

# Predictors of prostate volume reduction following neoadjuvant cytoreductive androgen suppression

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## Abstract

**Purpose:** Limited duration cytoreductive neoadjuvant hormonal therapy (NHT) is used prior to definitive radiotherapeutic management of prostate cancer to decrease prostate volume. The purpose of this study is to examine the effect of NHT on prostate volume before permanent prostate brachytherapy (PPB), and determine associated predictive factors.

**Material and methods:** Between June 1998 and April 2012, a total of 1,110 patients underwent PPB and 207 patients underwent NHT. Of these, 189 (91.3%) underwent detailed planimetric transrectal ultrasound before and after NHT prior to PPB. Regression analysis was used to assess predictors of absolute and percentage change in prostate volume after NHT.

**Results:** The median duration of NHT was 4.9 months with inter quartile range (IQR), 4.2-6.6 months. Prostate-specific antigen (PSA) reduced by a median of 97% following NHT. The mean prostate volume before NHT was  $62.5 \pm 22.1 \text{ cm}^3$  (IQR: 46-76  $\text{cm}^3$ ), and after NHT, it was  $37.0 \pm 14.5 \text{ cm}^3$  (IQR: 29-47  $\text{cm}^3$ ). The mean prostate volume reduction was 23.4  $\text{cm}^3$  (35.9%). Absolute prostate volume reduction was positively correlated with initial volume and inversely correlated with T-stage, Gleason score, and NCCN risk group. In multivariate regression analyses, initial prostate volume ( $p < 0.001$ ) remained as a significant predictor of absolute and percent prostate volume reduction. Total androgen suppression was associated with greater percent prostate volume reduction than luteinizing hormone releasing hormone agonist (LHRHa) alone ( $p = 0.001$ ).

**Conclusions:** Prostate volume decreased by approximately one third after 4.9 months of NHT, with total androgen suppression found to be more efficacious in maximizing cytoreduction than LHRHa alone. Initial prostate volume is the greatest predictor for prostate volume reduction.

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**Key words:** brachytherapy, neoadjuvant hormonal therapy, prostate cancer, volume.

## Purpose

Permanent prostate brachytherapy (PPB) is a common treatment for early-stage prostate cancer with over 250,000 patients undergoing the procedure in the U.S. since the late 1990's [1]. Limited duration neoadjuvant hormonal therapy (NHT) is often used before PPB to decrease prostate volume, help avoid pubic arch interference during seed placement, and to decrease urinary obstructive symptoms [2,3,4,5]. Stone *et al.* has concluded that NHT may have its greatest benefit in urinary obstructive symptoms in men with a prostate size greater than 50  $\text{cm}^3$ , and in International Prostate Symptom Score (IPSS) of 15 or greater [3]. Other patients also receive NHT due to intermediate- or high-risk features, similar to approaches validated in external beam radiotherapy (EBRT) [4]. Some studies have also demonstrated a de-

crease in neighboring organ toxicity from radiotherapy in patients first treated with NHT versus those not treated with NHT [6,7]. While NHT has many potential therapeutic advantages, identifying patients who are appropriate candidates for NHT remains a subject of interest, as its use must be balanced with the potential acute and late side effects of hormonal therapy.

Neoadjuvant hormonal therapy has been shown to decrease prostate size by 10.8-54.0% before definitive management, and the extent of downsizing is related to the duration of NHT [3,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27]. A randomized trial by Gleave *et al.* found a decrease of 37% in transrectal ultrasound (TRUS)-determined prostate volume when three months of NHT were given, versus 45% when eight months of NHT were given before prostatectomy [8]. Studies have demonstrated

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an advantage with using total androgen suppression (TAS) with a combination of luteinizing hormone releasing hormone agonist (LHRHa) and antiandrogen compared to LHRHa alone [15]. Similarly, studies have demonstrated an advantage of LHRHa over antiandrogen alone [11,17]. However, no published studies have examined differences between medications within classes or the predictive ability of pre-treatment variables, such as, T-stage, Gleason score, pre-treatment prostate specific antigen (PSA), and National Comprehensive Cancer Network (NCCN) risk stratification in regard to prostate volume reduction following NHT. The goals of this study are to examine the degree of pre-PPB prostate size

reduction after NHT, and the influence of pre-treatment variables on the magnitude of prostate volume reduction.

