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Stereotactic body radiotherapy (SBRT) as a treatment for localized prostate cancer: a retrospective analysis

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Abstract

Background External beam radiotherapy (EBRT) is a standard treatment for localized prostate cancer, with recent advancements favoring a reduced number of treatment sessions. Stereotactic body radiotherapy (SBRT) is a form of radiotherapy that delivers higher doses per fraction, typically in five or fewer sessions. This retrospective study aims to evaluate the implementation of the PACE-SBRT protocol for localized prostate cancer at our center by assessing the incidence and severity of toxicity, as well as biochemical relapse-free survival.

Methods We conducted a retrospective analysis of patients with localized prostate cancer treated with SBRT at the Iridium Network in Antwerp, Belgium, who were treated between January 1, 2020, and December 31, 2022. Data were extracted from electronic medical records and included descriptive information on patient outcomes. Acute and late genitourinary (GU) and gastrointestinal (GI) toxicities were graded according to the Common Terminology Criteria for Adverse Events (CTCAE) version 4.0. Acute toxicity was defined as events occurring within 90 days post-SBRT, whereas late toxicity was evaluated at 6 months, 1 year, 2 years, and 3 years post treatment. Biochemical recurrence was defined via the Phoenix criteria, as a rise in PSA levels of 2 ng/mL or more above the post treatment nadir.

Results A total of 267 patients met the eligibility criteria for this study. In total, 9% of patients were low risk, 51% were intermediate risk, and 40% were high risk. The cumulative incidence of Grade 2 or higher GU toxicity was 27%, and for GI toxicity, it was 2%. At 24 months, 11.5% (20/175) of patients experienced CTCAE grade 2 or higher GU toxicity, and 1.7% (3/175) experienced grade 2 or higher GI toxicity. Biochemical relapse occurred in 1.5% (4/267) of patients, leading to a 2-year biochemical relapse-free survival rate of 98.5%.

Conclusion SBRT for localized prostate cancer has favorable oncological outcomes with a low incidence of Grade 2 or higher toxicity. The results of this study are consistent with findings from prospective trials, suggesting that SBRT is an effective treatment modality.

Trial registration Retrospectively registered.

Keywords Stereotactic body radiotherapy, Prostate cancer, Urinary toxicity, Gastrointestinal toxicity, Biochemical recurrence

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Background

Prostate cancer is the second most frequently diagnosed malignancy and the fifth leading cause of cancer-associated death in men worldwide, having a high impact on the health of the world's population [1, 2]. Various treatment modalities for localized prostate cancer are available, such as active surveillance, surgery, and radiotherapy, with similar survival rates across the three groups [3]. External beam radiotherapy (EBRT) is a standard treatment option for the treatment of localized prostate cancer with a recent evolution to fewer sessions or fractions of radiotherapy. A higher dose of radiotherapy per fraction in five or fewer fractions, which requires high accuracy, is typically referred to as Stereotactic body radiotherapy (SBRT). Several nonrandomized phase 2 trials have shown excellent oncological results with low acute and late grade 2 or higher toxicity rates. This finding was recently confirmed in a randomized phase III trial comparing SBRT with conventional radiotherapy (CRT) [4]. The PACE B trial showed comparable results between SBRT and CRT concerning biochemical relapse-free survival, with no significant differences in gastrointestinal or genitourinary toxicity [5].

We implemented the PACE protocol in our center in 2020, following the publication of acute toxicity results [4] and the systematic review of phase 2 trials [8]. This study aimed to evaluate the incidence and the severity of toxicity, as well as biochemical relapse-free survival in patients treated with SBRT for localized prostate cancer at our center. We hope to contribute to evidence-based research supporting the safe use of SBRT in prostate cancer treatment. Furthermore, we aim to compare our results with those of existing studies and consider potential adjustments to our treatment approach.

Methods

Patients

In this retrospective study, 352 patients diagnosed with prostate cancer underwent SBRT between January 2020 and December 2022 at our institution. The study included patients with localized prostate cancer, regardless of risk stratification, who had not received prior treatment for prostate cancer and had a minimum follow-up duration of 3 months post treatment. Patients eligible for staging per EAU guidelines [6], underwent imaging with an abdominal CT scan combined with bone scintigraphy or a prostate-specific membrane antigen positron emission tomography (PSMA-PET) scan. All patients without contraindications underwent a baseline MRI for either staging or planning purposes. Patients who were diagnosed with metastatic disease, who required pelvic radiotherapy per in-house standards, or who had received previous treatment for prostate cancer were excluded from the study. Pelvic radiotherapy is only recommended in house for patients with a combination of 2 high risk factors (T3a stage or higher and ISUP 4 or higher) and none of the patients included here fulfilled those criteria.

