

UCSF

UC San Francisco Previously Published Works

Title

Immediate versus deferred initiation of androgen deprivation therapy in prostate cancer patients with PSA-only relapse. An observational follow-up study.

Permalink

<https://escholarship.org/uc/item/1fb075k1>

Journal

European journal of cancer (Oxford, England : 1990), 51(7)

ISSN

0959-8049

Authors

Garcia-Albeniz, X
Chan, JM
Paciorek, A
[et al.](#)

Publication Date

2015-05-01

DOI

10.1016/j.ejca.2015.03.003

Peer reviewed



HHS Public Access

Author manuscript

Eur J Cancer. Author manuscript; available in PMC 2016 May 01.

Published in final edited form as:

Eur J Cancer. 2015 May ; 51(7): 817–824. doi:10.1016/j.ejca.2015.03.003.

Immediate vs. deferred initiation of androgen deprivation therapy in prostate cancer patients with PSA-only relapse. An observational follow-up study

X. Garcia-Albeniz,

Department of Epidemiology. Harvard T.H. Chan School of Public Health. Boston, MA

J. M. Chan,

Departments of Epidemiology and Biostatistics. University of California, San Francisco. San Francisco, CA

Department of Urology. University of California, San Francisco. San Francisco, CA

A. Paciorek,

Departments of Epidemiology and Biostatistics. University of California, San Francisco. San Francisco, CA

R. W. Logan,

Department of Epidemiology. Harvard T.H. Chan School of Public Health. Boston, MA

S. A. Kenfield,

Department of Urology. University of California, San Francisco. San Francisco, CA

M. R. Cooperberg,

Departments of Epidemiology and Biostatistics. University of California, San Francisco. San Francisco, CA

Department of Urology. University of California, San Francisco. San Francisco, CA

P. R. Carroll, and

Department of Urology. University of California, San Francisco. San Francisco, CA

M. A Hernán

Departments of Epidemiology and Biostatistics. Harvard T.H. Chan School of Public Health. Boston, MA; Harvard-MIT Division of Health Sciences and Technology, Boston, MA

Abstract

© 2015 Published by Elsevier Ltd.

Correspondence: Xabier Garcia-Albeniz., Department of Epidemiology, Harvard T.H. Chan School of Public Health 677 Huntington Ave. Boston, MA 02115. xabi@post.harvard.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conflict of interest statement: there are no conflicts to disclose.

Background—The optimal timing to start androgen deprivation therapy (ADT) in prostate cancer patients with rising PSA as the only sign of relapse is unknown.

Methods—We identified men with prostate cancer in the Cancer of the Prostate Strategic Urologic Research Endeavor (CaPSURE) study who would have been eligible (cT3aN0M0, primary radical prostatectomy or radiotherapy, PSA relapse as the only evidence of recurrence) for a randomized trial comparing “immediate” versus “deferred” ADT initiation. We emulated such trial by assigning patients to the “immediate” strategy if they initiated ADT within 3 months of PSA relapse and to the “deferred” strategy if they initiated ADT when they presented with metastasis, symptoms or a short PSA doubling time. We censored patients when they deviated from the assigned strategy and adjusted for this censoring via inverse probability weighting.

Results—Of 2096 eligible patients (median age 69, interquartile range 63 to 75 years), 88% were white, 35% had a Gleason score ≥ 7 , 69% were treated with radical prostatectomy and 31% received radiotherapy only as primary treatment. The mean time from primary treatment to PSA relapse was 37.4 (standard deviation [SD] 34.2) months. Mean follow-up from primary treatment was 91.4 (SD 48.4) months. The adjusted mortality hazard ratio for immediate vs. deferred ADT was 0.91 (95% CI, 0.52 to 1.60), which would be translated into a similar 5-year survival (difference between groups: -2.0% (95% CI: -10.0% to 5.9%)).

Conclusion—Our analysis suggests that prostate cancer patients undergoing immediate ADT initiation within three months after PSA-only relapse had similar survival to those who deferred ADT initiation within 3 months after clinical progression.

Keywords

androgen deprivation therapy; prostate cancer; PSA relapse

Introduction

Androgen deprivation therapy (ADT) is the first line of therapy for advanced prostate cancer [1]. However, the optimal timing to administer ADT is unknown in patients diagnosed with localized disease and treated with curative intention that later present a PSA-only relapse (no symptoms, no detectable metastasis)[2]. Specifically, there are no published randomized trials of immediate versus deferred ADT initiation in this subset of patients [3]. The American Society of Clinical Oncology guidelines state that “the Panel cannot make a strong recommendation for the early use of ADT”, and that “the critical issue is to determine whether there is benefit and how large it is for starting ADT while patients are asymptomatic” [4].

