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Treatment and 30-Day Mortality after Myocardial Infarction in Prostate Cancer Patients: A Population-Based Study from Norway

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Keywords
Prostatic neoplasms · Myocardial infarction · Registries · Comorbidity · Mortality

Abstract
Introduction: There is limited knowledge about the use of invasive treatment and mortality after acute myocardial infarction (AMI) in prostate cancer (PCa) patients. We therefore wanted to compare rates of invasive treatment and 30-day mortality between AMIs in patients with PCa and AMIs in the general Norwegian male population. ***Methods:*** Norwegian population-based registry data from 2013 to 2019 were used in this cohort study to identify AMIs in patients with a preceding PCa diagnosis. We compared invasive treatment rates and 30-day mortality in AMI patients with PCa to the same outcomes in all male AMI patients in Norway. Invasive treatment was defined as performed angiography with or without percutaneous coronary intervention or coronary artery bypass graft surgery. Standardized mortality (SMR) and incidence ratios, and logistic regression were used to evaluate the association between PCa risk groups and invasive treatment. ***Results:*** In 1,018 patients with PCa of all risk groups, the total rates of invasive treatment for AMIs were similar to the rates in the general AMI population. In patients with ST-segment elevation AMIs, rates were lower in metastatic PCa compared to localized PCa (OR 0.15, 95% CI: 0.04–0.49). For non-ST-segment elevation AMIs, there were no differences between PCa risk groups. The 30-day mortality after AMI was lower in PCa patients than in the total population of similarly aged AMI patients (SMR 0.77, 95% CI: 0.61–0.97). ***Conclusion:*** Except for patients with metastatic PCa experiencing an ST-segment elevation AMI, PCa patients were treated as frequent with invasive treatment for their AMI as the general AMI population. 30-day all-cause mortality was lower after AMI in PCa patients compared to the general AMI population.

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Introduction

Survival following prostate cancer has improved during the last decades, putting survivors at risk for other conditions, including cardiovascular disease (CVD) [1–4]. Previous studies have shown that prostate cancer patients may have higher risks of cardiovascular morbidity and death compared to the general population [5], with androgen deprivation therapy as a possible detrimental factor. However, cancer patients have also been reported to have poorer outcomes after acute myocardial infarction (AMI) in general, including higher in-hospital and long-term mortality compared with noncancer AMI patients [6–9]. As people with cancer historically have been excluded from trials evaluating treatment [10], current guidelines on AMI do not adequately address treatment for people with co-existing cancer [11]. The current European Society of Cardiology guidelines for the treatment of non-ST-segment elevation AMIs (NSTEMI) note cancer as a reason to withhold more invasive treatment but do not give further information [12], which may contribute to lower rates of invasive treatment in this group [8].

Most previous studies on cancer and AMI have included a mixture of cancer types, mainly breast, gastrointestinal, and lung cancer. A recent study found that NSTEMI patients with cancer that were treated invasively had better outcomes when compared to medical treatment, with the highest benefit if coronary angiography was performed within 72 h of admission [13]. This study, however, only included 8 (4%) patients with prostate, testicular, or penile cancers. Current recommendations suggest a case-based approach to treatment of AMI in cancer patients but only discuss cancer patients in general [14].

As the majority of patients newly diagnosed with PCa have almost the same life expectancy as the population without prostate cancer [15] and PCa is reported to be one of the most common cancer diagnoses in the population admitted to hospital for an AMI [16, 17], it is of particular interest to address whether poorer treatment of AMI could be an additional contributing factor to increased risk of cardiovascular morbidity and mortality in this population.

The aims of this study were therefore (i) to compare rates of invasive treatment and 30-day mortality between AMIs in patients with PCa and AMIs in the general population and (ii) to compare rates of invasive treatment for AMI in patients with PCa between PCa prognostic risk groups. Invasive treatment was defined as performed angiography with or without percutaneous coronary intervention (PCI) or coronary artery bypass graft surgery (CABG).