Treatment

All patients were treated at the Iridium Network in Antwerp, Belgium. Gold fiducial markers were implanted in the prostate before planning the MRI and CT simulations. Delineation and treatment planning (Volumatric Modulated Arc Therapy, VMAT) was performed with Eclipse. A dose of 36.25 Gy in 5 fractions was delivered to 95% of the planning target volume (PTV), with a maximum dose of 40 Gy to 2% of the PTV. The PTV consisted of the prostate and no (low risk), one centimeter (intermediate risk), or two centimeters (high risk) of seminal vesicles with a margin of 5 mm in all directions. During the first 2 years, we did not use a dose of 40 Gy for the clinical target volume (CTV) as per PACE protocol. Since 05/2021, the 40 Gy to the CTV has been used for all high-risk patients. The posterior PTV margin was reduced from 5 to 3 mm from 05–2021. Gold marker matching with verification of bowel and bladder filling on cone beam CT was performed for every fraction. Real-time gold fiducial tracking was done during every fraction. Treatment was delivered every other day on a Varian Truebeam allowing 6 dimensional setup corrections. We also allowed SBRT using 6×6 Gy once weekly in frail patients [7].

The use of adjuvant androgen deprivation was discussed with patients having unfavorable intermediate- to high-risk prostate cancer for 6 or 24–36 months respectively. The duration of treatment depended on individual risk profiles and tolerance for the treatment. Patients with high-risk prostate cancer were not treated with an androgen receptor pathway inhibitor (ARPI) as this is not reimbursed in Belgium.

Data collection and outcome measures

The electronic medical records were retrospectively analyzed between November 2023 and April 2024. The clinical stage was documented via the TNM classification. Patient characteristics such as age, Gleason score, D'Amico risk classification, International Society of Urological Pathology (ISUP) score, prostate-specific antigen (PSA) levels before treatment, PSA nadir after treatment, dose of radiation, and use of androgen deprivation therapy (ADT) were recorded. Physician-scored acute and late genitourinary (GU) and gastrointestinal (GI) toxicity events were retrospectively scored via the Common Terminology Criteria for Adverse Events (CTCAE) version 4.0. Acute toxicity was defined as toxicity occurring in the first 90 days after the completion of SBRT.

Late toxicity was assessed at 6 months, 1 year, 2 years, and 3 years after treatment. Biochemical recurrence was defined as a rise in the PSA level of 2 ng/mL or more above the nadir after treatment following the Phoenix criteria. Ethics approval was obtained from the Medical Research Ethics Committee at our center.

Statistical analysis

The statistical analysis was conducted via SPSS software version 29.0 (IBM Corporation, Armonk, NY). We used descriptive statistics to report the clinical and treatment characteristics. Additionally, we performed a Kaplan–Meier analysis to estimate the cumulative incidence of grade 2 or higher genitourinary (GU) and gastrointestinal (GI) toxicities, as well as the biochemical recurrence-free survival (BRFS) rates.

Results

Patient characteristics

Between January 1, 2020, and December 31, 2022, 352 patients with prostate cancer were treated with SBRT at our center. After the electronic medical records were analyzed, 267 patients were deemed eligible for inclusion in this study, while 85 patients were excluded. The exclusion criteria were as follows: 42 patients were lost to follow-up immediately after treatment, 15 patients had previous treatment for prostate cancer (such as radical prostatectomy, brachytherapy, or high-intensity focused ultrasound (HIFU)), 22 patients had metastatic prostate cancer, and 6 patients received hemostatic radiotherapy for symptom control. Patient characteristics and descriptive data are shown in Table 1. Three-month follow-up data for all included patients were available. At 6, 12, 24, and 36 months after treatment, follow-up data from 265, 260, 175, and 55 patients, respectively, were available for analysis. A flowchart of the patient selection process is shown in Fig. 1.

Table 1 Patient characteristics and descriptive data

Characteristic	Value
Total number of patients, n	267
Age at treatment, years *Mean (range)*	75 (51 – 92)
Clinical staging (TNM), n (%) *cT1c* *cT2a* *cT2b* *cT2c* *cT3a* *cT3b*	103 (39%) 67 (25%) 25 (9%) 35 (13%) 32 (12%) 5 (2%)
Gleason score / ISUP score, n (%) *6/1* *7 (3 + 4)/2* *7 (4 + 3)/ 3* *8/4* *9 (4 + 5 and 5 + 4)/5*	54 (20%) 87 (33%) 79 (30%) 28 (10%) 19 (7%)
PSA level at diagnosis (iPSA), ng/mL *Mean (range)*	12.6 (2–215)
D'Amico risk classification *Low risk* *Intermediate risk* *High risk*	25 (9%) 135 (51%) 107 (40%)
Prostate volume, cubic centimeters (cc) *Median (standard deviation)*	37 (18,48)
Dose of radiation, n (%) *5 × 7,25 Gy* *6 × 6 Gy*	260 (97%) 7 (3%)
Adjuvant ADT, n (%) *None* *6 months* *1 year* *2 years* *3 years*	98 (36%) 96 (36%) 8 (3%) 58 (22%) 7 (3%)
PSA Nadir, ng/mL *Mean (range)*	0.6 (< 0.01–3.12)
Time until Nadir reached, months *Mean (range)*	9 (1–33)

TNM tumor, node, metastasis, *ISUP* internation society of urological pathology, *PSA* prostate-specific antigen, *ADT* androgen deprivation therapy

