvage therapy (elevated PSA and/or delayed rise in PSA after surgery). PSA was defined as the PSA value before initial treatment and pre-radiotherapy PSA was defined as the PSA value just before radiotherapy.

The method of treatment is shown in Table II. Hormonal therapy was administered either alone or in combination with orchiectomy, estrogen agents, luteinizing hormone-releasing hormone (LH-RH) agonists or antiandrogens after radiotherapy. The median duration of hormonal therapy was 15.4 months (range, 0.1-77.6 months). Regarding chemotherapy, 11 patients (14%) were also treated with chemotherapy, such as estramustine and 5-fluorouracil.

Regarding radiotherapy, the majority of patients were treated with >10 MV linear accelerators and also treated with 4 or more portals. The median radiation dose delivered to the prostate bed was 60 Gy (range, 50-70 Gy), and the median dose per fraction was 2 Gy (range, 2-2.2 Gy). Thirty patients (39%) received treatment to the pelvic nodes in addition to prostate bed, and the remaining 46 patients (61%) received irradiation only to the prostate bed. Regarding lymph node status, 6 out of 7 patients (86%) with pathologically positive lymph nodes received treatment to the pelvic nodes in addition to prostate.

nPSA12 was defined as the lowest PSA level achieved during the first year after completion of radiotherapy. The median number of PSA evaluations within 12 months after radiotherapy was 4 times (range, 1-17) in all 76 patients. The median follow-up of all patients was 47.9 months (range, 12.4-101.3 months), and all patients without biochemical failure had at least 1 year's follow-up. Biochemical failure is defined according to the Phoenix consensus definitions: failure is considered when PSA levels reach 2 ng/ml or more above nadir (27). Concerning clinical failure, patients were categorized as having progression after radiotherapy if they developed local, pelvic nodal, or distant failure. Alone or combination of chest radiography, liver ultrasound, computed tomography scans and magnetic resonance imaging scans were used for confirmation of suspected progression.

Statistical analyses were performed using the Statistical Analysis System at the PCS statistical center (28). Overall survival,

Table I. *Patient characteristics.*

	No. of patients
Age (median: 67.0116 years)	
<70	51
≥70	25
Type of therapy	
Adjuvant	42
Salvage	34
Surgical margin	
–	31
+	15
Unknown	30
Capsular invation	
–	15
+	34
Unknown	27
Seminal vescicle invation	
–	30
+	14
Unknown	32
Pathological T stage	
T0-2	11
T3-4	62
Unknown	3
Pathological N stage	
N0	52
N1	7
Unknown	17
KPS (%)	
≤80	17
>80	58
Unknown	1
Pre-treatment PSA (ng/ml)	
Median (range)	14.7 (0.0-268.2)
<20	40
≥20	29
Unknown	7
Pre-radiotherapy PSA (ng/ml)	
Median (range)	0.6435 (0.01-22.90)
<2	42
≥2	12
Unknown	22
Gleason combined score	
≤6	24
>6	19
Unknown	33
Differentiation	
Well/Moderate	49
Poor	22
Unknown	5

KPS, Karnofsky performance status; PSA, prostate-specific antigen.

progression-free survival (PFS), biochemical relapse-free survival (BRFS) and local control rates were calculated actuarially according to the Kaplan-Meier method (29) and were measured from the start of radiotherapy. Differences between groups were estimated using the chi-square test, Student's *t*-test, Mann-Whitney *U*-test and the log-rank test (30). Multivariate analysis was performed using the Cox regression model (31). A probability level of 0.05 was chosen for statistical significance. The Radiotherapy Oncology Group (RTOG) late toxicity scales were used to assess the late morbidity (32).

Table II. *Treatment characteristics.*

	No. of patients
Radiation field	
Whole pelvis plus boost	30
Prostate only	46
CT-based treatment planning	
Yes	63
No	13
Conformal therapy	
Yes	30
No	40
Unknown	6
Total radiation dose (Gy)	
<60	30
≥60	46
Use of hormonal therapy	
Yes	57
No	18
Unknown	1
Use of chemotherapy	
Yes	11
No	62
Unknown	3

KPS, Karnofsky performance status; PSA, prostate-specific antigen.

Results

Seven out of 76 patients (9%) died during the period of this analysis. Of these patients, 6 patients died of prostate cancer and the remaining 1 patient died without any sign of clinical recurrence (intercurrent diseases). The 5-year actuarial overall survival, PFS, BRFS and local control rates in all 76 patients after radiotherapy were 86.1%, 77.8%, 80.0% and 92.2%, respectively (Figures 1 and 2). With regard to the site of recurrence, 15 patients had clinical failure (local only in 3, local with distant metastases in 2, regional in 1, distant metastasis in 7, regional and distant metastasis in 1 and unknown site in 1 patient). Distant metastases and/or regional lymph node metastases developed in 11 patients (11%) after radiotherapy, while local progression was observed in only 5 patients (7%). Regarding the total radiation dose (Table III), 51 out of 56 patients (91%) treated with less than 66 Gy achieved local control, while 20 out of 20 patients (100%) treated with 66 Gy or more achieved local control (p=0.17). Regarding the radiation field used, 28 out of 30 patients (93%) treated for the whole pelvis with boost and 43 out of 46 patients (93%) treated with a local field achieved local control; this difference was not statistically significant (p=0.98).

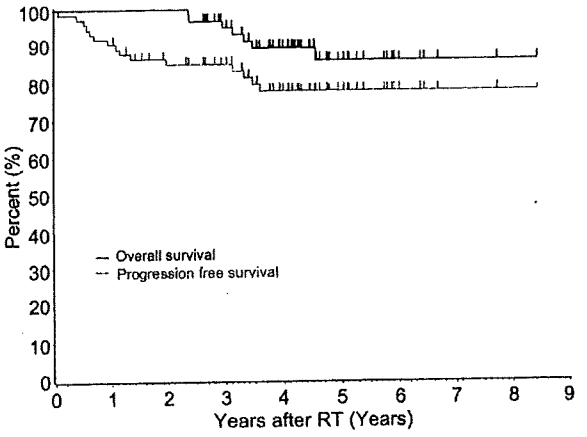

Figure 1. *Actuarial overall and progression-free survival curves for 76 patients with prostate cancer treated with postoperative radiotherapy.*

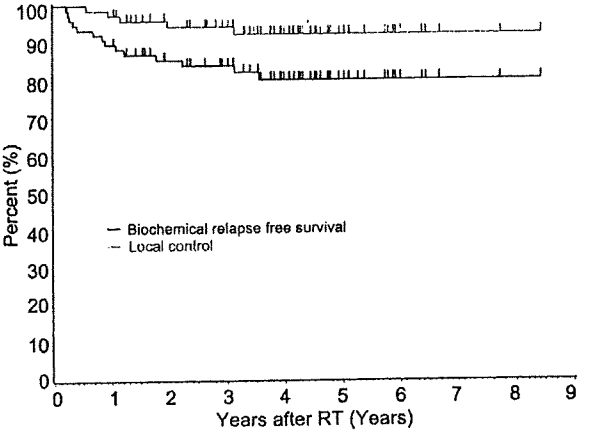

Figure 2. *Actuarial biochemical-free survival and local control curves for 76 patients with prostate cancer treated with radiotherapy.*

Table III. *Local control according to the radiation dose and field.*

Total dose (Gy)	No. of pts	No. of pts with LC	Incidence of LC	
			WP + B	Local
50-59.9	30	28 (93%)	18/19	10/11
60-61.9	23	21 (91%)	9/9	12/14
62-63.9	0	0	0/0	0/0
64-65.9	3	2 (67%)	1/2	1/1
66-67.9				
68-69.9	9	9 (100%)	0/0	9/9
70	11	11 (100%)	0/0	11/11
Total	76	71 (93%)	28/30 (93%)	43/46 (93%)

Pts, Patients; LC, local control; WP, whole pelvis; B, boost.

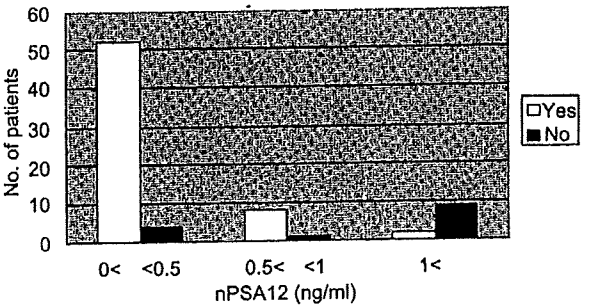

Figure 3. *Distribution of nPSA12 values according to biochemical control (yes: controlled, no: not controlled). Over 80% of patients with biochemical control had a nPSA12 <0.5 ng/ml, while only 29% of patients who experienced biochemical failure had a nPSA12 <0.5 ng/ml.*

Of all 76 patients, the median nPSA12 in patients with biochemical failure and that in patients without biochemical failure were 1.16 ng/ml and 0.05 ng/ml, respectively. Patients treated with adjuvant therapy had significantly lower nPSA12 (median: 0.07 ng/ml) than those treated with salvage therapy (median: 0.23 ng/ml, p=0.018). On the other hand, patients treated with hormonal therapy had almost similar nPSA12 (median: 0.10 ng/ml) compared to those without hormonal therapy (median: 0.09 ng/ml, p=0.45). Figure 3 shows the distribution of nPSA12 according to the achievement of biochemical control. Over 80% of patients with biochemical control (52 out of 62 patients, 84%) had a nPSA12 of <0.5 ng/ml, while only 4 patient out of 14 patients (29%) with biochemical failure had a nPSA of <0.5 ng/ml (p<0.0001). For the 52 patients who achieved a nPSA12 level <0.5 ng/ml and who did not experience biochemical failure, the median time from the completion of radiotherapy to achievement of a nPSA12 level <0.5 ng/ml was 2.0 months (range, 0.2-11.5 months).

When dividing patients into low (<0.5 ng/ml) and high (>0.5 ng/ml) nPSA12 groups, the 5-year BRFS rates in patients with low nPSA12 and those with high nPSA12 were 92.7% and 42.2%, respectively (p<0.0001) (Figure 4). In univariate analysis, nPSA12, pre-radiotherapy PSA, Karnofsky performance status (KPS) and the use of chemotherapy had a significant impact on BRFS, and other factors, such as type of therapy (adjuvant *vs.* salvage), the total radiation dose and the use of hormonal therapy, did not influence BRFS (Table IV). In multivariate analysis, nPSA12 alone was an independent prognostic factor for BRFS after radiotherapy (Table V).

