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The potential benefits of radiotherapy in elderly patients with early-stage triple-negative breast cancer

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Background: Breast cancer (BC) is the most common cancer in women in the U.S. and a leading cause of cancer-related deaths. The incidence rises with age, especially in women over 70. Older patients often face multiple comorbidities, complicating treatment decisions. This study will analyze the role of radiotherapy (RT) in early-stage triple-negative breast cancer (TNBC) among elderly patients using the SEER database to assess its impact on survival outcomes.

Methods: The patients aged 70+ with T1-2N0-1M0 TNBC were selected from the SEER database (2010–2015) according to specific inclusion and exclusion criteria. Statistical analyses involved chi-square tests, propensity score matching (PSM), and Cox regression to identify risk factors. A nomogram was developed, and Kaplan-Meier analysis compared overall (OS) and breast cancer-specific survival (BCSS) across different groups.

Results: A total of 3,024 elderly patients with early-stage TNBC were analyzed. After employing PSM to eliminate baseline differences, survival analysis indicated that the breast-conserving surgery (BCS) group could benefit from RT (OS, HR = 0.68, $p < 0.001$; BCSS, HR = 0.64, $p = 0.001$). Cox regression analysis on the non-RT cohort within the BCS group identified age, tumor grade, and T stage as independent risk factors. Subsequently, a nomogram was developed to stratify patients and found that RT significantly improved OS and BCSS in the intermediate-risk (OS, HR = 0.49, 95% CI = 0.34–0.71, $p = 0.001$; BCSS, HR = 0.40, 95% CI = 0.21–0.77, $p = 0.018$) and high-risk group (OS, HR = 0.67, 95% CI = 0.55–0.81, $p < 0.001$; BCSS, HR = 0.61, 95% CI = 0.45–0.83, $p = 0.007$), while showing no significant benefit in the low-risk group (all p-values > 0.05).

Conclusion: RT significantly improves OS and BCSS in early-stage TNBC patients after BCS, particularly for intermediate to high-risk individuals, while low-risk patients may omit it.

KEYWORDS

triple-negative breast cancer (TNBC), elderly patient, radiotherapy, propensity score matching (PSM), nomogram, SEER program

1 Introduction

According to the 2023 Global Cancer Statistics, breast cancer (BC) has emerged as one of the most prevalent cancers among women in the United States and is the second leading cause of cancer-related deaths in women, following lung cancer (1). It is estimated that in 2023, more than 290,000 new cases of BC will be diagnosed, and over 40,000 deaths will occur due to BC (1). The incidence of BC correlates positively with age, with women aged over 70 years accounting for more than 30% of all diagnosed cases (2). Besides, another study shows that 45% of BC cases occur in women aged 65 and older, with 33% in those over 70. Yet, only 3% of women over 70 participate in clinical research. This may lead to significant discrepancies in the clinical management of this patient group (≥70's) (3, 4). Due to the lack of sufficient research, physicians may hesitate in treatment choices, potentially affecting the treatment outcomes and quality of life for elderly patients. Previous studies have shown that BC incidence has been rising by 1.0% annually for women in their 60's since 2004, and by 1.2% annually for women over 70's since 2005 (5). And although breast cancer mortality has generally declined, with a 58% reduction in the United States from 1975 to 2019, the decrease in mortality is smaller among elderly breast cancer patients compared to other age groups (6–8). Older patients often have multiple underlying health conditions and diminished physical function compared to other populations. Additionally, they experience a higher incidence of postoperative complications, which complicates clinical management (9). Furthermore, the inadequate representation of older adults in clinical trials has resulted in a dearth of prospective studies focused on breast cancer in this population. Consequently, the management of elderly patients in clinical practice increasingly prioritizes personalized treatment strategies (10).

Radiotherapy (RT) is a standard first-line treatment for breast cancer, used to eradicate residual cancer cells and minimize the risk of recurrence. Nonetheless, the necessity of RT for elderly BC patients continues to be a subject of considerable debate. Research indicates that the elderly population has a higher prevalence of hormone receptor-positive tumors, which are typically associated with reduced biological aggressiveness. Consequently, it is often advisable for treatment strategies to adopt a more conservative approach (11, 12). Certain studies indicate that the high prevalence of comorbidities and other factors contribute to elevated mortality rates in elderly patients. As a result, RT does not enhance survival in those with early-stage BC (13–16). On the other hand, numerous studies suggest that RT reduces local recurrence rate (LRR) in BC patients, while a conservative treatment approach for the elderly may worsen breast cancer-specific survival (BCSS) (17, 18). Furthermore, it is important to highlight that several prior studies have not adequately addressed molecular subtyping, which is a crucial determinant in shaping treatment strategies for BC patients. Triple-negative breast cancer (TNBC) is a subtype of BC distinguished by the lack of estrogen receptors (ER), progesterone receptors (PR), and human epidermal growth factor receptor 2 (HER2) in tumor cells (19). Due to the absence of relevant receptor markers, patients with TNBC do not respond to standard endocrine or HER2-targeted therapies, leading to a generally poor prognosis. According to previous study, TNBC patients were more likely to experience distant recurrence (HR = 2.6; 95% CI = 2.0–3.5; $p<$ 0.0001) and mortality (HR = 3.2; 95% CI = 2.3–4.5; $p < 0.001$) within 5 years of diagnosis compared to those with other subtypes (20). Over 50% of patients experience recurrence within 3 to 5 years of diagnosis, and the median overall survival (OS) with current treatment approaches is just 10.2 months (19, 21).

