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Where Prostate Cancer Meets the Heart

Zero Us Too
New York Prostate Cancer Support Group
Weill Cornell Medicine Department of Urology
January 15. 2026

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Goals and Objectives

- Discuss the burden of Prostate Cancer and Cardiovascular Disease
- Understand the cardiovascular risks associated with prostate cancer and its treatments
- Explore specific cardiovascular risk with ADT and ARPI
- Identify high-risk patients and appropriate cardiac monitoring strategies
- Discuss evidence-based approaches for prevention and management of cardiac complications

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Abbreviations I will use…

- CVD: Cardiovascular Disease
- PCa: Prostate Cancer
- CAD: Coronary Artery Disease
- HF: Heart Failure
- VTE: Venous Thromboembolism (“DVT”)
- MACE: Major Adverse Cardiac Events
- ADT: Androgen Deprivation Therapy
- GNRH Agonist:

  Leuprolide (Lupron®/Eligard®), Goserelin (Zoladex®)
- GNRH Antagonist:

  Degarelix (Firmagon®) – injectable; **Relugolix (Orgovyx®)** – oral
- ARPI: Androgen Receptor Pathway Inhibitors:

  AR ANTAGONISTS (i.e. enzalutamide apalutamide, darolutamide)

  CYP17 INHIBITORS (i.e. abiraterone)

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Prostate cancer is the most common cancer affecting men in western nations

Estimated New Cases

Males

Prostate	268,490	27%
Lung & bronchus	117,910	12%
Colon & rectum	80,690	8%
Urinary bladder	61,700	6%
Melanoma of the skin	57,180	6%
Kidney & renal pelvis	50,290	5%
Non-Hodgkin lymphoma	44,120	4%
Oral cavity & pharynx	38,700	4%
Leukemia	35,810	4%
Pancreas	32,970	3%
All Sites	**983,160**	**100%**

Estimated Deaths

Males

Lung & bronchus	68,820	21%
Prostate	34,500	11%
Colon & rectum	28,400	9%
Pancreas	25,970	8%
Liver & intrahepatic bile duct	20,420	6%
Leukemia	14,020	4%
Esophagus	13,250	4%
Urinary bladder	12,120	4%
Non-Hodgkin lymphoma	11,700	4%
Brain & other nervous system	10,710	3%
All Sites	**322,090**	**100%**

Only approximately 13% of men with prostate cancer die from their disease.

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Siegel et al. 2022. Cancer statistics, 2022.

Men with Early Stage Prostate Cancer More Likely to Die of CVD

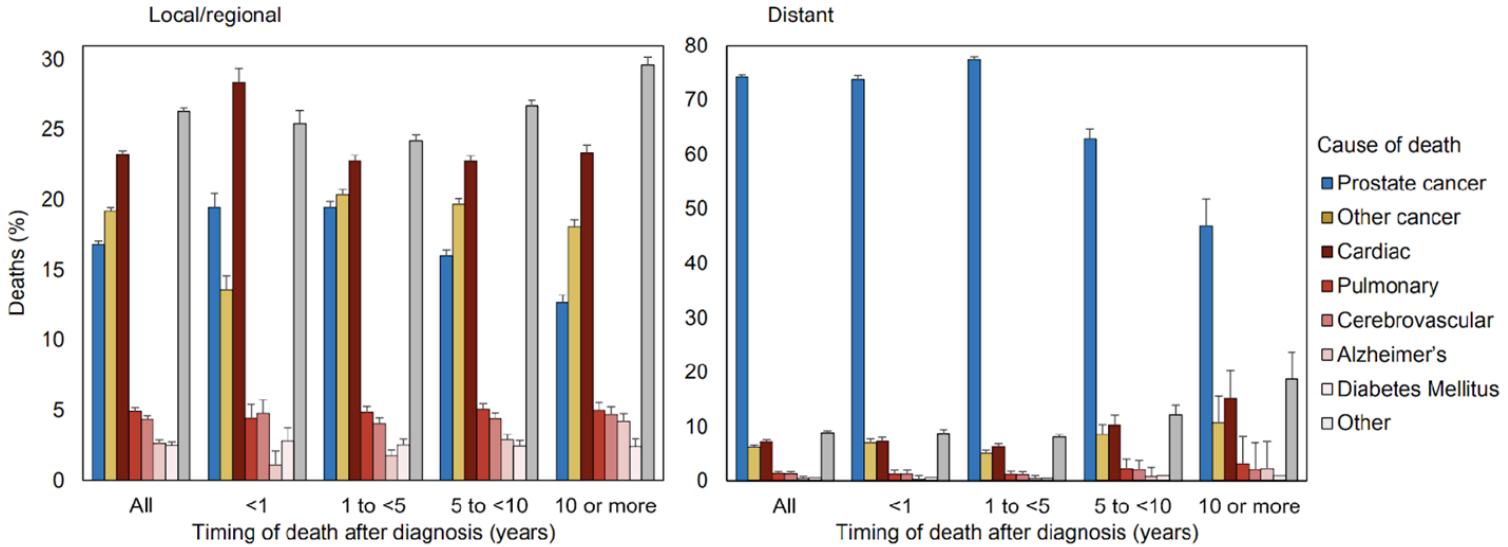

Figure 2. Causes of death by stage after the diagnosis of prostate cancer. Error bars are upper 95% confidence intervals.

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Weiner AB, Schaeffer EM. Cause of death during prostate cancer survivorship: A contemporary, US population-based analysis. Cancer. 2021 Aug 15;127(16):2895-29042021 Apr 21. PMID: 33882145

Epidemiology of Prostate Cancer and Cardiovascular Disease

- 1 in 5 patients with PCa have established CVD
- Pts with established PCa have higher risk for CAD, HF, VTE (vs. gen pop)
- CVD is most common cause of death in pts with localized PC

  In non-met PCa, CVD > PC death

  In met PCa, HR of 1.48 CVD (i.e. 50% higher risk of death)

  In a SEER database from 1973-2012, more CVD in pts w/ PCa than any other cancer type

TABLE 1 Prevalence Rates of CVD in Prostate Cancer Populations From Different Geographic Regions

Region	Prostate Cancer Population	CVD Prevalence	Specific Conditions
North America (United States)	90,494 Veterans[3]	17%	Atherosclerotic CVD: coronary artery disease, stroke, peripheral vascular disease
North America (Canada)	2,492 (prospective cohort study)[4]	22%	Coronary artery disease (13%), cerebrovascular disease (5%), peripheral arterial disease (2%), atrial fibrillation (6%), heart failure (2%)
South America, Asia, Australia, Israel	1,065 (prospective cohort study)	24%	Coronary artery disease (14%), cerebrovascular disease (6%), peripheral arterial disease (4%), atrial fibrillation (6%), heart failure (5%)
United Kingdom	175,639 patients with nonmetastatic prostate cancer[5]	15%	Previous CVD hospitalization
China	4,253 (retrospective study)[5]	27%	43% had hypertension, poorly controlled in one-half
Saudi Arabia	Retrospective study[67]	16%	Stroke (2%), deep vein thrombosis (2%), peripheral vascular disease (0.5%), percutaneous coronary intervention (19%), other cardiac disease (4%)

CVD = cardiovascular disease.

BURDEN OF CVD in PROSTATE CANCER PATIENTS IS HIGH!

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Leong, D. et al. Cardiovascular Risk in Prostate cancer: JACC Cardio-Oncology State of the Art Review. Vol 6, No. 6

Why do Men with Prostate Cancer Have Such a High CVD Burden?

1. Improving prostate cancer survival
2. High CVD Risk Factor Burden in PCa Population
3. Systemic Inflammation
4. Androgen Deprivation Therapy (ADT) linked to CVD [complex…]

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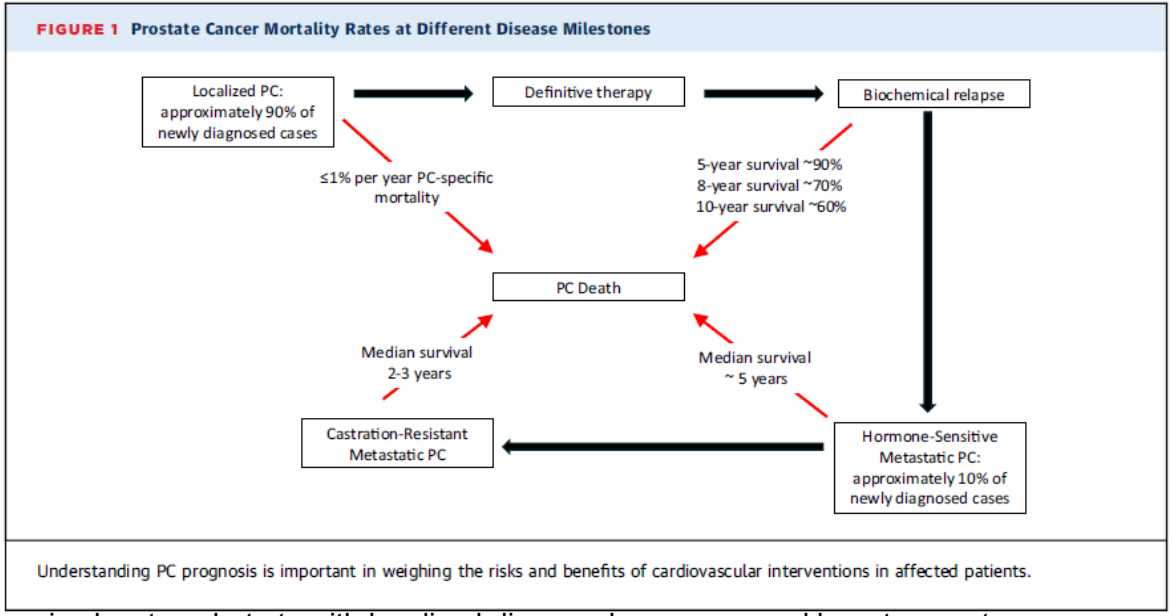
Improved Prostate Cancer Survival



- PC survival varies by stage but pts with localized disease have very good long-term outcomes.
- Overall low mortality and high longitudinal survival lend themselves to pts living longer enough to develop comorbid conditions
- Even in pts with biochemical relapse, 5 yr survival >90%
- Met PC largely incurable, but typically 4-5 yr survival
- Castration resistant PC (mean survival 25.6 mo) require treatment beyond ADT alone

Leong, D. et al. Cardiovascular Risk in Prostate cancer: JACC Cardio-Oncology State of the Art Review. Vol 6, No. 6

Is CVD Mortality in Competition with Prostate Ca Mortality?