## Material and methods

Between June 1998 and April 2012, a total of 1,110 consecutive patients with early-stage prostate cancer were treated by PPB at our institution and provided research authorization. Of these patients, 207 patients received NHT and 189 (91.3%) underwent TRUS before and after NHT. All patients received an LHRHa. Patients were treated with NHT for one or more reasons: 1) to decrease prostate size in order to minimize pubic arch interference; 2) to decrease prostate size in order to decrease patient's urinary obstructive symptoms, so that they may be more appropriate PPB candidates; and/or 3) to enhance treatment efficacy in patients with intermediate or high risk features. Of the 207 patients receiving LHRH agonists, 194 patients (93.2%) received leuprolide, while 13 (6.8%) received goserelin. Ninety-two (44.4%) patients received TAS, while 115 (56.6%) received LHRHa alone. A total of 52.2% of patients receiving LHRH antagonist alone received short course bicalutamide for coverage of possible testosterone flare. Of these patients, the median duration of bicalutamide was 10 days, and mean was 13.8 days (range, 7-30 days). Baseline characteristics of all patients in the population including age, presenting clinical stage, presenting PSA value, and Gleason score were available for analysis.

Detailed measurements of prostate volume were performed by TRUS before and after NHT. One of six experienced ultrasonographers manually contoured the prostate gland as it appeared on each TRUS axial image at 5 mm increments using a TRUS probe holder, stepper and stabilization device (Barzell-Whitmore, Sarasota, FL, USA) used for PPB. Prostate volume, in cubic centimeters (cm<sup>3</sup>), was determined, using both a three-dimensional manual planimetry method and a conventional prolate spheroid measurement, as they are considered to be the most accurate measurements of prostate volume [28,29].

Mean prostate volume and PSA comparisons before and after NHT were made with matched pair's *t*-tests. Differences in mean volume reductions and PSA changes between treatment groups were compared using Student's *t*-test. Bivariate and multivariable association between absolute and percentage prostate volume reduction and pre-treatment variables were made using linear regression analysis. Results were reported as unstandardized multivariate regression coefficients and the associated standard errors. All statistical analysis was performed using JMP version 10.0, and SAS version 9.3. A *p*-value < 0.05 was considered significant.

## Results

The patients' demographics are provided in Table 1. The median age at the time of NHT was 70 ± 5.9 years (range: 55-86 years). The majority of patients were diagnosed with low-risk features, T1c/T2a (91.8%), Gleason score 6 (67.2%), and with pre-treatment PSA of less than 10 ng/ml (74.6%). Patients treated with goserelin as compared to leuprolide were diagnosed with more

**Table 1.** Characteristics of 189 neoadjuvant hormonal therapy patients treated with brachytherapy

Factors	Patients, No.
Age, years	
Mean ± SD (range)	70 ± 5.9 (55-86)
Clinical stage	
T1c	120 (65.6%)
T2a	48 (26.2%)
T2b	8 (4.4%)
T2c	4 (2.2%)
T3a	2 (1.1%)
T3b	1 (0.5%)
n/a	6
Gleason score	
5	3 (1.6%)
6	127 (67.2%)
7	53 (28.0%)
8	6 (3.2%)
Pre-NHT PSA group	
< 10 ng/ml	141 (74.6%)
10-20 ng/ml	45 (23.8%)
≥ 20 ng/ml	3 (1.6%)
NCCN risk stratification	
Low	92 (50.3%)
Intermediate	81 (44.3%)
High	10 (5.5%)
n/a	6
Duration NHT, months	
Median (IQR)	4.9 (4.2, 6.6)

NHT – neoadjuvant hormonal therapy, PSA – prostate specific antigen, NCCN – National Comprehensive Cancer Network, IQR – interquartile range, SD – standard deviation

**Table 2.** Prostate volume and prostate specific antigen measurements before and after neoadjuvant hormonal therapy

End-point	Pre-NHT	Post-NHT	Absolute reduction	Percent reduction
Prostate volume (cm <sup>3</sup> )				
<i>n</i>	189	189	189	189
Median (IQR)	63 (46-76)	37 (29-47)	23 (12-32)	38% (27-45%)
Mean ± SD	63 ± 22	39 ± 14	23 ± 13	36 ± 13%
PSA (ng/ml)				
<i>n</i>	189	179	179	179
Median (IQR)	6.5 (4.9-10.1)	0.17 (0.11-0.5)	6.2 (4.6-9.6)	97% (91-98%)
Mean ± SD	7.9 ± 5.2	0.44 ± 0.63	7.5 ± 5.2	94 ± 8%