Accurate selection of elderly patients (≥70's) for radiotherapy is essential. This study will use the Surveillance, Epidemiology, and End Results (SEER) database to analyze early-stage elderly patients with TNBC. The patients will be divided into RT and non-RT cohorts to assess the impact of RT on OS and BCSS. Additionally, we will construct a nomogram to evaluate individual patient scores and categorize them based on these scores, thereby aiding in the identification of the most appropriate candidates for RT.

2 Methods

2.1 Study population

We selected T1-2N0-1M0 TNBC patients over the age of 70 from the SEER*Stat program (version 8.4.4) for this study. Established in 1973, the SEER database is a crucial resource provided by the National Cancer Institute (NCI). Its primary aim is to offer publicly accessible epidemiological data to support cancer research, prevention, and control efforts. The database includes information from numerous states and regions, covering ∼30% of the U.S. population, thereby ensuring the representativeness of the data (22).

The inclusion criteria for our study are as follows: 1. Diagnosis between 2010 and 2015, as the SEER database began collecting data on chemotherapy and radiotherapy after 2010; 2. Female patients aged 70 years or older; 3. Tumor staging classified as T1-2N1M0; 4. Molecular subtype identified as TNBC; 5. Surgical interventions comprising either modified radical mastectomy or breast-conserving surgery. The exclusion criteria are: 1. Cases where breast cancer is not the sole or initial diagnosis of two or more primary cancers; 2. Absence of critical information, including grade classification, survival months, race, and marital status; 3. Follow-up duration of <1 month. Based on the aforementioned criteria, our study included a total of 3,024 patients. Based on whether patients received RT, the overall population was categorized into a RT group ($N = 2{,}045$) and a non-RT group ($N = 979$). The primary endpoints of this investigation are OS and BCSS. OS is defined as the time from disease diagnosis (or treatment initiation) until death from any cause. BCSS refers to the duration patients with breast cancer live post-diagnosis without succumbing to cancer-related complications or progression (Figure 1).

2.2 Variable selection

The specific study variables included: age at diagnosis (70–74, 75–79, 80–84, and ≥85 years); race (white, black, other); marital status (married, unmarried); pathological type (infiltrating duct carcinoma, other); tumor location (left, right); American Joint

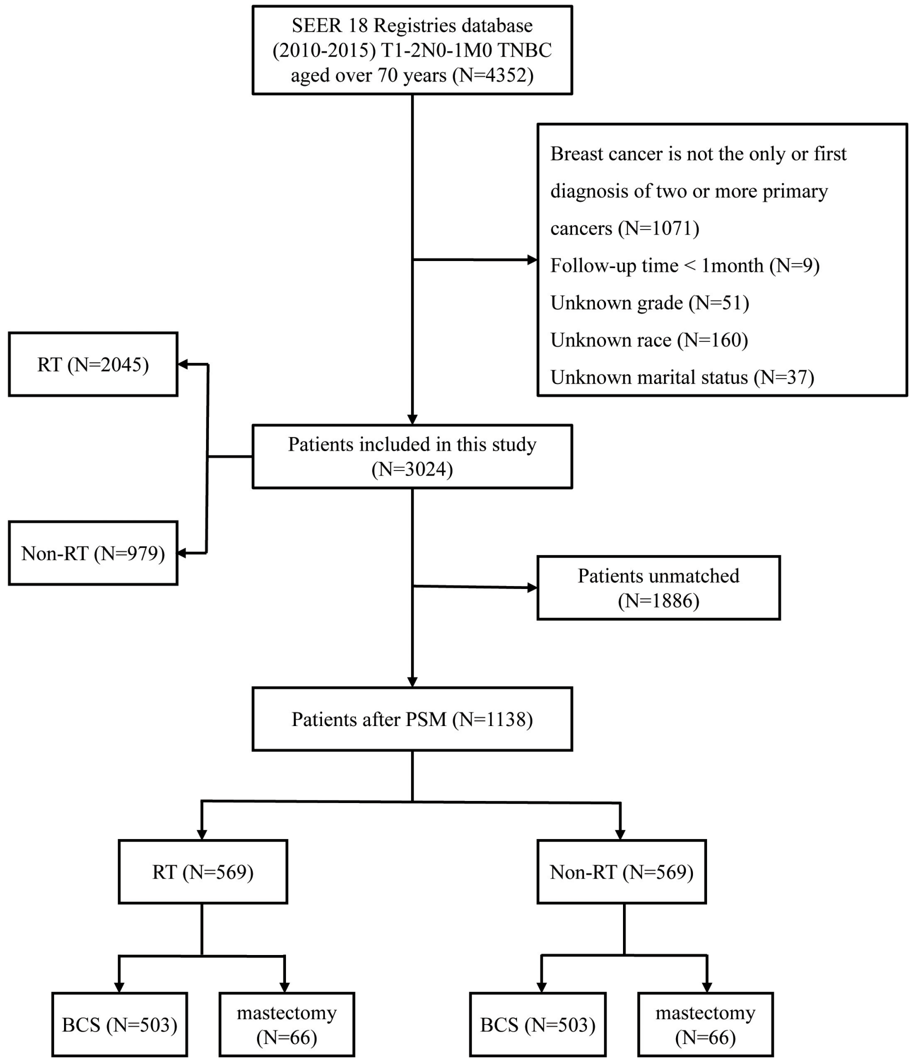

FIGURE 1
Flowchart of the study. TNBC, triple-negative breast cancer; RT, radiotherapy; PSM, propensity score matching; BCS, breast-conserving surgery.

Committee on Cancer (AJCC) T staging (T1, T2); AJCC N staging (N0, N1); surgical method (modified radical mastectomy, breast-conserving surgery); and chemotherapy status (yes, none).