Table IV. *Univariate analysis of various potential prognostic factors for biochemical-free survival in patients with prostate cancer treated with postoperative radiotherapy.*

	Univariate analysis		
	n	BFS, 5-year rate (%)	*p*-Value
nPSA12 (ng/ml)			
<0.5	56	92.7%	**0.0002**
≥0.5	20	42.2%	
Therapy			
Adjuvant	42	81.9%	0.6615
Salvage	34	77.3%	
Surgical margin			
–	31	84.8%	0.2738
+	15	68.6%	
CAP			
–	15	92.9%	0.2497
+	34	75.2%	
SV			
–	30	88.4%	0.4448
+	14	75.0%	
Pathological T stage			
T0-2	62	100.0%	0.3445
T3-4	11	77.2%	
Pathological N stage			
N0	52	78.4%	0.6818
N1	7	71.4%	
Pelvic irradiation			
Yes	30	86.7%	0.3865
No	46	75.5%	
Age (years)			
<70	51	76.9%	0.2856
≥70	25	86.5%	
KPS (%)			
≤80	17	64.2%	**0.0239**
>80	58	84.6%	
Pre-treatment PSA (ng/ml)			
<20	40	72.5%	0.2022
≥20	29	85.0%	
Pre-radiotherapy PSA (ng/ml)			
<2	42	89.5%	**0.0160**
≥2	12	50.0%	
Gleason combined score			
≤6	24	95.8%	0.1315
>6	19	78.6%	
Differentiation			
Well/Moderate	49	79.0%	0.4524
Poor	22	82.6%	
T stage			
T0-2	62	100.0%	0.3445
T3-4	11	77.2%	
Use of chemotherapy			
Yes	11	45.5%	**0.0033**
No	62	86.6%	
Use of hormone therapy			
Yes	57	75.7%	0.1717
No	18	93.8%	
Use of postRT hormonetherapy			
Yes	40	73.8%	0.4407
No	26	82.0%	
Total radiation dose (Gy)			
<60	30	78.9%	0.7143
≥60	46	80.6%	

nPSA12, Nadir prostate-specific antigen within 12 months; KPS, Karnofsky performance status; BFS, biochemical-free survival; PSA, prostate-specific antigen.

Table V. *Multivariate analysis of various potential prognostic factors for biochemical-free survival in patients with prostate cancer treated with postoperative radiotherapy.*

	Multivariate analysis	
	RR (95% CI)	*p*-Value
nPSA12 (ng/ml)		
<0.5	7.403 (1.296-42.287)	**0.0244**
≥0.5		
KPS (%)		
≤80	2.156 (0.423-10.981)	0.3552
>80		
Pre-radiotherapy PSA (ng/ml)		
<2	2.107 (0.441-10.077)	0.3507
≥2		
Use of chemotherapy		
Yes	0.471 (0.061-3.608)	0.4685
No		

PSA, Prostate-specific antigen; KPS, Karnofsky performance status; RR, relative ratio; CI, confidence intervals.

Regarding clinical control, the median nPSA12s in patients without clinical failure after radiotherapy and those with clinical failure were 0.04 ng/ml (range, 0.00-5.90 ng/ml) and 0.90 ng/ml (range, 0.00-5.00 ng/ml), respectively. The 5-year actuarial PFS rates in patients with high nPSA12 levels and patients with low nPSA12 levels were 92.7% and 35.9%, respectively (Figure 5). The difference between these two groups was statistically significant ($p<0.0001$). In a univariate analysis, nPSA12, surgical margin status, KPS, pre-radiotherapy PSA and the use of chemotherapy had a statistically significant impact on PFS (Figure 5; Table VI). However, in a multivariate analysis, no factors were independent prognostic factors for PFS (Table VII).

Late morbidity of RTOG grade 2-3 was observed in 8 patients (11%). A total of 4 patients experienced late rectal toxicity and the remaining 4 patients had late urinary toxicity. There were no cases of grade 4 toxicity (Table VIII). Regarding 4 patients who suffered grade 3 late complications, CT-based treatment planning was carried out in only 1 patient (25%), and conformal therapy was supplemented in 1 patient (25%).

Discussion

The current study indicated that postoperative radiotherapy gave an excellent local control rate for patients treated with radical prostatectomy. Several reports have also indicated that postoperative radiotherapy gave an excellent local control rate for these tumors (11, 33-35). The EORTC trial reported the cumulative incidence of locoregional failure at 5 years of follow-up, and a statistically lower incidence of failure was seen

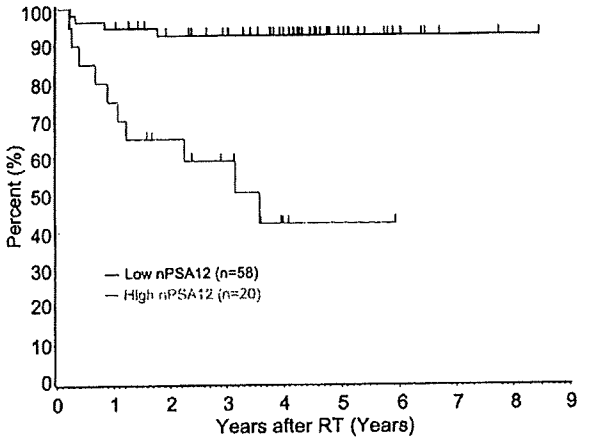

Figure 4. *Actuarial biochemical-free survival curves according to the level of nPSA12. There were significant differences in PFS between patients with a low nPSA12 value (<0.5 ng/ml) and those with a high nPSA12 value (≥0.5 ng/ml).*

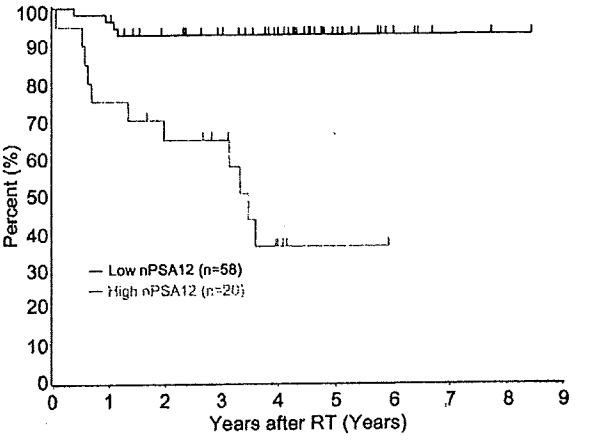

Figure 5. *Actuarial progression-free survival curves according to the level of nPSA12. There were significant differences in PFS between patients with a low nPSA12 value (<0.5 ng/ml) and those with a high nPSA12 value (≥0.5 ng/ml).*

in the adjuvant radiotherapy arm (5.4%) than in the observation arm (15.4%) (11). Cozzarini *et al.* retrospectively analyzed 237 patients who underwent postoperative radiotherapy (within 6 months of surgery), and indicated that the actuarial 8-year local control rate was 93% (33). In the current study, only 5 out of 76 patients (7%) developed local failure after radiotherapy.

Although the dose response in patients who undergo postoperative radiotherapy for localized prostate cancer has not yet been clearly established, higher doses with curative intent can result in favorable outcomes in some patients. In the current study, the 5-year local control in 76 patients treated with a median dose of 60 Gy was 92.2%, and 22 out of 22 patients (100%) treated with 66 Gy or more had achieved local control. Several reports have suggested that radiation doses of 65 Gy or more are associated with improved biochemical PFS (36, 37). Therefore, radiation doses of 65 Gy or more appear to be appropriate for prostate cancer patients when treated with postoperative radiotherapy. However, in the current study, it is important to note that the almost all patients who suffered grade 3 late complications were treated without CT-based treatment planning and/or conformal therapy. Therefore, CT-based treatment planning and/or conformal therapy should be required to reduce the late complications. Concerning the radiation field, we did not find significant differences in local control between patients treated for the whole pelvis with or without boost and those treated with a localized field only. Therefore, localized field irradiation may be sufficient in this patient population. Further studies are required to determine whether a localized field is sufficient for these patients.

The current study also indicated that patients with a high nPSA12 had a significantly lower BRFS rate than patients with a low nPSA12, and nPSA12 was an independent prognostic factor for BRFS in patients with localized prostate cancer treated with postoperative radiotherapy. Moreover, patients with low nPSA12 levels had significantly higher PFS than those with high nPSA12 level, although nPSA12 was not an independent prognostic factor for PFS in the multivariate analysis. To our knowledge, this is the first report to demonstrate the utility of nPSA12 in determining prognosis in patients with localized prostate cancer treated with postoperative radiotherapy. Concerning previously untreated prostate cancer, Alcantara *et al.* indicate that nPSA12 is independent of radiation dose, T stage, Gleason score, pretreatment initial PSA, age and PSA doubling time, and dichotomized nPSA12 (≤2 *versus* >2 ng/ml) was independently related to distant metastasis and cause-specific mortality (15). Ray *et al.* indicated that patients with nPSA12 ≤2.0 ng/ml had significantly higher 8-year PSA failure-free survival and overall survival than patients with nPSA12 >2.0 ng/ml, and nPSA12 was an independent prognostic factor for prostate cancer patients treated with radiotherapy alone (16). Furthermore, Ogawa *et al.* indicated that nPSA12 was an independent prognostic factor for hormone-refractory prostate cancer patients treated with radiotherapy (38). These results suggest that nPSA12 may be a useful marker for patients with localized prostate cancer treated with postoperative radiotherapy as well as patients with previously untreated prostate cancer treated with radiotherapy and clinically localized hormone-refractory prostate cancer.

