

Five-fraction stereotactic body radiotherapy for prostate cancer in octogenarians and nonagenarians: A single-institution retrospective cohort study

ATSUTO KATANO and HIDEOMI YAMASHITA

Department of Radiology, The University of Tokyo Hospital, Tokyo 113-8655, Japan

Received June 5, 2026; Accepted September 10, 2026

DOI: 10.3892/ol.2026.15917

Abstract. The incidence of prostate adenocarcinoma (PCa) increases with age. Stereotactic body radiotherapy (SBRT) is a curative option; however, the evidence in elderly patients remains limited. This single-institution retrospective cohort study included consecutive patients aged ≥ 80 years with localized PCa treated with definitive SBRT between May 2016 and June 2023. SBRT was delivered in five fractions with a total dose of 36.25–45.00 Gy. A total of 118 patients with a median age of 82 years (range, 80–93 years) were included. Risk stratification identified three low-risk, 15 favorable intermediate-risk, 32 unfavorable intermediate-risk, 48 high-risk and 20 very high-risk patients. With a median follow-up of 47.7 months, there were seven deaths from any cause and nine biochemical recurrences, with no PCa-related deaths observed. The 3- and 5-year overall survival rates were 99.1 and 94.2%, respectively, whereas the 3- and 5-year biochemical progression-free survival rates were 94.5 and 83.2%, respectively. No acute genitourinary or gastrointestinal toxicities of grade 3 or higher were observed. Late grade 3 genitourinary and gastrointestinal toxicities were each observed in three patients, with no grade higher than 3 events. Definitive prostate SBRT achieved favorable survival outcomes with acceptable toxicity in carefully selected octogenarians and nonagenarians, supporting its feasibility as a curative-intent treatment option in this elderly population.

Introduction

The incidence and prevalence of prostate cancer increase with advancing age (1). The global burden continues to increase with population growth and aging demographics (2). According to the National Comprehensive Cancer Network (NCCN) guidelines, curative treatment is commonly stratified by risk

classification and life expectancy (3). Non-curative strategies, such as active surveillance or androgen deprivation therapy, are appropriate for patients with limited life expectancy and low- or selected intermediate-risk disease. Elderly patients, including those with intermediate- or high-risk prostate cancer, are significantly less likely than younger patients to receive curative intent treatment (4).

However, localized prostate cancer in elderly patients is not uniformly indolent, and a clinically meaningful subset warrants definitive therapy. Age-stratified analyses of radical prostatectomy specimens have demonstrated that increasing age is associated with a higher prevalence of high Gleason scores, more frequent extracapsular extension, and greater tumor volume, suggesting a tendency toward biologically higher-risk diseases in elderly patients (5). The International Society of Geriatric Oncology recommends that treatment decisions in elderly patients be guided by overall health status rather than chronological age and emphasizes that fit elderly patients should be offered standard curative-intent therapies (6,7).

Radiotherapy is a local curative treatment modality that is particularly well suited for elderly patients (8,9). Previous studies have shown that acute and late gastrointestinal (LGI) and genitourinary toxicities associated with external beam radiotherapy are not strongly influenced by patient age (10). More recently, stereotactic body radiotherapy (SBRT), also referred to as ultra-hypofractionated radiotherapy, has gained increasing attention (11,12). This approach delivers high-dose radiation with submillimeter precision in a few fractions, substantially shortening the overall treatment time while maintaining curative dose intensity. Randomized phase III trials have demonstrated that SBRT is feasible and yields short-term toxicity profiles comparable to those of conventional or moderately hypofractionated regimens in patients with low- and intermediate-risk prostate cancer (13,14).

Nevertheless, despite these phase III data, evidence remains limited for patients aged >80 years, who are frequently under-represented in clinical trials despite constituting a growing proportion of the prostate cancer population. Therefore, this single-institution retrospective cohort study focused on octogenarians and nonagenarians treated with definitive prostate SBRT. This study aimed to describe clinical outcomes, with particular emphasis on overall survival (OS) and biochemical progression-free survival, and to characterize acute and late treatment-related toxicities.

Correspondence to: Dr Hideomi Yamashita, Department of Radiology, The University of Tokyo Hospital, 7-3-1 Hongo, Bunkyo, Tokyo 113-8655, Japan
E-mail: yamachan07291973@yahoo.co.jp

Key words: prostate cancer, stereotactic body radiotherapy, ultra-hypofractionation, elderly, octogenarian, toxicity, survival

Materials and methods

Study design and patients. This retrospective cohort study was conducted at a single institution. The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Medicine, University of Tokyo (IRB No. 3372-(9); approval date: October 29, 2025). In line with institutional approval, patients are informed through an institutional notice that their clinical information and examination results may be used for research purposes. All the procedures were performed in accordance with the principles of the Declaration of Helsinki. The institutional medical records of consecutive patients with localized prostate cancer who underwent definitive prostate SBRT between May 2016 and June 2023 were screened. Patients were included in this retrospective cohort study if they met all of the following criteria: (i) histologically confirmed adenocarcinoma of the prostate; (ii) clinically localized prostate cancer without evidence of distant metastasis at diagnosis; (iii) age 80 years or older at the start of SBRT; (iv) definitive-intent prostate SBRT delivered in five fractions at our institution; and (v) availability of clinical records allowing assessment of survival outcomes and toxicity. Patients were excluded if they had (i) a history of definitive local treatment for prostate cancer, including radical prostatectomy or definitive radiotherapy; (ii) androgen deprivation therapy (ADT) administered for more than 12 months before the initiation of SBRT; or (iii) long-term ADT use exceeding 3 years, including both pre- and post-SBRT periods. Risk stratification was performed according to the NCCN categories.

