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Basic Original Report

Contemporary prostate cancer radiation therapy in the United States: Patterns of care and compliance with quality measures

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Abstract

Purpose: Quality measures represent the standards of appropriate treatment agreed upon by experts in the field and often supported by data. The extent to which providers in the community adhere to quality measures in radiation therapy (RT) is unknown.

Methods and materials: The Comparative Effectiveness Analysis of Surgery and Radiation study enrolled men with clinically localized prostate cancer in 2011 and 2012. Patients completed

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surveys and medical records were reviewed. Patients were risk-stratified according to D'Amico classification criteria. Patterns of care and compliance with 8 quality measures as endorsed by national consortia as of 2011 were assessed.
Results: Overall, 926 men underwent definitive RT (69% external beam radiation therapy [EBRT]), 17% brachytherapy (BT), and 14% combined EBRT and BT with considerable variation in radiation techniques across risk groups. Most men who received EBRT had dose-escalated EBRT (>75 Gy; 93%) delivered with conventional fractionation (<2 Gy; 95%), intensity modulated RT (76%), and image guided RT (85%). Most men treated with BT received I125 (77%). Overall, 73% of the men received EBRT that was compliant with the quality measures (dose-escalation, image-guidance, appropriate use of androgen deprivation therapy, and appropriate treatment target) but only 60% of men received BT that was compliant with quality measures (postimplant dosimetry and appropriate dose). African-American men (64%) and other minorities (62%) were less likely than white men (77%) to receive EBRT that was compliant with quality measures.
Conclusions: Most men who received RT for localized prostate cancer were treated with an appropriately high dose and received image guidance and intensity modulated RT. However, compliance with some nationally recognized quality measures was relatively low and varied by race. There are significant opportunities to improve the delivery of RT and especially for men of a minority race.
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Introduction

With the passage of the Patient Protection and Affordable Care Act, there is renewed emphasis on improving the quality of medical care while containing costs.[1,2] This is particularly relevant in prostate cancer (PCa) care where considerable variations in the quality of cancer care exist,[3-5] and the costs of care are expected to increase at least 35% over the next decade.[6] Quality measures are tools that evaluate health care processes that are associated with high-quality health care.[7] Quality measures for PCa radiation therapy (RT) have largely been identified by a combination of dedicated research groups and consensus recommendations.[8,9] These groups have set standards with regard to radiation doses and techniques.

Although considerable effort has been made to identify radiation oncology quality measures,[10-12] contemporary RT practice patterns and compliance with quality measures have not been well-characterized for PCa. Therefore, we evaluated radiation practice patterns and characterized treatment compliance with radiation quality measures among men who enrolled in the prospective population-based Comparative Effectiveness Analysis of Surgery and Radiation (CEASAR) study.

Methods and materials

Patient population

The CEASAR study enrolled men from January 2011 to February 2012 who were <80 years of age with clinically localized PCa and a prostate-specific antigen level <50 ng/mL. Patients were recruited from 5 Surveillance, Epidemiology, and End Results Program (SEER) registries (Atlanta, Los Angeles, Louisiana, New Jersey, and Utah) and a PCa patient registry (Cancer of the Prostate Strategic Urologic Research Endeavor).[13] Details of the study design and objectives of the CEASAR study were described previously.[14] The 926 men who underwent definitive RT for their PCa were evaluated for this analysis (Fig. 1).

Data collection

Baseline surveys that were completed by the study subjects captured sociodemographic data and comorbidity as previously described.[14] Treatment details were obtained from medical chart abstraction that was performed 1 year after enrollment. The records of a total of 878 of 926 men underwent medical chart abstraction. Comorbidity was scored in accordance with the Total Illness Burden Index for Prostate Cancer.[15] Race and ethnicity was categorized into Caucasian, African-American (AA), and other races/ethnicities on the basis of patient reports or, when missing, registry data.

Quality measures

Five quality measures for external beam radiation therapy (EBRT) and 3 for brachytherapy (BT) were selected from the recommendations of the 2011 National Comprehensive Cancer Network Prostate Cancer guidelines,[16] American Brachytherapy Society guidelines,[17] Quality Research in Radiation Oncology (QRRO),[9,18] Physician Quality Reporting Initiative,[19] and National Radiation Oncology Registry[20] (Table 1). Radiation treatment guidelines change over time so compliance was measured as adherence to the guidelines that were established at the time of study enrollment as of 2011. However, we evaluated the more inclusive BT doses as recommended by the American Brachytherapy Society that were published during the enrollment period rather than the more stringent BT doses as recommended by the 2011 National Comprehensive Cancer Network guidelines.