NHT – neoadjuvant hormonal therapy, PSA – prostate specific antigen, IQR – interquartile range, SD – standard deviation

advanced T-stage ( $p = 0.049$ ). Patients treated with TAS as compared to LHRHa alone were diagnosed with less advanced T-stage ( $p < 0.0001$ ), lower NCCN risk stratification ( $p = 0.0003$ ), and larger pre-NHT prostate volume with means of 70.4 cm<sup>3</sup> and 53.5 cm<sup>3</sup> ( $p < 0.0001$ ). Other patient characteristics were not significantly different between the subgroup of patients treated with leuprolide versus goserelin or TAS versus LHRHa alone, including age, Gleason score, and pre-treatment PSA.

The median duration of NHT was 4.9 months (range: 0.77-23.77 months). Most patients (97.4%) received at least 3 months of NHT; 81.0% received at least 4 months. Those treated with leuprolide had a median treatment duration of 5.0 months (range: 0.77-23.77 months) while those treated with goserelin had a median duration of 4.4 months (range, 3.43-8.5 months). Student’s *t*-test demonstrated a difference between the mean duration between these groups with  $p = 0.03$ .

The mean TRUS-determined prostate volume before NHT was 62.5 ± 22.1 cm<sup>3</sup> (IQR: 46-76 cm<sup>3</sup>) and after NHT, it was 39.0 ± 14.0 cm<sup>3</sup> (IQR: 29-47 cm<sup>3</sup>), resulting in a mean percent reduction of 35.9% (Table 2) with a maximum volume reduction of 63.1%. Figure 1 shows the distribution of prostate volumes before and after the start of NHT. Figure 2A demonstrates that the absolute volume change is strongly correlated ( $r = 0.77$ ,  $p < 0.001$ ) with the initial volume. In Figure 2B, the percentage volume reduction is shown.

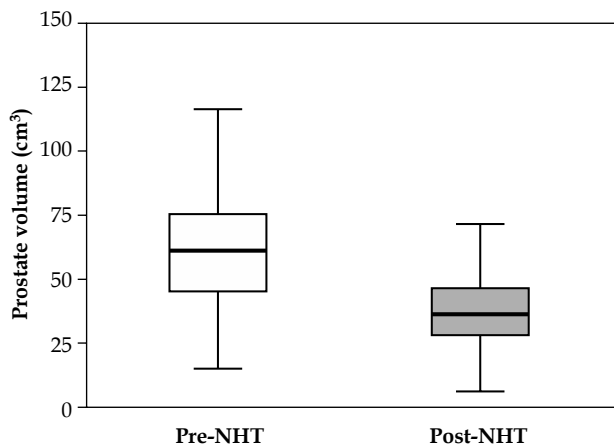
The median PSA before NHT was 6.5 ng/ml (IQR, 4.9-10.1 ng/ml), and after NHT it was 0.17 ng/ml (IQR, 0.11-0.5 ng/ml) (Table 2). This resulted in a mean percent PSA reduction of 93.7%. A total of 60 (31.7%) patients had PSA levels less than 0.15 ng/ml after NHT.

Absolute and percent prostate volume reductions were analyzed using bivariate and multivariate regression analysis (Table 3). Absolute prostate volume reduction was positively correlated with initial volume and inversely correlated with T-stage, Gleason score, and NCCN risk group. In multivariate regression analysis, only initial prostate volume ( $p < 0.001$ ) remained as a significant predictor of absolute volume reduction. Initial prostate volume and T-stage were predictive of percent