Methods

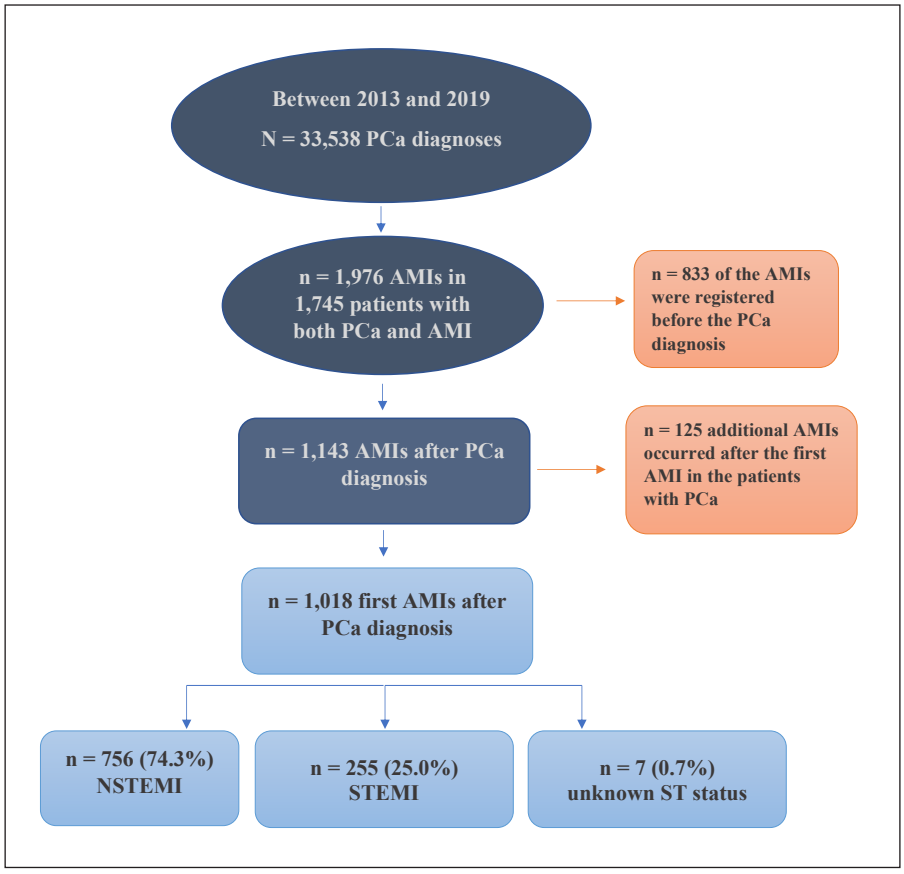
Study Population and Data Sources

This is a registry-based cohort study using nationwide data from Norway. The population included all male residents in Norway, diagnosed with PCa between 2013 and 2019, who subsequently suffered an AMI after their PCa diagnosis, within the same time-period. For analyses comparing invasive treatment among the PCa patients to the general AMI population, we included all males ≥40 years that experienced an AMI between 2013 and 2019. Close-to complete national data on all patients registered with PCa in the Cancer Registry of Norway (CRN) [18] were identified using International Classification of Diseases-10 (ICD-10) coding, and additional clinically relevant information specific to PCa was obtained from the Norwegian Prostate Cancer Registry (NoPCR) [19]. Data included age and date of PCa diagnosis, Gleason score, prostate-specific antigen (PSA) and clinical staging of the primary tumor, regional lymph nodes, and evidence of distant metastasis (cTNM) and WHO performance status [20], all at diagnosis. Data from the Norwegian Cardiovascular Disease Registry [21], including data on AMI from the Norwegian Myocardial Infarction Registry (NORMI) (cases of ICD-10 I21 and I22) [22], were linked to provide detailed data on AMI events, including age and date at time of the event, type of AMI, ST-segment elevation AMI (STEMI) versus NSTEMI and in-hospital treatment. The first AMI event after PCa diagnosis was included for analyses. Comorbidity scoring was provided by the Norwegian Patient Registry (NPR) [23] and deaths by the Norwegian Cause of Death Registry (NCoDR) [24].

Necessary PCa-specific variables obtained from the CRN were used to derive the risk groups for recurrence based on the European Association of Urology (EAU) guidelines, which are used in clinical practice in Norway [25, 26]: localized disease: low-risk: Gleason score ≤6 and PSA <10 ng/mL and cT1-2a; intermediate-risk: Gleason score 7 or PSA 10–20 ng/mL or cT2b; high-risk: Gleason Score >7 or PSA >20 ng/mL or cT2c; locally advanced: cT3–4 or cN+; distant metastases: cM+ or PSA >100 ng/mL.

Charlson Comorbidity Index (CCI) has been calculated in our population using records from NPR for the two years prior to PCa diagnosis [27]. In our PCa population, the score has a range from 0 to 14 which we categorized as 0, 1, 2, and 3+. WHO performance status classification was reported at the time of PCa diagnosis to indicate level of functional ability. The categories for this variable include normal functionality, light reduction, ambulatory more than 50% of waking hours, ambulatory less than or equal to 50% of waking hours to bedridden.

We defined invasive treatment as any of the following: investigation by coronary angiography with or without PCI or CABG. Although angiography without PCI is not strictly a form of treatment, it was included, as a completed angiography implies that appropriate investigation was undertaken to determine treatment needs. For our analyses on invasive treatment by PCa risk groups, we used an intention-to-treat approach and included patients that had a referral for angiography and/or PCI after discharge but may not have been reported as performed within our dataset. This could include a few patients that were referred for treatment at another location or who died prior to the procedures. Based on information obtained from the NCoDR, we focused on deaths from any cause that occurred within 30 days of admission of the AMI.