Men who received EBRT alone (without BT) were evaluated for adherence with: 1) Prescription dose ≥75 Gy if treated with conventional fractionation[9,16,18,20]; 2) treatment with image guided radiation therapy (IGRT)[9,16,18,20]; 3)

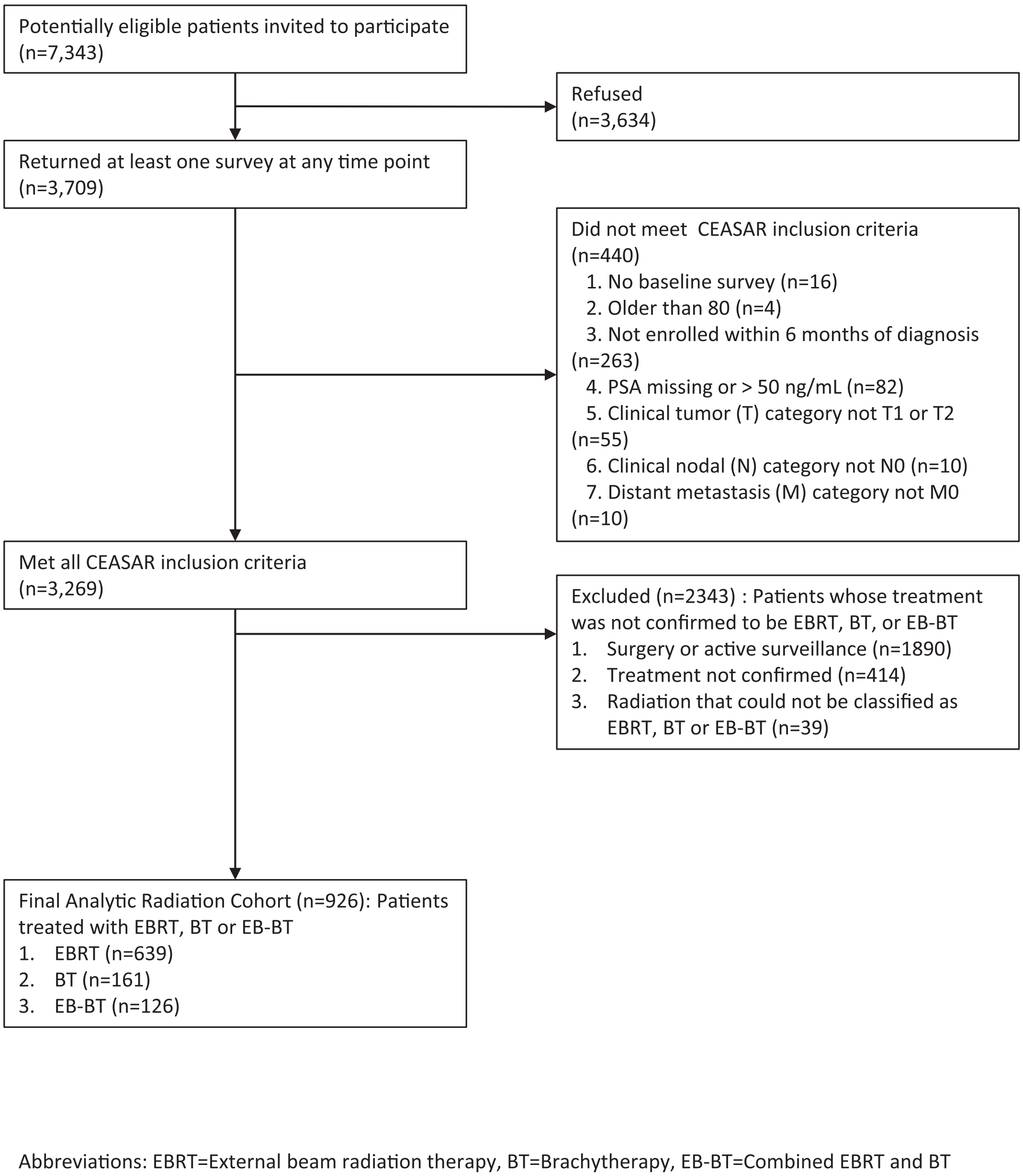

Figure 1 Diagram of the Assembly of the Comparative Effectiveness Analyses of Surgery and Radiation (CEASAR) Study Radiation Cohort. Abbreviations: EBRT=External beam radiation therapy, BT=Brachytherapy, EB-BT=Combined EBRT and BT.