Toxicity

Genitourinary toxicity

The incidence of cumulative grade 2 or worse genitourinary toxicity over time was 27% at 2 years and 35% at the 3-year follow-up (Fig. 2). Within the first three months following radiotherapy, the incidence of CTCAE grade 2 genitourinary toxicity was 31.1% (83 of the 267 patients). This incidence decreased to 9.4% (25 out of 265 patients) six months postradiotherapy, but slightly increased temporarily to 11.9% (31/260) at 12 months. Grade 3 urinary toxicity was observed in 4 patients (1.5%) one year postradiotherapy and in 4 different patients (2.3%) 2 years postradiotherapy. These patients presented with irritative lower urinary tract symptoms (LUTS) such as alguria, urgency, dysuria, and urinary incontinence. Six of these 8 patients had macroscopic hematuria. These symptoms are caused by necrotic tissue or calcifications in the prostate, for which transurethral resection of the prostate (TURP) is performed. No patients exhibited CTCAE grade 4 or higher genitourinary toxicity throughout the follow-up period. All data are available in Table 4, which is shown in the appendix. A schematic representation of the incidence of toxicity is shown in Fig. 3. The most common genitourinary symptoms were urinary dysuria, frequency, and urgency. An overview of symptom incidence for each follow-up period is shown in Table 2.

Gastrointestinal toxicity

The cumulative grade 2 or worse gastrointestinal toxicity was 2% at 2 years and 2% at 3 years (Fig. 2). Within the