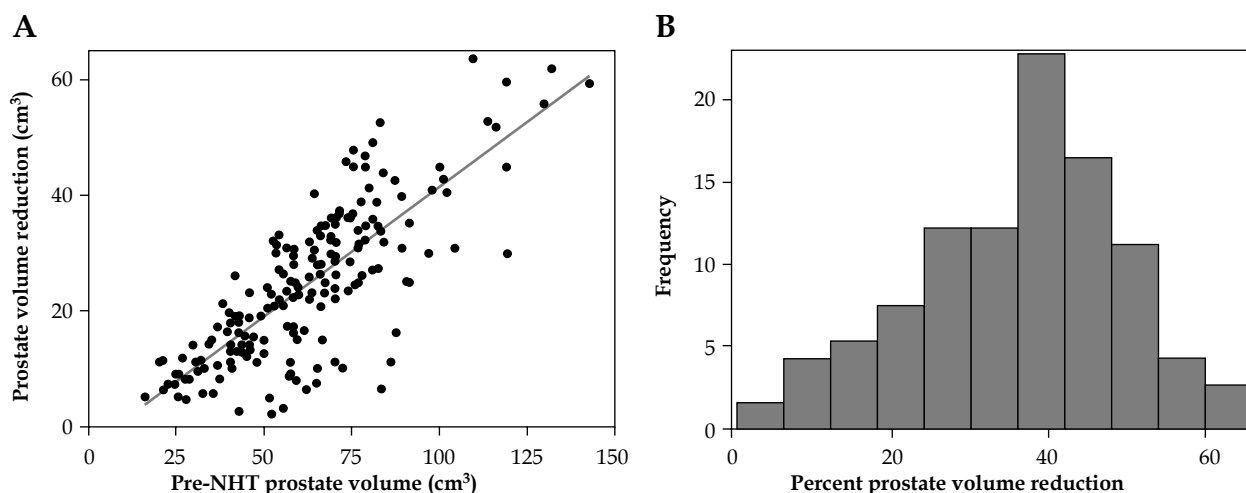
prostate volume reduction on univariate analysis, however, only initial prostate volume remained as significant on multivariate regression analysis.

The reduction in prostate volume and PSA after NHT was evaluated separately by type of LHRHa: leuprolide ( $n = 177$ ) versus goserelin ( $n = 12$ ), and total androgen suppression ( $n = 92$ ) versus LHRHa alone ( $n = 97$ ). The pre-treatment prostate volumes for the leuprolide versus goserelin comparison were not significantly different ( $p = 0.97$ ), however, there was a difference between those receiving TAS versus LHRHa alone ( $p < 0.001$ ) with a mean of 70.4 cm<sup>3</sup> and 53.5 cm<sup>3</sup>, respectively. The mean percent prostate volume reduction was 36.5% and 29.8% for the leuprolide and goserelin groups, respectively. Student’s *t*-test did not demonstrate a significant difference between means of both groups ( $p = 0.18$ ). Mean percent prostate volume reduction was 38.8% and 33.5% for the TAS and LHRHa alone groups, respectively ( $p = 0.001$ ).

The change in PSA after NHT was similarly examined as a function of type of androgen suppression. No significant difference was seen in pre-treatment PSA between those treated with leuprolide or goserelin ( $p = 0.06$ ), or between those treated with TAS compared to LHRHa



**Fig. 1.** Distribution of prostate volume before and after neoadjuvant hormonal therapy



**Fig. 2.** Change in prostate volume after neoadjuvant hormonal therapy. **A)** Scatter plot of absolute reduction vs. initial volume. **B)** Histogram of percentage reduction in prostate volume

alone ( $p = 0.20$ ). The mean percent PSA reduction was 93.8% and 91.8% for the leuprolide and goserelin groups, respectively. The mean percent PSA reduction was 95.5% and 91.4% for those treated with TAS and LHRHa alone, respectively. Student's  $t$ -test did not identify a difference between mean percent PSA reduction in those treated with leuprolide compared to goserelin ( $p = 0.36$ ). However,

there was a significant difference between those treated with TAS compared to LHRHa alone ( $p < 0.001$ ).