receipt of androgen deprivation therapy (ADT) if high-risk disease[9,16,18,20]; 4) no ADT if low-risk disease[9,16,18,20]; and 5) no pelvic radiation if low-risk disease.[16,20] Men who received low-dose rate (LDR) BT alone (without EBRT) were evaluated for: 1) Documentation of postimplant dosimetry[9,16,18,20]; 2) prescription dose of 140 Gy to 160 Gy for iodine 125; (I125)[16] and 3) prescription dose of 110 Gy to 125 Gy for palladium 103 (Pd103).[16] These quality measures were selected in part because they could be reliably extracted from the medical record.

Statistical analysis

Patients' demographic and clinical characteristics were summarized by RT received (EBRT, BT, and EBRT+BT). Treatment-specific compliances and practice pattern outcomes were summarized by individual factors and overall. Patient characteristics among the treatment groups were compared using the Wilcoxon rank sum (continuous variables) and χ^2 tests (categorical variables). Differences in compliances and practice pattern outcomes among the different levels of sociodemographic factors were compared similarly. To further evaluate the effect of sociodemographic factors on compliance to recommended treatment strategies for RT, multivariable logistic regressions were used adjusted for age, race (black vs white, other vs white), education level (high school or less vs some college vs college graduate vs graduate/professional school), insurance status (Medicaid/no insurance/Veterans Affairs vs private insurance/health maintenance

Table 1 Patient characteristics

	EBRT (n = 639)	BT (n = 161)	EB+BT (n = 126)	Combined (n = 926)	*P*-value
Age at time of diagnosis, median (IQR)	69.0 (64.0, 73.0)	66.0 (63.0, 71.0)	67.0 (61.0, 72.0)	68.0 (63.0, 73.0)	.001
Race					
White	446 (70%)	133 (84%)	92 (74%)	671 (73%)	.007
Black	119 (19%)	16 (10%)	25 (20%)	160 (17%)	
Other	68 (11%)	9 (6%)	8 (6%)	85 (9%)	
TIBI score					
0-2	99 (17%)	42 (27%)	25 (21%)	166 (19%)	.028
3-6	379 (66%)	86 (55%)	82 (68%)	547 (64%)	
≥7	99 (17%)	29 (18%)	14 (12%)	142 (17%)	
Education					
High school graduate or less	209 (36%)	47 (30%)	33 (28%)	289 (34%)	.296
Some college	130 (23%)	46 (29%)	28 (24%)	204 (24%)	
College graduate	118 (21%)	33 (21%)	27 (23%)	178 (21%)	
Graduate/professional school	117 (20%)	31 (20%)	31 (26%)	179 (21%)	
Income					
<$30,000	167 (31%)	34 (23%)	19 (17%)	220 (28%)	.002
$30,001-$50,000	118 (22%)	31 (21%)	34 (30%)	183 (23%)	
$50,001-$100,000	142 (27%)	59 (39%)	29 (26%)	230 (29%)	
>$100,000	104 (20%)	27 (18%)	30 (27%)	161 (20%)	
Insurance					
Uninsured, VA, or Medicaid	37 (6%)	5 (3%)	6 (5%)	48 (5%)	.044
Medicare	425 (67%)	94 (59%)	78 (62%)	597 (65%)	
Private/HMO	169 (27%)	61 (38%)	42 (33%)	272 (30%)	
Marital status					
Not married	150 (26%)	32 (21%)	27 (22%)	209 (25%)	.302
Married	422 (74%)	123 (79%)	93 (78%)	638 (75%)	
Clinical tumor stage					
T1	465 (73%)	133 (83%)	95 (75%)	693 (75%)	.039
T2	173 (27%)	28 (17%)	31 (25%)	232 (25%)	
Biopsy Gleason score					
≤6	220 (35%)	104 (65%)	36 (29%)	360 (39%)	< .001
3+4	216 (34%)	41 (25%)	45 (36%)	302 (33%)	
4+3	93 (15%)	11 (7%)	14 (11%)	118 (13%)	
≥8	107 (17%)	5 (3%)	31 (25%)	143 (15%)	
Prostate-specific antigen level					
0-4	87 (14%)	27 (17%)	18 (14%)	132 (14%)	< .001
4-10	417 (65%)	126 (78%)	94 (75%)	637 (69%)	
10-20	101 (16%)	8 (5%)	12 (10%)	121 (13%)	
20-50	34 (5%)	0 (0%)	2 (2%)	36 (4%)	
D'Amico risk criteria					
Low	185 (29%)	95 (59%)	33 (26%)	313 (34%)	< .001
Intermediate	294 (46%)	57 (35%)	57 (45%)	408 (44%)	
High	157 (25%)	9 (6%)	36 (29%)	202 (22%)	