Randomized controlled trials have shown that castration of asymptomatic patients not suitable for curative treatment resulted in longer time to disease progression [5,6] and lower prostate cancer mortality [4,7] as compared with castration at symptom onset. On the other hand, deferring ADT until overt progression (metastases or symptoms) may preserve quality of life [6,8,9] and cognitive function [10] for a longer period.

An intermediate strategy for patients with PSA-only relapse would be to use PSA levels and clinical events to decide the timing of ADT initiation. The National Comprehensive Cancer

Network considers asymptomatic patients with rising PSA level as a “therapeutic dilemma regarding the role of ADT” [11]. Given the strong association of PSA dynamics (i.e. PSA doubling time) with disease progression and prognosis [12–14], PSA evolution and clinical events-based initiation may provide the optimal balance between deferring ADT for patients who do not need it and starting ADT immediately in patients with an aggressive disease. Results from an ongoing phase III clinical trial that uses PSA and clinical events-based ADT initiation are not yet available [ClinicalTrials.gov identifier: NCT00110162].

Here we used observational data from a prospective study to emulate this trial. Because, PSA was both a time-varying confounder (it affects timing of treatment, it is associated with survival through biological aggressiveness of the tumor and other unmeasured variables) and was itself affected by prior therapy, we used statistical methods designed to appropriately adjust for time-varying confounders that are affected by prior treatment. [15,16]) Our goal was to provide a preliminary answer to the question “when to start ADT therapy in PSA-only relapsed patients”.

Methods

Study population

CaPSURE is a prostate cancer registry study of over 14,000 men with biopsy-proven prostate adenocarcinoma enrolled consecutively from over 45 community-based clinics, 3 academic institutions and 3 Veterans Administration hospitals since 1995 [17]. Urologists ascertain clinical data at baseline and subsequent clinic visits. Baseline recorded variables include results of biopsy of the prostate and clinical TNM staging, complete pathology report of the surgical specimen, medical history and demographic characteristics. In addition, time-varying information is recorded at clinical visits (current disease stage, clinic procedures performed, new diagnoses, laboratory and imaging tests, signs and symptoms, Karnofsky functional status, and international prostate symptom score), hospital admissions (diagnosis and procedures) and with patient-directed questionnaires specifically designed to record information on health-related quality of life [18]. Additional details about CaPSURE have been previously reported [19].

Following the design of trial NCT00110162, our study was restricted to patients with cT3a, N0, M0, who had primary treatment with either radical prostatectomy or radiotherapy (external beam radiotherapy or brachytherapy) and a subsequent PSA relapse, defined as a PSA determination ≥ 0.2 ng/mL if the primary treatment was radical prostatectomy, or three rising levels one month apart if the primary treatment was radiation-based as the only sign of relapse. Patients fulfilling these criteria in the first postoperative assessment were included. We excluded patients with relapse diagnosed via CT scan, bone scan, pelvic MRI or symptoms (fatigue, bone pain, weight loss, anorexia, abdominal pain) at the time of PSA relapse. We also excluded patients with an orchiectomy before PSA relapse and patients who had received ADT in the 12 months before PSA relapse.

The outcome of primary interest was all-cause mortality. We also studied prostate cancer-specific mortality. CaPSURE obtains mortality information from the Bureau of Vital Statistics or National Death Index to verify the date and primary cause of death. Follow-up

started at the time of PSA relapse and finished at the time of death or 12 months after the most recent contact with the study (i.e. questionnaire, physician reporting patient withdrawal from the study, PSA determination, clinical visit, or treatment change).

ADT initiation strategies

Similarly to the trial NCT00110162, we compared two dynamic PSA-based strategies: ADT initiation at PSA relapse (immediate initiation) and ADT initiation at disease progression (deferred initiation). ADT was defined as the use of any LHRH-agonist or orchiectomy and progression as cancer relapse based on any imaging technique, severe cancer-related symptoms (fatigue, bone pain, weight loss or anorexia), a PSA doubling time <12 months for PSA ≥ 10 ng/mL, or PSA doubling time ≤ 6 months based on 3 consecutive measurements obtained ≥ 2 months apart. For our analysis, we considered strategies under which ADT initiation occurred uniformly [20] during a 3-month grace period. Local relapses candidate to rescue radiotherapy were allowed to be treated with radiotherapy (i.e., they do not influence the ADT initiation strategies under study).

The “deferred initiation” strategy of the trial NCT00110162 was ADT initiation at disease progression or more than 2 years after PSA relapse regardless of progression. We implemented this strategy as a secondary analysis for direct comparability with the trial. See Table 1 and the Appendix for a description of the protocol of trial NCT00110162 (information extracted from www.clinicaltrials.gov on March 1st 2014). Table 1 also summarizes how we used the observational data to emulate the trial protocol.

