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The clinical impact of strict criteria for active surveillance of prostate cancer in Korean population: Results from a prospective cohort

Jungyo Suh[1,2,†], Hyeong Dong Yuk[2], Minyong Kang[3], Bum Sik Tae[4], Ja Hyeon Ku[2,5], Hyeon Hoe Kim[2,5], Cheol Kwak[2,5], Chang Wook Jeong[2,5]

[1]Hospital Medicine Center, Seoul National University Hospital, Seoul, [2]Department of Urology, Seoul National University Hospital, Seoul, [3]Department of Urology, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, [4]Department of Urology, Korea University Ansan Hospital, Ansan, [5]Department of Urology, Seoul National University College of Medicine, Seoul, Korea

Purpose: To evaluate the clinical impact of strict selection criteria for active surveillance (AS) of prostate cancer in a Korean population.

Materials and Methods: A single-center, prospectively collected AS cohort from December 2016 to February 2019 was used. Following pre-determined criteria, patients were categorized into "strict AS" and "non-strict AS" groups. Clinicopathological progression-free survival (PFS) and treatment-free survival (TFS) of the two groups were compared using the Kaplan–Meier curve and log-rank test. Age-adjusted hazard ratios for clinicopathological progression was calculated using Cox proportional regression analysis.

Results: Of 54 eligible patients, 25 and 29 were assigned to "strict AS" and "non-strict AS," respectively. Clinicopathological progression and definitive treatment rates were 24.0% (6 of 25 patients) vs. 51.7% (15 of 29 patients) and 32.0% (8 of 25 patients) vs. 62.1% (18 of 29 patients) in "strict AS" and "non-strict AS" groups. Progress to high-risk cancer (pathologic T3 or surgical Gleason Grade 2 over) in radical prostatectomy was higher in "non-strict AS" than "strict AS". PFS (mean 34.6±2.9 mo vs. 22.6±2.7 mo; p=0.025) and TFS (mean 31.8±3.2 mo vs. 19.6±2.4 mo; p=0.018) favor the "strict AS" group than "non-strict AS" group. Age-adjusted hazard ratio for clinicopathological progression of strict criteria was 0.36 (95% confidence interval, 0.14–0.94; p=0.04).

Conclusions: PFS and TFS were better in the "strict AS" group than in the "non-strict AS" group. This finding should be informed to relevant patients during decision making and considered in Korean guidelines.

Keywords: Active surveillance; Patient selection; Prostate neoplasms

INTRODUCTION

Prostate cancer is the second most common malignancy in men and the sixth leading cause of cancer-related mortality worldwide [1]. The prostate specific antigen (PSA) based screening test accounts for a 21% risk reduction compared to a non-screening group [2]. Up to 80% of patients are diagnosed with low-risk prostate cancer [1]. The complications and clinical cost of definitive treatment lead to overtreatment issues in this indolent group [3,4]; thus, most clinical

guidelines endorse active surveillance (AS) as an alternative option for very low- or low-risk groups of patients [5-7].

AS is the strategy of deferred definitive treatment with regular monitoring of PSA, digital rectal exam, and prostate biopsy [8]. Although AS has been the accepted practice during the last decade, inclusion criteria, monitoring methods, and timing of therapeutic interventions are not clearly defined [9]. Moreover, current AS criteria derived from Western studies do not reflect the ethnic characteristics of prostate cancer, such as a higher Gleason score and advanced stage in Asian than in Western populations [10,11]. Thus, the direct application of Western criteria to Korean population is not acceptable for the risk of pathologic upgrading and upstaging [12].

Previously, we suggested that safer AS criteria for Korean populations were required on the basis of the rate of unfavorable pathology and biochemical recurrence-free survival from multicenter radical prostatectomy data [13]. In this study, we evaluated the clinical utility of strict AS criteria by comparing progression-free survival (PFS) and treatment-free survival (TFS) between "strict AS" and "non-strict AS" groups, using prospective, single-center cohort data.

MATERIALS AND METHODS

1. Ethics approval and informed consents

This study was approved by the Institutional Review Board (IRB) of the Seoul National University Hospital (approval number: 1610-145-806) and registered in clinicaltrial.gov (NCT02971085). Informed consent was obtained from each participant. All the study processes were performed in accordance with relevant guidelines and regulations.