### Discussion

We have examined the use of cytoreductive NHT and associated predictive factors in a series of patients under-

**Table 3.** Regression analysis between pretreatment variables and treatment endpoints of absolute and percent prostate volume reduction

	Univariable		Multivariable	
	Beta (SE)	$p$ -value	Beta (SE)	$p$ -value
a. Y = absolute volume reduction, cm <sup>3</sup>				
Pre-NHT volume	0.48 (0.03)	< 0.001	0.48 (0.03)	< 0.0001
Age	0.07 (0.16)	0.68	0.06 (0.11)	0.55
Pre-NHT PSA	0.01 (0.19)	0.94	-0.12 (0.15)	0.45
T-stage*	-3.7 (1.1)	0.001	-0.8 (0.8)	0.34
Gleason score	-6.9 (1.7)	< 0.001	-0.7 (1.7)	0.70
NCCN risk group**	-4.5 (1.6)	0.006	2.2 (1.9)	0.24
Duration of NHT	-0.46 (0.35)	0.19	-0.16 (0.23)	0.50
b. Y = percent volume reduction, %				
Pre-NHT volume	0.002 (0.0004)	< 0.0001	0.002 (0.0004)	0.0003
Age	0.11 (0.16)	0.51	0.002 (0.002)	0.30
Pre-NHT PSA	-0.08 (0.19)	0.68	-0.002 (0.002)	0.38
T-stage*	-2.3 (1.1)	0.047	-0.015 (0.01)	0.23
Gleason score	-2.6 (1.7)	0.13	-0.01 (0.03)	0.74
NCCN risk group**	-1.8 (1.6)	0.26	0.02 (0.004)	0.42
Duration of NHT	-0.42 (0.3)	0.23	-0.003 (0.004)	0.35

NHT – neoadjuvant hormonal therapy, PSA – prostate specific antigen, NCCN – National Comprehensive Cancer Network, SE – standard error

\*Coded as: 1 = T1x, 2 = T2x, 3 = T3x; \*\*Coded as: 0 = low, 1 = int, 2 = high

\*Univariate Spearman correlation coefficients ( $p$ -value); \*\*Multivariate regression correlation coefficients ( $p$ -value); \*Statistical significance with  $p < 0.05$

going PPB. In a recent survey of brachytherapy practice by Buyyounouski *et al.*, it is confirmed that this is a common treatment approach; 63% of respondents reported using androgen deprivation in conjunction with PPB, with 72% of those employing NHT for purposes of cytoreduction [30]. In this survey, the majority of brachytherapists indicated they prescribe NHT for 3 or 4 months. In terms of prostate volume, the maximum volume that practitioners indicated they would implant was  $> 60 \text{ cm}^3$  in 25% of respondents, and  $> 100 \text{ cm}^3$  in 5%. Of note, a previous survey study published in 1998 by Prestidge *et al.*, only 9% of respondents indicated they would implant prostates larger than  $60 \text{ cm}^3$  [31].

While current American Brachytherapy Society guidelines indicate that a prostate size  $> 60 \text{ cm}^3$  is a relative contraindication to brachytherapy; in practice, few patients may be ruled out as candidates for PPB based on size criteria alone. If patients are willing to undergo NHT, then patients may experience sufficient prostate cytoreduction such that the prostate size decreases below  $60 \text{ cm}^3$ . In the present study, 53% of patients presented with a prostate size  $> 60 \text{ cm}^3$ , including one patient with a size of  $138 \text{ cm}^3$ . Following NHT, only 8% of patients had prostate size  $> 60 \text{ cm}^3$ , but were nonetheless still able to undergo PPB. Implantation of prostates greater than  $100 \text{ cm}^3$  is possible as described by Stone and Stock in a series of 34 patients [32]. In a report by Grado, a patient with prostate size of  $165 \text{ cm}^3$  underwent PPB [33].

In the series described here, prostate volume decreased by a mean of 35.9% when it was given for 4.9 months. The results given in Table 4 are consistent with those seen in previous studies regarding the degree of cytoreduction with NHT [3,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26]. The largest study to date randomized 547 patients to either three or eight months of NHT. This study found a volume reduction of 37% after three months and 45% after eight months [8]. Crook *et al.* reported similar findings in a randomized trial of 378 patients who received either three or eight months of NHT prior to EBRT; patients receiving three months of NHT had a 29.3% reduction while those receiving eight months had a 46.3% reduction [9,10]. Thus, based upon these studies [8,9,10], and the collective literature on this topic [3,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26], a useful estimate is that prostate volume decreases by approximately one third after 3-4 months of NHT in the majority of patients.