2.3 Statistical analyses

Baseline characteristics were compared using the chi-square test. We employed propensity score matching (PSM) with a caliper of 0.001 to eliminate intergroup differences. PSM could reduce selection bias by matching individuals with similar propensity scores, resulting in more comparable study groups and enhancing the validity of comparisons (23). Univariate and multivariate Cox regression analyses identified independent risk factors in different populations, followed by subgroup analysis of the patients. A nomogram model was then constructed based on the independent risk factors. To evaluate the model's discriminative ability, the receiver operating characteristic (ROC) curve was plotted, along with the AUC and concordance index (C-index). The calibration plot evaluated whether the expected outcomes matched the actual findings. Then, the population was scored based on the nomogram, classifying patients into low-score, and high-score groups using X-tile software. Kaplan-Meier (KM) survival analysis was conducted to compare OS and BCSS among different cohorts. Statistical significance was assessed using a two-sided p-value of < 0.05 and data analysis was conducted using R software (version 4.4.1; http://www.R-project.org/).

3 Results

3.1 Baseline characteristics

Following strict adherence to our inclusion and exclusion criteria, a total of 3,024 elderly patients with early-stage TNBC were enrolled in this study. The population was divided into two groups based on the receipt of RT: the RT group (N = 2,045;

TABLE 1 Demographic, clinical, and laboratory features of TNBC patients aged over 70 with T1-2N0-1M0 stage before and after PSM.

Variables	Initial cohort		*P*	PSM cohort		*P*
	RT	Non-RT		RT	Non-RT	
	N = 2,045	*N* = 979		*N* = 569	*N* = 569	
Age (years)			<0.001			0.990
70–74	920 (45.0%)	325 (33.2%)		202 (35.5%)	207 (36.4%)	
75–79	584 (28.6%)	238 (24.3%)		147 (25.8%)	144 (25.3%)	
80–84	359 (17.6%)	206 (21.0%)		121 (21.3%)	119 (20.9%)	
85+	182 (8.9%)	210 (21.5%)		99 (17.4%)	99 (17.4%)	
Race			0.243			0.907
White	1,653 (80.8%)	766 (78.2%)		473 (83.1%)	469 (82.4%)	
Black	276 (13.5%)	148 (15.1%)		71 (12.5%)	72 (12.7%)	
Other	116 (5.7%)	65 (6.6%)		25 (4.4%)	28 (4.9%)	
Marital status			0.582			0.443
Married	894 (91.3%)	1,881 (92.0%)		533 (93.7%)	540 (94.9%)	
Unmarried	85 (8.7%)	164 (8.0%)		36 (6.3%)	29 (5.1%)	
Laterality						0.721
Left	1,074 (52.5%)	523 (53.4%)		301 (52.9%)	308 (54.1%)	
Right	971 (47.5%)	456 (46.6%)		268 (47.1%)	261 (45.9%)	
Histopathology			0.054			0.626
Duct carcinoma	1,735 (84.8%)	803 (82.0%)		475 (83.5%)	482 (84.7%)	
Other	310 (15.2%)	176 (18.0%)		94 (16.5%)	87 (15.3%)	
Grade			0.212			0.677
I–II	587 (28.7%)	259 (26.5%)		134 (23.6%)	141 (24.8%)	
III	1,458 (71.3%)	720 (73.5%)		435 (76.5%)	428 (75.2%)	
T			<0.001			0.951
T1	1,378 (67.4%)	508 (51.9%)		342 (60.1%)	344 (60.5%)	
T2	667 (32.6%)	471 (48.1%)		227 (39.9%)	225 (39.5%)	
N			<0.001			1.000
N0	1,716 (83.9%)	756 (77.2%)		468 (82.2%)	468 (82.2%)	
N1	329 (16.1%)	223 (22.8%)		101 (17.8%)	101 (17.8%)	
Surgery			<0.001			1.000
BCS	1,945 (95.1%)	587 (60.0%)		503 (88.4%)	503 (88.4%)	
Mastectomy	100 (4.9%)	392 (40.0%)		66 (11.6%)	66 (11.6%)	
Chemotherapy			<0.001			0.807
No/unknown	1,071 (52.4%)	671 (68.5%)		347 (61.0%)	352 (61.9%)	
Yes	974 (47.6%)	308 (31.5%)		222 (39.0%)	217 (38.1%)	

TNBC, triple-negative breast cancer; PSM, propensity score matching; BCS, breast-conserving surgery; RT, radiotherapy. For race, other includes American Indian, AK Native, Asian, and Pacific Islander.

67.6%) and the non-radiotherapy group ($N = 979$; 32.4%). Our analysis revealed that patients in the RT group were generally younger (RT, ≥85 years, 8.9% vs. non-RT, ≥85 years, 21.5%) and presented with earlier T, N staging. Furthermore, most patients in this cohort underwent BCS (breast-conserving surgery; $N =$ 1,945; 95.1%), whereas a large proportion, opted for chemotherapy compared to the non-RT group (RT, undergo chemotherapy, 47.6% vs. non-RT, undergo chemotherapy, 31.5%). It is clear that baseline characteristics between the two groups were unbalanced, prompting the use of PSM. After 1:1 matching with a caliper