2. Patient selection and follow-up protocol

The Seoul National University Prospectively Enrolled Registry for Prostate Cancer Active Surveillance (SUPER-PC-AS) is a sub-part of SUPER-PC; the prostate cancer targeted sub-cohort of the multidisciplinary, biobank-linked cohort of genitourinary cancer in high-volume tertiary institutions [14]. SUPER-PC comprises 5 sub-cohorts, determined by disease status and treatment modalities: radical prostatectomy (SUPER-PC-RP), active surveillance (SUPER-PC-AS), radiation therapy (SUPER-PC-RT), hormone sensitive prostate cancer (SUPER-PC-HSPC), and castration resistant prostate cancer (SUPER-PC-CRPC).

The SUPER-PC-AS cohort comprised pathologically proven low-risk prostate cancer patients who underwent AS as the initial treatment within the past 6 months. The patients included in this cohort were <80 years old and

were diagnosed with pathologically proven prostate cancer by transrectal ultrasound (TRUS) guided prostate biopsy with >10 cores and satisfied any of the criteria for AS [5-7]. The patients were considered "strict AS" if they met all of seven selection criteria [13]; pre-biopsy PSA ≤10 ng/mL, PSA density <0.15 ng/mL/mL, clinical stage T1-2a, biopsy Gleason grade ≤6, number of positive cores ≤2, maximum cancer involvement in any one core ≤20%, and no Prostate Imaging-Reporting and Data System (PIRADS) 5 lesion on multiparametric magnetic resonance imaging (MRI). Patients who did not meet the selection criteria were considered "non-strict AS." Non-strict AS population can refer with the subset of National Comprehensive Cancer Network low-risk prostate cancer, which met following definitions: clinical stages in T1–T2a, biopsy Gleason grade ≤6 and pre-biopsy PSA ≤10 ng/mL but does not qualify for strict AS group definition.

AS data from December 2016 to February 2019 were analyzed. The SUPER-PC-AS cohort received repeated prostate biopsies to determine pathologic progression by time path of 1, 2, 4, 7, and 10 years, and subsequently every 5 years. Repeat biopsies should have obtained >12 cores of systemic biopsy, and if there were visible lesions on TRUS or MRI additional target biopsies were performed. Prostate MRIs were annually checked until 5 years after the initial biopsy. Serum PSA levels were checked every 3 months for 2-year during the follow-up period, and every 6 months until 2–10 years post the follow-up period. After that, PSA was checked annually (Supplementary Fig. 1).

3. Definition of the endpoints

Clinicopathological progression free survival (PFS) is defined as the time from the initial prostate cancer diagnosis to the clinical or pathologic progression and was the primary endpoint in this study. New PIRADS 5 lesions appearing in follow-up MRIs were considered clinical progression and Gleason up-grading or cancer found in >3 cores in follow-up prostate biopsy were considered as pathologic progression. Treatment free survival, which was defined as the time from the initial prostate cancer diagnosis to definitive treatment included radical prostatectomy, radiation therapy, and androgen deprivation therapy. AS discontinuation was defined as the patient ceasing to follow the predefined AS protocol due to any cause, including clinical, pathologic progression or wanting treatment without any evidence of progression. Time from the initial diagnosis of prostate cancer to AS discontinuation was defined as the AS adherence period. In the subgroup analysis, the pathologic stages of the patients who received a radical prostatectomy were compared between the "strict AS" and "non-strict AS" groups.