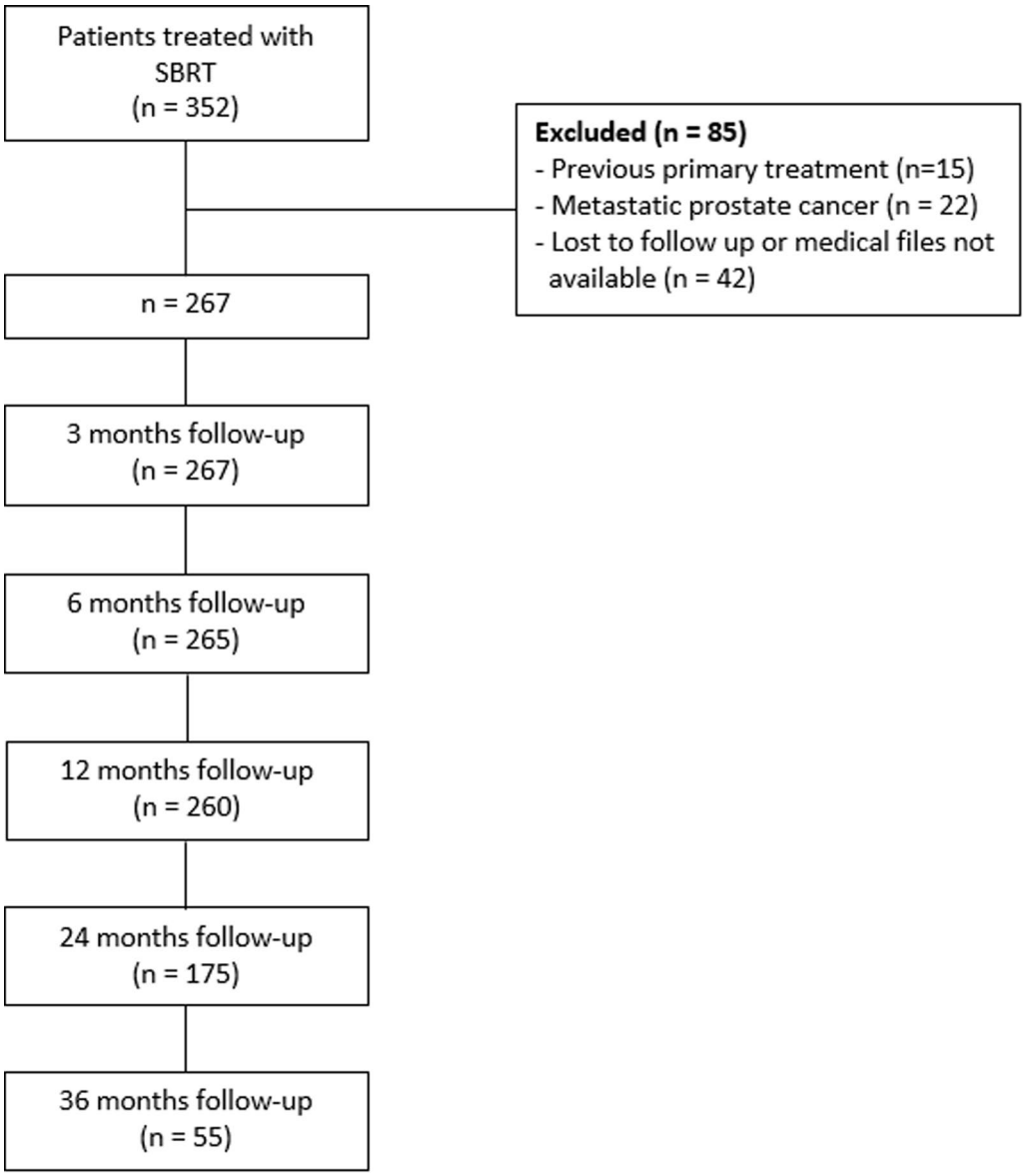

Fig. 1 Flowchart of patient selection

first 3 months after radiotherapy, 4.2% (11/267 patients) experienced CTCAE grade 2 gastrointestinal toxicity. This percentage decreased to 0.4% (1/265 patients), 1.2% (3/260 patients), and 1.7% (3/175 patients) at 6, 12, and 24 months postradiotherapy, respectively. By 36 months, no gastrointestinal toxicity was observed. No CTCAE grade 3 or higher gastrointestinal toxicity occurred during the follow-up. A schematic representation of the incidence of toxicity is shown in Fig. 3. All data are available in Table 4, which is shown in the appendix. The most common gastrointestinal symptom was diarrhea. An overview of symptom incidence for each follow-up period is shown in Table 2.

Biochemical recurrence

Among the 267 patients, 1.5% (4 patients) experienced biochemical relapse within 36 months of follow-up, resulting in a 2-year biochemical-free survival rate of 98.5%. Two patients developed lymph node metastasis at recurrence and one patient had a bone metastasis. No clinical recurrence was found in the patients with biochemical recurrence (BCR). At the end of the follow-up period, no patients died from prostate cancer. Three patients had died from unrelated causes during the follow-up period (Fig. 4).

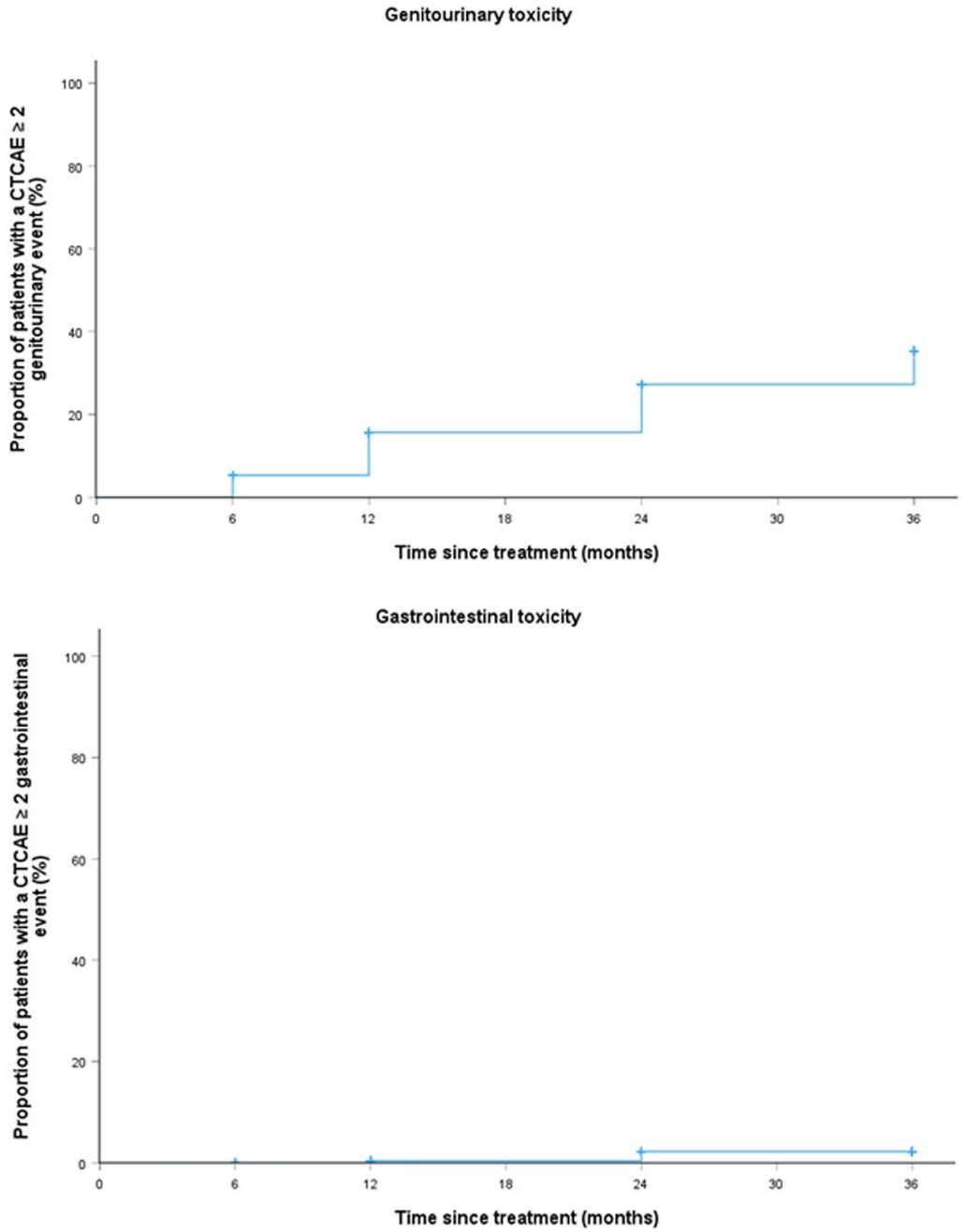

Fig. 2 Time to occurrence of worst CTCAE genitourinary and gastrointestinal toxicity