Statistical analysis

Patients were assigned to the initiation strategy (immediate or deferred ADT) that was consistent with their observed data at PSA relapse (baseline). We then estimated the mortality hazard ratio for “immediate ADT” vs. “deferred ADT” via a weighted (see below) pooled logistic model that included the indicator for strategy, a flexible function of time (restricted cubic splines to estimate the baseline hazard) and the following baseline covariates: Gleason score, percentage of positive biopsies at diagnosis, T-stage, type of primary treatment (radical prostatectomy +/- radiotherapy vs. radiotherapy-only based treatment), time from primary treatment to PSA relapse, calendar year of PSA relapse, and age. We calculated robust standard errors to compute conservative 95% confidence intervals for the hazard ratio estimate.

Patients who did not start ADT immediately at baseline could be assigned to either strategy. For example, a patient who did not progress and did not initiate ADT at month 2 had data consistent with both the “immediate ADT” strategy (which allows for a 3-month grace period), and with the “deferred ADT” strategy. We therefore created an exact copy of the data of these patients, assigned each copy to one of the strategies, and censored the copy assigned to one strategy when data stopped being consistent with that strategy [20]. To adjust for the potential selection bias due to censoring [21,22] we used inverse probability weighting. Informally, the denominator of the weights is each subject’s time-varying probability of having his own ADT history conditional on the previously listed baseline

covariates and the time-varying covariates PSA, Karnofsky functional status, fatigue, and bone pain.

These time-varying prognostic factors can influence the decision to initiate ADT (i.e., they are time-varying confounders) and are affected by ADT initiation. PSA doubling time, which may also influence the decision to initiate ADT [12–14], is implicitly adjusted for because both baseline PSA and time-varying PSA are included in the model.

We then stabilized the weights to emulate a uniform ADT initiation during the grace period [20]. Like previous applications of inverse probability weighting to compare dynamic strategies [23–25], we truncated them at percentile 99 to avoid undue influence of outliers. As a sensitivity analysis we repeated the analyses censoring patients at 24 months (as opposed to 12 months) after last contact.

To estimate survival probabilities under both strategies, we fit a weighted outcome model like the one described above that also included product (“interaction”) terms for strategy and time variables. The model’s predicted values were then used to estimate the 10-year predicted probability of survival from the moment when patients fulfilled the inclusion criteria until death. We used a non-parametric bootstrap based on 1000 resamplings to compute 95% CIs.

All analyses were conducted with SAS, version 9.3 (SAS Institute, Cary, North Carolina). The institutional review boards at University of California, San Francisco and Harvard School of Public Health approved our research.

Results

Of 9,344 patients staged cT3aN0M0 with PSA determinations and imaging tests after primary treatment, 5,351 underwent radical prostatectomy (with or without additional external beam radiotherapy) and 2,368 received external beam radiotherapy and/or brachytherapy as their primary treatment. Of these, 2,096 patients who never underwent orchiectomy (1,437 treated primarily with radical prostatectomy) were eligible for our analysis. See Figure 1 for a detailed flowchart that shows patients assigned to each strategy, including those initially assigned to both. Table 2 shows the baseline characteristics of the eligible patients. Mean age was 68.7 (standard deviation [SD] 8.4) years and mean time since primary treatment to PSA relapse was 37.4 (SD 34.2) months. The biopsy Gleason score was 7 in 34.8% of patients.

Mean follow-up after primary treatment and after PSA-only relapse was 91.4 (SD 48.4) months and 54.0 (SD 38.6) months respectively. Progression occurred in 337 patients: 86 developed symptoms, 226 had progression detected via imaging techniques and 92 had short PSA doubling time. Mean time from PSA relapse to progression was 35.8 months (SD 35.3). Four hundred and seventy three patients initiated ADT during the follow-up, 13 in the form of orchiectomy as the first ADT. One hundred and eighty patients received rescue radiotherapy and 53 of them are treated with ADT at some point afterwards.

At baseline 2,096 patients were assigned to the “immediate ADT” strategy and 2,058 to the “deferred ADT” strategy. As described in the Methods section, 38 patients contributed only to the “immediate ADT” strategy because they initiated ADT at PSA relapse; all other patients contributed to both strategies for at least one month of follow-up.

All-cause mortality

Of 161 total deaths during the follow-up, six occurred during months assigned to both strategies and are thus counted under both strategies. Of those assigned to the deferred ADT strategy, 117 (5.7%) died before documented progression and without initiating ADT (six of these were considered deaths secondary to prostate cancer).