Color version available online

Fig. 1. Inclusion of prostate cancer patients.

Statistical Analyses

Descriptive statistics included count and percentage (%) for categorical variables and median and interquartile range (IQR) for continuous variables. To compare rates of invasive treatment following an AMI in patients with PCa to that of the general AMI population, we calculated standardized incidence ratios (SIR). SIRs are calculated by dividing the observed number of patients that received invasive treatment in our PCa population by the expected number, calculated using the rates of invasive treatment in the general AMI population stratified by age-groups (40–59, 60–69, 70–79 and 80+ years) and calendar periods (2013–2015, 2016–2017, and 2018–2019). SIRs were calculated separately for NSTEMI and STEMI patients. The same methods were used to calculate standardized mortality ratios (SMRs) which compare 30-day mortality in the PCa population to the general population, after having an AMI. For SMRs, we were not able to stratify by time-period because several time-period strata had no deaths. The age-standardized 30-day mortality rates were calculated using the male population in Norway between 2013 and 2019 as a standard, in age bands of 45–59, 60–69, 70–79, and 80–85 years.

Univariable and multivariable logistic regression analyzes were used to examine whether there was a relationship between PCa risk groups (with low risk as the reference group) and invasive treatment received as the outcome, adjusting for age at AMI and the CCI score in the multivariable model. Odds ratios (OR) and 95% confidence intervals (CIs) were reported. Sensitivity analyses were performed by removing patients with a WHO performance status of a reduction in mobility of 50% or worse and by removing cases of planned angiography and/or PCI.

All analyses were performed using R version 4.0.2 [28]. The R package "popEpi" was used to perform the SIR/SMR calculations [29]. The study was approved by the Regional Committee for Medical and Health Research Ethics (130363).

Results

Patient Characteristics

Of the 33,538 PCa patients diagnosed between 2013 and 2019 in Norway, there were 1,976 AMI events among 1,745 people. After excluding 833 AMI events that occurred before PCa diagnosis and keeping the first event after PCa diagnosis, 1,018 AMIs were kept for analyses (Fig. 1). Median age at diagnosis for the 1,018 included PCa patients with AMI was 71 years (IQR 66–78) compared to 69 (63–74) in the total PCa population (Table 1). Median PSA at diagnosis was 10.0 in the patients with PCa and AMI and 8.7 ng/mL in the total PCa population.

Table 1. Characteristics of the 1,018 included patients with both prostate cancer and AMI

	Total AMI PCa population (*n* = 1,018)	NSTEMI (*n* = 756)	STEMI (*n* = 255)
Age at PCa diagnosis	71 (66–78)	72 (67–78)	69 (65–75)
Age-groups			
<60	70 (6.9)	46 (6.1)	24 (9.4)
60–69	344 (33.8)	238 (31.5)	104 (40.8)
70–79	393 (38.6)	306 (40.5)	85 (33.3)
80+	211 (20.7)	166 (22.0)	42 (516.5)
PCa EAU risk			
Low risk	134 (13.2)	83 (11.0)	51 (20.0)
Intermediate risk	312 (30.6)	231 (30.6)	80 (31.4)
High risk	231 (22.7)	181 (23.9)	48 (18.8)
Locally advanced	187 (18.4)	139 (18.4)	45 (17.6)
Distant metastases	92 (9.0)	74 (9.8)	17 (6.7)
Missing	62 (5.1)	48 (6.3)	14 (5.5)
Charlson Comorbidity Index			
0	580 (57.0)	409 (54.1)	166 (65.1)
1	184 (18.1)	143 (18.9)	39 (15.3)
2	138 (13.6)	105 (13.9)	33 (12.9)
3+	116 (11.4)	99 (13.1)	17 (6.7)
Missing	0 (0.0)	0 (0.0)	0 (0)
WHO performance			
Normal	496 (48.7)	355 (47.0)	139 (54.5)
Light reduction	182 (17.9)	140 (18.5)	41 (16.1)
Ambulatory >50%	85 (8.3)	75 (9.9)	9 (3.5)
Ambulatory ≤50%	26 (2.6)	19 (2.5)	5 (2.0)
Bedridden	3 (0.3)	2 (0.3)	1 (0.4)
Missing	226 (22.2)	165 (21.8)	60 (23.5)

Values are median (IQR) or *n* (%). AMI, acute myocardial infarction; NSTEMI, non-ST elevation myocardial infarction; PCa, prostate cancer; STEMI, ST elevation myocardial infarction; EAU, European Association of Urology.