BT, brachytherapy; EBRT, external beam radiation therapy; EB+BT combined external beam radiation therapy with brachytherapy; HMO, health maintenance organization; IQR, interquartile range; TIBI, total illness burden index; VA, Veterans Affairs

organization vs Medicare), and D'Amico risk category[21] (low, intermediate, high). Odds ratio (OR) and 95% confidence intervals (CIs) were reported as the measure of the effects of these factors on the outcomes. In multivariable analyses, a multiple imputation approach was used to take into account the missing covariate values.[22] Statistical significance was considered for all 2-sided *P*-values ≤5%. All analyses were conducted using R software version 3.3.

Results

Clinical and patient characteristics

The clinical and patient characteristics at the time of diagnosis are shown in Table 1. The median age was 68 years (interquartile range [IQR]: 63-73 years). Thirty four percent of the men had low-risk, 44% had intermediate-risk, and 22% had high-risk disease.

Table 2 Compliance with quality metrics

Metric	N	Overall (n = 633)	White (n = 446)	Black (n = 119)	Other (n = 68)	*P*-value [a]
External beam radiation therapy alone						
1. IGRT utilization	552					.02 [b]
Compliant		85% (471)	87% (341)	88% (86)	73% (44)	
Noncompliant		15% (81)	13% (53)	12% (12)	27% (16)	
2. Dose prescription for conventional fractionation >75 Gy	546					.004 [c]
Compliant		93% (507)	95% (363)	87% (87)	88% (57)	
Noncompliant		7% (39)	5% (18)	13% (13)	12% (8)	
3. No pelvic field irradiation for low-risk disease	170					< .001 [b]
Compliant		96% (163)	99% (120)	80% (24)	100% (19)	
Noncompliant		4% (7)	1% (1)	20% (6)	0% (0)	
ADT utilization						
4. No ADT for low-risk disease	179					.144 [b]
Compliant		92% (164)	94% (121)	88% (28)	83% (15)	
Noncompliant		8% (15)	6% (8)	12% (4)	17% (3)	
5. ADT for high-risk disease	155					.036 [b]
Compliant		81% (125)	78% (78)	77% (27)	100% (20)	
Noncompliant		19% (30)	22% (22)	23% (8)	0% (0)	
Care compliant with all guidelines for EBRT	568					.005 [c]
Compliant		73% (414)	77% (306)	64% (68)	62% (40)	
Noncompliant		27% (154)	23% (92)	36% (38)	38% (24)	
Low-dose rate brachytherapy alone						
Postbrachytherapy implant CT dosimetry						
6. Postimplant CT dosimetry	72					
Compliant		68% (49)	66% (39)	78% (7)	75% (3)	
Noncompliant		32% (23)	34% (20)	22% (2)	25% (1)	
Low-dose rate BT dosages						
7. I125 dose 140-160 Gy	80					
Compliant		90% (72)	88% (59)	100% (10)	100% (3)	
Noncompliant		10% (8)	12% (8)	0% (0)	0% (0)	
8. Pd103 dose 110-125 Gy	26					
Compliant		92% (24)	95% (18)	83% (5)	100% (1)	
Noncompliant		8% (2)	5% (1)	17% (1)	0% (0)	
Care compliant with all guidelines for BT	81					
Compliant		60% (49)	58% (39)	70% (7)	75% (3)	
Noncompliant		40% (32)	42% (28)	30% (3)	25% (1)	

ADT, androgen deprivation therapy; BT, brachytherapy; CT, computed tomography; EBRT, external beam radiation therapy, I125, iodine 125; IGRT: image guidance radiation therapy; Pd103, palladium 103

[a] Statistical tests were not attempted to low-dose rate BT-alone metrics due to limited sample size.