Cardiovascular mortality by cancer risk stratification in patients with localized prostate cancer: a SEER-based study

Zehao Luo[1,2], Kaiyi Chi[1,2], Hongjun Zhao[2,3], Linglong Liu[2,4], Wenting Yang[2,5], Zhijuan Luo[2,6], Yinglan Liang[2,4], Liangjia Zeng[2,7], Ruoyun Zhou[2,6], Manting Feng[1,2], Yemin Li[2,8], Guangyao Hua[9], Huying Rao[1], Xiaozhen Lin[10]* and Min Yi[1]*

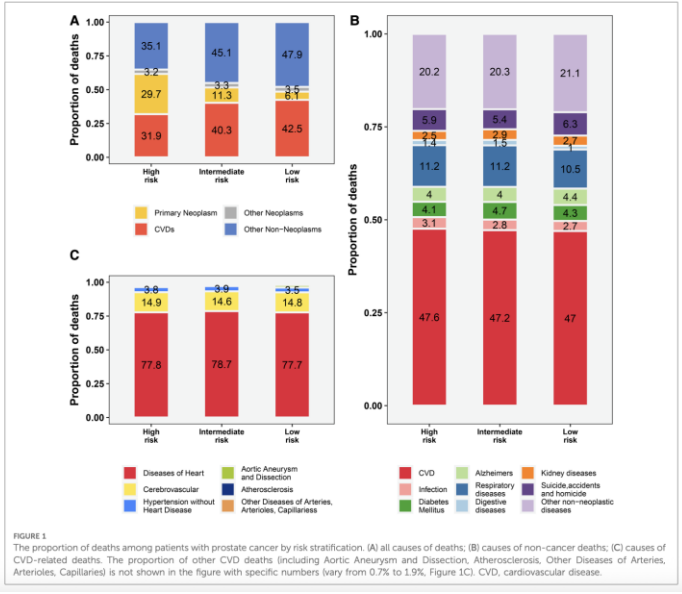


FIGURE 1
The proportion of deaths among patients with prostate cancer by risk stratification. (A) all causes of deaths; (B) causes of non-cancer deaths; (C) causes of CVD-related deaths. The proportion of other CVD deaths (including Aortic Aneurysm and Dissection, Atherosclerosis, Other Diseases of Arteries, Arterioles, Capillaries) is not shown in the figure with specific numbers (vary from 0.7% to 1.9%, Figure 1C). CVD, cardiovascular disease.

SEER Database to determine the risk of CVD death in patients with localized PCa by risk stratification.

340,806 cases in (SEER) database diagnosed with localized PCa between 2004 and 2016.

Results:
CVD-related death leading cause of death in patients with localized Pca

In the **low- and intermediate-risk groups: Cumulative** CVD-related death surpassed PCa nearly as soon as PCa was diagnosed

In the **high-risk group**, CVD surpassed PCa approximately 90 months later.

Patients with localized PCa have a higher risk of CVD-related death compared to the general population and the risk increases steadily with survival (SMR = 4.8, 95% CI 4.6–5.1 to SMR = 13.6, 95% CI 12.8–14.5). Conclusions:

CONCLUSIONS:
CVD-related death is a major competing risk in patients with localized PCa, and cumulative CVD mortality increases steadily with survival time and exceeds PCa in all three stratifications (low, intermediate, and high risk).

Patients with localized PCa have a higher CVD-related death than the general population.

Management of patients with localized PCa requires attention to both the primary cancer and CVD.

Men with PC have a High CVD Risk Factor Burden

2,811 consecutive men with PC from 24 sites internationally

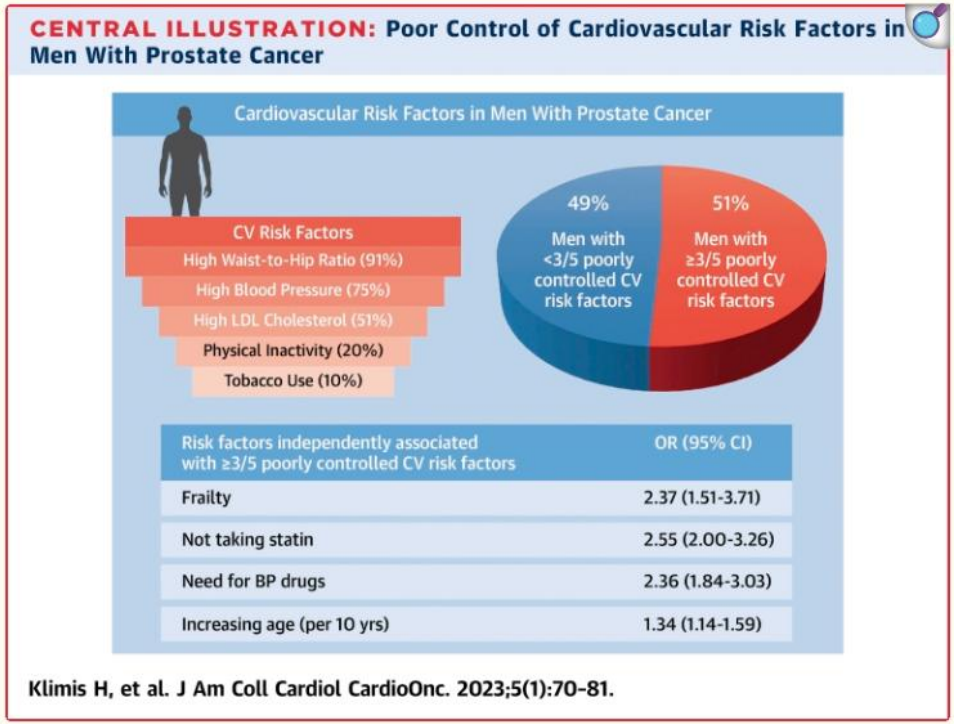
“poor overall risk factor control” defined as >/= 3 :

-suboptimal LDL cholesterol

-current smoker

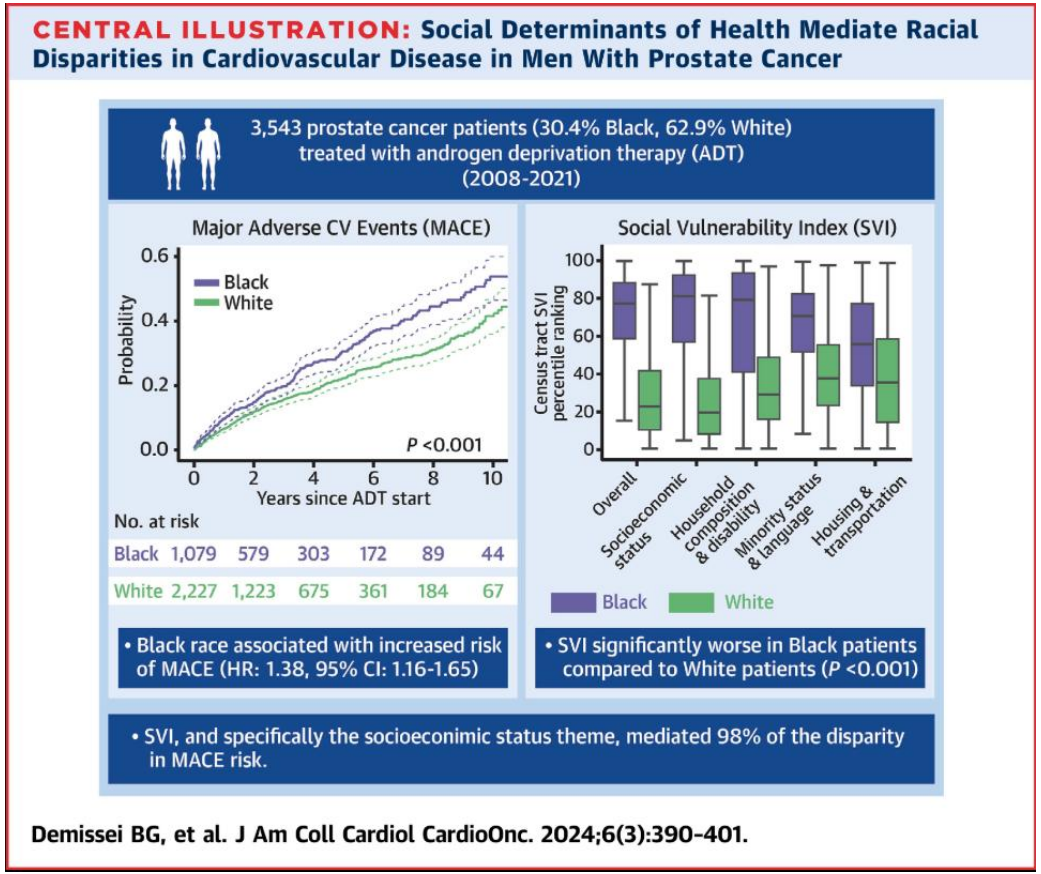
-physical inactivity (<600 MET min/wk)

- Suboptimal BP control
  - ≧ 140/90 no RFs
  - ≧ 120 +CVD
  - ≧ 130 if DM II)
- Waist:hip ratio > 0.9



99% had ≧ 1 uncontrolled RF

Black Patients are at Particularly High Risk for MACE



Demissei BG, et al. J Am Coll Cardiol CardioOnc. 2024;6(3):390-401.

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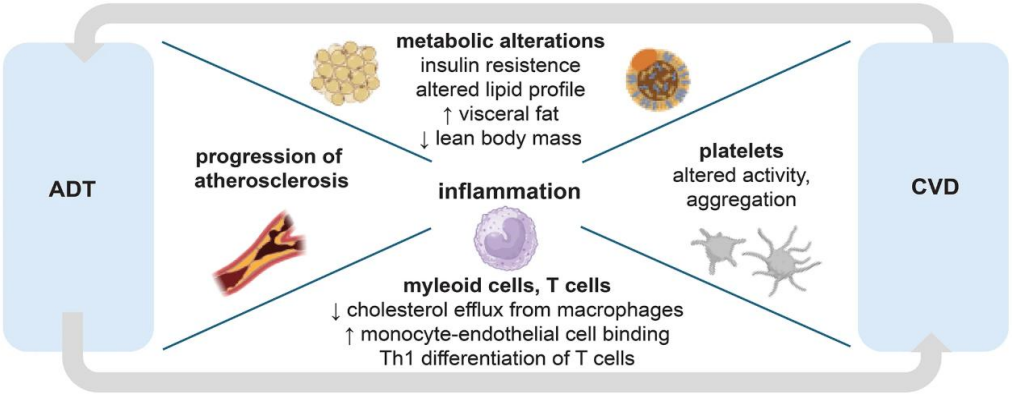
Inflammation



Schematic overview of potential mechanisms of increased risk for cardiovascular disease (CVD) during androgen deprivation therapy (ADT). ADT associated metabolic alterations contribute to increased CVD risk. Moreover, ADT may lead to pro-inflammatory changes in macrophages, monocytes and T-cells which further contribute to progression of atherosclerosis. Platelet activity and aggregation is modulated by androgens and may also play a role in ADT-associated CV risk. Figure created with BioRender.com

Evidence that inflammation may play part in development and progression of PC

Evidence in animal models suggesting accelerated atherosclerotic coronary disease in androgen deprived conditions, lack of androgens alters modulation of immune cells including monocytes, macrophages, and T cells toward pro-inflammatory phenotype

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Beitzen-Heineke , Wise, Berger *et al. Cardio-Oncology* (2024) 10:87
https://doi.org/10.1186/s40959-024-00278-2

Does Androgen Deprivation Therapy Promote Cardiovascular Disease and Increase CV Risk?