Of the patients diagnosed with AMI after PCa, low-risk disease was diagnosed in 13.8%, intermediate-risk in 30.6%, high-risk in 22.7%, locally advanced disease in 18.4%, and distant metastases in 9.4% of the patients (EAU prognostic PCa risk groups). About half (48.7%) had full functionality at diagnosis and 57.0% had low or no comorbidity as described by CCI. Table 2 shows comparable statistics of CVD risk factors, mortality, and invasive treatment in the general AMI population. At the time of the first AMI after PCa diagnosis, the median age was 74 years (IQR 68–80). The median time between PCa diagnosis and first AMI was 1.9 years (IQR 0.9–3.1). NSTEMI was found in 74%, and STEMI in 25% had of the patients.

AMI Invasive Treatment

Of the PCa patients that were under 85 years, invasive treatment was observed for 79% that had an NSTEMI and 94% that had a STEMI (Table 3). Among NSTEMI patients, 78% received coronary angiography, 55% PCI, and 8% CABG. Among STEMI patients, 94%, 89%, and 4% received angiography, PCI and CABG, respectively. Of the low- and intermediate-PCa risk groups, 84% and 83% received invasive treatment, whereas high-risk, locally advanced, and distant metastatic patients had invasive treatment at rates of 75%, 76%, and 66%, respectively.

When using logistic regression with NSTEMI patients (univariable model), there were no differences between rates of invasive treatment in the intermediate-risk, high-risk, or locally advanced, but lower rates in the distant metastatic population (OR 0.38, 95% CI: 0.17–0.84), compared to the low-risk group (Table 4). When adjusting for age and comorbidity, there were no differences between any of the risk groups in terms of invasive treatment. In addition, when comparing rates of invasive treatment in PCa patients to the general AMI population, there were no differences in receiving angiography or PCI in NSTEMI patients, SIR 1.06 (95% CI: 0.97–1.16)

Table 2. Characteristics of the AMI patients with a previous PCa diagnosis compared to characteristics of the general AMI population

	AMI patients with a previous PCa diagnosis (n = 1,018)	General AMI population (males ≥40 from 2013–2019) (n = 55,237)[a]
ST-segment elevation		
NSTEMI	74	72
STEMI	25	28
Age-groups at AMI		
40–59 years	3	25
60–69 years	27	26
70–79 years	43	25
80+ years	27	24
30-day mortality (unadjusted)	7.6	8
Invasive treatment		
Angiography	77	73
PCI	60	57
CABG	6	3

Values are percentages. AMI, acute myocardial infarction; CABG, coronary artery bypass graft surgery; NSTEMI, non-ST-segment elevation AMI; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation AMI. [a]Values from the general AMI population from 2013 to 2019, males over 40 years; anonymized data set for comparison.

Table 3. AMI invasive treatment, total group less than 85 years and by PCa risk group at diagnosis

NSTEMI	Total (n = 654)	Low risk (n = 80)	Intermediate risk (n = 208)	High risk (n = 153)	Locally advanced (n = 114)	Distant metastatic (n = 59)
Invasive treatment	514 (79)	67 (84)	172 (83)	115 (75)	87 (76)	39 (66)
Angiography	512 (78)	66 (82)	172 (83)	114 (75)	87 (76)	39 (66)
PCI	359 (55)	44 (55)	128 (62)	79 (52)	64 (56)	26 (44)
CABG	50 (8)	6 (8)	13 (6)	16 (10)	10 (9)	1 (2)
STEMI	Total (n = 238)	Low risk (n = 49)	Intermediate risk (n = 77)	High risk (n = 45)	Locally advanced (n = 40)	Distant metastatic (n = 14)
Invasive treatment	224 (94)	49 (100)	74 (96)	43 (96)	35 (88)	10 (71)
Angiography	223 (94)	49 (100)	72 (94)	43 (96)	35 (88)	10 (71)
PCI	212 (89)	46 (94)	73 (95)	41 (91)	32 (80)	10 (71)
CABG	9 (4)	1 (2)	3 (4)	2 (4)	3 (8)	0 (0)

Values are n (%). AMI, acute myocardial infarction; CABG, coronary artery bypass graft surgery; NSTEMI, non-ST-segment elevation AMI; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation AMI.

and SIR 1.08 (95% CI: 0.98–1.21), respectively (online suppl. table A; for all online suppl. material, see www.karger.com/doi/10.1159/000527636). For STEMI patients, there were high rates of invasive treatment for low-, intermediate-, and high-risk patients, 100%, 96%, and 96%, respectively (Table 3). Patients with locally advanced disease and distant metastasis had lower rates of invasive treatment, 88% and 71%, respectively. Due to lower numbers of patients in each risk group, we combined patients with localized disease into one group and metastatic disease into another. Compared to localized disease, patients with metastatic disease had lower rates of invasive treatment, after controlling for age and comorbidity (OR 0.15, 95% CI: 0.04–0.49) (Table 4). There were no differences in incidence of angiography or PCI between the PCa population and the general AMI population, SIR 1.04 (95% CI: 0.91–1.18) and SIR 1.07 (95% CI: 0.93–1.21), respectively (online suppl. table A).