Treatment. Definitive SBRT was delivered in five fractions on an every-other-day schedule using flattening filter-free volumetric modulated arc therapy on a linear accelerator. The prescribed doses were 36.25, 40, 42.5, or 45 Gy, selected at the discretion of the treating radiation oncologist. The use of a hydrogel rectal spacer was determined by the treating radiation oncologist, taking into account the patient's general condition. In all patients receiving a spacer, it was placed before simulation CT and SBRT treatment planning. The gross tumor volume was delineated based on areas of high signal intensity on diffusion-weighted magnetic resonance imaging. The clinical target volume included the entire prostate with seminal vesicle coverage according to risk: prostate only for low-risk disease, proximal 1 cm of the seminal vesicles for intermediate-risk disease, proximal 2 cm for high-risk disease, and entire seminal vesicles for seminal vesicle invasion. The planning target volume was generated by expanding the clinical target volume by 5 mm, except posteriorly, where a 3-mm margin was used. The prescribed dose was normalized such that 95% of the planning target volume received the prescribed dose. Patient positioning was verified immediately before each fraction using cone-beam computed tomography; however, fiducial markers, rectal balloons, or real-time intrafraction tracking were not used. Dose constraints included urethral maximum dose <105% of the prescription dose, bladder V20 Gy <50 cc and maximum dose <110%, rectal V40 Gy <25%, V25 Gy <45%, and maximum dose <43.9 Gy. The same target coverage objectives and rectal dose constraints were applied regardless of hydrogel rectal spacer use. These organ-at-risk dose constraints were met in all treatment plans,

with no deviations observed. ADT use and intended duration were generally determined according to the NCCN risk classification; however, they were individualized according to age, general condition, comorbidities, treatment tolerance, and patient preference, with occasional early discontinuation. Follow-up prostate-specific antigen (PSA) measurements were generally scheduled at 3, 6, 9, 12, 18, and 24 months after treatment; every 6 months during years 3-5; and annually thereafter, with intervals adjusted according to patient preference, comorbidities, and PSA kinetics.

Endpoints. The primary endpoints were OS and biochemical progression-free survival (bPFS). OS was defined as the time from SBRT initiation to death due to any cause. At the time of the database cutoff, patients were classified as being under active follow-up if they continued to attend regular follow-up visits. Patients who were no longer attending follow-up visits and for whom no subsequent survival or disease-status information was available were considered lost to follow-up. These patients were retained in the survival analyses. OS was censored at the date on which the patient was last confirmed to be alive, whereas bPFS was censored at the date on which the patient was last confirmed to be alive without biochemical recurrence. Patients who remained under active follow-up without an event were censored at their most recent assessment. Biochemical recurrence after radiotherapy was defined according to the Phoenix definition (PSA nadir + 2.0 ng/ml) (15). The bPFS was defined as the time from the start of SBRT to biochemical recurrence or death, whichever occurred first. Patients without events were censored at the date of their last follow-up visit. Acute and late toxicities were graded according to the Common Terminology Criteria for Adverse Events (CTCAE) version 5.0. Acute toxicity was defined as toxicity occurring during treatment or within 3 months of SBRT completion, and late toxicity was defined as toxicity occurring thereafter. For each patient, the maximum CTCAE grade was recorded for acute genitourinary (AGU), acute gastrointestinal (AGI), late genitourinary (LGU), and LGI events.

Statistical analysis. Time-to-event outcomes were estimated using the Kaplan-Meier method. All statistical analyses were performed using the R software (version 4.3.2; R Foundation for Statistical Computing, Vienna, Austria). Survival curves were generated for the overall cohort and stratified according to NCCN risk group. Statistical significance was set at $P < 0.05$. Associations among clinical factors, OS, and bPFS were evaluated using univariate Cox proportional hazards regression. A multivariate analysis was not performed because of the limited number of outcomes.