[b] Fisher's exact test

[c] Pearson's χ^2 test

Seventeen percent were African-American and 9% were Hispanic/Latino, Asian, or other. With regard to education status and income, 34% completed high school or less and approximately 28% earned <$30,000 per year.

Adherence with quality measures

Men who were treated with EBRT had relatively high compliance with the selected quality measures (Table 2). Most men who were treated with conventional fractionation received dose-escalated radiation of >75 Gy (93%) and most received IGRT (85%). The majority of men with low-risk PCa did not receive pelvic radiation (96%) and most did not receive ADT (92%). Eighty-one percent of patients with high-risk PCa received ADT. Overall 73% of men who received EBRT had treatment that complied with all relevant quality measures for men in their risk group: 66% for men with low-risk, 80% for intermediate-risk, and 68% for high-risk disease.

For men undergoing low dose BT alone, 68% had postimplant dosimetry performed. Of the men who received I125 BT seed implants, 90% received 140 Gy to 160 Gy and for those who received Pd103 implants, 92% received 110 Gy to 125 Gy (Appendix 1). Sixty percent of men who received BT in this cohort received BT that was compliant with both quality measures. Radiation records were obtained for all patients undergoing BT at least 90 days after their implant.

Table 3 Treatment details for radiation treatment by D'Amico risk criteria

	Low risk	Intermediate risk	High risk	Overall	*P*-value [a, b]
EBRT (n)	185	294	157	636	
Use of ADT					
% receiving ADT, (n)					< .001
Yes	8% (15)	44% (128)	81% (127)	43% (270)	
No	92% (166)	56% (166)	19% (30)	57% (362)	
Dose prescription for EBRT					
Conventional fractionation	91% (157)	95% (251)	98% (141)	95% (549)	.006
Median dose (IQR), Gy	79.2 (76.0, 79.2)	79.2 (77.4, 79.2)	79.0 (77.4, 79.2)	79.2 (76.0, 79.2)	.516
% receiving >75 Gy, (n)	139 (89%)	237 (94%)	134 (95%)	510 (93%)	.041
Moderate fractionation	1% (1)	2% (6)	1% (1)	1% (8)	
Ultra-hypofractionation	8% (14)	3% (7)	1% (2)	4% (23)	
Radiation fields for EBRT					
% receiving pelvic radiation, (n)					
Yes	4% (7)	13% (36)	40% (59)	17% (102)	< .001
No	96% (165)	87% (232)	60% (87)	83% (484)	
Use of image guidance					
% with IGRT, (n)					
Yes	85% (132)	85% (218)	87% (125)	85% (475)	.737
No	15% (24)	15% (39)	13% (18)	15% (81)	
BT					
No. receiving BT	95	57	9	161	
Low-dose rate BT (n)	81	34	7	122	
I125	84% (67)	68% (23)	43% (3)	77% (93)	.057
Median dose (IQR), Gy	145.0 (145.0, 145.0)	144.0 (144.0, 145.0)	111.2 (94.3, 128.1)	145.0 (144.0, 145.0)	.006
dose 140-160 Gy					
Yes	92% (54)	91% (20)	50% (1)	90% (75)	
No	8% (5)	9% (2)	50% (1)	10% (8)	
Pd103	15% (12)	29% (10)	57% (4)	21% (26)	
Median dose (IQR), Gy	125.0 (125.0, 125.0)	125.0 (125.0, 125.0)	125.0 (125.0, 125.0)	125.0 (125.0, 125.0)	.649
Dose 110-125 Gy					
Yes	83% (10)	100% (10)	100% (4)	92% (24)	
No	17% (2)	0% (0)	0% (0)	8% (2)	
Cs131	1% (1)	3% (1)	0% (0)	2% (2)	
High-dose rate BT (N)	14	23	2	39	
Median dose (IQR), Gy	39.0 (39.0, 39.0)	39.0 (39.0, 39.0)	—	39.0 (39.0, 39.0)	.376
Fractionation, Median dose (IQR), Gy	6.5 (6.5, 7.3)	6.5 (6.5, 6.5)	—	6.5 (6.5, 6.5)	.565
EB+BT					
No. receiving combined EB+BT	33	57	36	126	
IMRT					
Yes	73% (24)	93% (53)	89% (32)	87% (109)	.022
No	27% (9)	7% (4)	11% (4)	13% (17)	
Median dose (IQR), Gy	45.0 (45.0, 52.5)	45.0 (45.0, 52.5)	45.0 (45.0, 52.5)	45.0 (45.0, 52.5)	.461
No. with IGRT, (%)					
Yes	86% (25)	81% (44)	71% (25)	80% (94)	.31
No	14% (4)	19% (10)	29% (10)	20% (24)	
EB+BT (low-dose rate)	32	48	27	107	
I125	97% (29/30)	81% (38/47)	78% (21/27)	85% (88/104)	.089
Median dose (SD), Gy	80.0 (80.0, 106.5)	97.0 (80.0, 110.0)	90.0 (80.0, 110.0)	90.0 (80.0, 110.0)	.376
EB-BT (high-dose rate)	1	9	9	19	
Median dose (IQR), Gy	19.0 (19.0, 19.0)	21.0 (19.0, 22.0)	22.0 (22.0, 22.0)	22.0 (19.9, 22.0)	.009
Fractionation, Mean dose (SD), Gy	—	7.0 (5.5, 9.5)	5.5 (5.5, 5.5)	5.5 (5.5, 7.0)	.036