Table 4. Association between PCa risk group and invasive MI treatment

NSTEMI	Univariable OR (95% CI)	Multivariable OR (95% CI)[a]
Low risk	Ref	Ref
Intermediate risk	0.93 (0.45–1.82)	1.12 (0.52–2.24)
High risk	0.59 (0.28–1.16)	0.83 (0.39–1.72)
Locally advanced	0.63 (0.29–1.28)	0.81 (0.36–1.72)
Distant metastatic	0.38 (0.17–0.84)	0.57 (0.24–1.33)
STEMI	**Univariable OR (95% CI)**	**Multivariable OR (95% CI)[a]**
Localized	Ref	Ref
Metastatic	0.12 (0.03–0.39)	0.15 (0.04–0.49)

CI, confidence interval; NSTEMI, non-ST elevation myocardial infarction; OR, odds ratio; STEMI, ST elevate myocardial infarction. [a] Adjusted for age and comorbidity.

Sensitivity analyses performed to evaluate the impact after excluding those with reduced functional status found no changes in the results. There were also no changes in the findings of logistic regression analyses when referred angiography and/or PCI were removed (28 patients out of 738).

Mortality

There were 77 (7.6%) deaths among the PCa patients within 30 days from the AMI onset. In those under 85 years, deaths within 30 days included 59 (6.6%). When standardizing for age according to the distribution in the general population, the rate was 4.2%. The 30-day all-cause mortality was lower in the PCa population compared to the general AMI population, SMR 0.77 (95% CI: 0.61–0.97).

Discussion

In the present study, we found no differences in the total rates of angiography or PCI between AMI patients with a previous diagnosis of prostate cancer compared to the total AMI population. Rates of invasive treatment were high for both NSTEMI and STEMI patients, 79% and 94%, respectively, and comparable to the general AMI patient population. For NSTEMI patients, there were no differences in rates of invasive treatment based on PCa risk group, but for STEMI patients, those with metastatic disease were less likely to receive invasive AMI treatment. Patients with PCa had lower 30-day mortality after AMI than the general AMI population.

The probability of dying from prostate cancer is highly dependent on the stage of the disease at diagnosis. In Norway, the 5-year crude probability of death due to prostate cancer is below 1.0% for localized disease at 70 years of age, whereas the probability is nearly 50% for distant prostate cancer [30]. As patients with localized prostate cancer have life expectancy comparable to the general population [15], the cancer itself, should not be a reason to be treated differently for an AMI. Fortunately, our results are reassuring, as there is no indication of poorer AMI treatment quality for prostate cancer patients in general. However, patients with metastatic disease and a following STEMI were less likely to receive invasive AMI treatment. In these patients, factors such as life expectancy and functional status must be balanced against benefits and risks from treatment, such as higher risks of thrombocytopenia and bleeding [14]. Thus, a lower frequency of invasive treatment is to be expected in this group of patients. Nevertheless, as the expected survival in patients with metastatic prostate cancer can vary from a few months to many years, detailed knowledge of the factors that may influence survival is needed when deciding on treatment for AMI [31]. Further studies are needed to determine whether the level of treatment was appropriate in this patient group, but our results may pose an intersection for obtaining more accurate information on the individual patient`s life expectancy before treatment decision, and thereby possibly prolong survival and improve quality of life in patients with PCa experiencing AMIs.

Several previous studies have, in contrast to the results from our study, found reduced rates of invasive treatment in cancer patients. A US study including patients with cancer experiencing a STEMI, found lower rates of PCI than noncancer patients and higher rates of in-hospital mortality, interpreted as partly due to less invasive intervention [32]. Further, in a study of 6.5 million AMI patients in the USA with 3% of the population with a cancer

diagnosis, having a cancer diagnosis was associated with less invasive treatment [7]. A Swiss study, using data from the National Registry of Acute Myocardial Infarction in Switzerland (AMIS Plus), found that patients with a history of cancer were less likely to receive invasive treatment for their AMI than would normally be recommended [8]. However, none of these studies showed prostate cancer specific results.