Results

The patient characteristics are presented in Table I. The median age at the start of SBRT was 82 years (range, 80-93 years), and most patients had a good performance status. The median PSA level at diagnosis was 10.1 ng/ml (range, 1.8-160.3), and the median positive biopsy core ratio was 0.31 (range, 0.06-1.00). One patient was classified as having clinical stage Tx because magnetic resonance imaging was not feasible due to an implanted metallic device. According to the

NCCN risk classification, three patients (2.5%) were classified as low risk, 15 patients (12.7%) as favorable intermediate risk, 32 patients (27.1%) as unfavorable intermediate risk, 48 patients (40.7%) as high risk, and 20 patients (16.9%) as very high risk. A hydrogel rectal spacer was used in 45 patients (38.1%), whereas 73 patients (61.9%) were treated without spacer insertion. ADT was not administered in 30 patients (25.4%), whereas 68 patients (57.6%) and 20 patients (16.9%) received short- and longer-term ADT, respectively (Table II). In all the cases, ADT was initiated before SBRT. The median interval between the initiation of ADT and the start of RT was 2.76 months (range, 1.12-10.59 months). The median total duration of ADT was 5.0 months (range, 3.0-30.0 months). Because ADT was predominantly administered using long-acting depot formulations with effects lasting several months, the recorded ADT duration represented the intended effective treatment period, and exact pre- and post-SBRT durations could not be reliably distinguished. The duration of ADT according to the risk classification is summarized in Table II. In terms of radiotherapy dose and fractionation, 39 patients (33.1%) received 36.25 Gy in 5 fractions, 61 patients (51.7%) received 40 Gy in 5 fractions, four patients (3.4%) received 42.5 Gy in 5 fractions, and 14 patients (11.9%) received 45 Gy in 5 fractions.

Survival outcomes. Among the 118 patients, 81 (68.6%) were followed up for at least 3 years and 40 (33.9%) for at least 5 years. With a median follow-up of 47.7 months, there were seven deaths from any cause and nine biochemical recurrences, with no prostate cancer-related deaths observed; consequently, the prostate cancer-specific survival rate was 100%. At the time of the database cutoff, 78 patients (66.1%) remained under regular follow-up, 33 (28.0%) were lost to follow-up, and 7 (5.9%) had died. For the entire cohort, the 3- and 5-year OS rates were 99.1% (95% CI, 94.0-99.9) and 94.2% (95% CI, 84.8-97.9), respectively. The 5-year OS rates were 100% in the low- and favorable intermediate-risk groups, 90.4% in the unfavorable intermediate-risk group (95% CI, 64.3-97.7), 93.0% in the high-risk group (95% CI, 74.4-98.2), and 100% in the very high-risk group (Fig. 1A). The causes of death included other malignancies (renal cell carcinoma, hypopharyngeal carcinoma, and pancreatic cancer, n=3), pneumonia (n=2), and sepsis (n=2), all of which were considered unrelated to prostate cancer or its treatment. The 3- and 5-year bPFS rates were 94.5% (95% CI, 88.2-97.5) and 83.2% (95% CI, 72.2-90.2), respectively. The 5-year bPFS rates were 100% in the low- and favorable intermediate-risk groups, 87.0% in the unfavorable intermediate-risk group (95% CI, 62.1-96.0%), 82.6% in the high-risk group (95% CI, 64.4-92.1%), and 65.9% in the very high-risk group (95% CI, 31.7-85.9%) (Fig. 1B). Overall, bPFS tended to decline with increasing risk classification. Among the nine patients who experienced biochemical failure, the site of recurrence was radiologically confirmed in four patients, including three with bone metastases and one with pelvic lymph node involvement. Salvage ADT was initiated in seven patients, whereas the remaining two patients were managed with observation at the time of analysis. In univariate Cox proportional hazards analysis, an ECOG performance status of 1 was associated with a significantly higher risk of death than a performance status of 0 (hazard ratio, 6.307; 95% confidence interval, 1.022-38.91; P=0.047) (Table III).

Table I. Patient background and treatment characteristics (Age ≥80 cohort).

Variables	Total (n=118)
Age, years	82 (80-93)
ECOG PS	
0	105 (89.0)
1	13 (11.0)
PSA at diagnosis, ng/ml	10.1 (1.8-160.3)
Positive core ratio	0.31 (0.06-1.00)
Grade group	
1	7 (5.9)
2	24 (20.3)
3	29 (24.6)
4	28 (23.7)
5	30 (25.4)
Clinical T stage	
T1c	11 (9.3)
T2a	60 (50.8)
T2b	3 (2.5)
T2c	18 (15.3)
T3a	18 (15.3)
T3b	6 (5.1)
T4	1 (0.8)
Tx	1 (0.8)
National Comprehensive Cancer Network risk	
Low	3 (2.5)
Intermediate (favorable)	15 (12.7)
Intermediate (unfavorable)	32 (27.1)
High	48 (40.7)
Very high	20 (16.9)
Use of hydrogel rectal spacer	
Yes	45 (38.1)
No	73 (61.9)
Androgen deprivation therapy duration	
None	30 (25.4)
<12 months	68 (57.6)
12-36 months	20 (16.9)
Dose and fractionation	
36.25 Gy in 5 fractions	39 (33.1)
40 Gy in 5 fractions	61 (51.7)
42.5 Gy in 5 fractions	4 (3.4)
45 Gy in 5 fractions	14 (11.9)

Data are presented as n (%) or median (range). ECOG PS, Eastern Cooperative Oncology Group performance status; PSA, prostate-specific antigen.

No grade >2 AGU or AGI toxicities were observed in the study cohort (Table IV). Grade 3 LGU toxicities occurred in three patients (2.5%), all of whom developed grade 3 urinary retention requiring suprapubic cystostomy at 27.7, 54.4, and

Table II. Duration of androgen deprivation therapy according to risk classification.