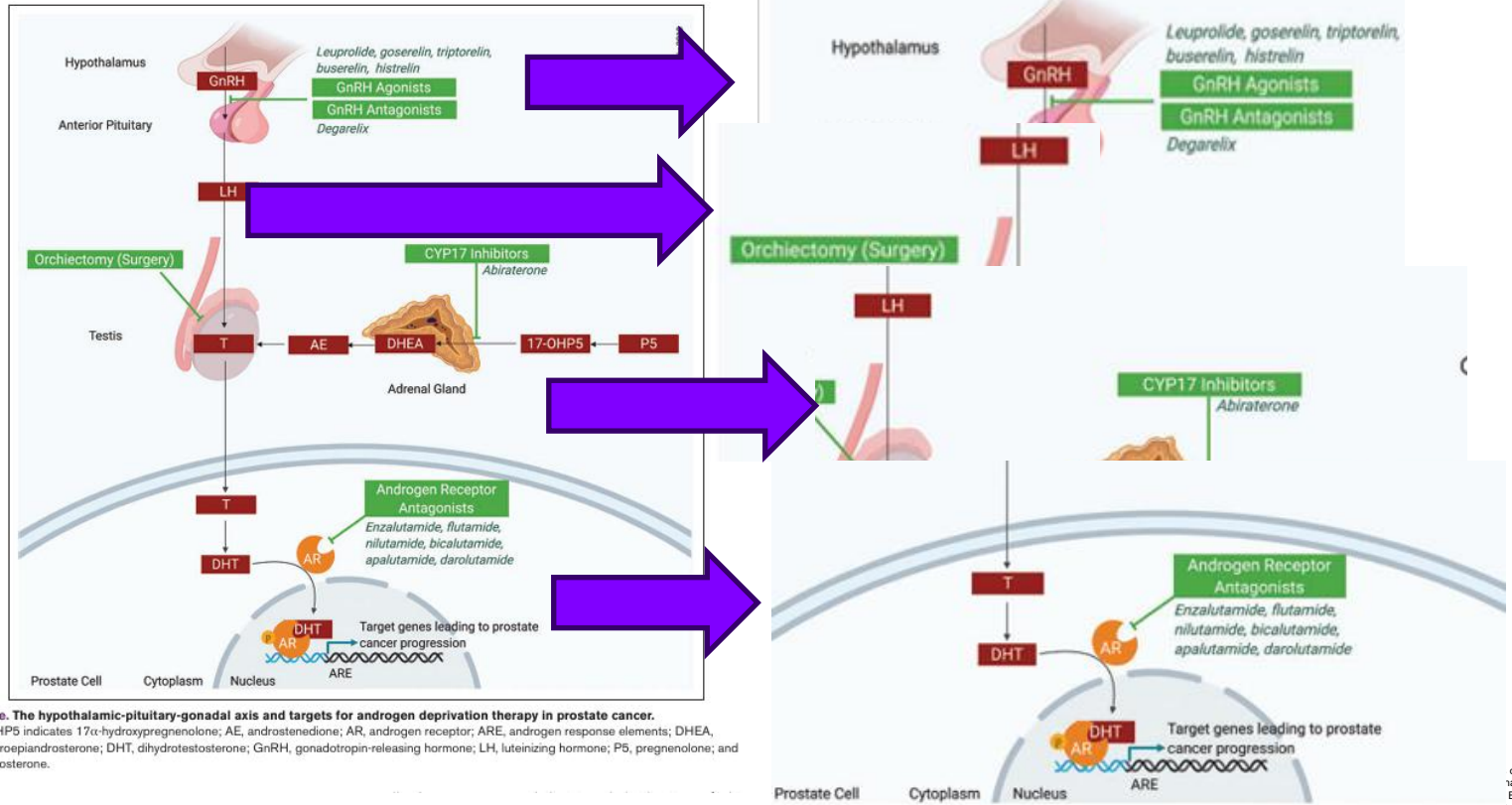


Figure. The hypothalamic-pituitary-gonadal axis and targets for androgen deprivation therapy in prostate cancer.
17-OHP5 indicates 17α-hydroxypregnenolone; AE, androstenedione; AR, androgen receptor; ARE, androgen response elements; DHEA, dehydroepiandrosterone; DHT, dihydrotestosterone; GnRH, gonadotropin-releasing hormone; LH, luteinizing hormone; P5, pregnenolone; and T, testosterone.

of Androgen Deprivation Therapy in Prostate Cancer
nalyses Jiun-Ruey Hu, Meredith S. Duncan, Alicia K.
Brown, Wouter C. Meijers, Matthew S. Freiberg, Joe-Elie
man, Javid J. Moslehi

Melloni C, Nelson A. Effect of Androgen Deprivation Therapy on Metabolic Complications and Cardiovascular Risk. J Cardiovasc Transl Res. 2020 Jun;13(3):451-462. doi: 10.1007/s12265-019-09942-w. Epub 2019 Dec 12. PMID: 31833002.

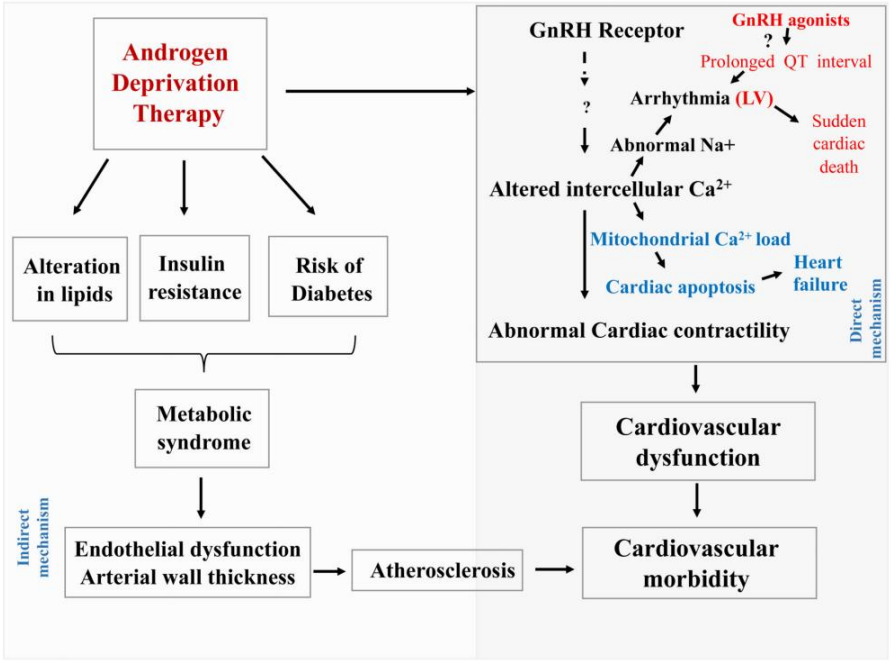
Population based studies support ADT increases risks for cardiac disease

Testosterone has multitude of cardioprotective effects.

- Maintaining lipid profiles
- Minimizing inflammation
- NO-mediated cGMP (vascular relaxation)

Therefore, BLOCKING Testosterone with ADT:

- Accelerates cardiometabolic risk factors
- Accelerates atherosclerosis
- Increases adiposity (SC vs visceral fat, decreased lean body mass)
- Increases insulin resistance
- Increases metabolic syndrome
- Leads to HTN (abiraterone, enzalutamide, via mineralocorticoid pathway)
- Promotes Endothelial Cell Dysfunction
- Increases arrhythmia potential (enzalutamide) via QT prolongation



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Lope et al. Circulation. 2021; slide courtesy of Dr Andrew Lacetti

ADT (vs. non-ADT) and Cardiovascular Risk

Table 1. Cardiovascular Mortality and Cardiovascular Disease Associated With ADT as a Pooled Group Compared With Non-ADT, According to Results of Meta-Analyses From 2010 to 2019

	Type	Treatment Agent (No. of Patients)	Comparator Agent (No. of Patients)	CV Mortality	Any Nonfatal CVD	Myocardial Infarction	Stroke
Nguyen et al[19]	RCT	ADT (n=2200)	Nonimmediate ADT (n=1941)	RR, 0.93 (CI, 0.79–1.10; *P*=0.41; I^2=0%; N=8)			
Bourke et al[20]	RCT	ADT (n=1065)	Nonimmediate ADT (n=814)	RR, 1.06 (CI, 0.80–1.40; *P*=0.69; I^2=0%; N=4)			
Zhao et al[18]	Obs.	ADT (n=129 802)*	Non-ADT (n=165 605)*	HR, 1.17† (CI, 1.04–1.32; *P*=0.01; I^2=57%; N=6)	HR, 1.10 (CI, 1.00–1.21; *P*=0.06; I^2=72%; N=6)	HR, 1.10 (CI, 0.97–1.26; *P*=0.14; I^2=68%; N=6)	
Zhao et al[18]	Obs.	ADT (n=39 465)*	Watchful waiting (n=43 648)*	HR, 1.30† (CI, 1.13–1.50; *P*=0.0003; I^2=0%; N=4)	HR, 1.19† (CI, 1.08–1.30; *P*=0.0004; I^2=0%; N=3)		
Carneiro et al[16]	Obs.	ADT (n=52 308)	Non-ADT (n=74 590)	OR, 1.92 (CI, 0.79–4.68; *P*=0.15; I^2=97%; N=3)	OR, 1.06 (CI, 0.70–1.61; *P*<0.78; I^2=100%; N=2)	OR, 2.05† (CI, 1.93–2.17; *P*<0.00001; I^2=100%; N=2)	OR, 1.07 (CI, 0.66–1.72; *P*=0.79; I^2=99%; N=2)
Carneiro et al[16]	RCT	ADT (n=8388)	Non-ADT (n=8411)	OR, 0.97 (CI, 0.81–1.18; *P*=0.79; I^2=0%; N=6)	OR, 1.55† (CI, 1.09–2.20; *P*=0.01; I^2=0%; N=3)	OR, 1.23 (CI, 0.92–1.64; *P*=0.16; I^2=0%; N=2)	OR, 1.02 (CI, 0.71–1.46; *P*=0.93; I^2=0%; N=2)
Meng et al[17]	Obs.	ADT (n=74 538)	Non-ADT (n=85 947)				HR, 1.12 (CI, 0.95–1.32; *P*=0.16; I^2=85%; N=6)
Meng et al[17]	Obs.	ADT (n=39 029)	Watchful waiting (n=42 073)				HR, 1.16† (CI, 1.03–1.31; *P*=0.01; I^2=0%; N=2)

n, total number of patients examined in the meta-analysis; N, number of studies or trials available for that outcome in the meta-analysis. ADT indicates androgen deprivation therapy; CV, cardiovascular; CVD, cardiovascular disease; HR, hazard ratio; Obs., meta-analysis of observational studies; OR, odds ratio; RCT, meta-analysis of randomized controlled trials; and RR, relative risk.

*The exact participant count in the study by Zhao et al[18] varies by outcome.

†Pooled effects that were statistically significant.

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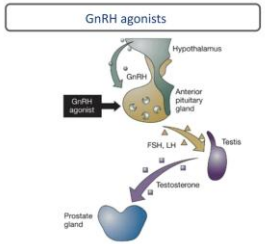
3 available meta-analyses of observational trials:
ADTs had positive associations (although not always significant) with CV events, CV Death and MI
Many (but not all) observational studies suggest a modest risk

3 available meta-analyses of RCTs:
no significant associations with cardiovascular outcomes except for a positive association with nonfatal cardiovascular disease compared in one analysis.
Randomized Controlled Trials of ADT vs. Control do not suggest increased CV Death

Therefore, in patients with low cardiovascular risk enrolled in RCTs, there is a suggestion but no conclusive increase in risk of cardiovascular adverse effects from ADT.