There may be several explanations for the lower 30-day mortality found in PCa patients after an AMI than in the general AMI population. Around 40% of nonmetastatic patients eligible for curative treatment in Norway have T1-localized disease [33]. This indicates that a significant number of patients diagnosed with localized disease are diagnosed as a consequence of PSA testing in asymptomatic men. Previous studies have shown more prevalent PSA testing in populations with higher socioeconomic status, conceivably due to better access to or different usage of the health care system [34, 35]. Although numbers were small, our data also indicate less daily smokers in the AMI population with PCa than in the general AMI population (online suppl. table B). Thus, it is likely that higher socioeconomic status and better general health among patients diagnosed with PCa may have influenced mortality. Further, positive lifestyle changes after their PCa diagnosis, and treatment of modifiable CVD risk factors may also be of importance.

There are risk factors present in cancer patients that can make them at higher risk of CVD morbidity and mortality, including smoking, hypertension, and advanced age, as well as sustained inflammation and cardiotoxicity from chemotherapy and radiotherapy [11]. There is also evidence for a possible increased risk of CVD from androgen deprivation therapy used in some groups of PCa patients [36–38]. However, these factors are not necessarily an issue in the majority of PCa patients. For example, the location of radiotherapy in PCa patients would not be expected to increase their risk of AMI, in contrast to cancer patients that receive radiotherapy closer to vessels involved in acute coronary syndrome. Also, chemotherapy has until recent years, mainly been used in more severe cases of castration-resistant, metastatic cancer [26]. These differences in PCa patients, along with the fact that PCa severity exists on a wide spectrum, means that considerations for the general cancer population in relation to AMI may not be appropriate for PCa patients.

Study Strengths and Limitations

To our knowledge, this is the first nationwide study of specific PCa and AMI characteristics in a large population of PCa patients that experienced an AMI. This analysis benefits from high-quality national registry data, including NORMI that had high coverage of all acute AMI hospitalizations with high validity and completeness [22, 39, 40]. The CRN also provides high coverage of all PCa cases in the country, offering wide generalizability of the findings [41]. Missing data and loss-to-follow-up were low. Using registry data in this manner allowed us to describe the real-life experience and treatment of AMI in a population that has been historically excluded from RCTs focused on AMI. The data on the general AMI population were aggregated, with only additional information on age and time-period. This limited our ability to control for additional factors. While we did include data from 2013 to 2019, the follow-up for the later diagnosed patients was relatively short and therefore limits the interpretation of the time-to AMI. We also had relatively low numbers of certain subpopulations, specifically STEMI patients.

Conclusion

To conclude, we found comparable rates of invasive treatment for AMI in patients with PCa to the general AMI population. No evidence supporting that PCa prognostic risk categories were associated with treatment pathway for NSTEMI patients were found, whereas STEMI patients with metastatic disease were less likely to receive invasive treatment. We also found longer 30-day survival after AMI in PCa patients, compared to the general AMI population. The current study represents a basis for further research to improve PCa patient outcomes after an AMI.

Statement of Ethics

The study was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. The study has been granted an exemption from requiring written informed consent and approved by the Regional Committee for Medical and Health Research Ethics, Norway, approval number 130363.

Conflict of Interest Statement

There are no relevant disclosures or conflicts of interest for any of the listed authors.

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Author Contributions

Rachel Bedenis Forster: conceptualization, data curation, formal analysis, investigation, methodology, validation, and writing – original draft and editing. Camilla Kjellstadli: data curation, methodology, and writing – review and editing. Tor Åge Myklebust: conceptualization, data curation, methodology, supervision, and writing – review and editing. Grace Egeland: conceptualization, methodology, and writing – review and editing. Gerhard Sulo: conceptualization, methodology, and writing – review and editing. Tone Bjørge: methodology, and writing – review and editing. Kaare Harald Bønaa: conceptualization, data curation, investigation, methodology, and writing – review and editing. Petur Benedikt Juliusson: project administration, resources, and writing – review and editing. Rune Kvåle: conceptualization, data curation, funding acquisition, investigation, methodology, project administration, supervision, and writing – review and editing.

Data Availability Statement

The data that support the findings of this study are available from national registries in Norway (https://helsedata.no: Cancer Registry of Norway, Norwegian Cardiovascular Disease Registry, Norwegian Patient Registry, Norwegian Cause of Death Registry). However, restrictions may apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the relevant registries. Further inquiries can be directed to the corresponding author.