ADT, androgen deprivation therapy; BT, brachytherapy; Cs131, Cesium 131; EBRT, external beam radiation therapy; EB+BT, combined external beam radiation therapy with brachytherapy; I125, iodine 125; IGRT, image guidance radiation therapy; IMRT, intensity modulated radiation therapy; IQR, interquartile range; Pd103, palladium 103; PSA, prostate-specific antigen; SD, standard deviation; VMAT, volumetric arc therapy

[a] Pearson's χ^2 test for categorical variables and Wilcoxon rank sum test for continuous variables unless otherwise noted

[b] Fisher's exact test

Table 4 Factors associated with compliance among patients who received EBRT (estimated from multivariable models)

	Compliant with all guidelines			Compliant with IGRT utilization			Compliant with adequate dose		
Factors	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Age (Q_3 vs Q_1)	1.05	(0.78-1.41)	.765	0.97	(0.66-1.41)	.857	0.74	(0.45-1.22)	.234
Race									
White	1 (ref)			1 (ref)			1 (ref)		
Black	0.54	(0.32-0.9)	.018	1.15	(0.56-2.35)	.704	0.22	(0.1-0.51)	< .001
Other	0.49	(0.27-0.9)	.022	0.45	(0.22-0.91)	.025	0.26	(0.1-0.7)	.007
D'Amico risk criteria									
Low	1 (ref)			1 (ref)			1 (ref)		
Intermediate	2.08	(1.3-3.33)	.002	1.08	(0.61-1.9)	.797	2.63	(1.21-5.69)	.014
High	1.38	(0.82-2.33)	.222	1.41	(0.71-2.81)	.329	3.1	(1.19-8.05)	.02
Education									
High school graduate or less	1 (ref)			1 (ref)			1 (ref)		
Some college	1.43	(0.8-2.58)	.228	0.99	(0.48-2.01)	.967	0.7	(0.26-1.9)	.482
College graduate	1.32	(0.73-2.39)	.358	1.44	(0.68-3.06)	.338	0.79	(0.28-2.21)	.647
Graduate/professional school	0.86	(0.49-1.52)	.609	0.89	(0.44-1.83)	.761	0.49	(0.18-1.31)	.155
Insurance									
Uninsured, VA, or Medicaid	1 (ref)			1 (ref)			1 (ref)		
Medicare	1.5	(0.62-3.66)	.372	1.98	(0.71-5.5)	.189	0.91	(0.18-4.64)	.905
Private/HMO	1.31	(0.53-3.24)	.564	1.71	(0.61-4.78)	.31	0.84	(0.16-4.46)	.838

CI, confidence interval; HMO, health maintenance organization; IGRT, image guided radiation therapy; OR, odds ratio; ref, reference; Q, quarter; VA, Veterans Affairs

Treatment details

Sixty-nine percent of patients received EBRT, 13% received LDR BT, 4% received high-dose rate BT, and 14% received combined EBRT+BT (Table 1). Treatment details for EBRT, BT, and EB+BT are shown in Table 3. Most of the men undergoing EBRT (Table 3) received intensity modulated radiation therapy (IMRT, 76%) that was delivered with IGRT (85%). Nearly all patients (95%) underwent conventional fractionation (<2 Gy per fraction) but only 1% received moderate hypofractionation (>2-3 Gy) and 4% received ultra-hypofractionation (>3 Gy). Only 3 men undergoing EBRT (0.5%) did not complete their radiation treatment: Two patients because they were not able to tolerate the procedure and 1 patient because of patient choice.