The mortality HR for “immediate ADT” vs. “deferred ADT” was 0.91 (95% CI: 0.52 to 1.60) (table 3). The corresponding estimated 5-year survival (95% CI) was 85.7% (77.7 % to 93.7%) under the immediate ADT strategy and 87.7% (84.8% to 90.6%) under the deferred ADT strategy (Figure 2). The 5-year survival difference was -2.0% (95% CI: -10.0 % to 5.9%). The 10-year estimated survival (95% CI) was 69.8.1% (54.5% to 85.1%) under the immediate ADT strategy and 69.3% (60.7% to 77.9%) under the deferred ADT strategy. The 10-year survival difference was 0.5% (95% CI: -16.7% to 17.6%).

Prostate cancer-specific mortality

There were few prostate cancer specific deaths, 15 under the immediate ADT strategy and 18 under the deferred ADT strategy. Two deaths occurred during months assigned to both strategies and are thus counted under both strategies. The HR of prostate cancer mortality was 1.09 (95% CI 0.31-3.78) for immediate versus deferred ADT (table 3). The estimated 5-year prostate cancer-specific survival (95% CI) was 92.8% (86.7% to 98.9%) under the immediate ADT strategy and 95.8% (92.7% to 98.9%) under the deferred ADT strategy (Figure 2). The 5-year survival difference was -3.0% (95% CI: -8.7 to 2.7). The corresponding 10-year estimated survival (95% CI) was 83.1% (71.8% to 94.4%) under the immediate ADT strategy and 84.5% (76.6% to 92.3%) under the deferred ADT strategy. The 10-year survival difference (95% CI) was -1.3 (-14.6% to 11.9%).

Results did not materially change in sensitivity analyses that censored patients 24 months after the most recent contact (Supplemental Table 1), that employed the same deferred strategy as trial NCT00110162 (Supplemental Table 2) and that employed the “Phoenix” definition for biochemical relapse (a rise by 2 ng/mL above the nadir PSA after radiation therapy [26], Supplemental Table 3).

Discussion

Our study suggests little or no survival benefit of immediate ADT initiation compared with deferred ADT initiation (at clinical progression) among prostate cancer patients with PSA-only relapse. No survival comparisons between ADT initiation strategies guided by PSA and clinical events have been previously reported for patients with biochemical-only relapse. Therefore our study provides at least a first approximation to answer the “when to start ADT” question in these patients.

Two randomized trials have compared immediate versus deferred ADT in other types of prostate cancer patients. The EORTC 30891 trial [6,27] compared deferred ADT at symptomatic progression versus immediate ADT (either orchiectomy or LHRH-agonist) in 985 patients not eligible for curative treatment. This trial found a 21% increased mortality (95% CI: 5% to 39%) and no differences in prostate cancer mortality (HR 1.05, 95% CI 0.83-1.33). About 26% of trial participants assigned to deferred initiation died without fulfilling criteria to start ADT, and only 55% of those who started ADT did so according to the protocol. The MRC PR03 trial [28] compared immediate versus deferred ADT initiation at clinical indication for treatment (criteria for “clinical indication” left to the treating physician) in 938 patients with locally advanced or asymptomatic metastatic prostate cancer. This trial found lower prostate cancer mortality, but not lower overall mortality, in the immediate treatment arm [7].

An observational study compared early versus late ADT initiation in patients with PSA-only relapse using observational data from the Department of Defense Center for Prostate Disease Research Database [29]. This study did not find a lower metastasis-free survival (overall survival was not evaluated) for early ADT, but the study results are hard to interpret because the analysis (i) was based on “prevalent” users rather than “incident” users, which may result in selection bias [30], and (ii) adjusted for PSA using standard regression, which may introduce bias because PSA is a time-varying confounder. Standard regression may not appropriately adjust for time-varying confounders affected by treatment [31]. The magnitude and direction of these potential biases cannot be predicted and their results should be taken with caution. In contrast, our study uses incident users and adjusts for time-varying confounders using inverse probability weighing to emulate the NCT00110162 trial. This methodology has been previously used to appropriately adjust for confounding in several clinical applications [23,25,32]. Had we used a naïve approach such as standard outcome regression with time-varying variables, the adjustment for confounding would have been incomplete (all-cause mortality HR 1.16, 95% CI 0.73-1.83).

Like any observational study, the validity of our estimates requires that all baseline and time-varying confounders are correctly measured. This requirement is especially important in our study because our estimates suggest that there is substantial confounding. The HR in the unadjusted analysis (2.12) went down considerably after adjusting for baseline confounders (1.51), probably because physicians tend to initiate ADT earlier in those patients with worse prognosis (e.g. higher Gleason grade). The HR moved even closer to the null (0.91) after adjusting for time-varying PSA, Karnofsky functional status, fatigue and bone pain. The effect of adjustment was even more evident when analyzing prostate-specific mortality. The downward movement of the HR with increasing levels of adjustment makes it conceivable that immediate ADT initiation might actually be beneficial, but that our adjustment for confounding was incomplete.