A significant decrease in prostate size after NHT was not found for all patients. Three patients had a negligible ( $< 4\%$ ) decrease. The factors that predict if a patient will have very little or no cytoreduction at present are unknown. This finding may in part be attributable to differences in TRUS operator technique, or interobserver variability in prostate segmentation by TRUS [34]. This finding is also consistent with previous studies that have demonstrated significant limitations in accuracy due to interobserver and intraobserver variability [35,36,37]. Zelefsky *et al.* reported that 2 of 22 patients had no prostate volume reduction after TAS [25]. All imaging modalities, including TRUS, are subject to inter- and intraobserver variability, which may account for a portion

of the absence of volume reduction after NHT [35,36,37,38,39,40].

Similarly, to other series, this study illustrated a significant reduction in PSA following NHT, with a mean reduction in PSA of 93.7%. In the comparison of three versus eight months of NHT by Gleave *et al.*, a PSA reduction of 98% was seen after three months of NHT [8]. Similarly, Crook *et al.* found a 97.3% reduction in PSA after three months, and a 98.5% reduction after 8 months [10]. The findings in this study did not reveal a significant difference in PSA reduction between those receiving leuprolide versus goserelin. However, there was a difference in those receiving TAS compared to LHRHa alone.

To date, few studies have evaluated NHT treatment effect in terms of prostate volume reduction as a function of pre-treatment variables of patient age, T-stage, Gleason score, pre-treatment PSA, or overall NCCN risk stratification. In the present study, T-stage, Gleason score, and NCCN risk group demonstrated an inverse correlation with absolute prostate volume reduction on univariate analysis of correlation. On multivariate regression analysis with adjustment for initial volume, none of these factors remained significant. Initial prostate volume and T-stage were the only significant predictors of percentage reduction in volume. Initial prostate volume was the only variable which remained significant on multivariate regression analysis. Our data confirms that the prognostic pre-treatment variables of Gleason score and clinical stage do not influence the degree of prostate gland regression with NHT. Other predictors of absolute volume reduction may be clinically useful in order to determine if NHT will result in a prostate volume  $< 60 \text{ cm}^3$  [2,6,7,22].

Some studies have suggested greater prostate volume reductions with the use of LHRHa versus antiandrogen alone. Stone *et al.* analyzed 299 patients treated with 3 months' total androgen suppression (251 patients) with LHRHa plus antiandrogen, LHRHa alone (41 patients), and antiandrogen alone (7 patients), and demonstrated prostate volume reductions of 32.8%, 27.6%, and 10.8%, respectively [11]. Henderson *et al.* identified a three-fold difference in patients treated with LHRHa versus antiandrogen, in favor of LHRHa [17]. Another subset analysis revealed that an LHRHa combined with antiandrogen resulted in larger prostate volume reduction than that of LHRHa alone (35% vs. 30%) [15]. This series was consistent with previous findings with prostate volume reductions of 38.8% and 33.5% in the TAS and LHRHa alone groups, respectively ( $p = 0.001$ ).

These data show that NHT with leuprolide or goserelin resulted in statistically indistinguishable volume reductions. However, a limitation of this finding is the small number of patients receiving goserelin ( $n = 12$ ). Another limitation is that the mean duration of NHT was different between the two groups, with patients receiving goserelin having a mean duration of therapy approximately one month shorter. As noted, other studies have compared three months vs. eight months, a sufficient time interval, in which to observe differences in the magnitude of cytoreduction.

This study has limitations, in that it was retrospective in nature and is subject to selection biases for ther-