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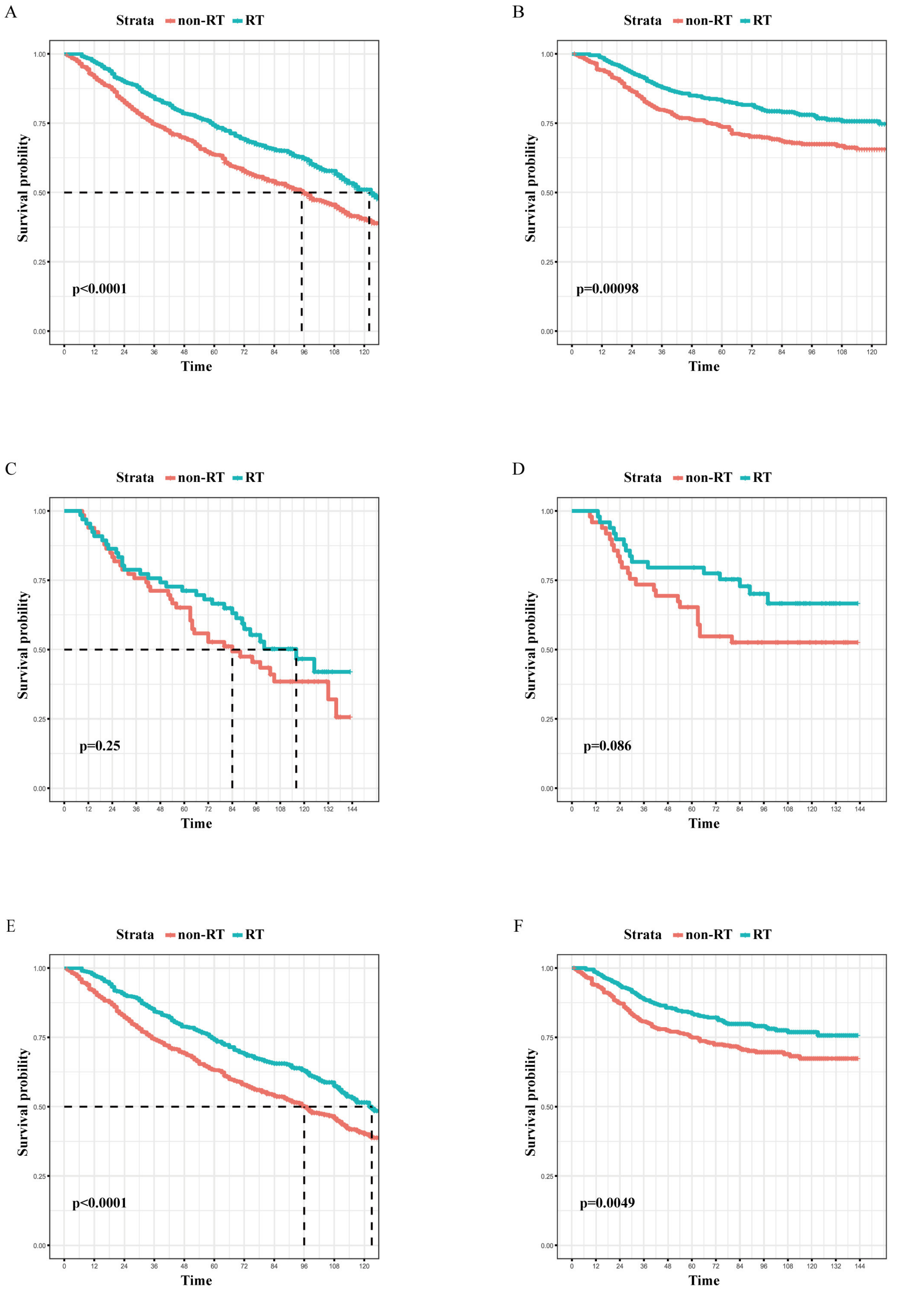

FIGURE 2
The Kaplan-Meier survival curves of the effect of RT on OS in the overall cohort **(A)**, the mastectomy cohort **(C)**, and the BCS cohort **(E)**, as well as the effect of RT on BCSS in the overall cohort **(B)**, the mastectomy cohort **(D)**, and the BCS cohort **(F)** after PSM. RT, radiotherapy; OS, overall survival; BCS, breast-conserving surgery; PSM, propensity score matching.