In summary, our study provides evidence on the when to start ADT question. In the absence of randomized trial results, our findings suggest that starting ADT at PSA relapse does not have a major impact on overall survival compared with deferred ADT initiation at disease progression.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This work was partly funded by NIH grant (P01-CA134294). XGA is a 2012-13 CaPSURE scholar and also a recipient of an "ASISA Fellowship" and a SEOM (Sociedad Española de Oncología Médica) grant. CaPSURE is supported in part by an independent, educational grant from Abbott.

Role of the funding source: The funding sources did not have any involvement in the study design, collection, analysis and interpretation of data, writing of the report or in the decision to submit the article for publication.

References

- [1]. Sharifi N, Gulley JL, Dahut WL. Androgen deprivation therapy for prostate cancer. *JAMA*. 2005; 294:238–44. [PubMed: 16014598]
- [2]. Walsh PC, DeWeese TL, Eisenberger MA. A structured debate: immediate versus deferred androgen suppression in prostate cancer-evidence for deferred treatment. *J Urol*. 2001; 166:508–15. [PubMed: 11458056]
- [3]. Scher HI, Heller G. Clinical states in prostate cancer: toward a dynamic model of disease progression. *Urology*. 2000; 55:323–7. [PubMed: 10699601]
- [4]. Loblaw DA, Virgo KS, Nam R, Somerfield MR, Ben-Josef E, Mendelson DS, et al. Initial hormonal management of androgen-sensitive metastatic, recurrent, or progressive prostate cancer: 2006 update of an American Society of Clinical Oncology practice guideline. *J Clin Oncol*. 2007; 25:1596–605. [PubMed: 17404365]
- [5]. Studer UE, Hauri D, Hanselmann S, Chollet D, Leisinger H-J, Gasser T, et al. Immediate versus deferred hormonal treatment for patients with prostate cancer who are not suitable for curative local treatment: results of the randomized trial SAKK 08/88. *J Clin Oncol*. 2004; 22:4109–18. [PubMed: 15483020]
- [6]. Studer UE, Whelan P, Albrecht W, Casselman J, de Reijke T, Hauri D, et al. Immediate or deferred androgen deprivation for patients with prostate cancer not suitable for local treatment with curative intent: European Organisation for Research and Treatment of Cancer (EORTC) Trial 30891. *J Clin Oncol*. 2006; 24:1868–76. [PubMed: 16622261]
- [7]. Kirk D. Timing and choice of androgen ablation. *Prostate Cancer Prostatic Dis*. 2004; 7:217–22. [PubMed: 15278095]
- [8]. Tsai HK, D'Amico AV, Sadetsky N, Chen M-H, Carroll PR. Androgen deprivation therapy for localized prostate cancer and the risk of cardiovascular mortality. *J Natl Cancer Inst*. 2007; 99:1516–24. [PubMed: 17925537]
- [9]. Saigal CS, Gore JL, Krupski TL, Hanley J, Schonlau M, Litwin MS. Androgen deprivation therapy increases cardiovascular morbidity in men with prostate cancer. *Cancer*. 2007; 110:1493–500. [PubMed: 17657815]
- [10]. Salminen EK, Portin RI, Koskinen A, Helenius H, Nurmi M. Associations between serum testosterone fall and cognitive function in prostate cancer patients. *Clin Cancer Res*. 2004; 10:7575–82. [PubMed: 15569988]
- [11]. National Comprehensive Cancer Network. Prostate Cancer. (Version 3.2012) n.d.
- [12]. Freedland SJ, Humphreys EB, Mangold LA, Eisenberger M, Dorey FJ, Walsh PC, et al. Risk of Prostate Cancer-Specific Mortality Following Biochemical Recurrence After Radical Prostatectomy. *JAMA*. 2005; 294:433–9. [PubMed: 16046649]
- [13]. Antonarakis ES, Chen Y, Elsamanoudi SI, Brassell S a, Da Rocha MV, Eisenberger M a, et al. Long-term overall survival and metastasis-free survival for men with prostate-specific antigen-recurrent prostate cancer after prostatectomy: analysis of the Center for Prostate Disease Research National Database. *BJU Int*. 2011; 108:378–85. [PubMed: 21091976]