GnRH Agonist Therapy and CV Risk



- Surge in FSH, LH and testosterone before suppression
- Microsurges in LH and testosterone on repeat injection
- FSH suppression, but not maintained long term

Fig. 1 Mechanism of action. Mechanism of action of GnRH agonist and antag releasing hormone, LH = luteinizing hormone

Springer

Agents:
Leuprolide (Lupron®/Eligard®), Goserelin (Zoladex®)

Among the ADTs, the strongest cardiovascular adverse event signal comes from observational studies of the GnRH agonists.

In the 3 meta-analyses of GnRH agonists compared with non-ADT, positive associations were found between GnRH agonists and CV death, nonfatal CV Disease, MI, and stroke

There are currently **no meta-analyses of RCTs of GnRH agonists and cardiovascular adverse events**.

Table 2. Cardiovascular Mortality and Cardiovascular Disease Associated With GnRH Agonists Compared With Non-ADT, According to Results of Meta-Analyses From 2010 to 2019

	Type	Treatment Agent (No. of Patients)	Comparator Agent (No. of Patients)	CV Death	Any Nonfatal CVD	Myocardial Infarction	Stroke
Zhao et al[18]	Obs.	GnRH agonist (n=89 865)*	Non-ADT (n=126 219)*	HR, 1.36† (CI, 1.10–1.68; *P*=0.004; I^2=91%; N=4)	HR, 1.19† (CI, 1.04–1.36; *P*=0.01; I^2=86%; N=3)	HR, 1.20† (CI, 1.05–1.38; *P*=0.008; I^2=82%; N=4)	
Bosco et al[21]	Obs.	GnRH agonist	Non-ADT		RR, 1.38† (CI, 1.29–1.48; *P*<0.001; I^2=85%; N=16)	RR, 1.57† (CI, 1.26–1.94; *P*<0.001; I^2=92%; N=6)	RR, 1.51† (CI, 1.24–1.84; *P*<0.001; I^2=90%; N=5)
Meng et al[17]	Obs.	GnRH agonist (n=49 292)	Non-ADT (n=47 309)				HR, 1.20† (CI, 1.12–1.28; *P*<0.001; I^2=0%; N=3)

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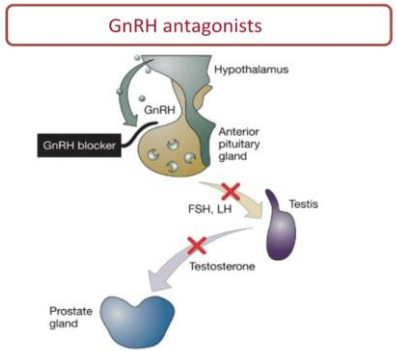
Meng F, Zhu S, Zhao J, Vados L, Wang L, Zhao Y, Zhao D, Niu Y. Stroke related to androgen deprivation therapy for prostate cancer: a meta-analysis and systematic review. BMC Cancer. 2016;16:180.

Zhao J, Zhu S, Sun L, Meng F, Zhao L, Zhao Y, Tian H, Li P, Niu Y. Androgen deprivation therapy for prostate cancer is associated with cardiovascular morbidity and mortality: a meta-analysis of Population-Based Observational Studies. PLOS ONE. 2014;9:e1

Bosco C, Bosnyak Z, Malmberg A, Adolfsson J, Keating NL, Van Hemelrijck M. Quantifying observational evidence for risk of fatal and nonfatal cardiovascular disease following androgen deprivation therapy for prostate cancer: a meta-analysis. Eur Urol. 2015;68:386–396 ▪

GnRH Antagonist Therapy and CV Risk
How do they compare to GnRH Agonists?



- Immediate suppression of FSH, LH and testosterone
- No microsurges
- Prolonged suppression of FSH, LH and testosterone

Agents:
Degarelix (Firmagon®) – injectable
Relugolix (Orgovyx®) – oral

Pooled analyses & meta-analyses (e.g., Abufaraj et al., *Eur Urol* 2021): GnRH antagonists associated with **~40–50% lower relative risk of CV events** compared with agonists.

Typical CV effects: Mild hypertension or QT prolongation (rare)

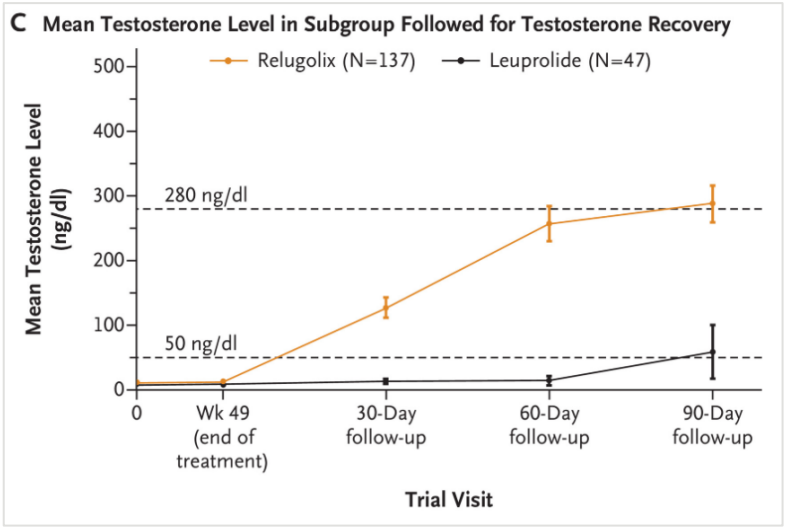
Lower risk of major cardiovascular events (MACE: MI, stroke, CV death) compared with agonists

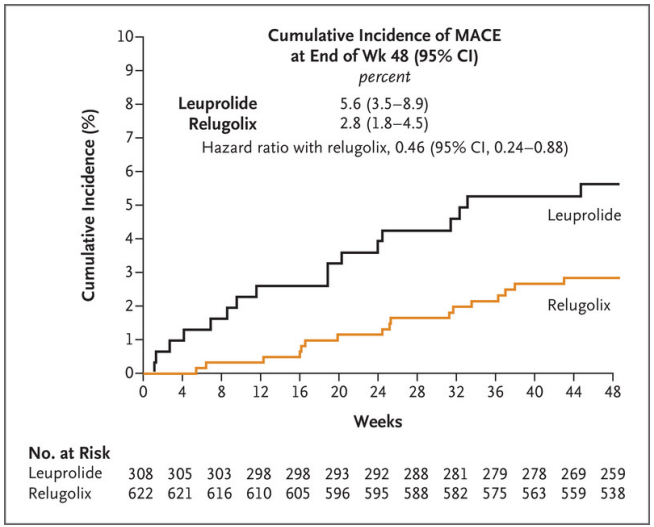
•Benefits most pronounced in men with **prior cardiovascular disease**.

Albertsen PC, Nilsson J et al. Cardiovascular morbidity associated with gonadotropin releasing hormone agonists and an antagonist. Eur Urol. 2014;65:565–573.
Scailteux LM, Oger E et al . Mortality, cardiovascular risk, and androgen deprivation therapy for prostate cancer: a systematic review with direct and network meta-analyses of randomized controlled trials and observational studies. Medicine (Baltimore). 2016;95:e3873.
Abufaraj M, Shariat SF. Et al Differential Impact of Gonadotropin-releasing Hormone Antagonist Versus Agonist on Clinical Safety and Oncologic Outcomes on Patients with Metastatic Prostate Cancer: A Meta-analysis of Randomized Controlled Trials. Eur Urol. 2021 Jan;79(1):44-53.

Relugolix (GnRH Antagonist): HERO Trial

Relugolix vs leuprolide in pts with advanced Prostate Ca x 48 weeks





Limitations:

- CV was not primary EP
- Small number of CV events
- Short F/U
- Imbalance in CV Risk in Leuprolide group

HERO trial (2020): Relugolix reduced risk of MACE by 54% vs leuprolide (2.9% vs 6.2% over 48 weeks).

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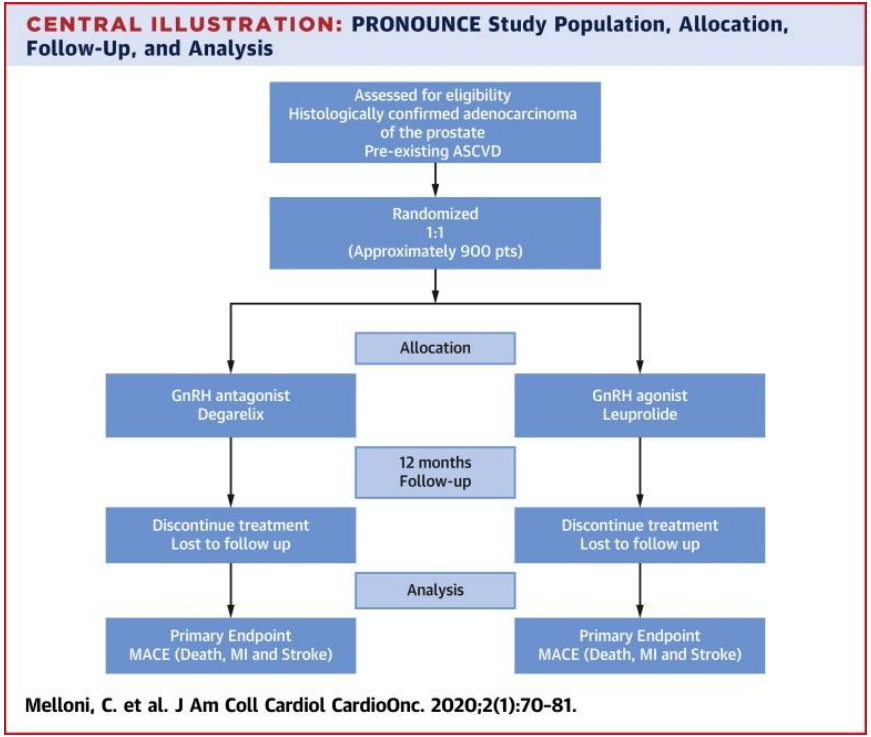
Shore, M.D., et al. for the HERO Study Investigators. Oral Relugolix for Androgen-Deprivation Therapy in Advanced Prostate Cancer N Engl J Med 2020;382:2187-2196

PRONOUNCE Trial

Designed to investigate CV toxicity differences between GnRH agonist vs antagonist

Terminated prematurely due to smaller than planned recruitment and events and no observed difference in MACE at 1 year between patients assigned to degarelix or leuprolide.

Primary outcome 15 (5.5%) degaralix vs 11 (4.1%) leuprolide (HR 1.28, p 0.53)



The relative cardiovascular safety of GnRH antagonists and agonists remains unresolved.

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Lope et al. Circulation. 2021

JACC: CARDIOONCOLOGY
VOL. 5, NO. 5, 2023

ORIGINAL RESEARCH

Cardiovascular Effects of GnRH Antagonists Compared With Agonists in Prostate Cancer

A Systematic Review

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ABSTRACT

BACKGROUND Androgen deprivation therapy is the cornerstone of treatment for patients with advanced prostate cancer. Meta-analysis of small, oncology-focused trials suggest gonadotropin-releasing hormone (GnRH) antagonists may be associated with fewer adverse cardiovascular outcomes compared with GnRH agonists.