Several previous studies have suggested other potential factors associated with the risk of prostate cancer recurrence, such as pre-radiotherapy PSA, PSA velocity and PSA doubling time (PSADT) (9, 39-42). For patients treated with salvage radiotherapy, Gleason score, pre-radiotherapy PSA level, surgical margins, PSADT and seminal vesicle invasion are

Table VI. *Univariate analysis of various potential prognostic factors for progression-free survival in patients with prostate cancer treated with postoperative radiotherapy.*

	Univariate analysis		
	n	PFS, 5-year rate (%)	*p*-Value
nPSA12 (ng/ml)			
<0.5	56	92.7%	**<0.0001**
≥0.5	20	35.9%	
Therapy			
Adjuvant	42	72.7%	0.1838
Salvage	34	69.8%	
Surgical margin			
–	31	96.8%	**0.0258**
+	15	56.7%	
CAP			
–	15	86.7%	0.7355
+	34	77.6%	
SV			
–	30	93.3%	0.0997
+	14	68.8%	
Pathological T stage			
T0-2	62	90.9%	0.4793
T3-4	11	78.5%	
Pathological N stage			
N0	52	76.6%	0.8399
N1	7	71.4%	
Pelvic irradiation			
Yes	30	76.5%	0.9782
No	46	78.7%	
Age (years)			
<70	51	73.3%	0.2382
≥70	25	87.0%	
KPS (%)			
≤80	17	57.3%	**0.0417**
>80	58	82.8%	
Pre-treatment PSA (ng/ml)			
<20	40	74.8%	0.6650
≥20	29	82.6%	
Pre-radiotherapy PSA (ng/ml)			
<2	42	90.4%	**0.0103**
≥2	12	44.4%	
Gleason combined score			
≤6	24	95.8%	0.0706
>6	19	71.8%	
Differentiation			
Well/Moderate	49	85.3%	0.0744
Poor	22	65.4%	
Use of chemotherapy			
Yes	11	45.5%	**0.0102**
No	62	83.8%	
Use of hormonetherapy			
Yes	57	75.6%	0.3841
No	18	82.6%	
Use of postRT hormone therapy			
Yes	40	73.1%	0.5473
No	26	84.6%	
Total radiation dose (Gy)			
<60	30	72.7%	0.6112
≥60	46	81.2%	

nPSA12, Nadir prostate-specific antigen within 12 months; KPS, Karnofsky performance status; PSA, prostate-specific antigen; PFS, progression-free survival.

Table VII. *Multivariate analysis of various potential prognostic factors for progression-free survival in patients with prostate cancer treated with postoperative radiotherapy.*

	Multivariate analysis	
	RR (95% CI)	*p*-Value
nPSA12 (ng/ml)		
<0.5	5.183 (0.326-82.512)	0.2439
≥0.5		
Surgical margin		
–	12.683 (0.656-245.321)	0.0928
+		
KPS (%)		
≤80	10.998 (0.426-283.891)	0.1483
>80		
Pre-radiotherapy PSA (ng/ml)		
<2	0.255 (0.010-6.570)	0.4094
≥2		
Use of chemotherapy		
Yes	0.174 (0.007-4.082)	0.2771
No		

PSA, Prostate-specific antigen; KPS, Karnofsky performance status; RR, relative ratio; CI, confidence intervals.

Table VIII. *Late complications in patients with prostate cancer treated with postoperative radiotherapy.*

	Toxicity grade		Total dose (Grade 3)
	Grade 2	Grade 3	
Rectal			
Bleeding	3	1	67.8 Gy
Urinary			
Ureteral obstruction	1	0	
Incontinence	0	2	60 Gy
Incontinence + Structure	0	1	56.6 Gy

prognostic variables for a durable response to salvage radiotherapy (41). Sasaki *et al.* indicated that a low pre-radiotherapy PSA level is a significant predictor of biochemical control for postoperative radiotherapy in patients with prostate cancer (42). King *et al.* reported that postoperative PSA velocity independently predicts for the failure of salvage radiotherapy after radical prostatectomy (39). Numata *et al.* indicated that PSADT appears to be a good predictor of response to salvage radiotherapy in patients with biochemical recurrence after radical prostatectomy (9).

Concerning the timing of radiotherapy, adjuvant radiotherapy following radical prostatectomy has been compared to salvage therapy in numerous retrospective studies that have included patients with high-risk pathological features (10, 43-45). Overall, the results from those studies support the

use of adjuvant radiotherapy, with demonstrated improvements in local and biochemical control. In the current study, there was no significant difference in biochemical control between the adjuvant radiotherapy group and the salvage radiotherapy group. One of the reasons may be the small number of patients in the current study. Our results also indicated that pre-radiotherapy PSA, KPS and the use of chemotherapy had a significant impact on BRFS, although multivariate analyses failed to confirm the significance. Further studies are required to evaluate the influence of additional factors, such as PSA velocity and PSADT, on clinical outcomes for localized hormone-refractory patients treated with radiotherapy.

In conclusion, our results indicated that postoperative radiotherapy gave an excellent local control rate for localized prostate cancer after radical prostatectomy, and should be considered the treatment of choice for these tumors. Our results also indicated that nPSA12 is an early predictor of biochemical failure that is independent of radiotherapy dose and other determinants of outcome after postoperative radiotherapy for prostate cancer patients treated with radical prostatectomy. Therefore, nPSA12 could potentially help identify patients at high risk who might benefit from the earlier application of systemic therapy. However, this study is a retrospective study with various treatment modalities, and further prospective studies are required to confirm our results.

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References

1 Van der Kwast TH, Bolla M, Van Poppel H, Van Cangh P, Vekemans K, Da Pozzo L, Bosset JF, Kurth KH, Schröder FH and Collette L; EORTC 22911: Identification of patients with prostate cancer who benefit from immediate postoperative radiotherapy: EORTC 22911. J Clin Oncol *25*: 4178-4186, 2007.

2 Kupelian P, Katcher J, Levin H, Zippe C and Klein E: Correlation of clinical and pathologic factors with rising prostate-specific antigen profiles after radical prostatectomy alone for clinically localized prostate cancer. Urology *48*: 249-260, 1996.

3 Zincke H, Oesterling JE, Blute ML, Bergstralh EJ, Myers RP and Barrett DM: Long-term (15 years) results after radical prostatectomy for clinically localized (stage T2c or lower) prostate cancer. J Urol *152*: 1850-1857, 1994.

4 Catalona WJ and Smith DS: Cancer recurrence and survival rates after anatomic radical retropubic prostatectomy for prostate cancer: intermediate-term results. J Urol *160*: 2428-2434, 1998.

5 Walsh PC, Partin AW and Epstein JI: Cancer control and quality of life following anatomical radical retropubic prostatectomy: results at 10 years. J Urol *152*: 1831-1836, 1994.

6 Gerber GS, Thisted RA, Scardino PT, Frohmuller HG, Schroeder FH, Paulson DF, Middleton AW Jr, Rukstalis DB, Smith JA Jr, Schellhammer PF, Ohori M, Chodak GW: Results of radical prostatectomy in men with clinically localized prostate cancer. JAMA *276*: 615-619, 1996.

7 Wheeler TM, Dillioglugil O, Kattan MW, Arakawa A, Soh S, Suyama K, Ohori M and Scardino PT: Clinical and pathological significance of the level and extent of capsular invasion in clinical stage T1-2 prostate cancer. Hum Pathol *29*: 856-862, 1998.

8 Swindle P, Eastham JA, Ohori M, Kattan MW, Wheeler T, Maru N, Slawin K and Scardino PT: Do margins matter? The prognostic significance of positive surgical margins in radical prostatectomy specimens. J Urol *174*: 903-907, 2005.

9 Numata K, Azuma K, Hashine K and Sumiyoshi Y: Predictor of response to salvage radiotherapy in patients with PSA recurrence after radical prostatectomy: the usefulness of PSA doubling time. Jpn J Clin Oncol *35*: 256-259, 2005.

10 Morgan SC, Waldron TS, Eapen L, Mayhew LA, Winquist E, Lukka H and Genitourinary Cancer Disease Site Group of the Cancer Care Ontario Program in Evidence-based Care: Adjuvant radiotherapy following radical prostatectomy for pathologic T3 or margin-positive prostate cancer: a systematic review and meta-analysis. Radiother Oncol *88*: 1-9, 2008.

11 Bolla M, van Poppel H, Collette L, van Cangh P, Vekemans K, Da Pozzo L, de Reijke TM, Verbaeys A, Bosset JF, van Velthoven R, Maréchal JM, Scalliet P, Haustermans K, Piérart M and European Organization for Research and Treatment of Cancer: Postoperative radiotherapy after radical prostatectomy: a randomised controlled trial (EORTC trial 22911). Lancet *366*: 572-578, 2005.

12 Vargas C, Kestin LL, Weed DW, Krauss D, Vicini FA and Martinez AA: Improved biochemical outcome with adjuvant radiotherapy after radical prostatectomy for prostate cancer with poor pathologic features. Int J Radiat Oncol Biol Phys *61*: 714-724, 2005.

13 National Comprehensive Cancer Network: NCCN clinical practice guidelines in oncologyTM. Prostate cancer. V.2. 2009. http://www.nccn.org/professionals/physician_gls/PDF/prostate.pdf.

14 Thompson IM Jr, Tangen CM, Paradelo J, Lucia MS, Miller G, Troyer D, Messing E, Forman J, Chin J, Swanson G, Canby-Hagino E and Crawford ED: Adjuvant radiotherapy for pathologically advanced prostate cancer: a randomized clinical trial. JAMA *296*: 2329-2335, 2006.

15 Alcantara P, Hanlon A, Buyyounouski MK, Horwitz EM and Pollack A: Prostate-specific antigen nadir within 12 months of prostate cancer radiotherapy predicts metastasis and death. Cancer *109*: 41-47, 2007.

16 Ray ME, Levy LB, Horwitz EM, Kupelian PA, Martinez AA, Michalski JM, Pisansky TM, Zelefsky MJ, Zietman AL and Kuban DA: Nadir prostate-specific antigen within 12 months after radiotherapy predicts biochemical and distant failure. Urology *68*: 1257-1262, 2006.

17 Zietman AL, Tibbs MK, Dallow KC, Smith CT, Althaüsen AF, Zlotecki RA and Shipley WU: Use of PSA nadir to predict subsequent biochemical outcome following external beam radiation therapy for T1-2 adenocarcinoma of the prostate. Radiother Oncol *40*: 159-162, 1996.

18 Lee WR, Hanlon AL and Hanks GE: Prostate-specific antigen nadir following external beam radiation therapy for clinically localized prostate cancer: the relationship between nadir level and disease-free survival. J Urol *156*: 450-453, 1996.

19 Crook JM, Bahadur YA, Bociek RG, Perry GA, Robertson SJ and Esche BA: Radiotherapy for localized prostate carcinoma. The correlation of pretreatment prostate-specific antigen and nadir prostate-specific antigen with outcome as assessed by systematic biopsy and serum prostate specific antigen. Cancer *79*: 328-336, 1997.