- [14]. Antonarakis ES, Feng Z, Trock BJ, Humphreys EB, Carducci M a, Partin AW, et al. The natural history of metastatic progression in men with prostate-specific antigen recurrence after radical prostatectomy: long-term follow-up. *BJU Int.* 2012; 109:32–9. [PubMed: 21777360]
- [15]. Young J, Cain L, Robins J, O'Reilly E, Hernan M. Comparative effectiveness of dynamic treatment regimes: an application of the parametric g-formula. *Stat Biosci.* 2011; 3:119–43. [PubMed: 24039638]
- [16]. Cain LE, Robins JM, Lanoy E, Logan R, Costagliola D, Hernán MA. When to start treatment? A systematic approach to the comparison of dynamic regimes using observational data. *Int J Biostat.* 2010; 6 Article 18.
- [17]. Lubeck DP, Litwin MS, Henning JM, Stier DM, Mazonson P, Fisk R, et al. The CaPSURE database: a methodology for clinical practice and research in prostate cancer. CaPSURE Research Panel. *Cancer of the Prostate Strategic Urologic Research Endeavor. Urology.* 1996; 48:773–7.
- [18]. Glass AS, Cowan JE, Fuldeore MJ, Cooperberg MR, Carroll PR, Kenfield S a, et al. Patient demographics, quality of life, and disease features of men with newly diagnosed prostate cancer: trends in the PSA era. *Urology.* 2013; 82:60–5. [PubMed: 23706257]
- [19]. Cooperberg MR, Broering JM, Litwin MS, Lubeck DP, Mehta SS, Henning JM, et al. The contemporary management of prostate cancer in the United States: lessons from the cancer of the prostate strategic urologic research endeavor (CapSURE), a national disease registry. *J Urol.* 2004; 171:1393–401. [PubMed: 15017184]
- [20]. Cain LE, Robins JM, Lanoy E, Logan R, Costagliola D, Hernán MA. When to start treatment? A systematic approach to the comparison of dynamic regimes using observational data. *Int J Biostat.* 2010; 6 Article 18.
- [21]. Hernán MA, Lanoy E, Costagliola D, Robins JM. Comparison of dynamic treatment regimes via inverse probability weighting. *Basic Clin Pharmacol Toxicol.* 2006; 98:237–42. [PubMed: 16611197]
- [22]. Hernán MA, Hernández-Díaz S, Robins JM. A structural approach to selection bias. *Epidemiology.* 2004; 15:615–25. [PubMed: 15308962]
- [23]. Ray M, Logan R, Sterne JAC, Hernández-Díaz S, Robins JM, Sabin C, et al. The effect of combined antiretroviral therapy on the overall mortality of HIV-infected individuals. *AIDS.* 2010; 24:123–37. [PubMed: 19770621]
- [24]. Cole SR, Hernán MA. Constructing inverse probability weights for marginal structural models. *Am J Epidemiol.* 2008; 168:656–64. [PubMed: 18682488]
- [25]. Cain LE, Logan R, Robins JM, Sterne JAC, Sabin C, Bansi L, et al. When to initiate combined antiretroviral therapy to reduce mortality and AIDS-defining illness in HIV- infected persons in developed countries: an observational study. *Ann Intern Med.* 2011; 154:509–15. [PubMed: 21502648]
- [26]. Roach M, Hanks G, Thames H, Schellhammer P, Shipley WU, Sokol GH, et al. 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.* 2006; 65:965–74. [PubMed: 16798415]
- [27]. Studer UE, Whelan P, Wimpfissinger F, Casselman J, de Reijke TM, Knönagel H, et al. Differences in Time to Disease Progression Do Not Predict for Cancer-specific Survival in Patients Receiving Immediate or Deferred Androgen-deprivation Therapy for Prostate Cancer: Final Results of EORTC Randomized Trial 30891 with 12 Years of Follow-up. *Eur Urol.* 2013
- [28]. Immediate versus deferred treatment for advanced prostatic cancer: initial results of the Medical Research Council Trial. The Medical Research Council Prostate Cancer Working Party Investigators Group. *Br J Urol.* 1997; 79:235–46. [PubMed: 9052476]
- [29]. Moul JW, Wu H, Sun L, McLeod DG, Amling C, Donahue T, et al. Early versus delayed hormonal therapy for prostate specific antigen only recurrence of prostate cancer after radical prostatectomy. *J Urol.* 2004; 171:1141–7. [PubMed: 14767288]
- [30]. Hernán MA, Alonso A, Logan R, Grodstein F, Michels KB, Willett WC, et al. Observational studies analyzed like randomized experiments: an application to postmenopausal hormone therapy and coronary heart disease. *Epidemiology.* 2008; 19:766–79. [PubMed: 18854702]

- [31]. Robins, J.; Hernan, M. Estimation of the causal effects of time-varying exposures. In: Fitzmaurice, G.; Davidian, M.; Verbeke, G.; Molenberghs, G., editors. *Longitud. Data Anal.* 1st. Boca Raton: Chapman & Hall/CRC: 2009. p. 553-99.
- [32]. Toh S, Hernández-Díaz S, Logan R, Robins JM, Hernán MA. Estimating absolute risks in the presence of nonadherence: an application to a follow-up study with baseline randomization. *Epidemiology.* 2010; 21:528–39. [PubMed: 20526200]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Highlights

- There are no clinical trials to guide the use of ADT in patients with PSA-only relapse.
- Our findings suggest that starting ADT at PSA relapse does not have a major impact on overall survival compared with deferred ADT initiation at disease progression.
- This can help leverage decisions when there are concerns about ADT toxicity.