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┌─────────────────────────┐
│  All included patients  │
│        (n=59)           │
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            │                    ┌──────────────────────────────────────────────┐
            │                    │  Excluded (n=5)                              │
            ├───────────────────→│  · Incidentally founded cancer, HoLEP (n=3)  │
            │                    │  · Non-eligible for AS, gleason grade 3 (n=1) │
            │                    │  · Cannot use MRI (n=1)                      │
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┌─────────────────────────┐
│  Eligible for analysis  │
│        (n=54)           │
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   ┌───┴────┐   ┌───┴────────┐
   │ Strict │   │ Non-strict │
   │   AS   │   │     AS     │
   │ (n=25) │   │   (n=29)   │
   └────────┘   └────────────┘
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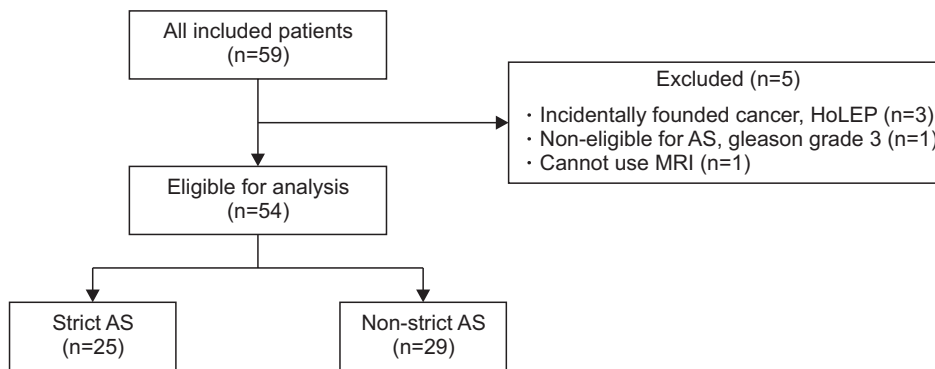
Fig. 1. Patient enrollment flowchart. HoLEP, holmium laser enucleation of the prostate; AS, active surveillance; MRI, magnetic resonance imaging.

4. Statistical analysis

All continuous variables were described as the mean±standard deviation (interquartile range), whereas categorical variables were described as frequency (percentage). Continuous variables were compared using the Student's t-test, and categorical variables were compared using the chi-squared test or Fisher's exact test. The Kaplan–Meir curve and log-rank tests were used for comparing clinical or pathologic reclassification-free survival, TFS, and AS adherence survival between the "strict AS" and "non-strict AS" groups. The mean survival times with 95% confidence interval (CI) were described after survival analysis. Cox proportional regression analysis was used to calculate the age adjusted hazard ratios of strict criteria for AS. Statistical analyses were performed using R package version 3.5.3 (www.r-project.org). For statistical comparisons, a p-value of <0.05 was considered to be significant.

RESULTS

1. Patient characteristics

Of 54 patients that were eligible for analysis, 25 were classified as "strict AS" and 29 as "non-strict AS" (Fig. 1). PSA level (4.8±1.7 ng/mL vs. 6.0±2.2 ng/mL; p=0.03), PSA density (0.10±0.04 ng/mL^2 vs. 0.16±0.03 ng/mL^2; p<0.01), and maximum tumor involvement in any cores (11.2±4.3% vs. 24.6±17.5%; p<0.01) were significantly different between the two groups. All the enrolled patients' characteristics are demonstrated in Table 1.

2. Follow-up outcomes

The median follow-up period was 20.5±8.2 months (interquartile range, 15.0–27.0 mo) for the "strict AS" and 20.9±10.8 months (interquartile range, 14.0–31.0 mo) for the "non-strict AS" group (p=0.90). The AS discontinuation rate was significantly different between the "strict AS" (8 of 25 patients, 32.0%) and "non-strict AS" (18 of 29 patients, 62.1%) groups

(p=0.03). For 3 patients for each group (p>0.99) were discontinued AS follow-up protocol by patient's request, mostly based on anxiety of untreated cancer. AS adherence periods were significantly longer in the "strict AS" group than in the "non-strict AS" group (18.8±10.0 mo vs. 13.8±8.3 mo; p<0.05).

Protocol based AS discontinuation by pathologic or clinical progression was significantly lower in the "non-strict AS" group than in the "strict AS" group (24.0% [6 of 25 patients] vs. 51.7% [15 of 29 patients]; p=0.04). Clinical progression rates were not different for "strict AS" and "non-strict AS" (8.0% [2/25 patients] vs. 3.4% [1/29 patients]; p=0.60). Detailed data is described in Table 2. Only one patient was changed to watchful waiting owing to old age, and all other patients received definitive treatment. A majority of the patients were administered definitive treatment by means of radical prostatectomy (Table 3).

3. Surgical pathology

Eight and fourteen patients received radical prostatectomy for definitive treatment in the "strict AS" and "non-strict AS" groups, respectively. The presence of pathologic T3 was lower in the "strict AS" group than in the "non-trict AS" group (12.5% [1 of 8 patients] vs. 28.6% [4 of 14 patients]; p=0.61). The Gleason grade group involved tumor volume and adverse pathologic features (over pathologic T3 or over Gleasone grade group 2) on surgical pathology were not significantly different between the two groups (Table 4).