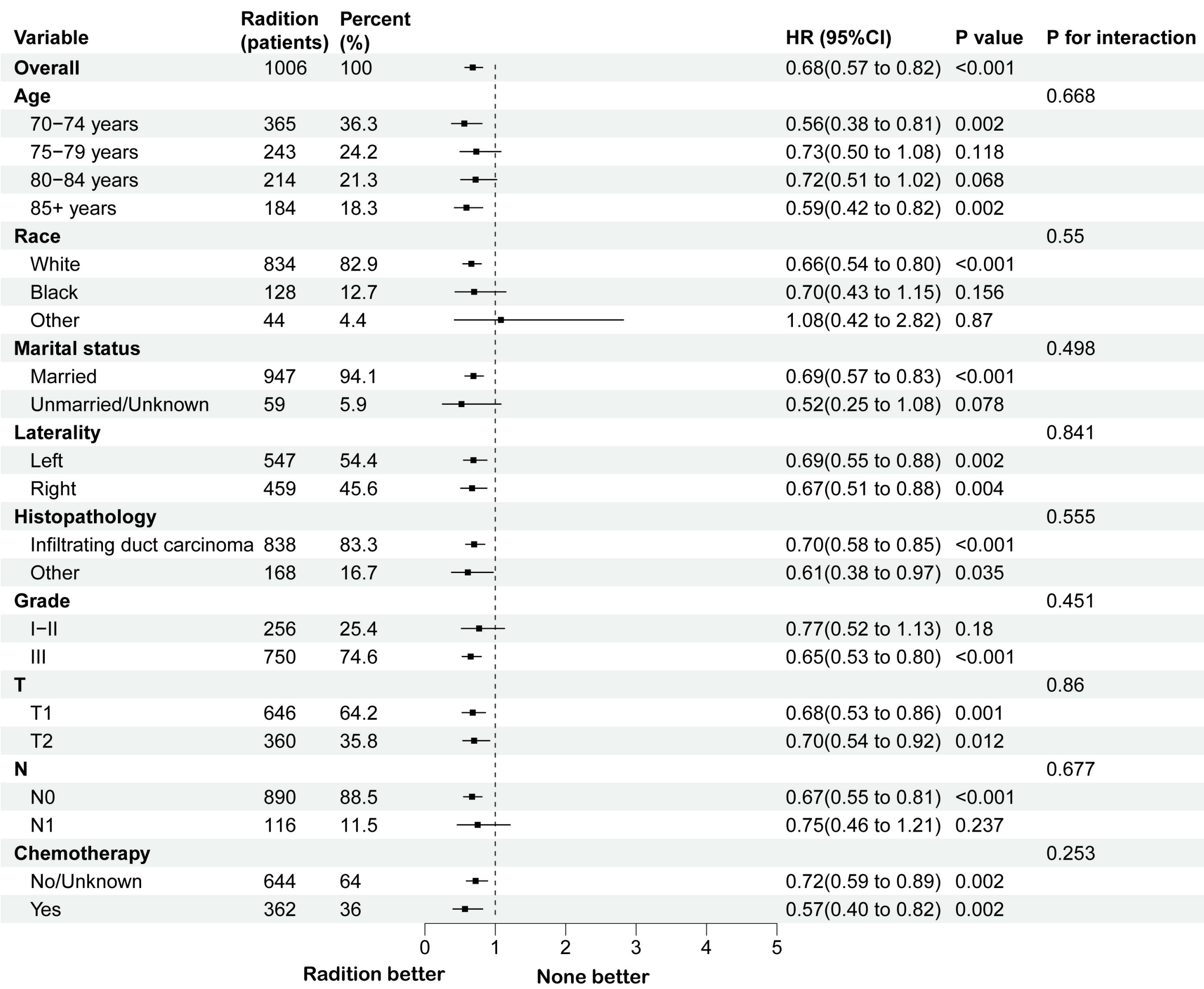

FIGURE 3
Subgroup analysis for OS between RT and no RT groups after PSM in BCS group. RT, radiotherapy; OS, overall survival; PSM, propensity score matching; BCS, breast-conserving surgery.

width of 0.001, 569 patient pairs were successfully matched. The covariates between the two groups were all below 0.05, indicating a robust balance that significantly mitigated confounding bias in the study. The baseline characteristics of the population before and after PSM are presented in Table 1.

3.2 Survival analysis of individuals following PSM and subgroup analysis in BCS group

A survival analysis on the matched cohort was performed (Figure 2), revealing that the RT group experienced significantly greater survival benefits, as evidenced by both OS (HR = 0.69; 95% CI = 0.60–0.79; $p < 0.001$) and BCSS (HR = 0.64; 95% CI = 0.51–0.80; $p = 0.001$). Postoperative RT is typically regarded as a standard treatment modality following BCS. For patients who have undergone modified radical mastectomy with more than three lymph node metastases or tumors measuring 5 cm or greater, RT is generally recommended (24). Accordingly, we performed further survival analysis based on the type of surgical intervention. As illustrated in Figure 2, RT offers significant survival benefits for the BCS population, both in terms of OS (HR = 0.68; 95% CI = 0.58–0.79; $p < 0.001$) and BCSS (HR = 0.65; 95% CI = 0.51–0.84; $p = 0.005$). However, this benefit is not evident in the modified radical mastectomy group, where the p-values are >0.05. Then, subgroup analysis of OS and BCSS in the BCS group showed that, similar to previous studies, RT improved both OS and BCSS. It was statistically significant for OS in patients with age (70–74/>85 years), race (White), marital status (married), Grade (III), T stage (T1, T2), N stage (N0), and chemotherapy (yes/no). For BCSS, RT showed statistical significance in patients with age (70–74/>85 years), race (White), marital status (married), Grade (III), T stage (T1, T2), N stage (N0), and chemotherapy (yes; Figures 3, 4).

Variable	Radition (patients)	Percent (%)	HR (95%CI)	P value
Overall	1006	100	0.66(0.49 to 0.88)	0.005
Age				
70−74 years	365	36.3	0.45(0.25 to 0.79)	0.006
75−79 years	243	24.2	0.73(0.36 to 1.47)	0.376
80−84 years	241	21.3	0.76(0.43 to 1.32)	0.327
85+ years	184	18.3	0.55(0.31 to 0.97)	0.039
Race				
White	571	81.5	0.63(0.45 to 0.88)	0.007
Black	128	12.7	0.79(0.40 to 1.57)	0.505
Other	44	4.4	0.54(0.10 to 2.79)	0.462
Marital status				
Married	947	94.1	0.67(0.49 to 0.90)	0.009
Unmarried/Unknown	59	5.9	0.51(0.16 to 1.67)	0.267
Laterality				
Left	547	54.4	0.74(0.50 to 1.10)	0.138
Right	459	45.6	0.56(0.36 to 0.88)	0.012
Histopathology				
Infiltrating duct carcinoma	838	83.3	0.70(0.51 to 0.95)	0.024
Other	168	16.7	0.39(0.15 to 1.04)	0.059
Grade				
I−II	256	25.4	0.99(0.48 to 2.03)	0.977
III	750	74.6	0.60(0.43 to 0.83)	0.002
T				
T1	646	64.2	0.63(0.41 to 0.97)	0.036
T2	360	35.8	0.66(0.44 to 0.98)	0.039
N				
N0	890	88.5	0.63(0.45 to 0.87)	0.005
N1	116	11.5	0.82(0.41 to 1.65)	0.582
Chemotherapy				
No/Unknown	644	64.0	0.75(0.52 to 1.08)	0.127
Yes	362	36.0	0.51(0.31 to 0.84)	0.008