**Table 4.** Summary of literature evaluating prostate volume reduction after neoadjuvant hormonal therapy

Study	No.	Volume reduction %	NHT type	NHT duration (months)	Imaging modality	Patient group	Comments
Present study	189	30.1	TAS, LHRHa	5.6	TRUS	Before PPB, or EBRT/PPB	T-stage and Gleason score inversely related to prostate reduction after NHT
Gleave <i>et al.</i> [8]	547	37-45	TAS	3-8	TRUS	Before PPB	Decreased positive margin rate with 8 months NHT
Crook <i>et al.</i> [9,10]	378	29.3-46.3	TAS	3-8	TRUS	Before EBRT	Improved 5-year disease-free survival in high-risk patients receiving 8 months NHT
Stone and Stock [11]	299	10.8-33.1	LHRHa, TAS, AA + 5AR	3	TRUS	Before PPB, or EBRT/PPB	NHT with LHRHa + AA was more successful at reducing prostate volume than LHRHa alone, or flutamide + finasteride
Mason <i>et al.</i> [12]	244	35.3-36.0	TAS or LHRHan	3	TRUS	Before EBRT	Degarelix was non-inferior to goserelin + bicalutamide in terms of prostate volume reduction
Stone <i>et al.</i> [3]	204	26	TAS or LHRHa	3	TRUS	Before PPB	NHT most beneficial for patients with large prostate and an IPSS $\geq$ 15
Ebara <i>et al.</i> [13]	188	18.1-41.2	LHRHa, AA alone, TAS	1-13+	TRUS	Before PPB	No added benefit for those treated greater than 3 months; TAS provided the greatest prostate volume reduction
Sanghani <i>et al.</i> [14]	152	30	TAS	2.0	MRI	Before EBRT	Measurements were taken of primary tumor volume; 14% primary tumors increased in volume
Kucway <i>et al.</i> [15]	107	33	TAS or LHRHa	3.7	TRUS	Before PPB	Larger prostate volume and duration of therapy associated with greater percent prostate volume reduction; TAS produced greater reductions than LHRHa alone
Stone and Stock [16]	106	35	TAS	3	TRUS	Before PPB	-
Henderson <i>et al.</i> [17]	81	8-26	LHRHa alone or AA	3+	TRUS	Before PPB	Goserelin produced greater prostate volume reductions than bicalutamide alone
Solhjem <i>et al.</i> [18]	78	34	TAS or LHRHa	4	TRUS	Before PPB	-
Kang <i>et al.</i> [19]	55	38	LHRHa	3+	TRUS	Before PPB	-
Whittington <i>et al.</i> [20]	54	33	LHRHa alone	3+	TRUS	Before PPB	-
Pu <i>et al.</i> [21]	44	35.4-39.6	-	3-8	TRUS	Before LRP	Surgical positive margin rate was lower in those receiving NHT vs. those in the adjuvant setting
Merrick <i>et al.</i> [22]	31	33.6	AA + 5AR	3	TRUS	Before PPB	Pretreatment prostate volume associated with absolute prostate volume change; Gleason score and higher body mass index were predictive of percent prostate volume change
Samper <i>et al.</i> [23]	28	24	TAS	2	TRUS	Before EBRT	NHT can significantly reduce the $V_{60}$ for the rectum and bladder
Shearer <i>et al.</i> [24]	22	54	LHRHa alone	2-4	TRUS	T3, T4 before EBRT	-
Zelefsky <i>et al.</i> [25]	22	25	TAS	3	CT (DVHs)	Bulky before EBRT	-
Langenhuijsen <i>et al.</i> [26]	20	31-37	TAS	9	CT	Before EBRT	Optimal duration of NHT was 6 months

NHT – neoadjuvant hormonal therapy, TAS – total androgen suppression, LHRHa – luteinizing hormone releasing hormone agonist, LHRHan – luteinizing hormone releasing hormone antagonist, AA – antiandrogen, 5AR – 5-alpha reductase inhibitor, TRUS – transrectal ultrasound, PPB – permanent prostate brachytherapy, EBRT – external beam radiotherapy, LRP – laparoscopic radical prostatectomy,  $V_{60}$  – volume of organ receiving 60 Gy or higher



apy. While this study is larger than many similar studies (range 20-547), the cohort size included less than 200 patients, and the comparison between leuprolide and goserelin is statistically limited with 12 patients having received goserelin. The homogeneity of the patient cohort, with the majority having low-risk disease, may limit the capacity of this data set to identify any associations between pre-treatment variables and the degree of prostate gland downsizing. Additionally, inter- and intra-observer variability in prostate volume determination may have also affected this study, however, it is noted that the ultrasonographers involved in the study were dedicated and had additional training relative to prostate ultrasonography.

## Conclusions

Neoadjuvant hormonal therapy remains a useful tool in managing patients with enlarged prostates who are otherwise suitable candidates for permanent prostate brachytherapy. In this series, prostate volume decreased by approximately one third after 4.9 months of NHT with a maximum reduction of 63% observed. Initial prostate volume is the greatest predictor of prostate volume reduction following NHT.

## Disclosure

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