4. Survival analysis

The Kaplan–Meier curve with log-rank test of progression-free survival, TFS, and AS adherence survival is shown on Fig. 2. The progression-free survival (34.6±2.9 mo vs. 22.6±2.7 mo; p=0.025, Fig. 2A) and treatment free survival (31.8±3.2 mo vs. 19.6±2.4 mo; p=0.018, Fig. 2B) favor the "strict AS" group rather than the "non-strict AS" group. AS adherence survival was not significantly different between the

Table 1. Patient's demographics and clinical parameters of "strict criteria" and "non-strict criteria" AS groups

Characteristic	Strict criteria AS (n=25)	Non strict criteria AS (n=29)	p-value
Age (y)	66.9±5.2 (63–77)	65.5±7.8 (63–71)	0.45
Body mass index (kg/m^2)	24.8±3.2 (23.3–27.1)	25.4±2.8 (23.9–27.1)	0.51
Diabetes	4 (16.0)	8 (27.6)	0.28
Hypertension	8 (32.0)	13 (44.8)	0.94
Dyslipidemia	9 (36.0)	4 (13.8)	0.11[a]
Prostate specific antigen (ng/mL)	4.8±1.7 (4.3–5.5)	6.0±2.2 (4.4–7.3)	0.03
Abnormality in digital rectal examination	0 (0.0)	1 (3.4)	>0.99[a]
Prostate volume (mL)	51.7±27.7 (33.5–63.0)	40.4±17.9 (30.0–43.9)	0.09
Abnormality in trans rectal ultrasound	2 (8.0)	3 (10.3)	>0.99[a]
Prostate specific antigen density (ng/mL^2)	0.10±0.04 (0.08–0.12)	0.16±0.03 (0.12–0.18)	<0.01
Clinical stage			0.68[a]
T1c	23 (92.0)	25 (86.2)	
T2a	2 (8.0)	4 (13.8)	
Gleason Grade Groups			
Gleason Grade Group 1	25 (100.0)	29 (100.0)	
Gleason Grade Group 2	0 (0.0)	0 (0.0)	
Number of positive cores			0.17[a]
1	19 (76.0)	27 (93.1)	
2	6 (24.0)	2 (6.9)	
Percentage positive core (%)	10.2±3.6 (8.3–8.3)	8.9±2.0 (8.3–8.3)	0.12
Maximum tumor involvement in any cores (%)	11.2±4.3 (8.0–14.3)	24.6±17.5 (13.3–33.3)	<0.01
MRI visible tumor	15 (60.0)	20 (69.0)	0.69
MRI PIRADS score			0.59[a]
PIRADS ≤3 lesion	7 (46.7)	6 (30.0)	
PIRADS 4 lesion	8 (53.3)	13 (65.0)	
PIRADS 5 lesion	0 (0.0)	1 (5.0)	

Values are presented as mean±standard deviation (interquartile range) or number (%).
AS, active surveillance; MRI, magnetic resonance imaging; PIRADS, Prostate Imaging-Reporting and Data System.
[a]:Fisher's exact test.

Table 2. Reason of AS discontinuation of "strict criteria" and "non-strict criteria" AS groups

Variable	Strict criteria AS (n=25)	Non strict criteria AS (n=29)	p-value
Discontinuation of AS	8 (32.0)	18 (62.1)	0.03
Protocol based discontinuation	6 (24.0)	15 (51.7)	0.04
Pathologic reclassification in follow-up biopsy	5 (20.0)	14 (48.2)	0.05[a]
Pathologic Gleason upgrading in follow-up biopsy	3 (12.0)	8 (27.6)	0.20[a]
Cancer founded more than 3 cores in follow-up biopsy	4 (16.0)	9 (31.0)	0.22[a]
Clinical reclassification	2 (8.0)	1 (3.4)	0.60[a]
New PIRADS 5 lesion during follow-up MRI			
Patients request	3 (12.0)	3 (10.3)	>0.99[a]
Active surveillance adherence periods (mo)	18.8±10.0 (12.0–26.0)	13.8±8.3 (9.0–15.0)	<0.05

Values are presented as number (%) or mean±standard deviation (interquartile range).
AS, active surveillance; PIRADS, Prostate Imaging-Reporting and Data System; MRI, magnetic resonance imaging.
[a]:Fisher's exact test.

two groups (28.3±3.2 mo vs. 20.4±2.6 mo; p=0.076, Fig. 2C). The age adjusted cox regression result shows the strict criteria accounted for a 0.36 (95% CI, 0.14–0.94; p-value=0.04) risk reduction in the AS group.