Discussion

The primary aim of this study was to evaluate the outcomes of SBRT for patients with localized prostate cancer at our center and compare them with those reported in the literature. Specifically, we benchmarked our results against data from high-impact randomized prospective trials, including the PACE series and the HYPO-RT-PC trial. The PACE-B trial [4], which compared SBRT with CRT, was published in 2019. The PACE-B data presented in Table 3 reported a composite of the worst toxicity exceeding baseline symptoms. The PACE-A trial (comparing SBRT with radical prostatectomy) and the PACE-C trial (examining SBRT versus CRT in high-risk prostate cancer patients) have not been fully published. However, partial results were presented at ASCO GU 2023 and ESTRO 2024 [8]. In 2019, Jackson et al. conducted a

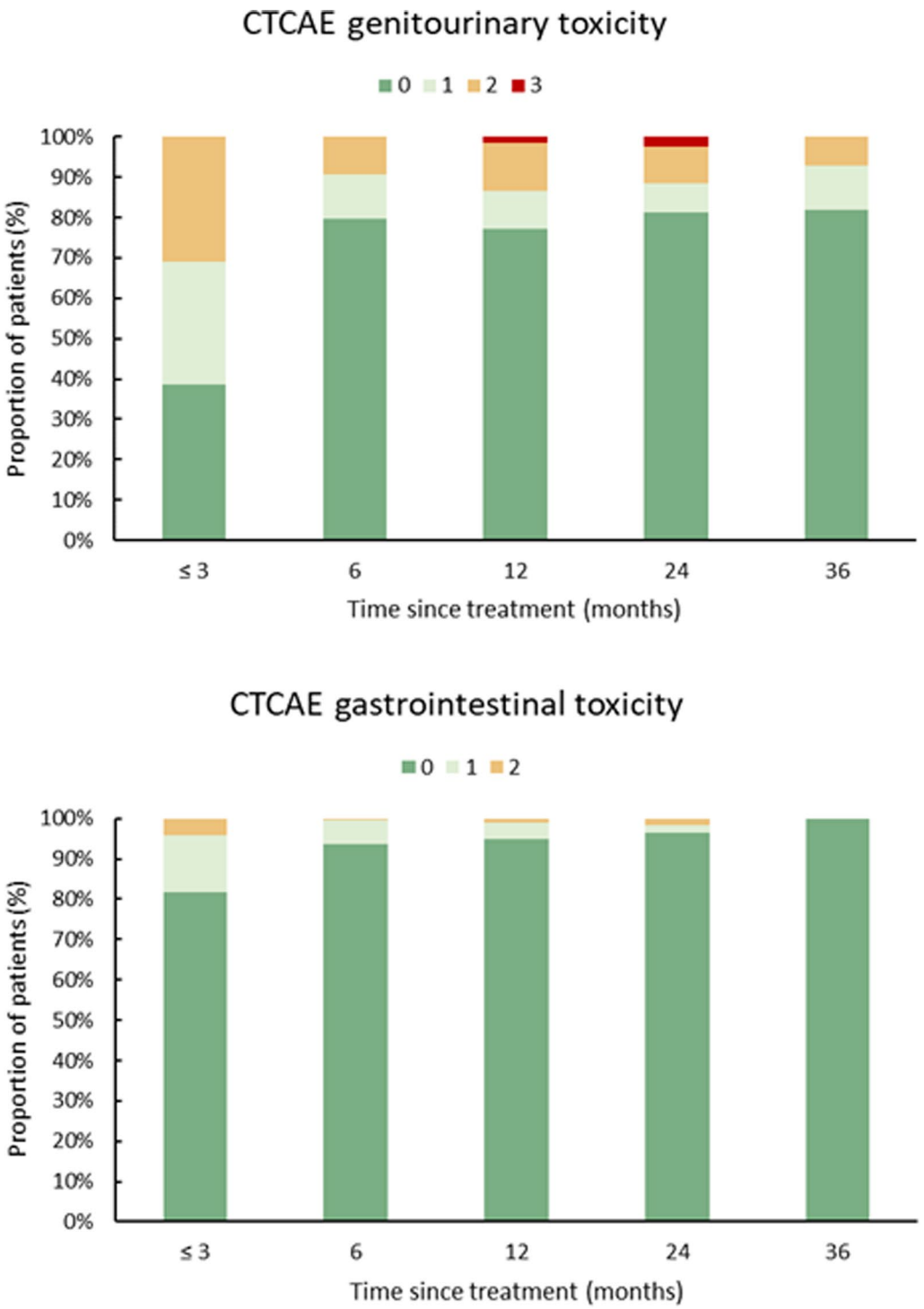

Fig. 3 Schematic representation of the incidence of CTCAE genitourinary and gastrointestinal toxicity from ≤ 3 to 36 Months post-radiotherapy

systematic review and meta-analysis on the efficacy and safety of SBRT for localized prostate cancer [9]. Their systematic review and meta-analysis analyzed grade 3 or higher toxicity rates. Our study's results were also compared with their findings, as detailed in Table 3. Our study's acute toxicity outcomes were comparable to those reported in these trials. Similarly, late toxicity at two years postradiotherapy showed consistent results across