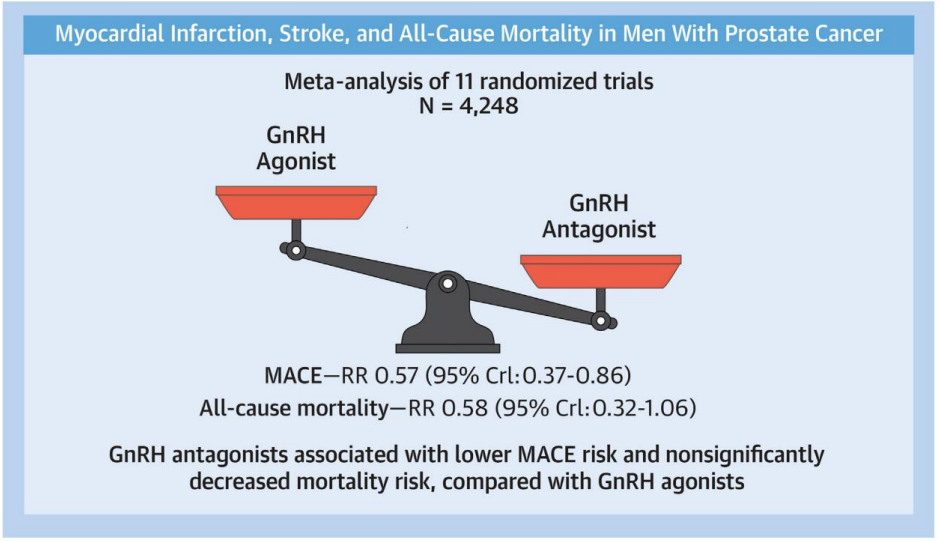
OBJECTIVES This study sought to determine whether GnRH antagonists were associated with fewer major adverse cardiovascular events compared with GnRH agonists.

METHODS Electronic databases were searched for all prospective, randomized trials comparing GnRH antagonists with agonists. The primary outcome was a major adverse cardiovascular event as defined by the following standardized Medical Dictionary for Regulatory Activities terms: "myocardial infarction," "central nervous system hemorrhages and cerebrovascular conditions," and all-cause mortality. Bayesian meta

RESULTS A total of 11 eligible studies of a maximum duration of 3 t participants were included. Only 1 trial used a blinded, adjudicated e trials given their open-label design. A total of 152 patients with pri (2.9%) in GnRH antagonist-treated participants and 76 of 1,593 (4. GnRH agonists, the pooled OR of GnRH antagonists for the primary e and 0.58 (95% credible interval: 0.32-1.08) for all-cause death.

CONCLUSIONS Despite the addition of the largest, dedicated ca quality of available data to definitively answer this question remai the available data suggest that GnRH antagonists are associated w mortality, compared with GnRH agonists. (J Am Coll Cardiol Cardi Published by Elsevier on behalf of the American College of Card under the CC BY-NC-ND license (http://creativecommons.org/lic

CENTRAL ILLUSTRATION Systematic Review of Randomized Controlled Trials Evaluating Gonadotropin-Releasing Hormone Antagonists vs Agonists

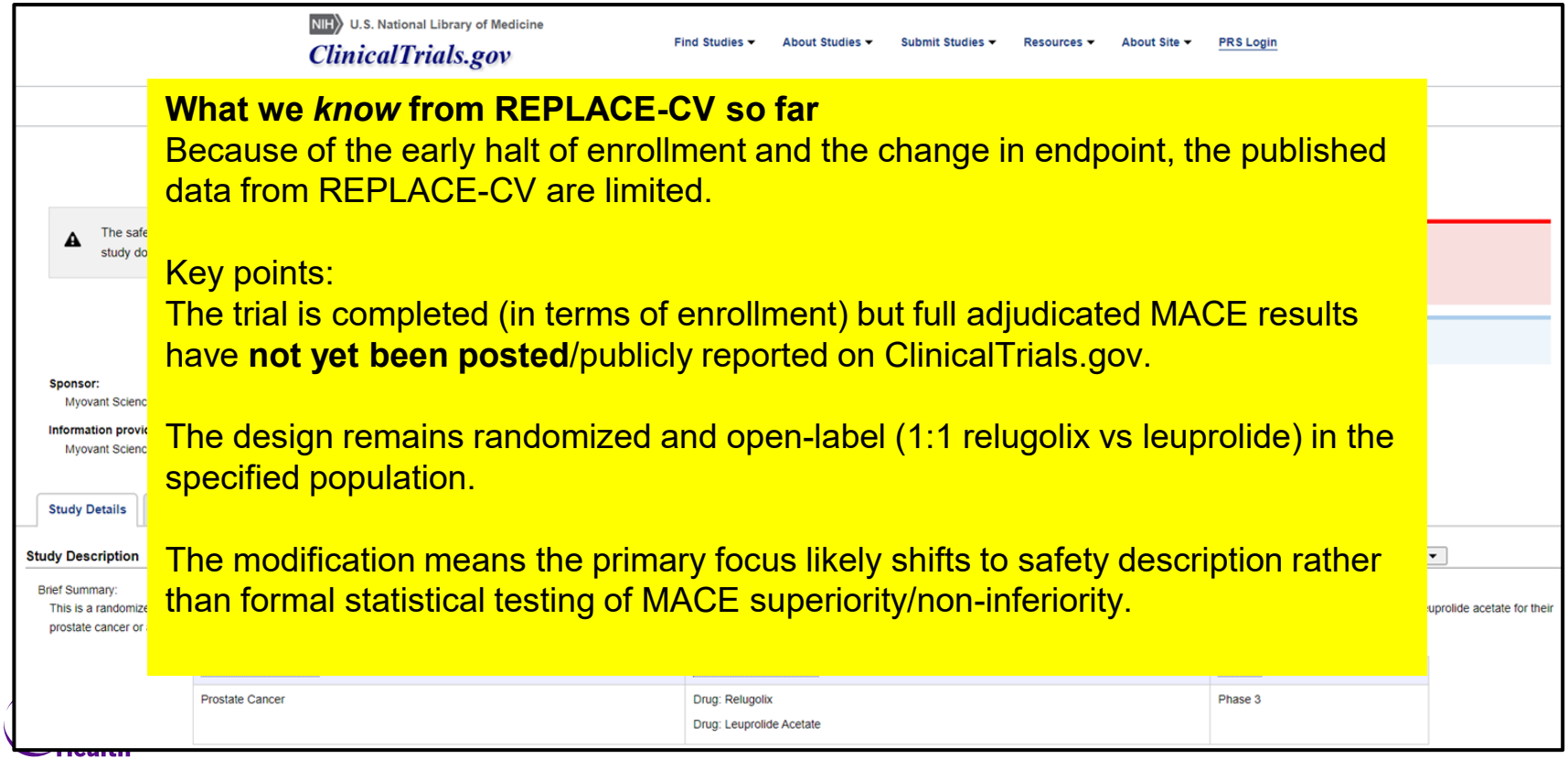


Nelson AJ, et al. J Am Coll Cardiol CardioOnc. 2023;5(5):613-624.

Included randomized controlled trials evaluating gonadotropin-releasing hormone (GnRH) antagonists and agonists among patients with prostate cancer. Forest plot

CONCLUSIONS Despite the addition of the largest, dedicated cardiovascular outcome trial, the volume and quality of available data to definitively answer this question remain suboptimal. Notwithstanding these limitations, the available data suggest that GnRH antagonists are associated with fewer cardiovascular events, and possibly mortality, compared with GnRH agonists. (J Am Coll Cardiol CardioOnc 2023;5:613-624) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Relugolix: REPLACE-CV



What we *know* from REPLACE-CV so far

Because of the early halt of enrollment and the change in endpoint, the published data from REPLACE-CV are limited.

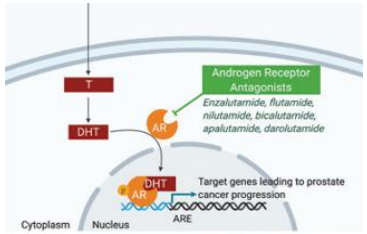
Key points:

The trial is completed (in terms of enrollment) but full adjudicated MACE results have **not yet been posted**/publicly reported on ClinicalTrials.gov.

The design remains randomized and open-label (1:1 relugolix vs leuprolide) in the specified population.

The modification means the primary focus likely shifts to safety description rather than formal statistical testing of MACE superiority/non-inferiority.

Androgen Receptor Pathway Inhibitors (ARPI)
AR Receptor Blockers, CYP17 Inhibitors, CAB, and CVD



AR ANTAGONISTS
(i.e. enzalutamide apalutamide, darolutamide)

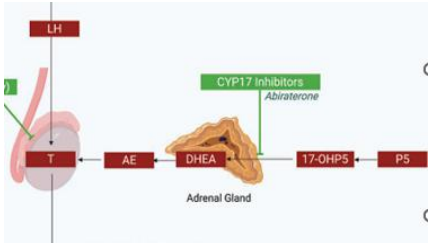
CV Risk: HTN, Rare ischemic HD, arrhythmia (QTc), Heart Failure

"CAB" = COMBINED ANDROGEN BLOCKADE: using GnRH agonist and AR antagonist:

- 2 meta-analyses of observational studies that examined CAB

  compared with non-ADT, there was a positive association with CV death, nonfatal cardiovascular

  disease, and
- The association with MI was not statistically significant



CYP17 INHIBITORS
(i.e. abiraterone)

CV Risk: HTN, edema/fluid retention, and hypokalemia
***Higher rate of CV Toxicity than AR Antagonists**

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Cardiovascular Effects of Androgen Deprivation Therapy in Prostate Cancer Contemporary Meta-Analyses Jiun-Ruey Hu,Javid J. Moslehi et al.
Meng F, Niu Y et al. Stroke related to androgen deprivation therapy for prostate cancer: a meta-analysis and systematic review. *BMC Cancer*. 2016;16:180
Zhao , Niu Yet al. Androgen deprivation therapy for prostate cancer is associated with cardiovascular morbidity and mortality: a meta-analysis of Population-Based Observational; Studies. *PLOS ONE*. 2014;9:e107516.