NCCN risk group	None, n (%)	<12 months, n (%)	12-36 months, n (%)	Total
Low	2 (66.7)	1 (33.3)	0 (0)	3
Intermediate (favorable)	14 (93.3)	1 (6.7)	0 (0)	15
Intermediate (unfavorable)	11 (34.4)	21 (65.6)	0 (0)	32
High	3 (6.2)	32 (66.7)	13 (27.1)	48
Very high	0 (0)	13 (65)	7 (35)	20
Total	30	68	20	118

NCCN, National Comprehensive Cancer Network.

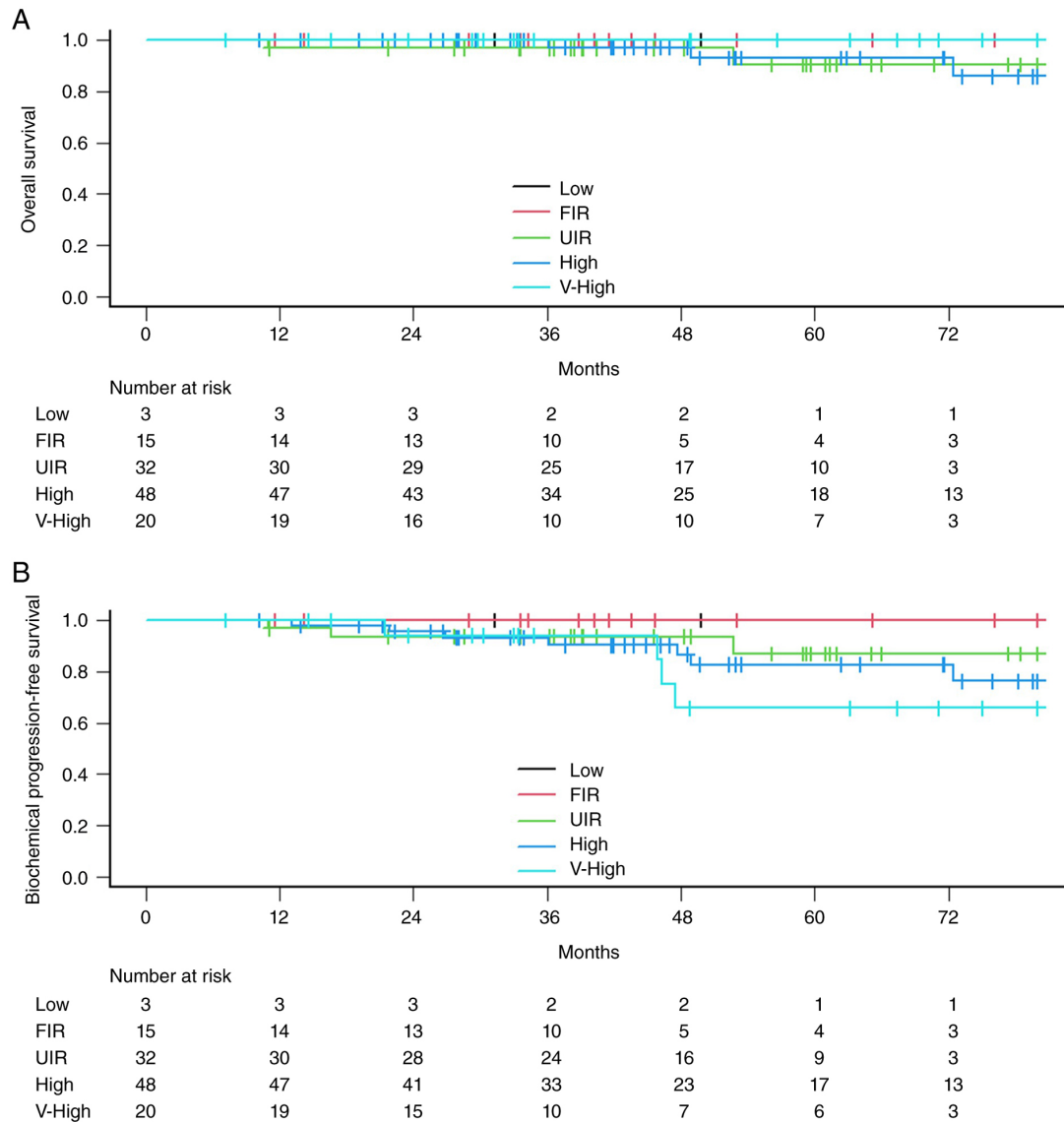


Figure 1. Kaplan-Meier curves for (A) overall survival and (B) biochemical progression-free survival according to National Comprehensive Cancer Network risk group. The curves are color-coded as follows: Black, low risk; red, favorable intermediate risk; green, unfavorable intermediate risk; blue, high risk; and cyan, very-high risk. FIR, favorable intermediate risk; UIR, unfavorable intermediate risk; V-High, very high risk.

64.4 months from the start of radiotherapy. Grade 3 LGI toxicities were observed in three patients (2.5%). One patient experienced grade 3 rectal perforation 10.6 months after the start of radiotherapy after receiving 45 Gy in five fractions

with a hydrogel rectal spacer and aspirin use. Two patients developed grade 3 rectal hemorrhage at 8.3 and 27.7 months, respectively; both had received 40 Gy in five fractions without a rectal spacer and were not receiving anticoagulant

Table III. Univariable Cox proportional hazards analysis for OS and bPFS.