20 Ray ME, Thames HD, Levy LB, Horwitz EM, Kupelian PA, Martinez AA, Michalski JM, Pisansky TM, Shipley WU, Zelefsky MJ, Zietman AL and Kuban DA: PSA nadir predicts biochemical and distant failures after external beam radiotherapy for prostate cancer: a multi-institutional analysis. Int J Radiat Oncol Biol Phys *64*: 1140-1150, 2006.

21 Hanlon AL, Diratzouian H and Hanks GE: Posttreatment prostate-specific antigen nadir highly predictive of distant failure and death from prostate cancer. Int J Radiat Oncol Biol Phys *53*: 297-303, 2002.

22 Pollack A, Hanlon AL, Movsas B, Hanks GE, Uzzo R and Horwitz EM: Biochemical failure as a determinant of distant metastasis and death in prostate cancer treated with radiotherapy. Int J Radiat Oncol Biol Phys *57*: 19-23, 2003.

23 Teshima T and Japanes PCS Working Group: Patterns of care study in Japan: Jpn J Clin Oncol *35*: 497-506, 2005.

24 Sasaki T, Nakamura K, Ogawa K, Onishi H, Otani Y, Koizumi M, Shioyama Y, Teshima T and Japanese Patterns of Care Study Working Subgroup of Prostate Cancer: Postoperative radiotherapy for patients with prostate cancer in Japan; Changing trends in national practice between 1996-98 and 1999-2001: Patterns of care study for prostate cancer. Jpn J Clin Oncol *36*: 649-654, 2006.

25 Hanks GE, Coia LR and Curry J: Patterns of care studies: past, present and future. Semin Radiat Oncol *7*: 97-100, 1997.

26 Owen JB, Sedransk J and Pajak TF: National averages for process and outcome in radiation oncology: Methodology of the patterns of care study. Semin Radiat Oncol *7*: 101-107, 1997.

27 Roach M 3rd, Hanks G, Thames H Jr, Schellhammer P, Shipley WU, Sokol GH and Sandler H: Defining biochemical failure following radiotherapy with or without hormonal therapy in men with clinically localized prostate cancer: recommendations of the RTOG-ASTRO Phoenix Consensus Conference. Int J Radiat Oncol Biol Phys *65*: 965-974, 2006.

28 SAS procedure reference, version 6. 1st ed. Tokyo: SAS Institute Iin Japan; 1995.

29 Kaplan EL and Meier P: Nonparametric estimation from incomplete observations. J Am Stat Assoc *53*: 457-481, 1958.

30 Mantel N: Evaluation of survival data and two new rank order statistics arising in its consideration. Cancer Chemother Rep *50*: 163-170, 1966.

31 Cox DR: Regression models and life tables. J R Stat Soc *34*: 187-220, 1972.

32 Cox JD, Stetz J and Pajak TF: Toxicity criteria of the Radiation Therapy Oncology Group (RTOG) and the European Organization for Research and Treatment of Cancer (EORTC). Int J Radiat Oncol Biol Phys *31*: 1341-1346, 1995.

33 Cozzarini C, Bolognesi A, Ceresoli GL, Fiorino C, Rossa A, Bertini R, Colombo R, Da Pozzo L, Montorsi F, Roscigno M, Calandrino R, Rigatti P and Villa E: Role of postoperative radiotherapy after pelvic lymphadenectomy and radical retropubic prostatectomy: a single institute experience of 415 patients. Int J Radiat Oncol Biol Phys *59*: 674-683, 2004.

34 Petrovich Z, Lieskovsky G, Langholz B, Jozsef G, Streeter OE Jr and Skinner DG: Postoperative radiotherapy in 423 patients with pT3N0 prostate cancer. Int J Radiat Oncol Biol Phys *53*: 600-609, 2002.

35 Choo R, Hruby G, Hong J, Hong E, DeBoer G, Danjoux C, Morton G, Klotz L, Bhak E and Flavin A: Positive resection margin and/or pathologic T3 adenocarcinoma of prostate with undetectable postoperative prostate-specific antigen after radical prostatectomy: to irradiate or not? Int J Radiat Oncol Biol Phys *52*: 674-680, 2002.

36 Macdonald OK, Schild SE, Vora SA, Andrews PE, Ferrigni RG, Novicki DE, Swanson SK and Wong WW: Radiotherapy for men with isolated increase in serum prostate-specific antigen after radical prostatectomy. J Urol *170*: 1833-1837, 2003.

37 Anscher MS, Clough R and Dodge R: Radiotherapy for a rising prostate-specific antigen after radical prostatectomy: the first 10 years. Int J Radiat Oncol Biol Phys *48*: 369-375, 2000.

38 Ogawa K, Nakamura K, Sasaki T, Onishi H, Koizumi M, Shioyama Y, Araya M, Mukumoto N, Mitsumori M and Teshima T: External beam radiotherapy for clinically localized hormone-refractory prostate cancer: Clinical Significance of Nadir Prostate-Specific Antigen value within 12 Months. Int J Radiat Oncol Biol Phys *74*: 759-765, 2009.

39 King CR, Presti JC, Brooks JD, Gill H and Spiotto MT: Postoperative prostate-specific antigen velocity independently predicts for failure of salvage radiotherapy after prostatectomy. Int J Radiat Oncol Biol Phys *70*: 1472-1477, 2008.

40 Wadasaki K, Kaneyasu Y, Kenjo M, Matsuura K, Murakami Y, Hashimoto Y, Ito K, Kiriu H and Ito A: Treatment results of adjuvant radiotherapy and salvage radiotherapy after radical prostatectomy for prostate cancer. Int J Clin Oncol *12*: 37-41, 2007.

41 Stephenson AJ, Shariat SF, Zelefsky MJ, Kattan MW, Butler EB, Teh BS, Klein EA, Kupelian PA, Roehrborn CG, Pistenmaa DA, Pacholke HD, Liauw SL, Katz MS, Leibel SA, Scardino PT and Slawin KM: Salvage radiotherapy for recurrent prostate cancer after radical prostatectomy. JAMA *291*: 1325-1332, 2004.

42 Sasaki T, Nakamura K, Shioyama Y, Ohga S, Toba T, Urashima Y, Yoshitake T, Terashima H, Koga H, Naito S, Noma H, Komatsu K, Yamaguchi A, Hiratsuka Y, Hirano T, Hanada K, Abe M, Fujisawa Y and Honda H: Low pre-radiotherapy prostate-specific antigen level is a significant predictor of treatment success for postoperative radiotherapy in patients with prostate cancer. Anticancer Res *26*: 2367-2374, 2006.

43 Schild SE, Wong WW, Grado GL, Halyard MY, Novicki DE, Swanson SK, Larson TR and Ferrigni RG: The result of radical retropubic prostatectomy and adjuvant therapy for pathologic stage C prostate cancer. Int J Radiat Oncol Biol Phys *34*: 535-541, 1996.

44 Morris MM, Dallow KC, Zietman AL, Park J, Althausen A, Heney NM and Shipley WU: Adjuvant and salvage irradiation following radical prostatectomy for prostate cancer. Int J Radiat Oncol Biol Phys *38*: 731-736, 1997.

45 Valicenti RK, Gomella LG, Ismail M, Strup SE, Mulholland SG, Dicker AP, Petersen RO and Newschaffer CJ: The efficacy of early adjuvant radiation therapy for pT3N0 prostate cancer: a matched-pair analysis. Int J Radiat Oncol Biol Phys *45*: 53-58, 1999.

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全国放射線治療施設の2007年定期構造調査報告(第1報)

JASTROデータベース委員会

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JAPANESE STRUCTURE SURVEY OF RADIATION ONCOLOGY IN 2007 (FIRST REPORT)

JASTRO Database Committee

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Abstract: A national structure survey of radiation oncology in 2007 using questionnaires was conducted from March 2008 to January 2009 by JASTRO. The response rate was 721 out of 765 (94.2%) active radiotherapy institutes. The total number of new cancer patients and the total number of cancer patients (new+repeat) treated with radiation were estimated to be approximately 181,000 and 218,000, respectively. The numbers of linac, telecobalt, Gamma Knife®, ^{60}Co RALS, and ^{192}Ir RALS in actual use were 807, 15, 46, 45, and 123, respectively. The linac has a dual energy function in 539 (66.8%), 3DCRT in 555 (68.8%), and IMRT in 235 (29.1%). The numbers of JASTRO-certified radiation oncologists, full time equivalent (FTE) radiation oncologists, medical physicists, radiotherapy QA personnel, radiation therapists, radiation therapy nurses, and clerks were 477, 826 FTE, 64 FTE, 106 FTE, 1,634 FTE, 494 FTE, and 329, respectively. There were significant increases in the use of ^{125}I for prostate cancer patients by 52% and IMRT by 271% between 2005 and 2007. Geographically, there was still a significant variation in the use of radiotherapy from 0.8 new patients per 1,000 population to 1.8 (average 1.3).

Key words: Structure survey, Radiotherapy facility, Radiotherapy equipment, Radiotherapy personnel

はじめに

1990年に恒元らによって第1回日本放射線腫瘍学会(JASTRO)全国放射線治療施設構造調査が実施された[1]. 1993年以降は定期的(2年ごと)に構造調査を学会事業として行っている[2)-10)]. これらのデータ分析によってJASTROは, わが国における放射線治療のおかれている状況を装備, 人員, 患者数などを中心に正確に把握し, 国や地方自治体レベルでの施策の提言や個々の医療機関における構造の改善に役立つ情報を提供してきた. この調査への協力はJASTROによる放射線治療施設の施設認定制度における認定を受けるための必要条件ともなっている.

今回, 2007年を対象とした第9次全国放射線治療施設の構造調査を行った. データはすでにJASTROホームページ(http://www.jastro.jp/)よりdownload可能にしている[11]. 本報告ではこれらのデータを示すとともに, データベース委員会が注目しているデータについて解説と考案を行った. なお, 人員負荷などの詳細な分析は, 第2報以降に報告する.

このデータはJASTROの共有財産であり, 各施設の構造を改善するために利用されることを最終目標としている.