References

1 Elmehrath AO, Afifi AM, Al-Husseini MJ, Saad AM, Wilson N, Shohdy KS, et al. Causes of death among patients with metastatic prostate cancer in the US from 2000 to 2016. JAMA Netw Open. 2021;4(8):e2119568.
2 Epstein MM, Edgren G, Rider JR, Mucci LA, Adami H-O. Temporal trends in cause of death among Swedish and US men with prostate cancer. JNCI J Natl Cancer Inst. 2012;104(17):1335–42.
3 Chang HM, Moudgil R, Scarabelli T, Okwuosa TM, Yeh ETH. Cardiovascular complications of cancer therapy: best practices in diagnosis, prevention, and management: Part 1. J Am Coll Cardiol. 2017;70(20):2536–51.
4 Strongman H, Gadd S, Matthews A, Mansfield KE, Stanway S, Lyon AR, et al. Medium and long-term risks of specific cardiovascular diseases in survivors of 20 adult cancers: a population-based cohort study using multiple linked UK electronic health records databases. Lancet. 2019;394(10203):1041–54.
5 Van Hemelrijck M, Garmo H, Holmberg L, Ingelsson E, Bratt O, Bill-Axelson A, et al. Absolute and relative risk of cardiovascular disease in men with prostate cancer: results from the Population-Based PCBaSe Sweden. J Clin Oncol. 2010;28(21):3448–56.
6 Roule V, Verdier L, Blanchart K, Ardouin P, Lemaitre A, Bignon M, et al. Systematic review and meta-analysis of the prognostic impact of cancer among patients with acute coronary syndrome and/or percutaneous coronary intervention. BMC Cardiovasc Disord. 2020;20(1):38.
7 Bharadwaj A, Potts J, Mohamed MO, Parwani P, Swamy P, Lopez-Mattei JC, et al. Acute myocardial infarction treatments and outcomes in 6.5 million patients with a current or historical diagnosis of cancer in the USA. Eur Heart J. 2020;41(23):2183–93.
8 Rohrmann S, Witassek F, Erne P, Rickli H, Radovanovic D. Treatment of patients with myocardial infarction depends on history of cancer. Eur Heart J Acute Cardiovasc Care. 2018;7(7):639–45.
9 Nakatsuma K, Shiomi H, Morimoto T, Watanabe H, Nakagawa Y, Furukawa Y, et al. Influence of a history of cancer on long-term cardiovascular outcomes after coronary stent implantation (an observation from coronary revascularization demonstrating outcome study-kyoto registry cohort-2). Eur Heart J Qual Care Clin Outcomes. 2018;4(3):200–7.
10 Milazzo V, Cosentino N, Campodonico J, Lucci C, Cardinale D, Cipolla CM, et al. Characteristics, management, and outcomes of acute coronary syndrome patients with cancer. J Clin Med. 2020;9(11):3642.
11 Costa IBSd S, Andrade FTd A, Carter D, Seleme VB, Costa MS, Campos CM, et al. Challenges and management of acute coronary syndrome in cancer patients. Front Cardiovasc Med. 2021;8:590016.
12 Collet JP, Thiele H. The "Ten Commandments" for the 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J. 2020;41(37):3495–7.
13 Balanescu DV, Donisan T, Deswal A, Palaskas N, Song J, Lopez-Mattei J, et al. Acute myocardial infarction in a high-risk cancer population: outcomes following conservative versus invasive management. Int J Cardiol. 2020;313:1–8.
14 Zamorano JL, Lancellotti P, Rodriguez Muñoz D, Aboyans V, Asteggiano R, Galderisi M, et al. 2016 ESC position paper on cancer treatments and cardiovascular toxicity developed under the auspices of the ESC Committee for Practice Guidelines. Eur Heart J. 2016;37(36):2768–801.
15 Cancer Registry of Norway. Cancer in Norway 2021: cancer incidence, mortality, survival and prevalence in Norway. 2022. https://www.kreftregisteret.no/Generelt/Rapporter/Cancer-in-Norway/cancer-in-norway-2021/.
16 Potts JE, Iliescu CA, Lopez Mattei JC, Martinez SC, Holmvang L, Ludman P, et al. Percutaneous coronary intervention in cancer patients: a report of the prevalence and outcomes in the United States. Eur Heart J. 2019;40(22):1790–800.
17 Matetic A, Mohamed M, Miller RJH, Kolman L, Lopez-Mattei J, Cheung WY, et al. Impact of cancer diagnosis on causes and outcomes of 5.9 million US patients with cardiovascular admissions. Int J Cardiol. 2021;341:76–83.
18 Larsen IK, Smastuen M, Johannesen TB, Langmark F, Parkin DM, Bray F, et al. Data quality at the Cancer Registry of Norway: an overview of comparability, completeness, validity and timeliness. Eur J Cancer. 2009;45(7):1218–31.
19 Hernes E, Kyrdalen A, Kvale R, Hem E, Klepp O, Axcrona K, et al. Initial management of prostate cancer: first year experience with the Norwegian National Prostate Cancer Registry. BJU Int. 2010;105(6):805–11. discussion 11
20 Oken MM, Creech RH, Tormey DC, Horton J, Davis TE, McFadden ET, et al. Toxicity and response criteria of the eastern cooperative oncology group. Am J Clin Oncol. 1982;5(6):649–56.