Covariables	Comparison/scale	N	OS		bPFS	
			HR (95% CI)	P-value	HR (95% CI)	P-value
Age, years	Continuous	118	0.325 (0.097-1.088)	0.068	0.922 (0.736-1.156)	0.483
ECOG PS	0 (reference)	105	1		1	
	1	13	6.307 (1.022-38.911)	0.047	2.503 (0.695-9.017)	0.161
Serum PSA, ng/ml	Continuous	118	0.956 (0.811-1.126)	0.589	1.005 (0.971-1.040)	0.786
Grade group	1-3 (reference)	60	1		1	
	4-5	58	0.856 (0.170-4.320)	0.851	1.974 (0.671-5.805)	0.217
Clinical T stage	T1-2 (reference)	92	1		1	
	T3-4	26	0.462 (0.046-4.695)	0.514	2.335 (0.806-6.763)	0.118
NCCN risk group	Low/intermediate (reference)	50	1		1	
	High/very high	68	1.019 (0.169-6.164)	0.983	2.650 (0.738-9.520)	0.135
Androgen deprivation therapy	No (reference)	30	1		1	
	Yes	88	1.896 (0.221-16.277)	0.56	5.192 (0.682-39.519)	0.112
Prescription dose	36.25 Gy (reference)	39	1		1	
	>36.25 Gy	79	0.174 (0.019-1.619)	0.124	0.594 (0.204-1.728)	0.339

NCCN, National Comprehensive Cancer Network; bPFS, biochemical progression-free survival; OS, overall survival; HR, Hazard ratio; CI, confidence interval; PSA, prostate-specific antigen; ECOG PS, Eastern Cooperative Oncology Group performance status.

Table IV. Distribution of acute and late gastrointestinal and genitourinary toxicities stratified by hydrogel rectal spacer use.

Endpoint	Grade	Total, n (%)	No hydrogel spacer, n (%)	Use of hydrogel spacer, n (%)	P-value
Acute gastrointestinal toxicity	0	78 (66.1)	47 (64.4)	31 (68.9)	0.661
	1	38 (32.2)	24 (32.9)	14 (31.1)	
	2	2 (1.7)	2 (2.7)	0 (0.0)	
	3	0 (0.0)	0 (0.0)	0 (0.0)	
Acute genitourinary toxicity	0	27 (22.9)	21 (28.8)	6 (13.3)	0.101
	1	65 (55.1)	39 (53.4)	26 (57.8)	
	2	26 (22.0)	13 (17.8)	13 (28.9)	
	3	0 (0.0)	0 (0.0)	0 (0.0)	
Late gastrointestinal toxicity	0	67 (56.8)	39 (53.4)	28 (62.2)	0.918
	1	38 (32.2)	25 (34.2)	13 (28.9)	
	2	10 (8.5)	7 (9.6)	3 (6.7)	
	3	3 (2.5)	2 (2.7)	1 (2.2)	
Late genitourinary toxicity	0	17 (14.4)	9 (12.3)	8 (17.8)	0.431
	1	71 (60.2)	46 (63.0)	25 (55.6)	
	2	27 (22.9)	15 (20.5)	12 (26.7)	
	3	3 (2.5)	3 (4.1)	0 (0.0)	

or antiplatelet therapy (Table V). No late grade >3 GU or GI toxicities were observed.

Discussion

In this single-institution cohort of octogenarians and nonagenarians treated with definitive prostate SBRT, favorable long-term survival outcomes with high 3- and 5-year OS and bPFS rates

and limited toxicities were observed. These findings support the feasibility of curative-intent SBRT in carefully selected elderly patients, for whom shorter treatment courses may reduce the logistical burden while maintaining effective disease control. Aghdam *et al* (16) reported that only a minority of patients with clinically localized prostate cancer experienced clinically meaningful quality-of-life impairments after SBRT, suggesting acceptable treatment tolerability in this elderly population.

Table V. Clinical characteristics and details of grade 3 gastrointestinal adverse events after stereotactic body radiotherapy.

Patient no.	Age, years	Risk group	SBRT dose	Spacer	ADT duration, months	Grade 3 event	Time to event, months	Comorbidities	Anticoagulant/ antiplatelet therapy
1	84	Very high	45 Gy/5 fractions	Yes	13	Rectal perforation	10.6	Idiopathic interstitial pneumonia, prior myocardial infarction, diabetes mellitus, hypertension, dyslipidemia	Aspirin
2	82	Very high	40 Gy/5 fractions	No	21	Rectal hemorrhage	27.7	Hypertension, thymic cyst	None
3	85	Favorable intermediate	40 Gy/5 fractions	No	12	Rectal hemorrhage	8.3	Type 2 diabetes mellitus with diabetic neuropathy, chronic kidney disease, hypertension, dyslipidemia, hyperuricemia, and benign prostatic hyperplasia	None