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Table 1 Category of radiation oncology facilities

調査票送付時の分類	集計時の分類
[U]：大学附属病院	U：大学附属病院
[N]：独立行政法人国立病院機構(がんセンター等を除く)	G：国立がんセンター・成人病センター・地方がんセンター*
[P]：公立(都道府県市町村立)病院(がんセンター等を除く)	N：独立行政法人国立病院機構(がんセンター等を除く)
[G]：国立がんセンター・成人病センター・地方がんセンター	P：公立(都道府県市町村立)病院(がんセンター等を除く)
[S]：赤十字病院・済生会病院	O：赤十字病院・済生会病院，企業／公社病院，国保／社保／共済／労災／組合／厚生連病院等
[C]：企業／公社病院	H：医療法人・医師会病院・個人病院・その他
[L]：国保／社保／共済／労災／組合／厚生連病院等	
[H]：医療法人・医師会病院・個人病院等	
[O]：その他	

*厚生労働省の本省に置かれた6つの国立高度専門医療センターを含める．

各施設での具体的交渉用にcustomizeされたデータが必要な場合，常時応ずるので連絡願いたい．

調査対象と調査経過

2008年3月末に，2007年に放射線治療装置があると想定された全国814施設にJASTRO事務局から，2007年1月1日～12月31日までの放射線治療の診療実態についての構造調査票が郵送された．2008年度JASTRO会長とデータベース委員長連名にて，本調査への協力を正式に依頼した．2009年1月末までに721施設から回答が得られた．すでに放射線治療を止めている施設もあり，2007年に放射線治療を行っている施設は765施設と推定された．解析対象施設数は721施設(94.2%)となった．調査票の内容は2007年4月から，委員会で調査開始直前まで検討された．2005年の調査票との整合性を保ちながら，新たな調査項目としてlinacのIGRT機能，focal(CT on rail)機能：同室CT機能，on board imaging (OBI)機能：照射位置照合機能を加えた．さらに放射線腫瘍医の常勤，非常勤勤務の兼務による実質的マンパワー分析のために，名前や会員番号によって常勤の病院と非常勤の病院におけるデータ照合ができるようにした．放射線治療担当技師の実質的なマンパワーFTE(full time equivalent：週40時間放射線治療専任業務に換算)数，医学物理士FTE数，放射線治療品質管理士FTE数，放射線治療担当看護師FTE数も加えた．また，2005年調査データと同様に，国際原子力機関IAEAの施設構造調査DIRAC(Directory of Radiotherapy Centres)へのデータ協力のための調査も同時に行い，573施設(79.5%)からデータ提供の承諾を得た．ウィーンのIAEA本部で沼崎委員により，2008年10月31日にデータ更新を完了した．これは装置名などの詳細な情報であり，IAEAのホームページ(http://www-naweb.iaea.org/nahu/dirac/default.asp)にすでに公開されている．

結　果

1. 施設分類，規模，地域と施設数

Table 1 に，施設分類一覧を示す．集計時の分類として[S]：赤十字病院・済生会病院，[C]：企業／公社病院，[L]：国保／社保／共済／労災／組合／厚生連病院等をOとして一括した．[H]：医療法人・医師会病院・個人病院等，[O]：その他をHとして一括した．厚生労働省の本省に置かれた6つの国立高度専門医療センターはGに含めた．

Table 2 に，地域と施設数を示している．関東(27.5%)，近畿(17.6%)，九州・沖縄，東海，東北，中国，信越・北陸，北海道，四国(3.7%)の順となっている．2005年に比して，関東で0.7%，近畿で1.4%増加している．

Table 3 に，施設組織区分と施設規模(年間新患者数)を示す．U：大学附属病院，G：国立がんセンター・成人病センター，地方がんセンターではF：500人以上が最も多かった．N：国立病院機構，P：公立病院，O：赤十字病院・済生会病院，企業／公社病院，国保／社保／共済／労災／組合／厚生連病院等，H：医療法人・医師会病院・個人病院・その他ではB：100～199人が最も多くなっていた．全体で見ると，Bが32.3%，A：99人以下が25.4%，C：200～299人が16.0%，D：300～399人が10.1%，E：400～499人は5.1%であった．F：500人以上を治療する施設は11.1%である．わが国の74%の施設は300人未満の年間新患者数(A, B, C)を治療している．2005年に比してBの施設割合で0.7%，D，EおよびFの施設で，それぞれ1.1%，0.6%，1.9%増加していた．

2. 年間患者数

Table 4-1 に，施設規模別の年間新患者数を示す．721施設で総計170,229人の新患者が治療されていた．全国の実施施設数を765施設とした場合に，推定新患者数は約18万1,000人であった．施設組織区分では，U：大学附属病院が29.6%と最も多く，P：公立病院20.7%，O：赤十字病院・済生会病院，企業，保険団体，厚生連が18.4%であった．施設規模では，F：500人以上が34.0%，B：100～199人が19.2%，C：200～299人が16.4%，D：14.6%，E：9.4%であった．2005年と比較すると，A，BおよびCの施設で全体患者数に占める割合が減少し，D，EおよびFの施設で増加している．Table 4-2 に，施設規模別の年間実患者数(新患+再患)を示す．実患者数未入力の施設が35施設あり，新患

Table 2 Region and number of radiation oncology facilities

地域(都道府県数)	郵送施設数	回答施設数 (対郵送施設割合[%])	解析施設数 (対郵送施設割合[%])	解析施設数/全国[%]
北海道(1)	34	31(91.2)	30 (88.2)	4.2
東北(6)	64	61(95.3)	59 (92.2)	8.2
関東(8)	227	205(90.3)	198 (87.2)	27.5
信越・北陸(5)	57	51(89.5)	50 (87.7)	6.9
東海(4)	95	90(94.7)	87 (91.6)	12.1
近畿(6)	141	131(92.9)	127 (90.1)	17.6
中国(5)	59	54(91.5)	54 (91.5)	7.5
四国(4)	34	30(88.2)	27 (79.4)	3.7
九州・沖縄(8)	103	94(91.3)	89 (86.4)	12.3
全国(47)	814	747(91.8)	721*(88.6)	100

*2007年放射線治療実施施設数は765施設と推測され，721施設は94.2%に相当.

Table 3 Number of radiation oncology facilities by annual patient load and category

施設規模 (年間新患者数)	施設組織区分						Total	施設割合[%]
	U	G	N	P	O	H		
A(99人以下)	9	2	22	67	47	36	183	25.4
B(100～199人)	12	3	28	74	69	47	233	32.3
C(200～299人)	11	3	10	38	33	20	115	16.0
D(300～399人)	20	4	3	18	14	14	73	10.1
E(400～499人)	17	1	1	6	5	7	37	5.1
F(500人以上)	45	16	1	5	6	7	80	11.1
Total	114	29	65	208	174	131	721	
施設割合[%]	15.8	4.0	9.0	28.8	24.1	18.2		100

Table 4-1 Annual number of new cancer patients by patient load and category of radiation oncology facilities

施設規模(施設数)	施設組織区分(施設数)						Total (721)	対全患者数割合[%]	施設平均新患者数
	U(114)	G(29)	N(65)	P(208)	O(174)	H(131)			
A(183)	439	58	1,342	4,034	2,945	2,018	10,836	6.4	59.2
B(233)	1,796	453	3,909	10,316	9,538	6,686	32,698	19.2	140.3
C(115)	2,790	717	2,498	8,919	8,136	4,913	27,973	16.4	243.2
D(73)	6,847	1,341	995	6,057	5,087	4,490	24,817	14.6	340.0
E(37)	7,557	439	421	2,477	2,085	3,041	16,020	9.4	433.0
F(80)	30,922	13,786	731	3,481	3,584	5,381	57,885	34.0	723.6
Total(721)	50,351	16,794	9,896	35,284	31,375	26,529	170,229		
対全患者数割合[%]	29.6	9.9	5.8	20.7	18.4	15.6		100	
施設平均新患者数	441.7	579.1	152.2	169.6	180.3	202.5			236.1

2007年放射線治療実施施設数を765施設と推測した場合の推定新患者数：約18万1,000人.

者数×1.2で補正した．施設規模は新患者数での分類を踏襲した．721施設で総計205,087人が治療されていた．全国規模では推定実患者数は約21万8,000人であった．施設組織区分，施設規模ではTable 4-1 とほぼ同様の傾向を示した．2005年と比し，特にFの扱う患者数の全体に対する比率の増加がそれぞれ3.4%，3.7%と高い．

Table 5-1 に，地域別施設数と年間新患者数を示している．全新患者数比(%)で最も多いのは，関東の33.5%であった．次いで近畿の16.7%，九州・沖縄の11.2%，東海の10.8%と続いた．施設平均の新患者数は全国平均では236.1人で，関東288.0人，北海道275.6人，近畿224.1人と続いた．Table 5-2 に，同様に年間実患者数で示している．全実患者数比(%)も新患者同様の傾向であった．施設平均実患者数は全国平均284.4人で，北海道365.0人，関東342.4人，

Table 4-2 Annual number of total cancer patients (new+repeat) by patient load and category of radiation oncology facilities*

施設規模** (施設数)	施設組織区分 (施設数)						Total (721)	対全患者数割合 [%]	施設平均新患者数
	U (114)	G (29)	N (65)	P (208)	O (174)	H (131)			
A (183)	506	64	1,643	4,864	3,330	2,297	12,704	6.2	69.4
B (233)	2,095	515	4,623	11,993	11,395	8,463	39,084	19.1	167.7
C (115)	3,560	909	3,005	10,604	9,991	6,033	34,102	16.6	296.5
D (73)	8,374	1,800	1,258	7,861	5,802	5,472	30,567	14.9	418.7
E (37)	8,829	502	480	2,984	2,647	3,997	19,439	9.5	525.4
F (80)	37,191	17,178	804	4,105	4,245	5,668	69,191	33.7	864.9
Total (721)	60,555	20,968	11,813	42,411	37,410	31,930	205,087		
対全患者数割合 [%]	29.5	10.2	5.8	20.7	18.2	15.6		100	
施設平均新患者数	531.2	723.0	181.7	203.9	215.0	243.7			284.4

2007年放射線治療実施施設数を765施設と推測した場合の推定実患者数：約21万8,000人.
* 実患者数＝新患者数＋再患者数. 実患者未入力の施設は，新患者数×1.2で補正(未入力施設：35施設).
** 施設規模は新患者数を100人単位で区切った分類を使用.