Table 2 Patient counts by symptom and CTCAE grade across follow-up periods

Follow up	≤ 3 m		6 m		12 m			24 m			36 m	
CTCAE	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**
Genitourinary symptoms												
Symptom												
Nocturia	11(4.1%)	13(4.9%)	3(1.1%)	4(1.5%)	1(0.4%)	3(1.2%)	0	1(0.6%)	0	0	0	0
Frequency	54(20%)	34(13%)	13(4.9%)	11(4.2%)	8(3.1%)	15(5.8%)	1(0.4%)	4(2.3%)	6(3.4%)	3(1.7%)	1(1.8%)	1(1.8%)
Urgency	9(3.4%)	20(7.5)	18(6.8)	15(5.7)	13(5%)	21(8.1)	3(1.2%)	8(4.6%)	10(5.7)	4(2.3%)	3(5.5%)	3(5.5%)
Urinary incontinence	0	1(0.4%)	1(0.4%)	1(0.4%)	0	2(0.8%)	0	0	1(0.6%)	0	0	1(1.8%)
Dysuria	21(7.9%)	46(17%)	1(0.4%)	5(1.9%)	3(1.2%)	7(2.7%)	1(0.4%)	0	2(1.1%)	0	0	0
Mictalgia	5(1.9%)	9(3.4%)	0	0	0	0	0	0	0	0	0	0
AUR	0	1(0.4%)	0	0	0	0	0	0	0	0	0	0
Penile pain	0	1(0.4%)	0	2(0.7%)	0	0	0	0	1(0.6%)	0	0	0
Hematuria	0	0	1(0.4%)	1(0.4%)	4(1.5%)	3(1.2%)	3(1.2%)	4(2.3%)	3(1.7%)	1(0.6%)	3(5.5%)	0

Follow up	≤ 3 m		6 m		12 m		24 m		36 m	
CTCAE	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Gastrointestinal symptoms										
Symptom										
Diarrhea	12 (4.5%)	5 (1.9%)	2 (0.7%)	1 (0.4%)	0	1 (0.4%)	0	2 (1.1%)	0	0
Tenesmus	15 (5.6%)	4 (1.5%)	8 (3.1%)	0	4 (1.5%)	0	1 (0.6%)	1 (0.6%)	0	0
Hematochezia	6 (2.2%)	2 (0.7%)	2 (0.7%)	0	2 (0.8%)	1 (0.4%)	2 (1.1%)	0	0	0
Soiling	1 (0.4%)	0	2 (0.7%	0	2 (0.8%)	1 (0.4%)	0	0	0	0
Mucus	5 (1.9%)	3 (1.1%)	3 (1.1%)	0	1 (0.4%)	1 (0.4%)	0	0	0	0
Constipation	1 (0.4%)	3 (1.1%)	1 (0.4%)	0	0	1 (0.4%)	0	0	0	0
Anal pain	0	0	0	0	0	1 (0.4%)	0	1 (0.6%)	0	0

CTCAE common terminology criteria for adverse events, *AUR* acute urinary retention.