Cardiovascular events among men with prostate cancer treated with androgen receptor signaling inhibitors: a systematic review, meta-analysis, and network meta-analysis

Akihiro Matsukawa[1,2], Takafumi Yanagisawa[1,2], Mehdi Kardoust Parizi[1,3], Ekaterina Laukhtina[1], Jakob Klemm[1,4], Tamás Fazekas[1,5], Keiichiro Mori[1,2], Shoji Kimura[1,2], Alberto Briganti[6,7], Guillaume Ploussard[8], Pierre I. Karakiewicz[9], Jun Miki[2], Takahiro Kimura[2], Pawel Rajwa[1,10] and Shahrokh F. Shariat[1,5,11,12,13,14,15,16]✉

BACKGROUND: Androgen-receptor pathway inhibitors (ARPIs) have dramatically changed the management of advanced/metastatic prostate cancer (PCa). However, their cardiovascular toxicity remains to be clarified.
OBJECTIVE: To analyze and compare the risks of cardiovascular events secondary to treatment of PCa patients with different ARPIs.
METHODS: In August 2023, we queried PubMed, Scopus, and Web of Science databases to identify randomized controlled studies (RCTs) that analyze PCa patients treated with abiraterone, apalutamide, darolutamide, and enzalutamide. The primary outcomes of interest were the incidence of cardiac disorder, heart failure, ischemic heart disease (IHD), atrial fibrillation (AF), and hypertension. Network meta-analyses (NMAs) were conducted to compare the differential outcomes of each ARPI plus androgen deprivation therapy (ADT) compared to standard of care (SOC).
RESULTS: Overall, 26 RCTs were included. ARPIs were associated with an increased risk of cardiac disorders (RR: 1.74, 95% CI: 1.13–2.68, $p = 0.01$), heart failure (RR: 2.49, 95% CI: 1.05–5.91, $p = 0.04$), AF (RR: 2.15, 95% CI: 1.14–4.07, $p = 0.02$), and hypertension (RR: 2.06, 95% CI: 1.67–2.54, $p < 0.01$) at grade ≥3. Based on NMAs, abiraterone increased the risk of grade ≥3 cardiac disorder (RR:2.40, 95% CI: 1.42–4.06) and hypertension (RR:2.19, 95% CI: 1.77–2.70). Enzalutamide was associated with the increase of grade ≥3 AF(RR: 3.17, 95% CI: 1.05–9.58) and hypertension (RR:2.30, 95% CI: 1.82–2.92).
CONCLUSIONS: The addition of ARPIs to ADT increases the risk of cardiac disorders, including IHD and AF, as well as hypertension. Each ARPI exhibits a distinct cardiovascular event profile. Selecting patients carefully and vigilant monitoring for cardiovascular issues is imperative for those undergoing ARPI + ADT treatment.

Prostate Cancer and Prostatic Diseases (2025) 28:298–308; https://doi.org/10.1038/s41391-024-00886-0

Table 2. Summary of meta-analysis on cardiovascular events with ARSIs.

		Data summary of included studies	Pooled RR (95% CI), *p*-value	Cochran's Q test
Cardiac disorder	Any grade	5 studies 5786 patients	1.39 (1.10–2.22), $p < 0.01$	$p = 0.06$
	Grade ≥3	7 studies 6546 patients	1.74 (1.13–2.68), $p = 0.01$	$p = 0.06$
Heart failure	Any grade	9 studies 11,255 patients	1.60 (0.96–2.67), $p = 0.07$	$p > 0.9$
	Grade ≥3	7 studies 8988 patients	2.49 (1.05–5.91), $p = 0.04$	$p > 0.9$
IHD	Any grade	6 studies 7215 patients	2.36 (1.53–3.65), $p < 0.001$	$p = 0.03$
	Grade ≥3	5 studies 5820 patients	2.04 (0.91–4.62), $p = 0.09$	$p < 0.01$
AF	Any grade	9 studies 9412 patients	1.41 (1.02–1.94), $p = 0.04$	$p = 0.5$
	Grade ≥3	7 studies 7028 patients	2.15 (1.14–4.07), $p = 0.02$	$p > 0.9$
Hypertension	Any grade	19 studies 17,180 patients	1.68 (1.38–2.05), $p < 0.001$	$p < 0.001$
	Grade ≥3	16 studies 15,868 patients	2.06 (1.67–2.54), $p < 0.01$	$p = 0.1$

ARSI androgen receptor signaling inhibitor, *RR* risk ratio, *CI* Confidence Interval, *IHD* Ischemic heart disease, *AF* atrial fibrillation

First meta-analysis and network metaanalysis to compare CV events in advanced PCa pts treated with ARPI's+ ADT (vs SOC)

26 Trials included

ARPI added to ADT increased risk overall of CV events
(grade ≥ 3 RR 1.74, p = 0.06)

Abiraterone + ADT = increased overall CV events and HTN

Enzalutamide + ADT = Increased Ischemic Heart Disease and HTN

Adding ARPI to ADT increased risk of cardiac disorder by 39%, and increased risk of a high-grade toxicity by 74%

Summary of Prostate Cancer Therapy Related Cardiac Toxicity

TABLE 1 | Summary of cardiovascular complications of agents used in prostate cancer treatment.

Medication	CV complications	Potential mechanism
ADT		
GnRH antagonist GnRH agonist First-generation antiandrogens	Ischemic heart disease Hypertension Heart failure QTc interval prolongation Atrial fibrillation	Sarcopenic obesity, lipid profiles (increases in total cholesterol, low-density lipoprotein, high-density lipoprotein, and triglycerides), reduced insulin sensitivity and diabetes, increased inflammation, atherogenic plaque formation, and plaque destabilization (Scragg et al., 2004; Faris and Smith, 2010; Tzortzis et al., 2017)
Second-generation androgen receptor blockers		
Enzalutamide	Ischemic heart disease Hypertension QTc interval prolongation	Delayed rectifier K^+ current, enhancement of late Na^+ current, and decrease in NO production in the endothelium (Ikeda et al., 2005; Salem et al., 2019; Zhu and Wu, 2019)
Darolutamide	Ischemic heart disease Heart failure	Unknown
Apalutamide	Ischemic heart disease Hypertension	Unknown
Androgen metabolism inhibitor		
Abiraterone acetate	Ischemic heart disease Hypertension Atrial fibrillation QTc interval prolongation	Increased mineral corticoid production, reduced androgen synthesis, and fluid retention (Attard et al., 2008)
Chemotherapy		
Docetaxel	Heart failure Left ventricular dysfunction	Direct cytotoxic effect, oxidative stress, and endothelial dysfunction (Montero et al., 2005; Hung et al., 2015)
Immunotherapy		
Pembrolizumab	Myocarditis Pericarditis Conduction diseases Rhythm disturbances Hypertension Heart failure Ischemic heart disease	Autoimmune reaction due to T-lymphocytes activation against cardiac tissue cells (Nishimura et al., 2001; Wang et al., 2010; Longoria and Tewari, 2016)
Sipuleucel-T	Hypertension Cerebrovascular events	Unknown

Notes: ADT, androgen deprivation therapy; GnRH, gonadotropin-releasing hormone; QTc, corrected; QT, interval; LDL, low-density lipoprotein; HDL, high-density lipoprotein; NO, nitric oxide.

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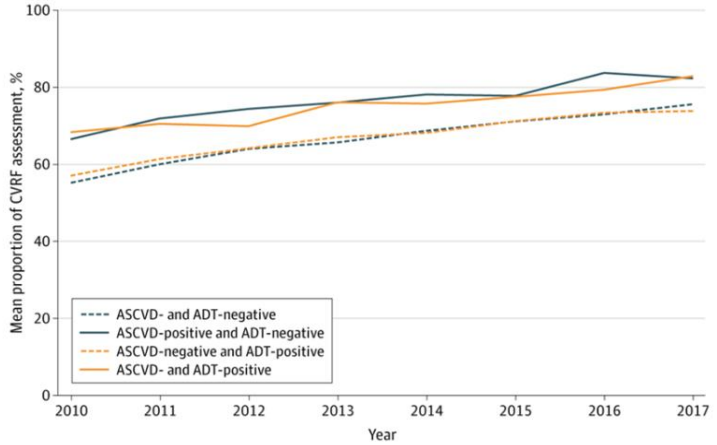
Wilk et al. Front Pharmacol. 2020

Are cardiovascular risk factors assessed and appropriately managed in patients with Pca initiating ADT?

Figure 2. Proportion of Comprehensive Cardiovascular Risk Factor (CVRF) Assessment Over Time, According to Androgen Deprivation Therapy (ADT) and Atherosclerotic Cardiovascular Disease (ASCVD) Group



Go to Figure in Article

Patients were categorized into 4 groups based on history of ASCVD and receipt of ADT within a year of diagnosis. Yearly unadjusted proportions of patients with recorded measurements for all 3 CVRFs (blood pressure, glucose, and cholesterol levels) within the study period are shown.

90,494 veterans

- 22 700 men (25.1%) received ADT
- 68.1% received comprehensive CVRF assessment
- 54.1% had uncontrolled CVRFs
- 29.6% (95% CI, 29.2%-30.0%) of those with uncontrolled CVRFs were not receiving corresponding cardiac risk–reducing medication

Conclusions and Relevance

veterans with PC had a high rate of underassessed and undertreated CVRFs, and ADT initiation was not associated with substantial improvements in CVRF assessment or management. These findings highlight gaps in care and the need for interventions to improve CVRF mitigation in this population.

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Sun L, Ky B. Assessment and Management of Cardiovascular Risk Factors Among US Veterans With Prostate Cancer. JAMA Netw Open. 2021 Feb 1;4(2):e210070.

Baseline Risk Assesment for CV Risk in Prostate Cancer

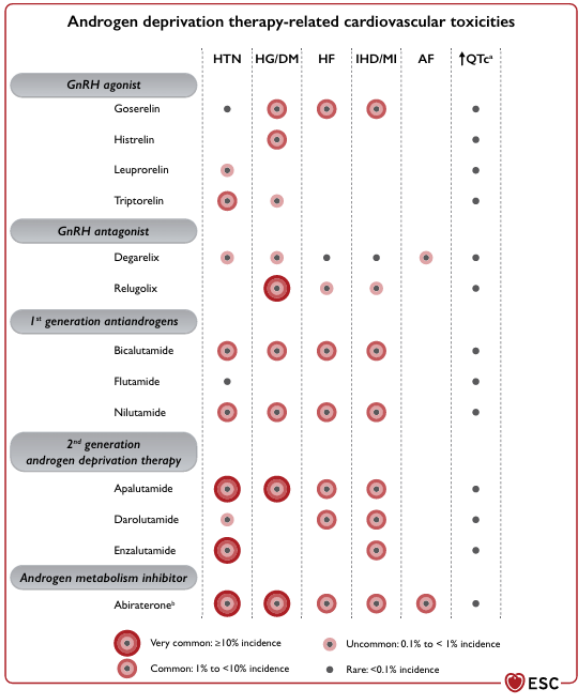

Figure 21 Androgen deprivation therapy-related cardiovascular toxicities. ADT, androgen deprivation therapy; AF, atrial fibrillation; DM, diabetes mellitus; EMA, European Medicines Agency; FDA, Food and Drug Administration; GnRH, gonadotropin-releasing hormone; HF, heart failure; HG, hyperglycaemia; HTN, hypertension; IHD, ischaemic heart disease; MedDRA, medical dictionary for regulatory activities; MI, myocardial infarction; ↑QTc, corrected QT interval prolongation; TdP, torsade de pointes. Adverse reactions reported in multiple clinical trials or during post-marketing use are listed by system organ class (in MedDRA) and frequency. If the frequency is unknown or cannot be estimated from the available data, a blank space has been left. [a]ADT may prolong the QTc interval. In patients with a history of risk factors for QT prolongation and in patients receiving concomitant medicinal products that might prolong the QT interval, physicians should assess the benefit/risk ratio including the potential for TdP prior to initiating the treatment. [b]Increased risk of QTc prolongation in combination with ADT.[49,339,340,349,350] Figure developed from EMA prescribing information,[352] FDA prescribing information.[353]

Recommendation Table 16 — Recommendations for baseline risk assessment and monitoring during androgen deprivation therapy for prostate cancer

Recommendations	Class[a]	Level[b]
Baseline CV risk assessment[c] and estimation of 10-year fatal and non-fatal CVD risk with SCORE2 or SCORE2-OP[d] is recommended in patients treated with ADT without pre-existing CVD.[19,341,342]	I	B
Baseline and serial ECGs are recommended in patients at risk of QTc prolongation during ADT therapy.[e,339–342]	I	B
A GnRH antagonist should be considered in patients with pre-existing symptomatic CAD[f] who require ADT.[341,342]	IIa	B
Annual CV risk assessment[c] is recommended during ADT.[19,339,341,342]	I	B

© ESC 2022

ACS, acute coronary syndromes; ADT, androgen deprivation therapy; BP, blood pressure; CAD, coronary artery disease; CCS, chronic coronary syndromes; CV, cardiovascular; CVD, cardiovascular disease; ECG, electrocardiogram; GnRH, gonadotropin-releasing hormone; HbA1c, glycated haemoglobin; QTc, corrected QT interval; SCORE2, Systematic Coronary Risk Estimation 2; SCORE2-OP, Systematic Coronary Risk Estimation 2—Older Persons.
[a]Class of recommendation.
[b]Level of evidence.
[c]BP, lipids, fasting glucose, HbA1c, ECG, and patient education on healthy lifestyle and lifestyle risk factor control is recommended.
[d]SCORE2 (<70 years) or SCORE2-OP (≥70 years) CV risk stratification: <50 years: low risk <2.5%, moderate risk 2.5% to <7.5%, high risk ≥7.5%; 50–69 years: low risk <5%; moderate risk 5% to <10%; high risk ≥10%; ≥70 years: low risk <7.5%, moderate risk 7.5% to <15%, high risk ≥15%.
[e]See *Table 9*.
[f]CCS and ACS.