Table 5-1 Numbers of annual new cancer patients and radiation oncology facilities by region

地域 (都道府県数)	解析施設数	新患者数	全新患者数比 [%]	施設平均新患者数
北海道(1)	30	8,268	4.9	275.6
東北(6)	59	12,043	7.1	204.1
関東(8)	198	57,015	33.5	288.0
信越・北陸(5)	50	10,750	6.3	215.0
東海(4)	87	18,352	10.8	210.9
近畿(6)	127	28,460	16.7	224.1
中国(5)	54	10,858	6.4	201.1
四国(4)	27	5,424	3.2	200.9
九州・沖縄(8)	89	19,059	11.2	214.1
全国(47)	721	170,229	100	236.1

2007年放射線治療実施施設数を765施設と推測した場合の推定新患者数：約18万1,000人.

Table 5-2 Numbers of annual total cancer patients (new+repeat) and radiation oncology facilities by region

地域 (都道府県数)	解析施設数	実患者数	全実患者数比 [%]	施設平均実患者数
北海道(1)	30	10,951	5.3	365.0
東北(6)	59	14,753	7.2	250.1
関東(8)	198	67,799	33.1	342.4
信越・北陸(5)	50	12,311	6.0	246.2
東海(4)	87	22,910	11.2	263.3
近畿(6)	127	33,789	16.5	266.1
中国(5)	54	13,132	6.4	243.2
四国(4)	27	6,273	3.1	232.3
九州・沖縄(8)	89	23,169	11.3	260.3
全国(47)	721	205,087	100	284.4

2007年放射線治療実施施設数を765施設と推測した場合の推定実患者数：約21万8,000人.

近畿266.1人と続いた. 施設平均実患者数は，2005年より7.5%増加していた. 近畿で最も増加率が高かった.

3. 装備

Table 6 に，施設規模別の治療機器数とその機能を示している. 全体ではlinac 807台，TomoTherapy® 9 台，microtron 13台，telecobalt 15台(稼動分)，Gamma Knife®46台であった. このうち，linacはdual energy機能を539台(66.8%)に，3DCRT機能を555台(68.8%)に，IMRT機能を235台(29.1%)に有していた. 施設規模で見ると，A：99人以下の施設では，それぞれ47.1%，48.2%，12.4%であったが，F：500人以上の施設では，75.3%，86.7%，58.4%に有していた. さ

Table 6 Number of equipments and their function by annual patient load of radiation oncology facilities

治療機器と機能	A (183)	B (233)	C (115)	D (73)	E (37)	F (80)	Total (721)
linac	170	219	114	85	53	166	807
with dual energy function	80	141	89	61	43	125	539
with 3DCRT function (MLC width=<1.0 cm)	82	136	84	65	44	144	555
with IMRT function	21	35	31	25	26	97	235
with IGRT function	13	17	11	8	10	49	108
with CT on rail	12	11	5	8	0	11	47
with treatment position verification system	8	13	13	15	15	46	110
annual no. patients/linac	70.2	165.8	283.4	331.1	344.8	416.8	243.2
CyberKnife®	6	3	2	0	1	3	15
Novalis®	1	1	1	0	0	4	7
Synergy®	1	0	1	0	2	3	7
Trilogy®	2	1	0	0	2	4	9
Oncor®	4	3	1	1	1	4	14
TomoTherapy®	1	2	3	1	0	2	9
particle	1	0	0	0	0	5	6
betatron	0	0	0	0	0	0	0
microtron	1	2	4	1	1	4	13
telecobalt (actual use)	11(7)	2(2)	6(2)	3(0)	2(1)	4(3)	28(15)
Gamma Knife®	2	15	10	7	5	7	46
other accelerator	1	5	0	1	1	1	9
other external irradiation device	0	2	1	1	1	1	6
new type Co-60 RALS (actual use)	1(1)	5(5)	2(2)	2(2)	3(3)	3(3)	16(16)
old type Co-60 RALS (actual use)	2(1)	6(5)	9(6)	12(9)	5(4)	5(4)	39(29)
Ir-192 RALS (actual use)	1(1)	9(7)	19(19)	24(23)	17(17)	57(56)	127(123)
Cs-137 RALS (actual use)	0(0)	1(0)	0(0)	2(2)	0(0)	1(1)	4(3)

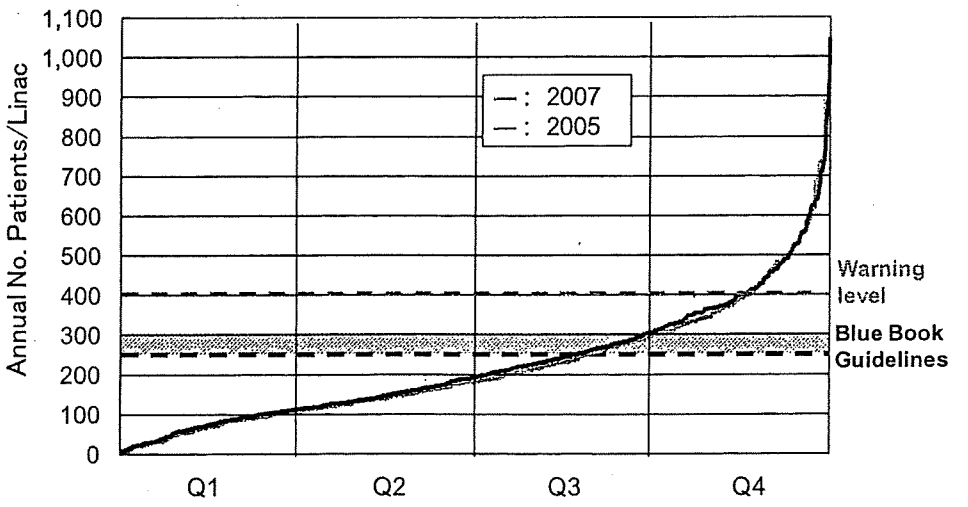

Fig. 1 Distribution of annual patient load/external treatment equipment in radiation oncology facilities. Horizontal axis represents facilities in order of increasing value of annual number of patients/treated equipment within facilities. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

らに全体で，IGRT機能を108台(13.4%)，CT同室システム(CT on rail)を47台(5.8%)，照射位置照合システムを110台(13.6%)に有していた．D：300～399人の施設では加速器を2台有し始め，Fの施設では全施設で2台以上有していた．1台のlinacで実患者数平均243.2人を治療していた．C：200～299人の施設では283.4人，D：300～399人で331.1人を治療していた．E：400～499人では344.8人，F：500人以上では416.8人を治療していた．全体で見ると，日本版ブルーブック[12]の基準である250～300人/装置以上を全体の35%の施設では治療していた．逆に，65%の施設では，この基準範囲以下の治療がなされていた(Fig. 1)．上位1/4の施設では300人を超えて治療していた．特に上位12%では，改善警告値400人を超える患者を1台のlinacで治療していた．最新の装置としてCyberKnife®15台，Novalis® 7台，Synergy® 7台，Trilogy® 9台，Oncor®14台が導入されていた．粒子線は，本登録では全国で6台稼動していた．小線源照射装置

Table 7 Number of treatment planning equipment and accessories by annual patient load of radiation oncology facilities

治療周辺機器	A (183)	B (233)	C (115)	D (73)	E (37)	F (80)	Total (721)
X-ray simulator	106	138	62	50	30	59	445
CT simulator	89	149	91	55	31	82	497
RTP computer (2 or more)	192 (13)	248 (24)	153 (26)	107 (25)	70 (14)	300 (66)	1,070 (168)
X-ray CT (2 or more)	296 (99)	501 (183)	310 (107)	223 (63)	129 (34)	369 (72)	1,828 (558)
for RT only	46	93	62	49	25	78	353
MRI (2 or more)	202 (33)	339 (100)	201 (81)	142 (59)	89 (31)	216 (66)	1,189 (370)
for RT only	0	2	3	5	0	3	13
computer use for RT recording	147	211	107	68	35	72	640
water phantom (2 or more)	160 (19)	223 (30)	120 (21)	80 (17)	47 (12)	116 (25)	746 (124)
film densitometer (2 or more)	67 (4)	78 (4)	59 (0)	45 (3)	23 (2)	71 (4)	343 (17)
dosemeter (3 or more)	421 (66)	620 (105)	365 (61)	209 (35)	164 (27)	402 (54)	2,181 (348)

Table 8 Number of treatment planning by its complexity and annual patient load by radiation oncology facilities (n=548*)

	放射線治療管理料数 (放射線治療管理料総数に対する割合 [%])						
	A (133)	B (181)	C (86)	D (52)	E (27)	F (69)	Total (548)
単純 (1 門照射, 対向 2 門照射)	5,424 (62.6)	15,128 (54.8)	10,932 (48.6)	8,797 (45.7)	6,100 (49.0)	20,793 (39.1)	67,174 (46.8%)
中間 (非対向 2 門照射, 3 門照射)	1,884 (21.8)	7,023 (25.4)	6,732 (29.9)	5,946 (30.9)	3,530 (28.3)	16,074 (30.3)	41,189 (28.7%)
複雑 (4 門以上の照射, 運動照射, 原体照射)	1,352 (15.6)	5,450 (19.7)	4,835 (21.5)	4,516 (23.4)	2,827 (22.7)	16,259 (30.6)	35,239 (24.5%)
合計	8,660	27,601	22,499	19,259	12,457	53,126	143,602

*放射線治療管理料数が未記入であった施設：173施設.