In our cohort, the treatment efficacy and treatment-related toxicity were comparable to those reported in previous studies. Grade 3 LGU and LGI events occurred in less than 3% of the patients. These findings are consistent with those of previous studies. Kim *et al* (17) reported that patients aged ≥ 75 years with high- or very high-risk prostate cancer treated with conventionally fractionated radiotherapy (total dose of 74.8 Gy in 34 fractions) achieved a 7-year biochemical failure-free survival rate of 66.7% and a 7-year OS rate of 68.6%, with acceptable toxicity profiles. Slama *et al* (18) reported outcomes in 80 patients with prostate cancer aged ≥ 70 years treated with 36.25 Gy in five fractions using robotic SBRT with real-time fiducial tracking, observing Grade 2 acute GU and GI toxicities in 11.25 and 5.0% of patients, respectively, and no Grade ≥ 3 acute or late toxicities or disease recurrence at a median follow-up of 12 months. A systematic review by Wang *et al* (19) further demonstrated that urinary toxicities after prostate SBRT are predominantly mild to moderate (Grade 1-2), with severe events (Grade ≥ 3) typically occurring in fewer than 3% of patients. Katz and Kang (20) also reported late grade 3 urinary toxicity in only 1.7% of 515 patients treated with robotic SBRT for localized prostate cancer.

The three grade 3 late rectal toxicity events occurred under different clinical circumstances and were not confined to a single spacer status or medication-use category. However, because only three grade 3 events occurred, these individual cases cannot support a comparative assessment of the effects of rectal spacer use or anticoagulant/antiplatelet therapy.

Accordingly, no protective or adverse effect of these factors, and no causal relationship with late rectal toxicity, can be inferred from the present study.

Consistent with our cohort, which included a relatively high proportion of high-risk cases, the potential benefit of definitive treatment in elderly patients appears to be most pronounced in those with intermediate- to high-risk disease. Fischer-Valuck *et al* (21) analyzed 19,920 men aged ≥ 80 years with high-risk prostate cancer and reported that definitive local therapy, including radiotherapy with or without ADT or surgery, was associated with a nearly 50% reduction in overall mortality compared to observation or ADT alone. However, a systematic review by Marotte *et al* (22), encompassing 24 studies, demonstrated that elderly men (variably defined as ≥ 70 -80 years) with intermediate- or high-risk prostate cancer are frequently undertreated based solely on chronological age, despite achieving oncologic outcomes and late toxicity rates comparable to those of younger patients treated with external beam radiotherapy. They concluded that except for clearly unfit individuals, elderly patients should remain candidates for optimal curative treatment regardless of age.

Historically, radical prostatectomy has been offered less frequently to elderly patients. However, contemporary evidence suggests that robot-assisted radical prostatectomy (RARP) can be safely performed in carefully selected elderly patients. Islamoglu *et al* (23) reported comparable oncological and perioperative outcomes between patients aged ≥ 70 years and those aged 60-69 years who underwent RARP, although

functional outcomes such as continence and erectile function were modestly inferior in elderly patients. Yu *et al* (24) similarly demonstrated comparable 1-year urinary continence rates between patients aged ≥ 75 years and younger in a multicenter cohort despite more advanced disease and lower nerve-sparing rates in the elderly group. Population-based data from the Surveillance, Epidemiology, and End Results (SEER) database showed that both radiotherapy and radical prostatectomy were associated with significantly improved overall and prostate cancer-specific survival compared to non-definitive therapy in men aged ≥ 80 years, reinforcing the potential value of definitive treatment in this population (25).

Long-term ADT (>1 year) is recommended by the NCCN guidelines for high- and very-high-risk prostate cancer in patients with sufficient life expectancy. However, in elderly patients, long-term ADT requires careful consideration because of its association with cardiovascular events, frailty, sarcopenia, and metabolic complications (26-28). In our cohort, favorable OS and bPFS were achieved despite a substantial proportion of high-risk (72.9%) and very high-risk (65.0%) patients receiving ADT for less than 1 year. Accumulating evidence suggests that short-term ADT may be sufficient in combination with dose-escalated radiotherapy (29). In selected elderly patients treated with high-dose SBRT, a shorter ADT duration may be a viable option without compromising disease control, although prospective validation is warranted.

This study had several limitations inherent to its retrospective, single-institution design. First, selection bias was considered. Our cohort consisted of patients who had already been referred for definitive radiotherapy, and the clinical decision-making process before referral, including selection between active surveillance, surgery, conventional radiotherapy, and SBRT, could not be reliably evaluated. Furthermore, detailed comorbidity information, standardized frailty measures, and comprehensive geriatric assessments were not systematically available for the entire cohort. This limited our ability to fully characterize the health status, vulnerability, and competing mortality risks of this elderly population and may restrict the generalizability of our findings. Second, treatment strategies were not fully standardized. The prescription dose, hydrogel rectal spacer use, and duration of ADT were individualized according to disease risk, patient condition, treatment tolerance, patient preference, and physician judgment. Consequently, the independent effects of these treatment-related factors on oncological outcomes and late toxicity could not be reliably disentangled from baseline disease risk and other patient-related factors. Moreover, the limited numbers of biochemical recurrence and severe toxicity events precluded meaningful subgroup or sensitivity analyses according to prescription dose, ADT duration, or spacer use. Therefore, the potential impact of these treatment-related factors on oncological outcomes and toxicity could not be adequately evaluated. Third, follow-up procedures were not uniform. Although a general follow-up schedule was used, the timing and frequency of clinical assessment and PSA surveillance varied according to the patient's condition, preference, and follow-up at other institutions, which may have affected the completeness of the outcome ascertainment. Fourth, the small number of outcome events reduced the statistical power