Factors associated with compliance

African-American and other men of a minority race were less likely to receive compliant care with all guidelines for EBRT compared with white men (Table 2). Seventy-seven percent of Caucasian men received EBRT that met all quality measures compared with 64% of AA men and 62% of other men of a minority race ($P < .01$). There was some variation in the association of race/ethnicity with compliance characteristics. AA men (80%) were less likely to avoid pelvic irradiation for low-risk disease than Caucasian men (99%) or men from other minority groups (100%; $P < .01$). Also, both AA men (87%) and men from other minority groups (88%) were less likely to receive dose-escalated EBRT compared with Caucasian men (95%; $P = .004$). Hispanic men and men from other race groups (73%) were less likely to receive IGRT than Caucasian men (87%) or AA men (88%; $P = .02$).

Men with more education (at least some college or more education) were more likely to avoid unnecessary pelvic radiation for low-risk disease compared with men with a high-school education (100% vs 88%; $P < .01$). Men with at least some college education more commonly received EBRT that was compliant with all quality measures but the difference was not statistically significant (76% vs 69%; $P = .07$). Men with a high school education or less were more likely to receive BT that meets all quality measures (81%) than men with at least a college education or more (51%; $P = .008$). There were no significant associations between compliance with quality measures for either EBRT or BT and insurance status.

In multivariable analyses on compliance with the quality measures among patients who underwent EBRT, age, education, and insurance status were not significantly associated with the outcomes (See Table 4). However, compared with white men, AA and other men of a minority race had 46% (OR: 0.54; 95% CI, 0.32-0.89; $P < .001$) and 51% (OR: 0.49; 95% CI, 0.27-0.91; $P = .007$) decreased odds, respectively, of receiving EBRT that met all quality measures. Compared with the low-risk criteria, men with intermediate-risk disease had a 108% increase (OR: 2.08; 95% CI, 1.3-3.33; $P = .002$) in odds of receiving EBRT that met all quality measures.

Discussion

The majority of men treated with RT for localized PCa in this population-based cohort study underwent EBRT, primarily dose-escalated IMRT delivered with IGRT, and conventional fractionation. Although there was an 80% to 90% compliance rate with most of the individual RT quality measures, 19% of men with high-risk disease did not receive ADT. Additionally, 27% of EBRT and 40% of BT did not adhere to all evaluated quality measures. There were racial disparities as nonwhite men were much less likely to receive guideline-concordant RT.

Although EBRT was the most common technique across all risk groups, there were variatios in the RT techniques by risk categorization. BT as a monotherapy was predominately used in low-risk PCa while combined EBRT+BT was more commonly administered for intermediate- and high-risk disease. Evolving EBRT techniques during this time period including proton radiation, ultra-hypofractionation, and CyberKnife were utilized for low-risk disease. However, the proportion of patients who received these techniques was small and each represented 6% to 8% of treatments for low-risk patients.

We found less frequent use of moderate hypofractionation than reported in a National Cancer Data Base (NCDB) study of men who were treated during the same time period.[23] This difference may be explained in part because the NCDB is a hospital-based registry[24] while our study patients were recruited from population-based registries. Additionally, our cohort is smaller than from the NCDB and both cohorts are drawn from different geographic areas. The rate of medical claims for SBRT in a population-based SEER-Medicare study during this time period[25] was similar to the frequency of CyberKnife and ultra-hypofractionation that was identified in our study that obtained RT details from medical chart reviews.