(実稼動数) は^{60}Co RALSの新型が16台，旧型が29台 (計45台)，^{192}Ir-RALSが123台，^{137}Cs-RALSが 3 台であった．施設規模ごとに検討すると，C：200～299人以上の大きい施設程，linacの各機能は充実していた．小線源治療装置もC以上の施設で装備され，特に^{192}Ir-RALSはF：500人以上で 7 割の施設に装備されていた．

Table 7 に，施設規模別の治療周辺機器数を示している．全体ではX線シミュレータ 445台，CTシミュレータ 497台，放射線治療計画コンピュータ (RTP) 1,070台，放射線治療専用CT 353台，放射線治療専用MRI 13台，放射線治療の記録でのコンピュータ使用は640施設，水ファントム保有 746施設，dosemeter 2,181台などであった．施設規模でCT simulatorの保有率を見ると，A：99人以下の施設では48.6%であったが，F：500人以上の施設では100%有していた．2005年に比べてX線シミュレータが減少し，CTシミュレータ，RTP，水ファントム，dosemeterが増加していた．

Table 8 に，放射線治療管理料数とその難易度を施設規模で示す．未記入施設が173施設あったが，最小規模施設Aと大規模施設Fでは単純 (1 門照射，対向 2 門照射) で23.5% (A多，F少)，中間 (非対向 2 門照射，3 門照射)，複雑 (4 門以上の照射，運動照射，原体照射) で，それぞれ8.5%，15.0% (A少，F多) の差が観察された．2005年に比べて，単純と複雑において差は拡大していた．しかし，それぞれの施設規模では単純が減少して，複雑が増加する傾向にあった．

4. 人員

Table 9 に，施設規模別の患者数とスタッフ数を示している．1 施設当たりの年間総患者数 (新患 + 再患) は284.4人であった．JASTRO認定医数 (常勤) は477人であった．常勤の治療担当医総数は1,007人，非常勤の治療担当医総数は534人であった．放射線治療専任業務時間を換算した実質的なマンパワーである合計 (常勤+非常勤) 治療担当医FTE数は826.3人であった．常勤治療担当技師総数は2,617人，治療担当技師FTE数は1,634.1人，常勤医学物理士総数は261人，医学物理士FTE数は63.9人，常勤放射線治療品質管理士総数は526人，放射線治療品質管理士FTE数は105.6人，治療担当看護師総数は1,064人，治療担当看護師FTE数は494.4人，看護助手数は86.4人，事務員数は242.5人であった．放射線治療担当医 1 FTE当たりの患者数負荷は，248.2 (205,087/826.3) 人であった[12]．(詳細分析は第 2 報参照)

5. 特殊治療

Table 10に，一般的外部照射以外の特殊治療を列記している．腔内照射は3,235例 (2005年 3,246例) が172施設にて行われていた．組織内照射 (前立腺ヨード治療を含む) は3,301例 (2005年 2,773例) が97施設にて行われ，前立腺ヨード治療は2,690例 (2005年 1,765例) が78施設にて行われていた．全身照射は1,633例 (2005年 1,738例) が185施設にて，術中照射は251例 (2005年 387例) が41施設にて，定位 (脳) 照射は

Table 9 Numbers of personnel and annual cancer patients by patient load of radiation oncology facilities

施設の構造と患者・スタッフ数	A (183)	B (233)	C (115)	D (73)	E (37)	F (80)	Total (721)
施設規模年間新患者数	≦99	100–199	200–299	300–399	400–499	500≦	
施設数/全施設数[%]	25.4	32.3	16.0	10.1	5.1	11.1	100
年間新患者総数	10,836	32,698	27,973	24,817	16,020	57,885	170,229
1施設当たり平均年間新患者数	59.2	140.3	243.2	340.0	433.0	723.6	236.1
年間実患者総数	12,704	39,084	34,102	30,567	19,439	69,191	205,087
1施設当たり平均年間総患者数	69.4	167.7	296.5	418.7	525.4	864.9	284.4
施設総病床数	60,375	99,133	56,419	45,507	25,931	63,165	350,530
放射線科病棟保有施設数(割合[%])	42(23.0)	63(27.0)	47(40.9)	45(61.6)	22(59.5)	62(77.5)	287(39.0)
放射線科病床数	158.5	333.0	256.0	335.0	199.0	960.0	2,241.5
放射線科病床/施設病床数[%]	0.3	0.3	0.5	0.7	0.8	1.5	0.6
1施設当たり放射線科病床数	0.8	1.5	4.1	6.8	7.7	13.2	3.6
放射線科病床保有施設当たり病床数	3.8	5.3	5.4	7.4	9.0	15.5	7.8
日医放専門医修練認定機関数(割合[%])	37(20.2)	86(36.9)	66(57.4)	52(71.2)	30(81.1)	73(91.3)	344(47.7)
日医放専門医修練協力機関数(割合[%])	38(20.8)	59(25.3)	24(20.9)	8(11.0)	4(10.8)	1(1.3)	137(18.6)
日医放会員数(常勤)	92	166	127	119	84	360	948
日医放専門医数(常勤)	75	151	117	97	70	275	785
JASTRO会員数(常勤)	49	133	109	114	77	351	833
JASTRO認定医数(常勤)	19	69	65	71	49	204	477
1施設当たりJASTRO会員数	0.3	0.6	0.9	1.6	2.1	4.4	1.2
常勤治療医勤務施設数(割合[%])	110(45.4)	157(65.7)	91(81.7)	59(91.8)	31(97.3)	64(97.5)	511(70.9)
常勤治療担当医総数	111	180	131	126	87	372	1,007
1施設当たり常勤治療担当医数	0.61	0.77	1.14	1.73	2.35	4.65	1.40
常勤治療担当医FTE*数	46.4	106.1	96.7	100.2	63.3	305.8	718.5
1施設当たり常勤治療担当医FTE数	0.25	0.46	0.84	1.37	1.71	3.82	1.00
非常勤治療担当医総数	175	180	71	39	9	60	534
1施設当たり非常勤治療担当医数	0.96	0.77	0.62	0.53	0.24	0.75	0.74
非常勤治療担当医FTE数	32.3	31.4	13.6	7.6	2.8	20.1	107.8
1施設当たり非常勤治療担当医FTE数	0.18	0.13	0.12	0.10	0.08	0.25	0.15
合計(常勤+非常勤)治療担当医FTE数	78.7	137.5	110.3	107.8	66.1	325.9	826.3
1施設当たり合計治療担当医FTE数	0.43	0.59	0.96	1.48	1.79	4.07	1.15
常勤診断担当医総数	203.0	398.1	308.0	302.0	293.0	794.0	2,298.1
非常勤診断担当医総数	197.0	299.2	149.9	107.5	67.0	155.0	975.6
常勤治療担当技師総数**	500	723	410	277	166	541	2,617
治療担当技師FTE数	254.1	395.7	251.3	182.6	124	426.4	1,634.1
常勤医学物理士総数**	29	62	33	32	21	84	261
医学物理士FTE数	6.2	15.5	5	6.6	6.4	24.2	63.9
常勤放射線治療品質管理士総数**	47	143	77	74	40	145	526
放射線治療品質管理士FTE数	8.3	25.9	14.6	14.1	7.9	34.8	105.6
常勤線量測定士総数**	22	40	38	30	7	66	203
線量測定士FTE数	3.9	6.7	7.6	4.9	1	17.4	41.5
常勤工作担当者総数**	52	66	55	48	17	64	302
常勤工作担当者FTE数	9.5	11.5	10.8	7.5	2.5	9.4	51.2
常勤治療担当看護師総数	171	287	182	139	81	204	1,064
治療担当看護師FTE数	52.8	98.4	74.2	68.4	47.6	153	494.4
看護助手数	9.2	32.5	4	9	5	26.7	86.4
事務員数	20.1	48.2	43.4	34.3	23.5	73	242.5

2007年放射線治療実施施設数を765施設と推測した場合の推定新患者数：約18万1,000人.
2007年放射線治療実施施設数を765施設と推測した場合の推定実患者数：約21万8,000人.
* FTE(full time equivalent)：週40時間放射線治療専任業務に換算し直した実質的マンパワー.
** 各スタッフ総数には重複が含まれる.

12,554例(2005年 11,122例)が186施設にて，定位(体幹部)照射は2,490例(2005年 1,658例)が123施設にて，IMRTは2,799例(2005年 755例)が58施設にて，温熱併用照射は340例(2005年 581例)が23施設にて，^{90}Sr翼状片治療は149例(2005年 184例)が4施設にて行われていた．それぞれ施行施設の全国での割合は，23.9%，13.5%，10.8%，25.7%，5.7%，25.8%，17.1%，8.0%，3.2%，0.55%であった．施設規模で見ると，F：500人以上の施設に多いが，全身照射，術中照

Table 10 Special radiation therapy other than external irradiation

施設規模と特殊照射	2007年							2005年	2003年
	A (183)	B (233)	C (115)	D (73)	E (37)	F (80)	Total (721)	Total (712)	Total (726)
腔内照射									
20例以上施行した施設数	0	2	3	10	7	43	65	65	68
1～19例施行した施設数	0	15	25	28	17	22	107	116	127
未施行施設数	183	216	87	35	13	15	549	531	531
治療例数	0	145	292	509	461	1,828	3,235	3,246	3,448
組織内照射									
10例以上施行した施設数	0	3	5	9	8	38	63	36	26
1～9 例施行した施設数	2	4	5	7	5	11	34	43	43
未施行施設数	181	226	105	57	24	31	624	633	657
治療例数	11	155	209	399	307	2,220	3,301	2,773	928
前立腺ヨード治療									
10例以上施行した施設数	0	2	5	6	7	37	57	24	2
1～9 例施行した施設数	1	1	5	4	4	6	21	15	0
未施行施設数	182	230	105	63	26	37	643	673	724
治療例数	7	119	195	276	223	1,870	2,690	1,765	40
全身照射									
10例以上施行した施設数	5	2	4	9	8	40	68	65	62
1～9 例施行した施設数	9	19	20	26	18	25	117	126	115
未施行施設数	169	212	91	38	11	15	536	521	549
治療例数	121	21	171	264	248	808	1,633	1,738	1,646
術中照射									
10例以上施行した施設数	0	0	0	2	1	3	6	9	15
1～9 例施行した施設数	5	4	6	6	2	12	35	57	71
未施行施設数	178	229	109	65	34	65	680	646	640
治療例数	10	8	13	61	18	141	251	387	549
定位(脳)照射									
20例以上施行した施設数	8	13	17	14	12	23	87	82	82
1～19例施行した施設数	5	28	20	15	9	22	99	115	104
未施行施設数	170	192	78	44	16	35	535	515	540
治療例数	639	2,125	2,636	1,990	1,613	3,551	12,554	11,122	12,610
定位(体幹部)照射									
20例以上施行した施設数	2	2	2	7	3	17	33	25	7
1～19例施行した施設数	2	19	17	9	14	29	90	67	63
未施行施設数	179	212	96	57	20	34	598	620	656
治療例数	151	211	275	316	235	1,302	2,490	1,658	838
IMRT									
20例以上施行した施設数	1	3	7	1	2	18	32	13	8
1～19例施行した施設数	2	4	2	4	4	10	26	20	9
未施行施設数	180	226	106	68	31	52	663	679	709
治療例数	79	164	574	191	132	1,659	2,799	755	370
温熱併用照射									
20例以上施行した施設数	0	1	0	0	0	5	6	7	8
1～19例施行した施設数	1	1	6	4	1	4	17	29	41
未施行施設数	182	231	109	69	36	71	698	676	677
治療例数	1	29	45	15	2	248	340	581	587
Sr-90翼状片治療									
20例以上施行した施設数	0	0	0	0	0	1	1	2	2
1～19例施行した施設数	0	0	1	0	1	1	3	3	4
未施行施設数	183	233	114	73	36	78	717	707	720
治療例数	0	0	1	0	13	135	149	184	226