DISCUSSION

The clinical role of AS is becoming more important in the management of low-risk prostate cancers in the last decade. Although AS is accepted for many clinical guidelines

as a treatment option in low-risk prostate cancer [5-7], the enrollment criteria and follow-up protocols remain controversial [9]. Clinical and pathologic characteristics of prostate cancer are more aggressive in Asian than in Western populations [11-13]; however, there were no suitable selection criteria for AS in Asian populations. Resolving this problem, we developed more suitable criteria for AS in Korean populations using a multi-institutional database [13]. In this study, we evaluated the clinical impact of strict selection criteria for AS in Korean populations by comparing PFS of "strict AS" and "non-strict AS" groups, using a prospective cohort of AS (SUPER-PC-AS; NCT02971085).

Current scientific evidence seems to be limited for the direct application of Western AS criteria to Korean population [12]. Kim et al. [12] found that 41.6% to 54.8% of patients had adverse pathology (over Gleason grade group 2 or pT3) in Korean patients who fulfilled six Western AS criteria; Johns Hopkins [15], Toronto [16], UCSF [17], PRIAS [18], MIAMI [19], and MSKCC [20], which is higher than that reported in the Western population (22%–33%) [21]. Koo et al. [22] found that pathological up-grading (over Gleason grade group 2 in RP specimen) and up-staging (over pT3 in RP specimen) from initial biopsy was 42.3% and 13.4%, respectively, in patients

eligible for at least one contemporary Western AS protocol, from a multicenter study in Korea. From these findings, we carefully suggest that more strict criteria would be suitable for Korean populations. In this study, we also founded pathologic progression on radical prostatectomy specimen was higher in "non-strict AS" group than "strict AS" group (Table 4), however only 8 patents from "strict AS" performed radical prostatectomy so it cannot reach statistical significance in these differences.

The evidence of the clinical utility of MRI on AS is continuously increasing; however, only limited AS selection criteria using MRI lesion for patients selection [23]. Although the clinical value of the PIRADS score is still unstable and has interobserver reproducibility issues [24], the clinical evidence of detecting high-grade cancer by PIRADS 5 lesion is continuously reported [25,26]. Moreover, MRIs with strong magnetic power (over 1.5 Tesla) makes for better image quality and identifying aggressive pathologic features than does lower magnetic powered MRIs [27,28]. We used the MRI PIRADS score, only in more than 1.5 Tesla MRI, for the selection of suitable patients for AS in Korea [13]. With additional criteria from MRI information, we can exclude the high-risk population of progression at the time of enrollment.

In this study the "strict AS" group showed better PFS and TFS than the "non-strict AS" group did. During the 2-year follow-up period, PFS was lower in the "strict AS" group than in the "non-strict AS" group (76.0% [19 of 25 patients] vs. 48.3% [14 of 29 patients]; p=0.037). Median survival to progression was 13.0 (95% CI, 11.79–14.22) months for the "non-strict AS" group; however, the "strict AS" group did not reach median time during the follow-up period. Compared with previous AS study result, "strict AS" for Korean populations showed similar outcomes with Western AS cohorts.

Table 3. Treatment conversion after AS discontinuation of "strict criteria" and "non-strict criteria" AS groups

Variable	Strict criteria AS (n=25)	Non strict criteria AS (n=29)
Definitive treatment	8 (32.0)	17 (58.6)
Radical prostatectomy	8 (32.0)	14 (48.3)
Radiation therapy	0 (0.0)	3 (10.3)
Watchful waiting	0 (0.0)	1 (3.4)

Values are presented as number (%).
AS, active surveillance.