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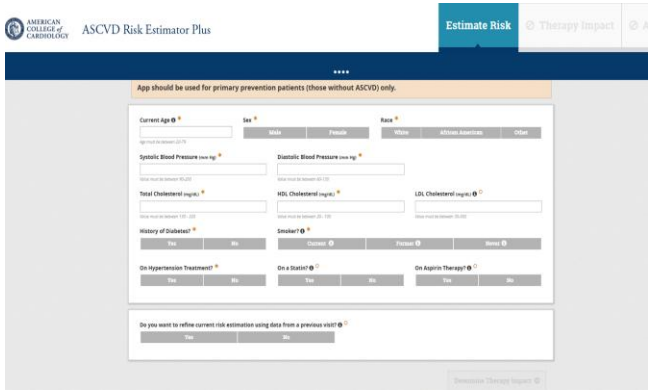
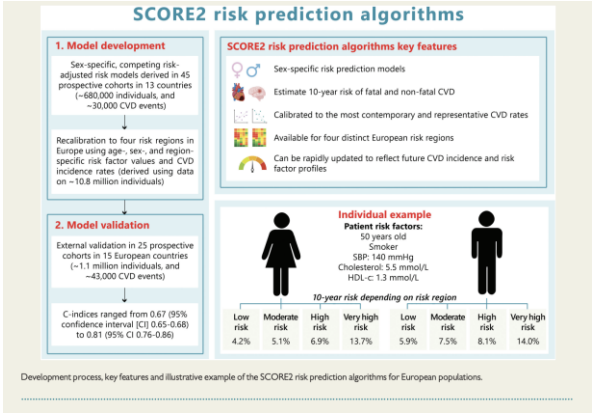
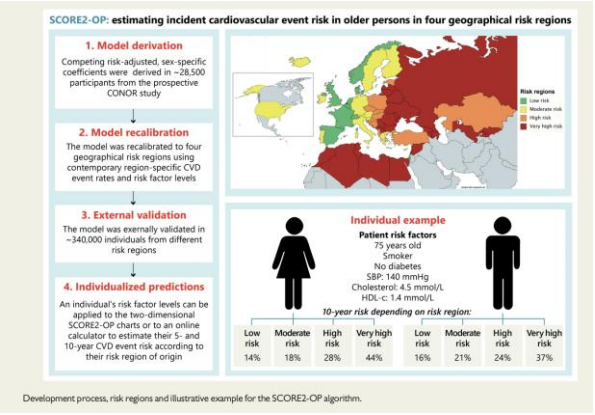
ESC Guidelines, Lyon et al. 2022; EHJ

Estimating CVD Risk in Patients with Pca: There is no Pca Specific Calculator





Development process, key features and illustrative example of the SCORE2 risk prediction algorithms for European populations.



Development process, risk regions and illustrative example for the SCORE2-OP algorithm.

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Artificial Intelligence in PC Risk Modeling

Article

Predicting Cardiovascular Risk in Patients with Prostate Cancer Receiving Abiraterone or Enzalutamide by Using Machine Learning

Dong-Yi Chen [1,2], Chun-Chi Chen [1,3], Ming-Lung Tsai [4,5], Chieh-Yu Chang [1,4], Ming-Jer Hsieh [1,4], Tien-Hsing Chen [4,6], Po-Jung Su [4,7], Pao-Hsien Chu [1,4], I-Chang Hsieh [1,4], See-Tong Pang [4,8,*] and Wen-Kuan Huang [4,7,*]

Variable	Total (n = 4739)	Training (n = 3318)	Validation (n = 1421)	p Value
Flutamide	161 (3.4)	111 (3.4)	50 (3.5)	0.763
Bicalutamide	1824 (38.5)	1254 (37.8)	570 (40.1)	0.133
Cyproterone	366 (7.7)	270 (8.1)	96 (6.8)	0.103
Follow-up year	2.1 ± 1.4	2.1 ± 1.4	2.2 ± 1.4	0.756

Abbreviations: ADT, androgen deprivation therapy; GnRH, gonadotropin-releasing hormone; PCa, prostate cancer; ARPI, androgen receptor signaling inhibitors. * Any one of the following: coronary heart disease, peripheral arterial disease, myocardial infarction, or stroke; data are presented as frequency (percentage), mean ± standard deviation, or median [25th percentile, 75th percentile].

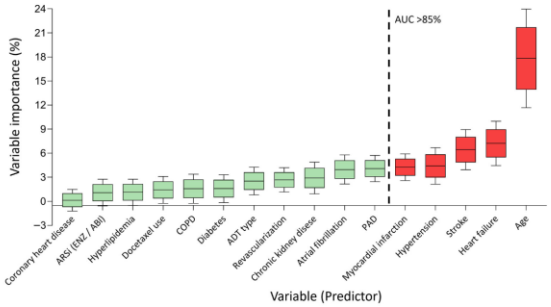


Figure 2. Variable importance distribution in random survival forest analysis. Distribution of variable importance across 16 parameters in the initial model. The five variables demonstrating the strongest correlation (AUC > 85%) were selected for the final model. The red bars correspond to five variables recognized as significant predictors in the final RSF model, whereas the green bars denote ten variables that were not deemed significant. Data derived from 1000 bootstrap samples. AUC, area under the curve.

Predicting Cardiovascular Risk in Patients with Prostate Cancer Receiving Abiraterone or Enzalutamide

Risk
Age (under 65 or over 75)
Heart failure
Stroke
Hypertension
Myocardial infarction

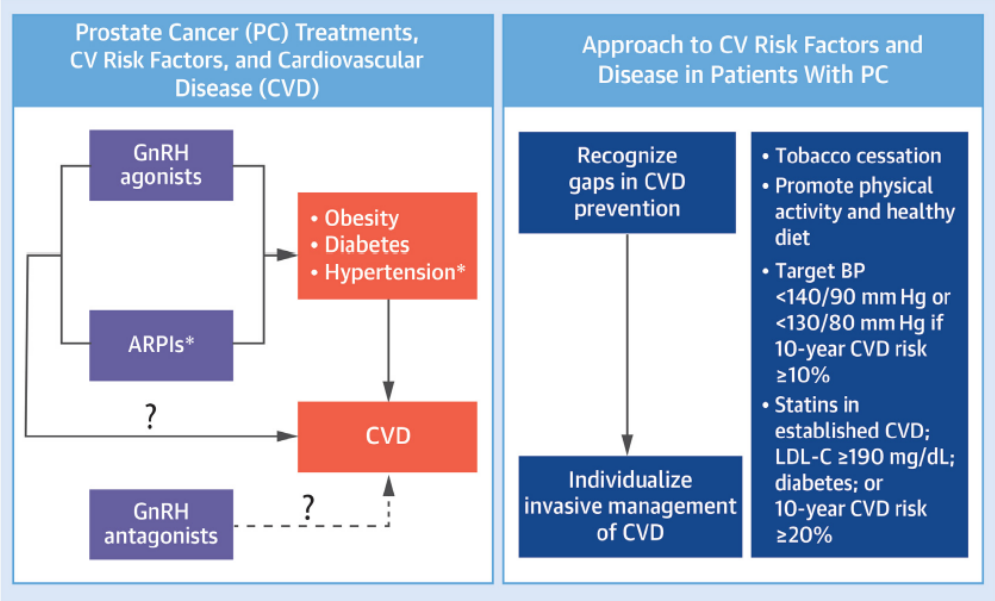
Feature number	Risk of MACE (%)*	Risk classification
≤ 1	6.9%	Low risk
2	15.3%	Intermediate risk
≥3	24.8%	High risk

* Mean follow up = 2.1 years

Figure 5. Risk stratification model for predicting cardiovascular events in patients with prostate cancer receiving abiraterone or enzalutamide. The **left** panel displays the five clinical risk factors included in the prediction model: age (categorized as under 65 or over 75 years), heart failure, stroke, hypertension, and myocardial infarction. The **right** panel presents the risk stratification system based on the number of risk factors present, with corresponding probabilities of major adverse cardiovascular events (MACE) and risk classifications.

The Role of Aggressive CVD Risk Factor Control

CENTRAL ILLUSTRATION The Relationship Between PC Treatments, Cardiovascular Risk Factors and Disease; and Strategies to Mitigate Cardiovascular Risk



Leong DP, et al. JACC CardioOncol. 2024;6(6):835-846.

GnRH agonists promote obesity, diabetes and hypertension; ARPIs promote hypertension. The relationship between GnRH antagonists and CVD is uncertain while the magnitude of cardiovascular risk directly attributable to GnRH agonists and ARPIs is to be defined. *ARPIs have been specifically been associated with the development of hypertension.

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The Role of Structured Exercise in Patients with Prostate Cancer

Systematic Review

Do Patients with Prostate Cancer Benefit from Exercise Interventions? A Systematic Review and Meta-Analysis

Martin Færch Andersen [1,*], Julie Midtgaard [2,3] and Eik Dybboe Bjerre [4]

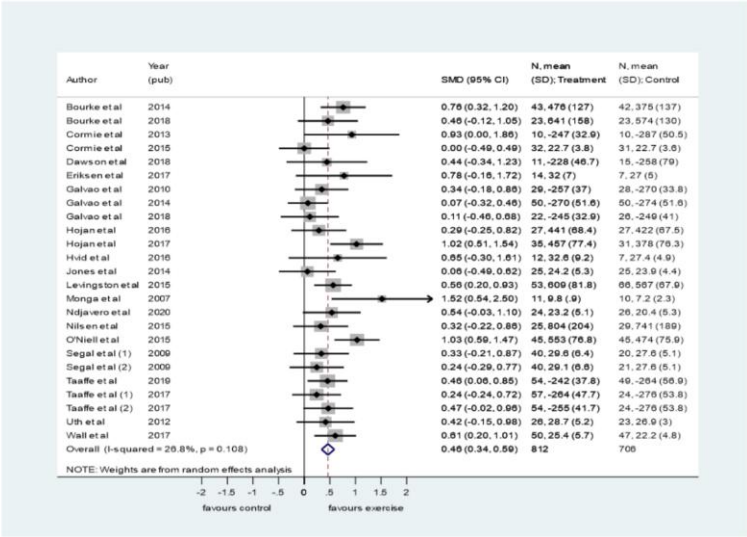


Figure 3. Pooled standard mean difference (SMD) on cardiovascular fitness comparing exercise interventions with usual care or control in men with prostate cancer. A random effects model of DerSimonian and Laird, with estimate of heterogeneity from the Mantel–Haenszel model, was used.