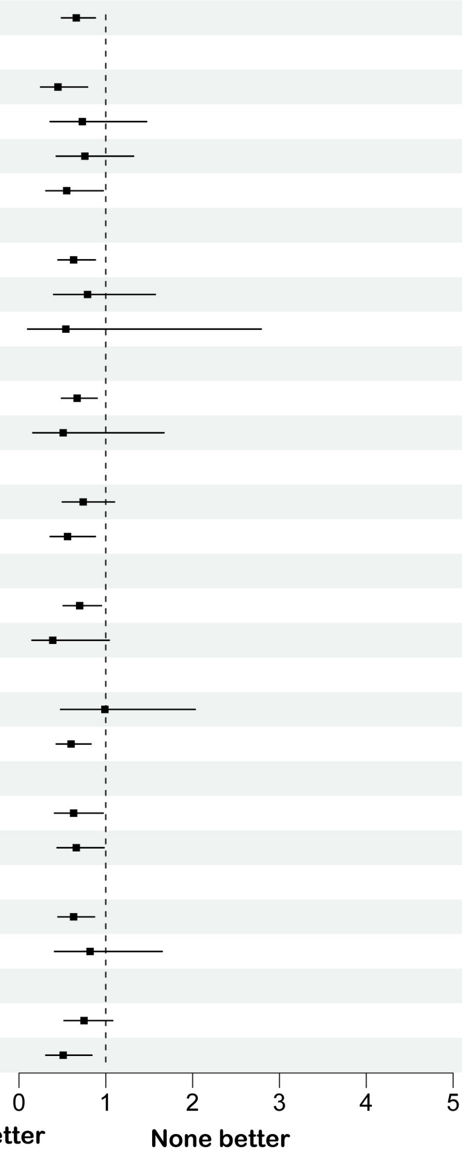

FIGURE 4
Subgroup analysis for BCSS between RT and no RT groups after PSM in BCS group. RT, radiotherapy; BCSS, breast cancer-specific survival; PSM, propensity score matching; BCS, breast-conserving surgery.

3.3 Establishment and validation of the nomogram model

To identify independent risk factors associated with BCSS in patients from non-RT following BCS, both univariate and multivariate Cox regression analyses were performed on this cohort. Univariate and multivariate cox regression analysis identified age, tumor grade, and T stage as independent risk factors for BCSS, with older age, higher grade, and advanced T stage worsening prognosis (all p-values < 0.05). The p-values, hazard ratios (HR), and 95% confidence intervals (CI) for each independent parameter are presented in Table 2. Subsequently, utilizing the three independent risk factors identified, we developed a nomogram to predict 3- and 5-year BCSS for each patient and computed the scores associated with each risk factor (Figure 5).

The model's reliability was assessed through ROC analysis, revealing AUCs of 0.736, and 0.734 for the 3- and 5-year BCSS nomogram, respectively. The C-index was determined to be 0.709. Given the constraints of sample size, patients from the RT group were utilized for external validation, yielding AUCs of 0.741 and 0.765 at 3 and 5 years, respectively, with a concordance index of 0.728 (Figure 6). Furthermore, the calibration curves for BCSS at 3 and 5 years in both the internal and external validation cohorts closely align with the standard curve (Supplementary Figure 1). This suggests that the model demonstrates robust reliability and effective discriminative capacity.

TABLE 2 Univariate and multivariate Cox regression analyses of BCSS in patients from the BCS group who did not receive RT.

Variables	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*P*	HR (95% CI)	*P*
Age (years)				
70–74	Reference		Reference	
75–79	0.84 (0.47–1.51)	0.581	0.94 (0.57–1.54)	0.849
80–84	1.88 (1.11–3.16)	0.017	2.04 (1.32–3.17)	0.007
85+	4.08 (2.22–6.89)	<0.001	4.39 (2.82–6.83)	<0.001
Race				
White	Reference			
Black	1.39 (0.89–2.16)	0.215		
Other	0.80 (0.37–1.72)	0.639		
Marital status				
Married	Reference			
Unmarried	1.33 (0.66–2.66)	0.497		
Laterality				
Left	Reference			
Right	0.96 (0.65–1.43)	0.873		
Histopathology				
Duct carcinoma	Reference			
Other	0.68 (0.37–1.24)	0.213		
Grade				
I–II	Reference		Reference	
III	2.62 (1.63–3.21)	<0.001	2.48 (1.53–4.03)	0.002
T				
T1	Reference		Reference	
T2	2.46 (1.77–3.42)	<0.001	2.04 (1.45–2.87)	<0.001
N				
N0	Reference			
N1	1.62 (0.95–2.77)	0.074		
Chemotherapy				
No/unknown	Reference			
Yes	0.83 (0.59–1.16)	0.368		

BCSS, breast cancer-specific survival; BCS, breast-conserving surgery; RT, radiotherapy.
For race, other includes American Indian, AK Native, Asian, and Pacific Islander.

3.4 Analysis of survival in risk stratification groups

Based on the scores derived from the nomogram, specific scores were calculated for all patients in the RT and non-RT groups following PSM. Subsequently, the x-tile software was employed to classify all patients into low-risk (total nomogram score <60, $N = 316$, 31.41%), intermediate-risk (total nomogram score ≥ 60 and <100, $N = 211$, 20.97%) and high-risk groups (total nomogram score ≥ 100, $N = 479$, 47.61%).