Table 4. Surgical pathology after treatment conversion of "strict criteria" and "non-strict criteria" AS groups

Characteristic	Strict criteria AS (n=8)	Non strict criteria AS (n=14)	p-value
Pathologic T stage			0.61[a]
T2	7 (87.5)	10 (71.4)	
T3	1 (12.5)	4 (28.6)	
Pathologic Gleason grade group			0.77
1 (3+3)	4 (50.0)	5 (35.7)	
2 (3+4)	3 (37.5)	6 (42.9)	
3 (4+3)	1 (12.5)	3 (21.4)	
Tumor Percentage (%)	5.0±3.8 (1.0–9.3)	5.38±2.7 (3.0–7.5)	0.79
Adverse pathology	2 (25.0)	7 (50.0)	0.37[a]

Values are presented as number (%) or mean±standard deviation (interquartile range).
AS, active surveillance.
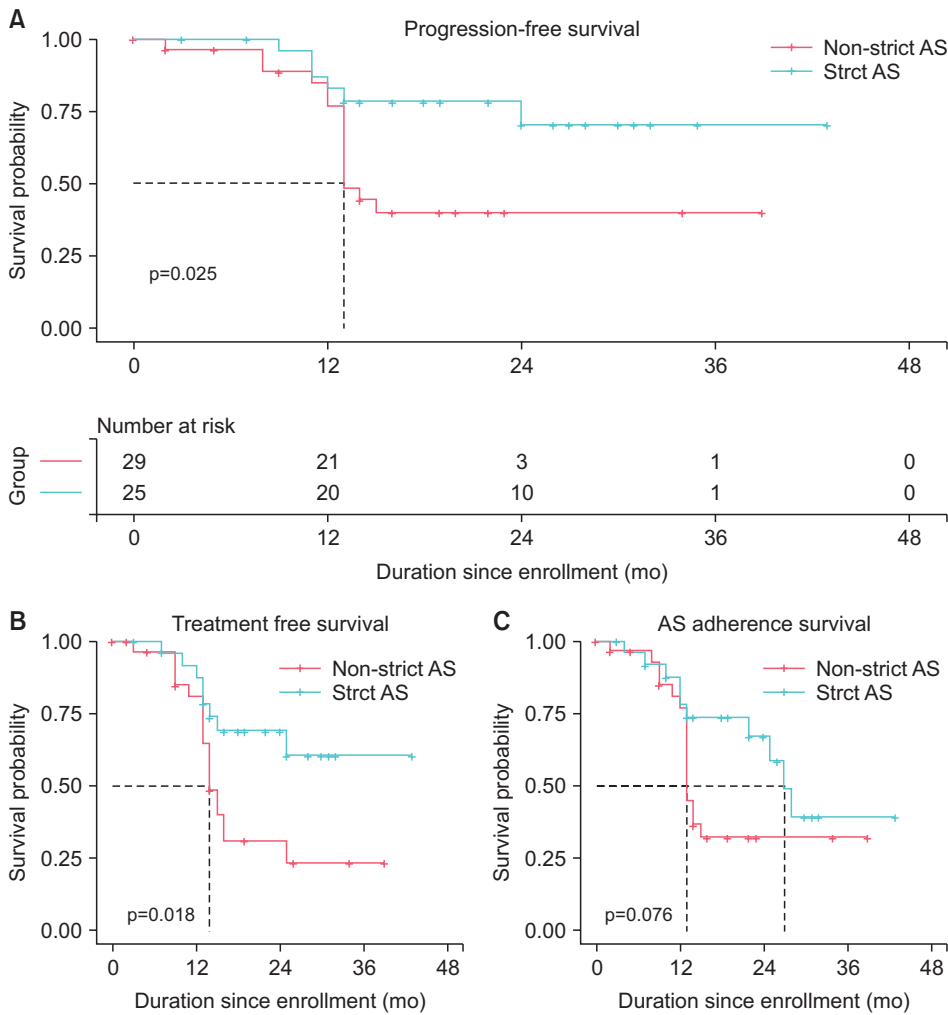[a]:Fisher's exact test.

Fig. 2. Follow-up result of "strict AS" and "non-strict AS". Kaplan–Meire curve and log-rank test for clinical or pathological progression free survival (A), treatment free survival (B) and AS adherence survival (C) to compare Strict AS and Non strict AS group. AS, active surveillance.