There was high compliance with the majority of individual quality measures for EBRT. Most men treated with conventional fractionation received dose-escalated radiation (>75 Gy), which improves PCa control.[26-29] The majority of men also received IGRT, which can improve the accuracy of targeting of the prostate while limiting toxicity to adjacent organs. Additionally, most men with low-risk disease appropriately did not receive unnecessary ADT or pelvic radiation, which can cause toxicity but does not improve outcomes.[30-34] Our study demonstrates the increased adoption of dose-escalated EBRT and IGRT compared with the QRRO Survey of men with PCa who were treated in 2007.[9]

A significant portion of men with high-risk PCa did not receive ADT with radiation. The addition of ADT to EBRT improves PCa survival for men with high-risk disease[35-37] but there is concern that ADT may increase cardiovascular morbidity and mortality.[38-40] We could not determine why ADT was not administered to some men with high-risk disease in our study. The possibility exists that there was under-ascertainment of ADT administration from the medical chart abstraction. However, population-based studies that analyzed medical claims data also have found a significant portion of men with high-risk PCa who do not receive ADT.[41,42]

Most men who were treated with BT received I125 LDR implants and approximately two-thirds had documentation of postimplant dosimetry. Postimplant dosimetry provides an assessment of implant quality and allows for feedback on continual technical improvement.[17] The QRRO survey[9] found similar utilization rates of I125 and Pd103; however, they reported significantly higher rates of postimplant dosimetry. These differences could reflect the fact that radiation centers agreed to participate in the QRRO study and report their radiation details whereas this population-based study pursued radiation records for all enrolled men. Our medical record abstraction may have underestimated the utilization of postimplant dosimetry if they did not have access to postimplant dosimetry documentation.

There was racial variation in the receipt of RT that complied with the evaluated quality measures. Men of a minority race were less likely to receive dose-escalated EBRT and Hispanic men were less likely to receive IGRT. Lack of compliance with quality measures that improve PCa control and reduce treatment toxicity may play a role in the disparity of PCa outcome as seen in men of a minority race.[43] Previous population-based studies of men undergoing radical prostatectomy and RT for PCa found no evidence of racial disparity.[44,45] However, these studies were based on available claims data and not able to capture specific details on the radiation techniques where we identified disparities.

The strengths of this study are that it is a population-based study that reflects how radiation is delivered in the community and that comprehensive medical chart reviews captured granular radiation technical details. Some items are worth noting. First, medical chart abstraction may underestimate the level of compliance with quality measures if treatment details are not accurately documented by providers. However, documentation of procedural and process measures is an essential component of quality medical care provisions and can itself be a proxy for quality care because it allows for accurate measurement, comparison, and improvement of outcomes. Second, we could not determine why care did not adhere to quality measures.

Third, the CEASAR study was designed to evaluate process and outcome measures and did not capture many structural measures. Although structural measures such as the resources of hospitals and providers can influence outcomes, the main measures were selected because they were endorsed by several consortia. We were unable to impact hospital type or facility volume. Fourth, we did not evaluate whether adherence to these quality measures impacted cancer control or treatment toxicity but this will be investigated in future studies.

Fifth, our cohort was enrolled from 5 SEER registries and the Cancer of the Prostate Strategic Urologic Research Endeavor registry and does not reflect geographic and regional treatment differences outside of these catchment areas. Finally, medical evidence and guidelines evolve over time. Randomized trials that demonstrate similar efficacy and toxicity for moderate hypofractionation compared with conventional fractionation for PCa[46,47] and a randomized trial that demonstrates a biochemical progression-free survival benefit for combined EBRT+BT over EBRT for men with intermediate- and high-risk PCa[48,49] were published after the study period. The utilization of moderate hypofractionation and combined EBRT+BT may increase in more recent years as a consequence of these publications.

The ability to measure patterns and quality of care, evaluate and compare performance, and identify opportunities for improvement in care delivery is increasingly important with the current movement toward shared accountability and value-based payment models. Large administrative data registries and prospective trials often lack granular patient-level details and heterogeneous patient populations to assess contemporary practice patterns or quality of care provided.[50] This study leverages its diverse patient population, wide array of providers from academic and community centers, and fine patient details from medical chart abstraction to show important practice patterns and significant gaps in care in the management of PCa that can be improved. In addition, we were able to identify potential areas for quality improvement and particularly for men of a minority race, which can have an impact on improving the disparities in health outcomes.

Conclusions

In this population-based cohort study, most men treated with RT for localized PCa received dose-escalated IMRT that was delivered with IGRT and conventional fractionation. Although most treatment complied with individual RT quality measures, compliance varied by race. There are opportunities to improve the quality of RT for localized PCa and especially for men of a minority race.

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