21 Norwegian Institute og Public Health. 2020. Report in Norwegian (Årlig driftsrapport for Helseregistre ved Folkehelseinstituttet 2019). https: //www.fhi.no/publ/2020/driftsrapport-2019-helseregistre-ved-folkehelseinstituttet/.
22 Govatsmark RES, Janszky I, Slordahl SA, Ebbing M, Wiseth R, Grenne B, et al. Completeness and correctness of acute myocardial infarction diagnoses in a medical quality register and an administrative health register. Scand J Public Health. 2020;48(1):5–13.
23 Bakken IJ, Ariansen AMS, Knudsen GP, Johansen KI, Vollset SE. The Norwegian patient registry and the Norwegian registry for primary health care: research potential of two Nationwide health-care registries. Scand J Public Health. 2020;48(1):49–55.
24 Pedersen AG, Ellingsen CL. Data quality in the causes of death registry. Tidsskr Nor Laegeforen. 2015;135(8):768–70.
25 Mottet N, Cornford P, van den Bergh RCN, Briers E, De Santis M, Gillessen S, et al. EAU guidelines on prostate cancer. Arnhem, The Netherlands: EAU Guidelines Office; 2021. Report No. 978–94–92671–13–4.
26 Norwegian treatment guidelines: [11. utgave Nasjonalt handlingsprogram med retningslinjer for diagnostikk, behandling og oppfølging av prostatakreft], in Norwegian Norwegian Directorate of Health 2021. https://www.helsedirektoratet.no/retningslinjer/prostatakreft-handlingsprogram.
27 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373–83.
28 Team RCR In: Commputing RFS, editor. A language and environment for statistical computing. R Foundationf or Statistical Computing. Vienna, Austria; 2020.
29 Miettinen J, Rantanen M. popEpi: functions for epidemiological analysis using population data. R package version 0.4.8. 2019.
30 Tå Myklebust BA, Nilssen Y, Johansson ALV, Rutherford MJ, Andersson TML, Lambert PC, et al. Cancer survival in Norway 1965–2021: extending standard reporting to improve communication of survival statistics; 2022. https://www.kreftregisteret.no/Generelt/Rapporter/Cancer-in-Norway/cancer-in-norway-2021/.
31 Storas AH, Fossa SD, Ursin G, Andreassen BK. Survival trends for patients with primary metastatic prostate cancer before and after the introduction of new antitumor drugs. Prostate Cancer Prostatic Dis. 2021.
32 Pothineni NV, Shah NN, Rochlani Y, Saad M, Kovelamudi S, Marmagkiolis K, et al. Temporal trends and outcomes of acute myocardial infarction in patients with cancer. Ann Transl Med. 2017;5(24):482.
33 Aas K, Axcrona K, Kvale R, Moller B, Myklebust TA, Axcrona U, et al. Ten-year mortality in men with nonmetastatic prostate cancer in Norway. Urology. 2017;110:140–7.
34 Liu L, Cozen W, Bernstein L, Ross RK, Deapen D. Changing relationship between socioeconomic status and prostate cancer incidence. JNCI J Natl Cancer Inst. 2001;93(9):705–9.
35 Larsen IK, Myklebust TA, Babigumira R, Vinberg E, Moller B, Ursin G. Education, income and risk of cancer: results from a Norwegian registry-based study. Acta Oncologica. 2020;59(11):1300–7.
36 Jespersen CG, Nørgaard M, Borre M. Androgen-deprivation therapy in treatment of prostate cancer and risk of myocardial infarction and stroke: a Nationwide Danish population-based cohort study. Eur Urol. 2014;65(4):704–9.
37 Zhao J, Zhu S, Sun L, Meng F, Zhao L, Zhao Y, et 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(9):e107516.
38 Keating NL, O'Malley AJ, Smith MR. Diabetes and cardiovascular disease during androgen deprivation therapy for prostate cancer. J Clin Oncol. 2006;24(27):4448–56.
39 Varmdal T, Mathiesen EB, Wilsgaard T, Njølstad I, Nyrnes A, Grimsgaard S, et al. Validating acute myocardial infarction diagnoses in national health registers for use as endpoint in research: the tromsø study. Clin Epidemiol. 2021;13:675–82.
40 Govatsmark RES, Halle KK, Berge VB, Sneeggen S, Bønaa KH. [Norsk hjerteinfarktregister: Årsrapport 2019. 2020]. Report in Norwegian https: //stolav.no/norsk-hjerteinfarktregister/Resultater.
41 Cancer Registry of Norway. 2020. [Årsrapport 2019 med resultater og fordedringstiltak fra Nasjonalt kvalitetsregister for prostatakreft Report in Norwegian https://www.kreftregisteret.no/Generelt/Rapporter/Arsrapport-fra-kvalitetsregistrene/Arsrapport-fra-prostatacancerregisteret-/arsrapport-for-prostatakreft-2021/.