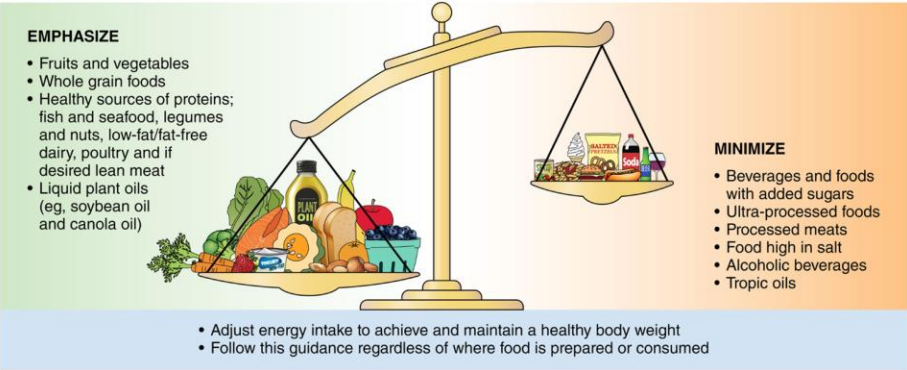
Meta-analysis of 33 randomized controlled trials (2,567 participants) found moderate-to-large effects of exercise (especially aerobic) on cardiovascular fitness (SMD ~0.46) and on lower-body strength, whole-body fat mass, blood pressure

For men with prostate cancer, whether undergoing active surveillance, treatment (e.g., androgen deprivation therapy, radiotherapy), or post-treatment, recommending exercise (combining aerobic + resistance) is a low-risk, beneficial supportive intervention to improve fitness, body composition, reduce fatigue, improve quality of life, and possibly improve cognitive/social functioning.

Circulation
Volume 144, Issue 23, 7 December 2021; Pages e472-e487
https://doi.org/10.1161/CIR.0000000000001031

AHA SCIENTIFIC STATEMENT

2021 Dietary Guidance to Improve Cardiovascular Health: A Scientific Statement From the American Heart Association



Evidence-Based Guidance on Dietary Patterns to Promote Cardiometabolic Health

Healthy dietary patterns comprise foods and their nutrient components. The Table and Figure summarize evidence-based guidance for dietary patterns to promote cardiovascular health. The following sections summarize the rationale and evidence for each of the 10 features.

Table 1. Evidence-Based Dietary Guidance to Promote Cardiovascular Health (Table view)

1. Adjust energy intake and expenditure to achieve and maintain a healthy body weight
2. Eat plenty of fruits and vegetables, choose a wide variety
3. Choose foods made mostly with whole grains rather than refined grains
4. Choose healthy sources of protein
a. mostly protein from plants (legumes and nuts)
b. fish and seafood
c. low-fat or fat-free dairy products instead of full-fat dairy products
d. if meat or poultry are desired, choose lean cuts and avoid processed forms
5. Use liquid plant oils rather than tropical oils (coconut, palm, and palm kernel), animal fats (eg, butter and lard), and partially hydrogenated fats
6. Choose minimally processed foods instead of ultra-processed foods*
7. Minimize intake of beverages and foods with added sugars
8. Choose and prepare foods with little or no salt
9. If you do not drink alcohol, do not start; if you choose to drink alcohol, limit intake
10. Adhere to this guidance regardless of where food is prepared or consumed

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The Role of Androgen Deprivation Therapy in CArdiovascular Disease – A Longitudinal Prostate Cancer Study (RADICAL PC1)- prospective cohort study

A RAndomizeD Intervention for Cardiovascular And Lifestyle Risk Factors in Prostate Cancer Patients (RADICAL PC2) – prospective randomized controlled (prevention) trial

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RADICAL PC1: A large prospective observational registry of men with newly-diagnosed prostate cancer (PC), or about to receive first-line androgen-deprivation therapy (ADT)

~2,492 men, mean age ~68 yrs

Inclusion criteria: diagnosed within ~1 year, or starting ADT for the first time (within ~6 months) etc. ✅ Main Published Results

92% of men had newly-diagnosed PC; intermediate-risk ~41%, high-risk ~50%.

58% were current or former smokers

22% had known cardiovascular disease

16% had diabetes

45% had hypertension

31% with BMI ≥ 30 kg/m²

24% low physical activity.

RADICAL PC2: A randomized controlled trial

RADICAL PC-2 is a randomized controlled trial (RCT) of a systematic intervention targeting cardiovascular and lifestyle risk factor modification vs usual care in men newly diagnosed with prostate cancer or starting ADT

Dr. Bloom's Top Recommendations for staying Healthy as a Patient with Prostate Cancer

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Get Moving!!!

- Get Regular Physical Activity
- Aim for at least 150 minutes/week of moderate-intensity aerobic exercise (think brisk walking, cycling, or swimming) *or* 75 minutes of vigorous activity — or a mix of both. *(American Cancer Society, American Heart Association)*
- Add strength/resistance training 2× per week to help preserve muscle mass and metabolic health, which is especially useful if you're on hormone therapy (ADT).
- Even modest improvements in cardiorespiratory fitness can benefit heart health and may relate to lower risks of mortality.
- Why it matters: Exercise improves blood pressure, cholesterol, blood sugar regulation, reduces inflammation, and helps manage body weight — all key cardiovascular risk factors.

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Eat Like Your Heart Depends on It!!!

Follow a Heart-Healthy, Plant-Forward Diet

Why it matters: These patterns are associated with

- better cholesterol levels
- lower blood pressure
- improved weight control
- reduced cardiovascular risk
- linked to lower all-cause and heart disease mortality after prostate cancer diagnosis.

Emphasize:	Limit:
nutrient-dense eating pattern that supports both heart and metabolic health	Saturated and trans fats
Fruits & vegetables	Processed/red meats
Whole grains Legumes	High-sodium foods
Lean proteins (fish, poultry, beans)	Sugar-sweetened beverages
Healthy fats (olive oil, nuts, avocados)	Excessive alcohol consumption

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Remember small Lifestyle “Hacks” to support your goals

- Quit smoking (if applicable).
- Limit alcohol — moderation or avoidance can support both cardiovascular and overall cancer outcomes
- Why it matters: Smoking and heavy drinking both increase cardiovascular risk significantly and can worsen overall health prospects.

Maintain a Healthy Body Weight

- Aim for a healthy BMI and waist circumference through diet and activity.
- Even moderate weight loss (if overweight) can improve blood pressure, glucose regulation, and lower cardiovascular risk.
- Why it matters: Excess body fat, especially around the waist, is strongly tied to heart disease, diabetes, and worse outcomes in prostate cancer survivors.

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Stress and Sleep Matter Too!

- Manage stress with mindfulness, good sleep habits, and enjoyable activities.
- Poor sleep and chronic stress can worsen cardiovascular risk and overall well-being.
- While less specific to prostate cancer, sleep quality and stress management support heart health and resilience in general

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Regular Health Monitoring & Medications When Appropriate

- “Know your numbers”: blood pressure, cholesterol, blood glucose/A1c.
- Work with your healthcare provider on cardiovascular risk management, including statins, blood pressure meds, or diabetes management if indicated.
- Why it matters: Many men with prostate cancer are older and may have co-existing cardiovascular risk factors that benefit from medical optimization.

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Take Home Points

- CVD Risk Factor Burden high in PCa pts
- CVD Risk Factors Likely to be Uncontrolled in PCa
- ADT accelerates CVD risk profile (in several ways)
- CV Profile of GnRH Agonists and Agonists are a moving Target
- ARPIs Increase HTN and Fluid Retention
- Risk Stratification and aggressive risk factor modification are critical

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The NYU Cardio-Oncology Program

December, 2023 : Official Establishment of NYU CO Program

Clinics in both Manhattan and Long Island

Recognized as an International Cardio-Oncology Society GOLD Center of Excellence (September, 2024)

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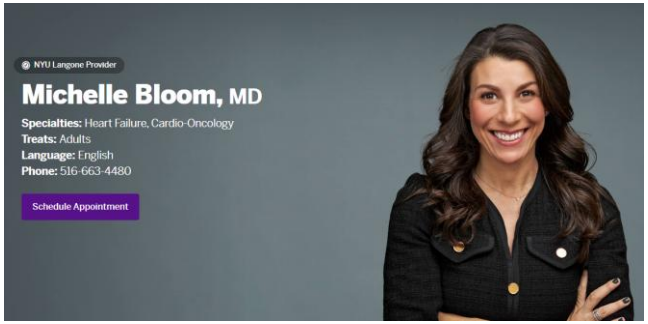
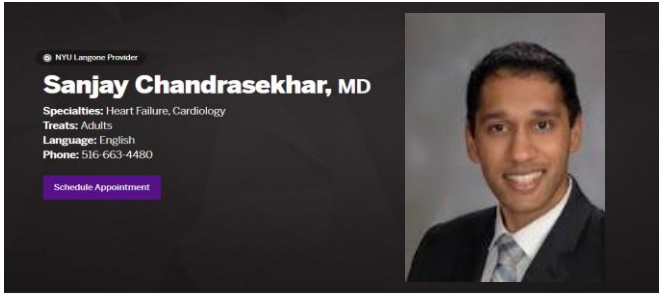
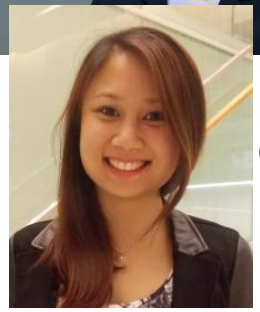
Who are the NYU Cardio-Oncologists?







Laraine Chiu,
Cardio-Oncology/HF NP

NYU Langone Provider

Jennifer Chao, MD

Cardiology, Internal Medicine

Treats Adults

NYU Langone at Great Neck Medical
488 Great Neck Road, 3rd Floor
Great Neck, NY 11021

516-482-6747

NYU Langone Provider

Jonathan N. Jordan, DO

Cardiology, Cardio-Oncology

Treats Adults

NYU Langone Ambulatory Care Garden City
1111 Franklin Avenue, 2nd Floor
Garden City, NY 11530

516-222-8600

NYU Langone Provider

William L. Blau, MD

Cardiology, Preventive Cardiology, Internal Medicine

Treats Adults

NYU Langone Ambulatory Care Lake Success—1999 Marcus Avenue
1999 Marcus Avenue, Suite 220
New Hyde Park, NY 11042

516-467-8674

To make an appointment with one of our cardio-oncologists, call:
(516) 663 4480 (option #5)

QUESTIONS?

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