射，定位照射，IMRT，温熱併用照射は，少数例が小規模施設でも施行されていた．

6. 原発巣別および脳，骨転移患者数

Table 11に，原発巣別新患者数を示している．多い部位としては，乳癌 36,344例(21.5%)，肺癌，気管・縦隔腫瘍 32,967例(19.5%)，泌尿器系腫瘍 22,013例(13.0%)，うち，前立腺癌 16,225例(9.6%)，頭頸部腫瘍 16,563例(9.8%)が挙げられる．15歳以下の小児症例は1,056例(0.6%)報告された．

Table 12に，脳および骨転移実患者数と実患者総数に対する割合を示している．脳転移は21,237例(10.4%)，骨転移は27,970例(13.6%)であった．施設規模で見ると，A：99人以下，B：100～199人，C：200～299人で，骨転移の比率が15～17%と，他より高かった．2005年に比べて脳転移症例の比率は2.4%増加した．

7. 地域別の放射線治療患者数，施設数，JASTRO認定医数

Table 13に，都道府県別の放射線治療患者数，施設数，JASTRO認定医数を示している[13]．人口1,000人当たりの放射線治療新患者数は全国平均で1.3人(2005年 1.2人)であった．地域的には，東京都，石川県 1.8人，群馬県 1.7人，宮城県，鳥取県 1.6人と高く，沖縄県，埼玉県 0.8人，佐賀県 0.9人と低く，地域差が観察された．1施設当たりが受け持つ人口規模は全国平均17万7,000人となっていた．地域的にも埼玉県の37万3,000人，徳島県の26万7,000人，千葉県の25万4,000人から，大分県の9万3,000人，鳥取県の10万人，秋田県の10万2,000人までの差が観察された．JASTRO認定医数が1人の地域は鳥取県，2人は徳島県，佐賀県，大分県，宮崎県であった．

Table 11 Annual number of new cancer patients by disease site*

原発巣	新患者数	(%)
脳・脊髄腫瘍	9,706	(5.8)
頭頸部腫瘍(甲状腺腫瘍を含む)	16,563	(9.8)
食道癌	10,169	(6.0)
肺癌，気管・縦隔腫瘍	32,967	(19.5)
うち，肺癌	29,185	(17.3)
乳癌	36,344	(21.5)
肝・胆・膵癌	6,432	(3.8)
胃・小腸・結腸・直腸癌	8,622	(5.1)
婦人科腫瘍	8,213	(4.9)
泌尿器系腫瘍	22,013	(13.0)
うち，前立腺癌	16,225	(9.6)
造血器リンパ系腫瘍	8,057	(4.8)
皮膚・骨・軟部腫瘍	4,570	(2.7)
その他(悪性腫瘍)	2,320	(1.4)
良性腫瘍	2,728	(1.6)
15歳以下の小児例(上記と重複)	1,056	(0.6)
合計	168,704	(100)

* 原発巣別新患者数が未記入の施設があったため，合計がTable 4-1の新患者数の合計と異なっている．

考　察

Table 14に，過去の8次のJASTRO構造調査データ[1)-10)]のまとめと今回の2007年度の第9次調査の結果との比較を示している．前回の2005年度調査[9), 10)]と比較して，回収率がやや低下した．推定新患者数は2005年より11.7%増加した．この増加率は，がん罹患数増加率である年2.4%(2年で4.8%)の2倍以上の率で推移しているようである．さらに詳細に解析すると，大島ら[14)]による2005年および2010年の罹患推計値より，2007年のがん罹患数は692,502人と推定されるため，そこから算出される全がんに対する放射線治療適応率は26.1%となり，2005年の24.5%より1.6%増加していた(Fig. 2)．装備としてlinacは5.5%増加した．^{60}Co装置は15台と報告された．^{192}Ir-RALS装置は横ばいであった．常勤放射線治療医数は残念ながら，ほとんど増えていなかったが，非常勤の放射線腫瘍医数は増加しており，FTE換算で826.3人のマンパワーを有しており，6.7%増加していた．認定医数は12%増加した．放射線治療担当技師数は，ほとんど増えていなかった．X線シミュレータは11.4%減少し，CTシミュレータは22.1%，放射線治療計画コンピュータは13.8%増加した．患者数の増加と常勤JASTRO認定医数の増加は，ほぼ併行していた．厚生労働省班研究では2007年には約19万人の新患者が治療を受けると予想していた[12)]が，今回はやや下回っていた．昨今の治療現場の治療業務複雑化，多忙化に伴い，特に大規模施設の患者数増加に直接・間接的な診療制限の影響が出始めていることが想定される．原因として，放射線腫瘍医や医学物理士の少なさがデータベース委員会で考察された．欧米並みに，がん患者の50%以上に放射線治療を有効，安全に提供するために，放射線腫瘍医とともに医学物理士の育成と職確保を含めた対策が必要である．がん対策基本法の支援を受けて，がん診療拠点病院を始めとして常勤ポスト確保が進むことを期待する．

Table 12 Annual number of total cancer patients (new+repeat) treated for brain metastasis and bone metastasis by patient load of radiation oncology facilities

転移	実患者数(放射線治療実患者総数に対する割合[%])						
	A (183)	B (233)	C (115)	D (73)	E (37)	F (80)	Total (721)
脳転移	1,098(8.6)	4,625(11.8)	3,414(10.0)	4,059(13.3)	2,382(12.3)	5,659 (8.2)	21,237(10.4)
骨転移	2,211(17.4)	6,416(16.4)	5,294(15.5)	3,747(12.3)	2,382(12.6)	7,843(11.3)	27,970(13.6)

Table 13 Number of patients, facilities, and certified personnel according to prefecture

都道府県名	人口[13] 単位：1,000人	放射線治療新患者数 （人口1,000人当たり新患数）	治療施設数 （1施設当たり人口，単位：1,000人）	施設当たりの 放射線治療新患数	JASTRO 認定医数
北海道	5,570	8,268(1.5)	30(186)	275.6	30
青森県	1,407	1,635(1.2)	10(141)	163.5	8
岩手県	1,364	1,637(1.2)	9(152)	181.9	4
宮城県	2,347	3,643(1.6)	13(181)	280.2	10
秋田県	1,121	1,687(1.5)	11(102)	153.4	3
山形県	1,198	1,328(1.1)	7(171)	189.7	5
福島県	2,067	2,113(1.0)	9(230)	234.8	4
茨城県	2,969	3,111(1.0)	16(186)	194.4	4
栃木県	2,014	2,594(1.3)	10(201)	259.4	7
群馬県	2,016	3,490(1.7)	14(144)	249.3	19
埼玉県	7,090	5,627(0.8)	19(373)	296.2	17
千葉県	6,098	7,226(1.2)	24(254)	301.1	24
東京都	12,758	22,846(1.8)	73(175)	313.0	58
神奈川県	8,880	11,100(1.3)	38(234)	292.1	30
新潟県	2,405	3,399(1.4)	13(185)	261.5	6
富山県	1,106	1,514(1.4)	8(138)	189.3	4
石川県	1,170	2,214(1.8)	8(146)	265.5	3
福井県	816	839(1.0)	6(136)	139.8	4
山梨県	877	1,021(1.2)	4(219)	255.3	3
長野県	2,180	2,874(1.3)	15(145)	191.6	6
岐阜県	2,104	2,403(1.1)	10(210)	240.3	4
静岡県	3,801	5,616(1.5)	27(141)	208.0	17
愛知県	7,360	8,534(1.2)	37(199)	230.6	14
三重県	1,876	1,799(1.0)	13(144)	138.4	5
滋賀県	1,396	1,623(1.2)	11(127)	147.5	3
京都府	2,635	3,773(1.4)	14(188)	269.5	14
大阪府	8,812	12,153(1.4)	51(173)	238.3	34
兵庫県	5,589	7,724(1.4)	35(160)	220.7	25
奈良県	1,410	1,892(1.3)	7(201)	270.3	7
和歌山県	1,019	1,295(1.3)	9(113)	143.9	4
鳥取県	600	965(1.6)	6(100)	160.8	1
島根県	731	804(1.1)	5(146)	160.8	6
岡山県	1,953	2,816(1.4)	11(178)	256.0	8
広島県	2,873	4,338(1.5)	18(160)	241.0	18
山口県	1,474	1,935(1.3)	14(105)	138.2	5
徳島県	800	1,079(1.3)	3(267)	359.7	2
香川県	1,006	1,143(1.1)	6(168)	190.5	4
愛媛県	1,452	2,087(1.4)	12(121)	173.9	7
高知県	782	1,115(1.4)	6(130)	185.8	3
福岡県	5,056	7,528(1.5)	27(187)	278.8	22
佐賀県	859	742(0.9)	4(215)	185.5	2
長崎県	1,453	1,951(1.3)	8(182)	243.9	5
熊本県	1,828	2,821(1.5)	14(131)	201.5	4
大分県	1,203	1,655(1.4)	13(93)	127.3	2
宮崎県	1,143	1,138(1.0)	5(229)	227.6	2
鹿児島県	1,730	2,091(1.2)	12(144)	174.3	6
沖縄県	1,373	1,133(0.8)	6(229)	188.8	4
合計	127,771	170,229(1.3)	721(177)	236.1	477

2007年放射線治療実施施設数を765施設と推測した場合の推定新患者数：約18万1,000人.

残念ながら2007年には，まだ十分反映されていない.

各施設の規模は200例未満が57.7%，300例未満が73.7%を占めている．2005年に比し，改善してきているが，依然として，わが国の放射線治療施設は小規模といえる．全体の新患者数の規模では，500人以上の施設が全国の34.0%，100～199人が19.2%，200～299人が16.4%，300～399人が