It was found that RT is a crucial treatment modality for patients in the intermediate-risk (OS, HR = 0.49, 95% CI = 0.34–0.71, $p = 0.001$; BCSS, HR = 0.40, 95% CI = 0.21–0.77, $p = 0.018$) and high-risk group (OS, HR = 0.67, 95% CI = 0.55–0.81, $p < 0.001$; BCSS, HR = 0.61, 95% CI = 0.45–0.83, $p = 0.007$), whereas in the low-risk group, patients appear to be exempt from RT (OS, HR = 0.89, 95% CI = 0.65–1.22, $p = 0.571$; BCSS, HR = 0.91, 95% CI = 0.50–1.65, $p = 0.806$; Supplementary Figure 2).

4 Discussion

Aging is a significant risk factor for many chronic diseases, including cardiovascular diseases, cancer, and neurodegenerative disorders (25–28). Advances in medical technology have significantly extended the average lifespan of patients globally, which also presents new challenges for the treatment of the elderly population (29). While certain studies indicate that postoperative RT may enhance survival outcomes in early-stage BC patients (30, 31), the requirement for this treatment in elderly patients remains a subject of debate. Multiple comorbidities, reduced physiological function, and higher postoperative complications in older individuals may reduce RT effectiveness. These issues worsen with age (9, 32).

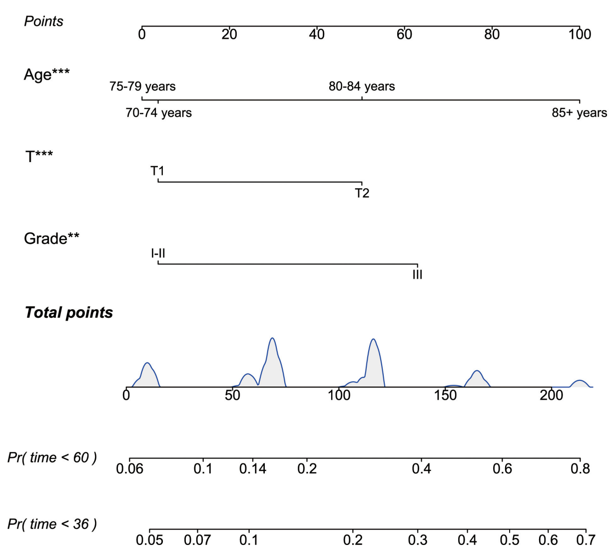

FIGURE 5
The nomogram to predict 3- and 5-year BCSS for the BCS cohort who did not receive RT after PSM. BCSS, breast cancer-specific survival; BCS, breast-conserving surgery; RT, radiotherapy; PSM, propensity score matching. $^{**}P < 0.01$; $^{***}P < 0.001$.

Due to the relatively poor prognosis of TNBC compared to other molecular subtypes (33), this study selected elderly women with early-stage TNBC from the SEER database to investigate the survival benefits of RT in this population, providing evidence for clinical decision-making.

In this study, we observed that RT offers substantial improvements in OS and BCSS among the population following PSM. In fact, the well-known CALGB 9343 study found that the local recurrence rate (LRR) in the RT group was 2% (95% CI, 96–99%), significantly lower than the 10% (95% CI, 85–93%) observed in the non-RT group. However, no significant difference in OS was identified between the two groups; the 10-year OS for the RT group was 67% (95% CI, 62–72%), compared to 66% (95% CI, 61–71%) for the non-RT group. In the follow-up PRIME II study, researchers concluded that postoperative RT after BCS led to a notable but moderate decrease in LRR over 5 years (14, 34). For some patients, the risk of ipsilateral breast tumor recurrence within this timeframe might be sufficiently low to justify the omission of RT (34). This finding appears to contradict our results. However, these two trials lacked comprehensive analysis of different molecular subtypes and tumor grades (14).

Given that the surgical approach is a crucial determinant of whether patients require postoperative RT (35–38), the population was categorized into the BCS group and the modified radical mastectomy group for a more detailed analysis. The results indicate that RT appears to provide more significant benefits for patients in the BCS cohort (OS, $p < 0.001$; BCSS, $p = 0.005$), while the effects are relatively modest for patients in the modified radical mastectomy group (OS, $p = 0.25$; BCSS, $p = 0.086$). This may be due to more complete cancer removal through modified radical mastectomy, which also increases surgical trauma and complications (39). However, it is important to recognize that a subset of the elderly population can benefit from postoperative RT (40, 41). Therefore, a Cox regression analysis was performed on the BCS group without RT, and a nomogram model for BCSS