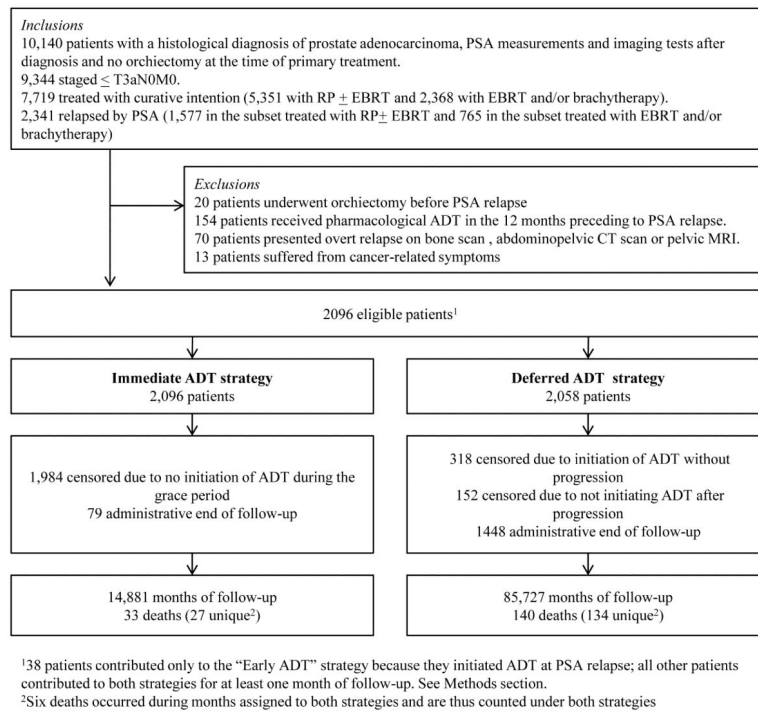


Figure 1.
 Flowchart of patient selection into the study, CaPSURE.

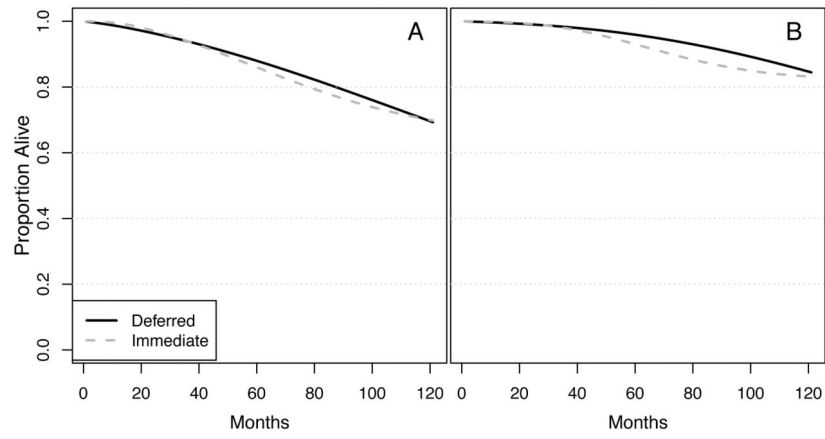


Figure 2. Overall (A) and prostate cancer-specific (B) survival, standardized for baseline and time-varying variables, for immediate vs. deferred ADT, CaPSURE 1974-2013

Table 1

Abusing observbreviated protocols of the NCT001 101 national CaPSURE data 62 randomized trial and the emulated trial