The TFS at 2-year follow-up in the PRIAS study was 77.3% [18] which was similar to that of the "strict AS" group (72.0% [18 of 25 patients]). TFS at 2-year follow-up in the "non-strict AS" group was 41.4% (12 of 29 patients; p=0.024) [16]. The TFS at 5-year follow-up in the Western AS cohort varies between studies, [15,16,18,19]; however, even in most liberal criteria from a Toronto group [16], TFS at 5 years was reported at 70%. Owing to the short follow-up period we were not able to assess the 5-year survival and the TFS at 2-year follow-up in the "non-strict AS" group which was already below those of the Western AS studies. Moreover, half of patients have adverse pathology on RP specimens in the "non-strict AS" group after conversion to definitive treatment. From these findings, we carefully considered the strict criteria of AS [13] is safer and more suitable for Korean populations.

Conversion to definitive treatment without clinical or pathologic evidence of progression is a major obstacle in AS. From most recent world-wide, multicenter study groups of Global Action Plan Prostate Cancer Active Surveillance initiative (GAP3), 12.8% of patients converted to active

treatment without evidence of disease progression during a 5-year follow-up period [29]. Numerous factors influence the patients or physicians decision to discontinue AS [30], including patients social or psychogenic support. From the PRIAS study, 26.5% of patients converted to active treatment without progression [18] with the most influential factor being anxiety of disease progression (8.9%). Similarly, 3 patients in both the "strict AS" (12.0% [3 of 25 patients]) and "non-strict AS" (10.3% [3 of 29 patients]) groups request for active treatment without evidence of progression. AS adherence survival at 3-year follow-up for "strict AS" (60.0% [15 of 25 patients]) decreased from AS adherence at 2-year follow-up (72.0% [18 of 25 patients]), with no changes to the "non-strict AS" group (Fig. 2C). This could be a result of the patients dropping out and visiting another hospital for a second opinion or just a delayed visit to the clinic. Owing to the relatively short follow-up periods, we require long-term analysis and emotional support for the patients during the process of AS for reducing anxiety of deferred treatment.

In this study, we analyzed only 54 patients who under-

went AS and mean follow-up period was 20 months. This is too small number in study population and short follow-up period to determine definitive conclusion of clinical impact of "strict AS" on PFS in Korean population, although we obtained statistical significance from this study. This prospective cohort designed with more than 10-year follow-up available, and we founded the potential benefit of "strict AS" in this early report. Moreover, the patients in the two groups were well matched and there was good compliance of the follow-up biopsy protocol gave strength of this study results. We need long-term follow-up analysis from this cohort in the future to confirm the benefit of "strict AS" in Korean population. The single center nature of this study is another limitation of this study. However, using predefined, well designed follow-up protocol and participate highly trained uro-oncologists covered clinical practitioner's preference related issue on decision making. Despite these limitations, this study successfully demonstrated the clinical impact of strict criteria for AS on Korean population in prospective cohort. Despite the cumulating clinical evidence suggesting the need for suitable selection criteria for Asian populations that cover racial differences, only a limited number of studies have focused on this issue. This study result may give an insight of the selection criteria suitable for other Asian populations.

CONCLUSIONS

The strict criteria of AS gave a 0.36 risk reduction in patients in this study after adjusting for age. Owing to short follow-up period and small study size, we carefully concluded that the "strict AS" group showed better PFS and TFS than the "non-strict AS" group for Korean population. This finding should be informed to relevant patients during decision making and considered in Korean guidelines. For getting concrete conclusion, we need long term follow-up and multicenter study for setting up optimize protocol of AS in Korean population.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHORS' CONTRIBUTIONS

Research conception and design: Chang Wook Jeong. Data acquisition: Jungyo Suh and Hyeong Dong Yuk. Statistical analysis: Jungyo Suh. Data analysis and interpretation: Jungyo Suh. Drafting of the manuscript: Jungyo Suh. Critical revision of the manuscript: Minyong Kang, Bum Sik Tae, Ja Hyeon Ku, Hyeon Hoe Kim, and Cheol Kwak. Obtaining funding: Chang Wook Jeong. Administrative, technical, or material support: Chang Wook Jeong. Supervision: Minyong Kang, Bum Sik Tae, Ja Hyeon Ku, Hyeon Hoe Kim, Cheol Kwak, and Chang Wook Jeong. Approval of the final manuscript: all authors.

SUPPLEMENTARY MATERIAL

Supplementary material can be found via https://doi.org/10.4111/icu.20200504.

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