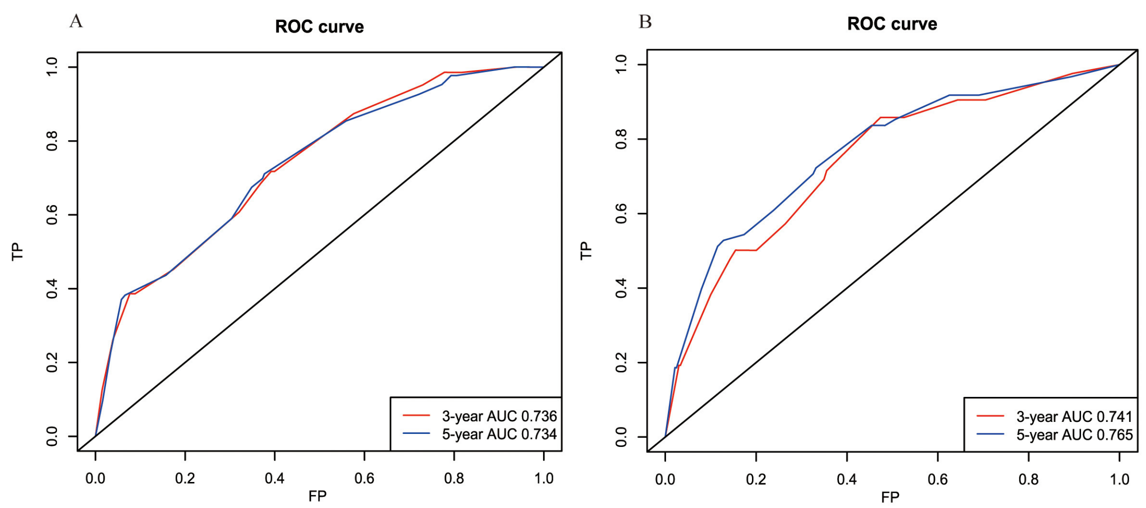

FIGURE 6
The receiver operating characteristic (ROC) curves for the BCSS model in the internal cohort **(A)** and external cohort **(B)**. BCSS, breast cancer-specific survival.

was developed based on independent risk factors. Although earlier studies used LRR to assess postoperative RT in BCS, the SEER database lacked relevant data. The predictive model focused on BCSS, which indirectly indicates LRR. It also helps predict OS in stratified analyses (42, 43). According to our nomogram model, an increase in tumor aggressiveness factors (such as T stage and Grade) and patient age are typically associated with a poorer prognosis. Therefore, when scoring based on patient risk levels, the low-risk group predominantly consists of younger individuals with smaller tumor sizes and lower grade classifications. Survival analysis revealed that RT provided no survival benefit for the low-risk group, regardless of OS (HR = 0.89, 95% CI = 0.65–1.22, $p = 0.571$) or BCSS (HR = 0.91, 95% CI = 0.50–1.65, $p = 0.806$). The same analysis was conducted for the intermediate-risk and high-risk groups. Surprisingly, the intermediate- (OS, HR = 0.49, 95% CI = 0.34–0.71, $p = 0.001$; BCSS, HR = 0.40, 95% CI = 0.21–0.77, $p = 0.019$) and high-risk groups (OS, HR = 0.67, 95% CI = 0.55–0.81, $p < 0.001$; BCSS, HR = 0.61, 95% CI = 0.45–0.83, $p = 0.007$) —demonstrated significant improvements in prognosis following RT, indicating benefits for both OS and BCSS. This suggests that in clinical management, low-risk patients may be exempt from RT based on individual characteristics, while patients with medium to high risk are recommended to undergo appropriate postoperative RT to enhance prognosis.

Therefore, in clinical practice, the treatment of elderly patients should not follow a one-size-fits-all approach. Based on our findings, patients in intermediate and high-risk groups may benefit from RT. A thorough evaluation of factors such as age, grade, and T stage is required to identify those likely to benefit from RT. This approach aims to personalize treatment based on individual risk profiles, in contrast to the generalized notion that conservative treatment is usually preferable for elderly patients. Our findings may provide new treatment strategies for elderly patients with early-stage TNBC and establish a model for BCS populations, emphasizing the importance of personalized treatment. Overall, this study is the first to examine the impact of postoperative RT in patients over 70 years old with T1-2N0-1M0 stage TNBC. Using PSM to adjust for confounders, significant survival differences were observed in the BCS group. Cox regression analysis of BCSS led to the development of nomogram and calibration curves, with AUC and C-index both >0.7, indicating strong predictive ability. As noted, due to the current lack of studies focused on elderly BC patients, this research offers valuable insights for improving clinical decision-making and providing more precise treatment for elderly BC patients. Based on our conclusions, we strongly recommend postoperative RT as an adjuvant treatment for patients in the intermediate and high-risk groups. Conversely, we do not recommend postoperative RT for low-risk patients. However, in clinical practice, a comprehensive assessment of the patient's overall health status and comorbidities should be conducted to inform treatment decisions.

The study has several limitations. First, the SEER database lacks specific chemotherapy regimens and detailed radiotherapy dosages. Consequently, despite utilizing PSM, potential confounding factors may still influence the results. Second, although the database was used as the data source, the sample size remains relatively small; the nomogram model is based on only 330 patients with BCSS, which may introduce bias. Future research should utilize real-world data to comprehensively address these issues and validate the findings in a real-world context. In conclusion, this study aims to address the ambiguity surrounding radiotherapy indications for elderly patients, improve current treatment protocols, and provide survival benefits for the elderly TNBC population.

5 Conclusions

RT markedly improves OS and BCSS in early-stage TNBC patients after undergoing BCS. For those identified as medium to high-risk groups, RT is a critical element of cancer management and is recommended whenever physically feasible. In contrast, low-risk early-stage TNBC patients may be considered for omitting RT.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

ZX: Writing – original draft, Writing – review & editing. CQ: Writing – original draft, Writing – review & editing. BC: Writing – review & editing. PR: Writing – original draft. MZ: Writing – review & editing. GC: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2024.1525425/full#supplementary-material

SUPPLEMENTAL FIGURE 1
Calibration curves for predicting patients' BCSS at 3- and 5- years in the internal cohort **(A, B)** and external cohorts **(C, D)**. BCSS, breast cancer-specific survival.

SUPPLEMENTAL FIGURE 2
The Kaplan-Meier survival curves of the effect of RT on OS in the low-risk cohort **(A)**, intermediate-risk cohort **(C)**, and the high-risk cohort **(E)**, as well as the effect of RT on BCSS in the low-risk cohort **(B)**, intermediate-risk cohort **(D)**, and the high-risk cohort **(F)**. RT, radiotherapy; OS, overall survival; BCSS, breast cancer-specific survival.

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