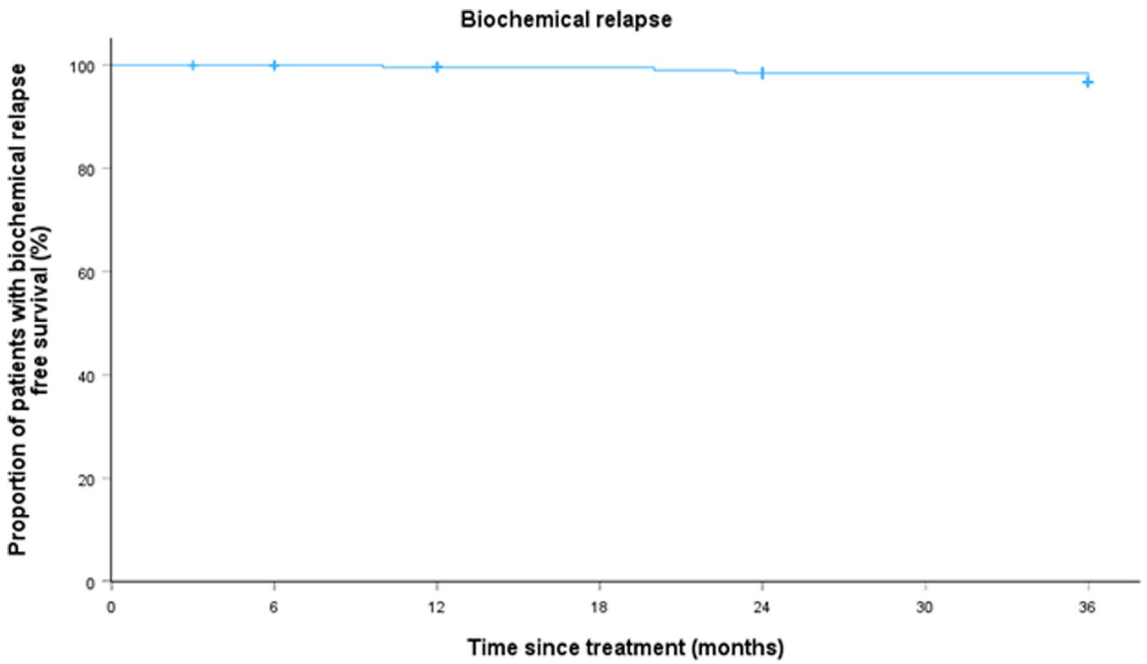

Fig. 4 Time to occurrence of biochemical relapse

Table 3 Comparison of study data with established randomized controlled trial outcomes and data from this study

	Acute toxicity (≤ 3 months)		Late toxicity (2 years)		Cumulative toxicity (2 years)		BCR
	GU	GI	GU	GI	GU	GI	
Pace A *n* = 58 Reported toxicity grade: CTCAE Grade ≥ 2	/	/	9.3%	0%	/	/	/
Pace B (2y) *n* = 433 Reported toxicity grade: CTCAE Grade ≥ 2	27.4%	15.3%	12%	3%	32.3%	12.5%	/
Pace B 5 year follow-up [10] *n* = 355 Reported toxicity grade: CTCAE Grade ≥ 2	GU-toxicity: 8,7% GI-toxicity: 2,5% BCR: 95,8%						
Pace C *n* = 584 Reported toxicity grade: CTCAE Grade ≥ 2	34%	17%	/	/	/	/	/
HYPO-RT-PC *n* = 589 Reported toxicity grade: CTCAE Grade ≥ 2	23%	7%	6%	3%	13%	6%	84% (5y)
Systematic Review *n* = 6116 Reported toxicity grade: CTCAE Grade ≥ 3	0,5%	0,06%	2%	1,1%	/	/	95.3% (5y)
This study (*n* = 267) *CTCAE grade ≥ 2* *CTCAE Grade ≥ 3*	31.1% 0%	4.2% 0%	11.4% 2.3%	1.7% 0%	27% /	2% /	98.5% (3y)

studies, including ours. Notably, a peak in urinary toxicity was observed one year postradiotherapy, which aligns with findings from the HYPO-RT-PC trial.

In addition to the eligibility criteria of the PACE-B trial, we also included high-risk patients to assess the broader applicability of this treatment modality as in PACE-C. The inclusion of high-risk patients did not appear to influence toxicity outcomes, as the choice of the dose of radiation and frequency of dose delivery does not depend on the risk stratification, ensuring comparable exposure to potential side effects. However, the inclusion of high-risk patients introduces a potential confounding factor when interpreting biochemical recurrence outcomes, as high-risk disease is inherently associated with a greater likelihood of recurrence. The difference in patient population limits the validity of direct comparisons of biochemical recurrence rates between our study and the PACE-B trial, emphasizing the need for caution in concluding disease control outcomes from such comparisons.

We reported excellent overall prostate cancer-specific survival and biochemical relapse-free survival rates, despite 40% of patients being at high risk. While the biochemical recurrence (BCR) outcomes in this study are comparable to those reported in the prospective trials summarized in Table 3 and align with data from other published studies [11, 12], the ability to draw definitive conclusions about BCR is limited by the number of patients with limited follow-up beyond three years. Furthermore, it is important to note that a substantial proportion of patients still received ADT at the end of their follow-up in this trial. A longer follow-up period will be necessary to draw definitive conclusions regarding biochemical recurrence in the selected patient cohort.

The combination of ADT with radiotherapy is an established treatment approach for prostate cancer across all risk groups. Its use has been shown to enhance treatment efficacy by improving biochemical control and reducing the risk of disease recurrence [13]. We acknowledge the variable use of ADT alongside SBRT for the treatment of localized prostate cancer in patients with intermediate- to high-risk disease. The decision to incorporate ADT and its duration (6 or 24–36 months) was guided by EAU guidelines, individual risk profiles, clinician judgment, patient preferences, and tolerance, reflecting a real-world dataset rather than a clinical trial. Future studies with standardized ADT protocols or stratified subgroup analyses are needed to better elucidate the impact of ADT on SBRT outcomes in this patient population.

Our paper highlights the difficulty of adherence to long-term ADT for patients with high-risk prostate cancer as 40% of our patients were high-risk and only 63% of them received 2–3 years of ADT. Even though we did not capture the reasons for not adhering to the guidelines, these numbers align with recent nationwide studies [14, 15]. Similarly, George et al. revealed that long-term adherence to ADT is low, particularly as treatment progresses. Possible reasons for these gaps include adverse side effects like sexual dysfunction, fatigue, and metabolic changes, which discourage patients from continuing therapy. Additionally, disparities in healthcare access, patient education, and physician adherence to guidelines contribute to the inconsistency. These findings underscore the need for improved patient support systems, clinician training, and strategies to minimize treatment-related adverse effects to enhance adherence and align real-world practices with evidence-based guidelines.