and precision of the Cox regression analyses and precluded reliable multivariate modeling. Accordingly, the results of the univariate prognostic analyses should be regarded as exploratory and interpreted with caution, particularly given the wide CIs for several estimates. Finally, due to the retrospective nature of this study, low-grade adverse events and other potentially relevant clinical factors may have been incompletely captured or underestimated.

In conclusion, definitive prostate SBRT delivered in five fractions achieved favorable long-term OS and bPFS in octogenarians and nonagenarians. Severe treatment-related toxicities were limited, although a longer follow-up period is warranted to fully characterize late adverse events. Future treatment strategies should aim to preserve oncologic efficacy while minimizing toxicity and optimizing the post-treatment quality of life in elderly patients.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

AK and HY conceived and designed the study. AK and HY were responsible for the acquisition, curation, analysis, and interpretation of clinical data. AK drafted the initial version of the manuscript, and AK and HY critically revised the manuscript for important intellectual content. HY supervised the study. AK and HY confirm the authenticity of all the raw data. Both authors have read and approved the final manuscript and agree to be accountable for all aspects of this work.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Medicine, University of Tokyo [approval no. 3372-(9); approval date, October 2025]. Patients were informed via institutional notice, in accordance with institutional approval, that their clinical data and examination results could be used for research purposes. All procedures were performed in accordance with the ethical standards of the institutional research committee and the Declaration of Helsinki.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Use of artificial intelligence tools

During the preparation of this work, artificial intelligence tools were used to improve the readability and language of the manuscript, and subsequently, the authors revised and edited the content produced by the artificial intelligence tools as necessary, taking full responsibility for the ultimate content of the present manuscript.