Components	NCT00110162 randomized trial	Emulated Trial using observational CaPSURE
Primary Aim	To compare the survival of prostate cancer patients assigned to immediate vs deferred androgen deprivation therapy (ADT), defined as either bilateral orchiectomy OR luteinizing hormone-releasing hormone agonist with or without oral antiandrogen therapy.	Same.
Study population *	Patients with prostate cancer treated with curative intention with a PSA-only relapse.	Same.
Eligibility	<p>Histologically confirmed adenocarcinoma of the prostate</p> <p>No symptomatic disease requiring therapy</p> <p>PSA relapse after definitive radical treatment (prostatectomy or radiotherapy), as evidenced by 1 the following:</p> <ul style="list-style-type: none"> • Post-prostatectomy PSA > 0.2 ng/mL • At least 3 rising PSA levels (post-radiotherapy) > 1 month apart, with the last PSA within the past 2 months <p>No metastatic disease by bone scan or abdomino-pelvic CT scan</p>	Same.
Follow-up	Patients are followed from randomization at PSA relapse every 3 months for 2 years, every 6 months for 3 years, and then periodically thereafter at the discretion of the principal investigator.	Patients are followed from PSA relapse. Participating urologist reports clinical data at follow-up visits under usual practice. Patients complete study-specific surveys at baseline and every six months thereafter.
Treatment assignment	<p>Patients are randomized to one of the following 2 dynamic strategies:</p> <ul style="list-style-type: none"> • Deferred ADT: initiation at progression ** or any time after 2 years since baseline, (continuous or intermittent). • Immediate ADT: initiation (continuous or intermittent) at baseline. 	<p>Patients are classified as following the same strategies (with a 3-month grace period):</p> <ul style="list-style-type: none"> • Deferred ADT: initiation at progression ** (continuous or intermittent). • Immediate ADT: initiation (continuous or intermittent) at baseline. <p><u>Supplementary analyses:</u></p> <ol style="list-style-type: none"> 1 Patients are classified as following the same strategies of NCT00110162 (with a 3-month grace period) 2 PSA relapse after radiotherapy is defined using the "Phoenix" definition (a rise by 2 ng/mL above the nadir PSA after radiation therapy)
ADT definition	LHRH agonist with or without antiandrogens or orchiectomy	Same
Primary endpoint	Death from any cause	Same
Statistical analysis	Information not provided.	Observational analog of a per protocol analysis, adjusted for baseline variables (Gleason score, percentage of positive biopsies at diagnosis, T-stage, type of primary treatment, time from primary treatment to PSA relapse, calendar year of PSA relapse, and age), and time-varying variables (PSA, Karnofsky functional status,

Components	NCT00110162 randomized trial	Emulated Trial using observational CaPSURE (fatigue, and bone pain)
------------	------------------------------	--

* The trial also included a second group of patients not candidate for curative treatment and not requiring immediate ADT.

** Progression defined as PSA doubling time of < 12 months with PSA ≥ 10 ng/mL OR PSA doubling time of ≥ 6 months based on 3 consecutive measurements obtained ≥ 2 months apart OR development of metastases or symptoms

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Baseline characteristics for 2096 men presenting a PSA-only relapse after treatment of localized prostate cancer treated with curative intention and enrolled in CaPSURE, 1974-2014.

Median age at relapse, years (IQR)		69.1 (63.0-74.7)
PSA at diagnosis (%)¹, ng/mL	<=6	703 (33.5)
	6.1-10	624 (29.8)
	10.1-20	428 (20.4)
	20.1-30	101 (4.8)
	30+	115 (5.5)
Median PSA at relapse (IQR), ng/mL		0.50 (0.22-1.51)
Total Gleason score (%)²	2-5	396 (18.9)
	6	838 (40.0)
	7-10	729 (34.8)
Percentage of positive biopsies (%)³	<34%	878 (41.9)
	>=34	932 (44.5)
Primary treatment (%)	RP +- EBRT	1437 (68.6)
	EBRT and/or brachytherapy	659 (31.4)
Race (%)	White	1842 (87.9)
	Black	195 (9.3)
	Other	59 (2.8)
cT stage (%)	cT1	843 (40.2)
	cT2	1205 (57.5)
	cT3	48 (2.3)
Median time since primary treatment, months (IQR)		26.8 (13.4-50.6)
Year (%)	1988-1992	50 (2.4)
	1993-1997	550 (26.2)
	1998-2002	651 (31.1)
	2003-2007	724 (34.5)
	2008-2014	121 (5.8)

IQR: interquartile range. RP: radical prostatectomy. EBRT: external beam radiotherapy.

¹ missing in 125 patients.

² missing in 133 patients.

³ missing in 286 patients

Table 3

Mortality analyses for immediate vs. deferred ADT initiation, CaPSURE 1974-2014 (N=2096).

	Deferred ADT	Immediate ADT
Person-months	85,727	14,881
Deaths	140	33
Prostate cancer deaths	22	18
All-cause mortality hazard ratio (95% confidence interval)		
Unadjusted	1 (ref)	2.12 (1.42 - 3.17)
Adjusted for baseline variables ^a	1 (ref)	1.51 (0.99 - 2.33)
Adjusted for baseline- and time-varying ^b variables	1 (ref)	0.91 (0.52 - 1.60)
Prostate cancer mortality hazard ratio (95% confidence interval)		
Unadjusted	1 (ref)	7.57 (3.89 - 14.72)
Adjusted for baseline variables ^a	1 (ref)	4.65 (1.98 - 10.92)
Adjusted for baseline- and time-varying ^b variables	1 (ref)	1.09 (0.31 - 3.78)

ADT: androgen deprivation therapy.

^aGleason score, percentage of positive biopsies at diagnosis, T-stage, type of primary treatment (radical prostatectomy +/- radiotherapy vs. radiotherapy-only based treatment), time from primary treatment to PSA relapse, calendar year of PSA relapse, and age.

^bPSA, Karnofsky functional status, bone pain, fatigue.