The use of androgen receptor pathway inhibitors (ARPIs) in combination with radiotherapy for localized and locally advanced prostate cancer has gained increasing attention. The first evidence of this therapeutic strategy was shown in a part of the STAMPEDE trial, where a combination of ADT (3 years) + abiraterone + / − enzalutamide (2 years) was evaluated in node-positive patients and high-risk node-negative patients (having at least 2 of the following risk factors: ≥ cT3, Gleason score ≥ 8, PSA ≥ 40 ng/mL). The trial showed a significant improvement in metastatic-free survival and overall survival in patients treated with additional ARPIs [16]. In the context of SBRT, the integration of ARPIs could further enhance disease control, particularly for patients with aggressive tumor biology. However, the role of ARPIs in combination with SBRT remains underexplored. This emphasizes a need for prospective trials to determine the optimal patient selection, timing, and duration of ARPI therapy in this setting. Future studies should aim to clarify whether the benefits observed with ARPIs in the STAMPEDE trial extend to patients treated with SBRT, ensuring alignment with evolving clinical guidelines.

Pelvic node radiotherapy (PNRT) is a treatment modality increasingly considered for patients with localized high-risk and very high-risk prostate cancer. The POP-RT trial is a randomized controlled trial comparing prostate-only radiotherapy with prophylactic pelvic node radiotherapy in patients with localized high-risk or very high-risk prostate cancer. It reported a significant improvement in BFFS and disease-free survival in favor of PNRT for patients with a high risk of nodal involvement (Roach formula) and a negative PSMA PET-CT. Acute toxicities were similar in both groups, although PNRT was associated with more late bladder toxicity [17]. It is sufficient to say more evidence is needed to support the benefit of prophylactic radiotherapy in patients with localized disease. Trials like PACE-NODES and the PRIME trial [18] will further elucidate the role of SBRT for pelvic nodal treatment.

As a retrospective analysis, our study design inherently has certain limitations. Recognizing these limitations is essential when interpreting our findings and comparing them with results from prospective or experimental studies. The retrospective design inherently relies on the reporting practices of the treating medical doctor (MD), which may lead to potential underreporting of less severe toxicities. Nonetheless, it is less likely that grade 2 or higher toxicities were underreported. Selection bias was minimized by implementing fixed selection criteria established before the analysis of medical records. To mitigate information bias, patients with ambiguous medical records were excluded from the study.

Our study reported favorable survival and biochemical relapse-free survival rates with toxicity profiles comparable to those documented in prospective research. Nevertheless, further studies are needed to assess the long-term survival rates and late toxicity associated with SBRT for localized prostate cancer patients.

Conclusion

Implementation of standardized protocols for SBRT as a treatment for localized prostate cancer results in a 2-year toxicity and oncological outcomes comparable to the published randomized trials.

Appendix

See Table 4 here.

Table 4 Incidence of toxicity by CTCAE grade across follow-up periods

Follow-up	≤ 3 m	6 m	12 m	24 m	36 m
Genitourinary toxicity					
CTCAE, n (%)					
0	103 (38.6%)	211 (79.6%)	201 (77.3%)	142 (81.1%)	45 (81.8%)
1	81 (30.3%)	29 (11%)	24 (9.3%)	13 (7.4%)	6 (10.9%)
2	83 (31.1%)	25 (9.4%)	31 (11.9%)	16 (9.2%)	4 (7.3%)
3	0	0	4 (1.5%)	4 (2.3%)	0
Gastrointestinal toxicity					
0	218 (81.6%)	248 (93.6%)	247 (95%)	169 (96.6%)	55 (100%)
1	38 (14.2%)	16 (6%)	10 (3.8%)	3 (1.7%)	0
2	11 (4.2%)	1 (0.4%)	3 (1.2%)	3 (1.7%)	0
3	0	0	0	0	0

CTCAE common terminology criteria for adverse events.

Abbreviations

EBRT	External beam radiotherapy
SBRT	Stereotactic body radiotherapy
CRT	Conventional Radiotherapy
PTV	Planning target volume
CTV	Clinical target volume
ARPI	Androgen receptor pathway inhibitor
ISUP	International Society of Urological Pathology
PSA	Prostate-specific antigen
GU	Genitourinary
GI	Gastrointestinal
CTCAE	Common Terminology Criteria for Adverse Events
BRFS	Biochemical recurrence-free survival
HIFU	High intensity focused ultrasound
TNM	Tumor, Node, Metastasis
LUTS	Lower urinary tract symptoms
TURP	Transurethral resection of the prostate
AUR	Acute urinary retention
BCR	Biochemical recurrence
PNRT	Pelvic node radiotherapy

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13014-025-02598-8.

Additional file1.

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Author contributions
BDC analyzed patients' medical records and compiled the dataset. BDC and PO conducted data analysis and performed the statistical assessments. BDC, PO, TD, TA, GL, BDT, MC, GDK, CM, and PD significantly contributed to the manuscript's writing and revision.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The ethics committee of the ZAS Augustinus Hospital in Antwerp approved this study in August 2023.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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