References

1. Tan EH, Burn E, Barclay NL, Delmestri A, Man WY, Golozar A, Serrano AR, Duarte-Salles T, Cornford P, Prieto Alhambra D, *et al*: Incidence, prevalence, and survival of prostate cancer in the UK. *JAMA Netw Open* 7: e2434622, 2024.
2. Chu F, Chen L, Guan Q, Chen Z, Ji Q, Ma Y, Ji J, Sun M, Huang T, Shong H, *et al*: Global burden of prostate cancer: Age-period-cohort analysis from 1990 to 2021 and projections until 2040. *World J Surg Oncol* 23: 98, 2025.
3. Spratt DE, Srinivas S, Adra N, Ahmed B, An Y, Bitting R, Chapin B, Cheng HH, Cho SY, D'Amico AV, *et al*: Prostate cancer, version 3.2026, NCCN clinical practice guidelines in oncology. *J Natl Compr Canc Netw* 23: 469-493, 2025.
4. de Camargo Cancela M, Comber H and Sharp L: Age remains the major predictor of curative treatment non-receipt for localised prostate cancer: A population-based study. *Br J Cancer* 109: 272-279, 2013.
5. Sun L, Caire AA, Robertson CN, George DJ, Polascik TJ, Maloney KE, Walthers PJ, Stackhouse DA, Lack BD, Albala DM and Moul JW: Men older than 70 years have higher risk prostate cancer and poorer survival in the early and late prostate specific antigen eras. *J Urol* 182: 2242-2248, 2009.
6. Boyle HJ, Alibhai S, Decoster L, Efstathiou E, Fizazi K, Mottet N, Oudard S, Payne H, Prentice M, Puts M, *et al*: Updated recommendations of the International society of geriatric oncology on prostate cancer management in older patients. *Eur J Cancer* 116: 116-136, 2019.
7. Droz JP, Albrand G, Gillessen S, Hughes S, Mottet N, Oudard S, Payne H, Puts M, Zulian G, Balducci L and Aapro M: Management of prostate cancer in elderly patients: Recommendations of a task force of the International society of geriatric oncology. *Eur Urol* 72: 521-531, 2017.
8. Katano A and Yamashita H: Radiotherapy in nonagenarian patients: A 20-year retrospective analysis in a single tertiary centre. *J Med Imaging Radiat Oncol* 68: 103-109, 2024.
9. Katano A, Miki Y, Minamitani M, Sawayanagi S and Yamashita H: Stereotactic body radiotherapy for early-stage non-small cell lung cancer in patients aged 80 years and older: A single-center retrospective cohort study of octogenarians and nonagenarians. *Clin Lung Cancer* 27: 127-134, 2026.
10. Jani AB, Parikh SD, Vijayakumar S and Gratzle J: Analysis of influence of age on acute and chronic radiotherapy toxicity in treatment of prostate cancer. *Urology* 65: 1157-1162, 2005.
11. Katano A, Minamitani M, Ohira S and Yamashita H: Recent advances and challenges in stereotactic body radiotherapy. *Technol Cancer Res Treat* 23: 15330338241229363, 2024.
12. Katano A: Exploring the current challenges and pioneering clinical applications of stereotactic radiotherapy in cancer treatment. *Technol Cancer Res Treat* 24: 15330338251333658, 2025.
13. Mo C, Chen C, Fan L, Li J, Fan N and Ding H: The safety and effectiveness of hypofractionated radiotherapy for localized prostate cancer: A systematic review and meta-analysis. *Crit Rev Oncol Hematol* 221: 105254, 2026.
14. Lilleby O, Meidahl Petersen P, Daugaard G and Anne Perell K: Current evidence for moderate and ultra-hypofractionated radiation therapy in prostate cancer: A summary of the results from phase 3 randomised trials. *Scand J Urol* 58: 21-27, 2023.
15. Roach M III, 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.
16. Aghdam N, Pepin A, Carrasquilla M, Johnson C, Danner M, Ayoob M, Yung T, Lei S, Collins BT, Kumar D, *et al*: Self-Reported Burden in elderly patients with localized prostate cancer treated with stereotactic body radiation therapy (SBRT). *Front Oncol* 9: 1528, 2020.
17. Kim YH, Jeong JU, Yang JH, Nam TK, Song JY, Yoon MS, Cho S and Ahn SJ: Comparison of definitive radiotherapy outcomes between younger and older patients with high- or very-high-risk prostate cancer. *Radiother Oncol* 205: 110763, 2025.
18. Slama Y, Baumont G, Arcambal A, Begue M, Maillot O, Sayah R, Castanet R, Caboche R, Liberati P, Slaoui H, *et al*: Retrospective study on the toxicity induced by stereotactic body radiotherapy: Overview of the reunion experience on prostate cancer in elderly patients. *Front Oncol* 14: 1302001, 2024.
19. Wang K, Mavroidis P, Royce TJ, Falchook AD, Collins SP, Sapareto S, Sheets NC, Fuller DB, El Naqa I, Yorke E, *et al*: Prostate stereotactic body radiation therapy: An overview of toxicity and dose response. *Int J Radiat Oncol Biol Phys* 110: 237-248, 2021.
20. Katz AJ and Kang J: Quality of life and toxicity after SBRT for organ-confined prostate cancer, a 7-year study. *Front Oncol* 4: 301, 2014.
21. Fischer-Valuck BW, Baumann BC, Brown SA, Filson CP, Weiss A, Mueller R, Liu Y, Brennenman RJ, Sanda M, Michalski JM, *et al*: Treatment patterns and overall survival outcomes among patients aged 80 yr or older with high-risk prostate cancer. *Eur Urol Open Sci* 37: 80-89, 2022.
22. Marotte D, Chand-Fouche ME, Boulahssass R and Hannoun-Levi JM: Irradiation of localized prostate cancer in the elderly: A systematic literature review. *Clin Transl Radiat Oncol* 35: 1-8, 2022.
23. Islamoglu E, Aksaray EE, Tas S, Ari O, Boga MS, Ates M and Savas M: Elderly patients' outcomes after robot-assisted radical prostatectomy: A single center experience. *J Laparoendosc Adv Surg Tech A* 33: 1097-1101, 2023.
24. Yu V, Treacy PJ, Thanigasalam R, Ahmadi N, Doeuk N, Woo H, Chan L, Bird J, Alexander K, Cotte J, *et al*: Robotic-assisted radical prostatectomy in the elderly patient-a study of functional, surgical, and oncological outcomes in an Australian cohort. *Prostate* 86: 158-166, 2026.
25. Kim IE Jr, Leapman MS, Kim MJ, Rahman S, Sprengle P, Renzulli J, Brito J, Hyams E, Kim J, Pareek G and Kim IY: Radical prostatectomy is associated with favorable outcomes in patients over 80 years old. *Am J Clin Exp Urol* 13: 33-42, 2025.
26. Nguyen PL, Alibhai SM, Basaria S, D'Amico AV, Kantoff PW, Keating NL, Penson DF, Rosario DJ, Tombal B and Smith MR: Adverse effects of androgen deprivation therapy and strategies to mitigate them. *Eur Urol* 67: 825-836, 2015.
27. Trost LW, Serefoglu E, Gokce A, Linder BJ, Sartor AO and Hellstrom WJ: Androgen deprivation therapy impact on quality of life and cardiovascular health, monitoring therapeutic replacement. *J Sex Med* 10 (Suppl 1): S84-S101, 2013.
28. Grossmann M and Zajac JD: Androgen deprivation therapy in men with prostate cancer: How should the side effects be monitored and treated? *Clin Endocrinol (Oxf)* 74: 289-293, 2011.
29. Demogeot N, Sargos P, Salleron J, Guérif S, de Crevoisier R, Calais G, Hannoun-Levi JM, Bouché G, Hennequin C, Cretin J, *et al*: Short-term androgen deprivation therapy and high-dose radiotherapy in intermediate- and high-risk localized prostate cancer: Results from the GETUG 14 randomized phase 3 trial. *Eur Urol* 88: 510-518, 2025.